Goodwyn Area Infill Development Offshore Project Proposal

Development Division

Revision 2

July 2024

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

ES1 INTRODUCTION

Overview of the Offshore Project

On behalf of the North West Shelf Joint Venture (NWSJV), Woodside Energy Limited (Woodside) proposes to undertake the Goodwyn Area Infill Development (the 'offshore project') (Table ES-1). The Goodwyn Area Infill Development is in Commonwealth waters, ~140 km north-west of Karratha, Western Australia (WA) (Figure ES-1).

The purpose of the Goodwyn Area Infill Development is to partially fill the ullage (unused production capacity) at the existing Goodwyn A (GWA) platform as production from existing wells and reservoirs decline, by providing an incremental volume of gas and condensate to the GWA platform between ~2026 and 2040.

The proposed Goodwyn Area Infill Development comprises multiple subsea tiebacks (within scope of this proposal) to existing Greater Western Flank (GWF) subsea infrastructure (out of scope of this proposal), which will transfer the reservoir fluids to the existing GWA platform (also out of scope of this proposal). The development will target both existing and previously undeveloped gas reservoirs west and south-west of the GWA platform in Commonwealth waters. Reservoirs within scope of the Goodwyn Area Infill Development include (but are not limited to): Echo Spur, Tidepole East, Wilcox, Yodel Updip, and Yodel South (Table ES-1). Reservoir fluids from the Goodwyn Area Infill Development will then be processed at the GWA platform before being exported (via the existing interfield line and export trunkline) to the Karratha Gas Plant (KGP) for final processing and subsequent export to domestic and international markets. The processing of gas at the GWA platform and the transport of that gas to KGP for future processing is not in scope of this proposal.

The Goodwyn Area Infill Development is a phased development, with construction (drilling of production wells and installation of subsea infrastructure) and start-up of operations occurring over multiple phases. The development includes an allowance for up to 8 production wells. End of field life (EOFL) decommissioning for the Goodwyn Area Infill Development will occur once the reservoirs have reached the end of their economic life. The indicative EOFL for the Goodwyn Area Infill Development is ~2040, to align with the currently approved EOFL for the GWA Facility[1]. Further description of the Goodwyn Area Infill Development is provided in Section ES5.

Woodside is targeting a final investment decision (FID) for the Goodwyn Area Infill Development in 2024. The initial phase of drilling and subsea installations is anticipated to start during 2025/2026, and delivery of first gas in 2026. Achieving these milestones is subject to several factors including NWSJV approvals, regulatory approvals, and commercial arrangements being finalised.

Table ES-1: Key characteristics for the Goodwyn Area Infill Development

Item	Description
Proponent	Woodside, for and on behalf of the NWSJV
Location	~140 km north-west of Karratha, WA
Water depths	~70–160 m for areas of proposed subsea infrastructure ~20–180 m for full extent of Project Area
Petroleum titles	The offshore project provides for a phased development which may incorporate these petroleum titles and gas reservoirs: • WA-5-L (Echo Spur, Tidepole East)

[1] In accordance with Schedule 3 of the OPGGS Act, the GWA Facility comprises the GWA platform and the subsea hydrocarbon system (production wells and infield infrastructure).

Item	Description
	• WA-24-L (Yodel Updip, Yodel South) • WA-7-R (Wilcox) The offshore project also provides for potential future development of gas reservoirs within these petroleum titles (above) and/or others (WA-6-L, WA-23-L, WA-56-L, WA-57-L, WA-58-L) within the Project Area
Petroleum activities	• drilling and completions – geotechnical sampling (if required to inform MODU mooring) – drilling operations (for up to 8 production wells) – formation evaluation – well completion – well unloading • subsea installation and pre-commissioning – installing Xmas trees, flowlines, electrohydraulic umbilicals, and other infield infrastructure – pre-commissioning • start-up and operations – initial start-up of wells and subsea infrastructure – subsea IMMR • decommissioning – plugging and abandoning wells – removing property • field support – operating MODUs, vessels, helicopters, and ROVs
Production wells	It is anticipated that the Goodwyn Area Infill Development may include: • up to 6 production wells drilled across multiple phases • allowance for up to an additional 2 production wells (as part of potential future developments)
Subsea infrastructure	It is anticipated that the Goodwyn Area Infill Development will include various infield infrastructure including (but not limited to): • wellheads, and Xmas trees • flowlines, electro-hydraulic umbilicals (EHUs), manifolds, pipeline end terminations (PLETs), flowline end terminations (FLETs), in-line trees (ILTs), umbilical termination assemblies (UTAs), electrical flying leads (EFLs), hydraulic flying leads (HFLs), flexible pipe jumpers, rigid spools, subsea intensifiers, cooling skids, pressure protection systems, and accumulator modules
Anticipated hydrocarbon	Gas and condensate
Design life	~20 years (wells), ~10 years (subsea infrastructure)
EOFL	2040

Purpose of the Offshore Project Proposal

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGS Act) provides the legal framework for petroleum activities in Commonwealth waters (i.e. those waters beyond three nautical miles (nm) of the territorial sea baseline to the outer extent of the continental shelf and Australian Exclusive Economic Zone at 200 nm). The OPGGS Act provides that before commencing an offshore project, an Offshore Project Proposal (OPP) must be submitted to NOPSEMA.

This OPP has been prepared in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (Cth) (referred to as the Environment Regulations), as administered by NOPSEMA.

In accordance with the Environment Regulations, the purpose of this OPP is to:

- appropriately identify and evaluate the environmental impacts and risks of the offshore project (including from planned activities and unplanned events)
- demonstrate that the environmental impacts and risks of the offshore project will be managed to an acceptable level
- demonstrate that the offshore project will be carried out in a manner consistent with the principles of ecologically sustainable development (ESD), as defined in section 3A of the EPBC Act.

The OPP defines project-specific environmental performance outcomes (EPOs) that are consistent with the principles of ESD and are the basis for assuring that impacts and risks associated with the offshore project will be managed to an acceptable level.

Proponent

Woodside is a global energy company, founded in Australia. Woodside's operations are characterised by strong safety and environmental performance in remote and challenging locations.

In accordance with regulation 7(2)(a) of the Environment Regulations, details of the proponent and its contact details are:

Woodside Energy Limited

11 Mount Street

Perth, Western Australia

T: 08 9348 4000

E: feedback@woodside.com

ACN: 63 005 482 986

Existing Environmental Approvals for the GWA Facility and KGP (not the subject of this Offshore Project Proposal)

This OPP does not include the existing operations of the GWA Facility and North West Shelf Project (NWS Project). These facilities are approved and operating under existing approvals, as described below and are not within the scope of this OPP. These existing operations (and any approved changes) will continue regardless of the proposed Goodwyn Area Infill Development.

On behalf of the NWSJV, Woodside operates the NWS Project, supplying Australian and international markets with gas from offshore gas fields in the Carnarvon Basin (off WA's Pilbara coast). The NWS Project commenced in 1984 with the commissioning of the KGP, which has since undergone several expansions and additions. The NWS Project includes processing, storage, and offloading facilities associated with operations at the KGP, as well as two export trunklines that extend from the North Rankin Complex in Commonwealth waters to the onshore KGP[2]. At present, the NWS Project processes natural gas and associated fluids from NWSJV field resources pursuant to Ministerial Statements granted under the *Environmental Protection Act 1986* (WA). NWS Project operations (including the KGP) are outside the scope of this proposal.

The GWA Facility commenced production in 1995 and is one of the NWSJV assets that supply gas and associated fluids to the KGP. The GWA Facility comprises a subsea hydrocarbon system (i.e. production wells and associated infield infrastructure) and a platform. Existing reservoirs and subsea tiebacks supplying hydrocarbons to the GWA platform include Echo, Goodwyn, Perseus,

[2] The operation of these export trunklines is within scope of the WA Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) accepted North West Shelf Trunklines State Waters Operations Environment Plan (EP) and the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) accepted North Rankin Complex Facility Operations EP.

Searipple, Yodel, and the Greater Western Flank (GWF) reservoirs (Goodwyn GH, Tidepole, Keast, Dockrell, Sculptor, Rankin, Lady Nora, and Pemberton). The GWA Facility, including the existing fields and subsea tiebacks, operate under existing environmental approvals, being the GWA Facility Operations EP, most recently accepted by NOPSEMA on 3 March 2022 which approves the production and processing of dry gas and condensate at the GWA platform and the export of processed fluids to the interfield line and KGP. The GWA Facility is out of scope of this proposal.

The existing subsea tiebacks to the GWA platform have been previously referred under the EPBC Act as follows:

- January 2001: Echo–Yodel tie-ins were approved with conditions under section 23 and 24A of the EPBC Act by the then Minister for the Environment and Heritage (EPBC 2000/11)
- February 2004: Perseus–Searipple tie-ins (Perseus over Goodwyn Development) was determined to be 'not a controlled action' (EPBC 2004/1326)
- April 2005: An additional development to the Echo–Yodel fields (Echo A / Upper E) was determined to be 'not a controlled action' (EPBC 2005/2042)[3]
- January 2006: Western Flank Gas subsea development was determined to be 'not a controlled action' (EPBC 2005/2464); this development incorporates GWF Phase 2 and Phase 3
- August 2011: GWF Phase 1 Gas Development was determined to be 'not a controlled action if undertaken in a particular manner' (EPBC 2011/5980).

On 27 February 2014 the process for streamlined environmental approvals for offshore petroleum and greenhouse gas (GHG) storage activities in Commonwealth waters came into effect. Following a strategic assessment of NOPSEMA's environmental management authorisation process under section 146 of the EPBC Act, the then Federal Minister for the Environment endorsed NOPSEMA's process set out in the *Program Report—Strategic Assessment of the environmental management authorisation process for petroleum and greenhouse gas storage activities administered by the National Offshore Petroleum Safety and Environmental Management Authority under the Offshore Petroleum and Greenhouse Gas Storage Act 2006* dated February 2014 (referred to as the Program) as meeting the requirements of Part 10 of the EPBC Act.

Subsequently, on 27 February 2014, the Minister approved a class of actions under section 146B of the EPBC Act which, if undertaken in accordance with the endorsed Program, will not require separate referral, assessment, and approval under the EPBC Act (Class Approval). The Class Approval is valid until 31 December 2040.

Petroleum activities that are within the scope of, and undertaken in accordance with, the NOPSEMA-accepted GWA Facility Operations EP are covered by the Class Approval issued by the Minister for the Environment.

ES2 WOODSIDE MANGEMENT SYSTEM

The Woodside Management System (WMS) provides a structured framework of documentation to set common expectations governing how employees and contractors at Woodside will work.

Within the WMS, the overall direction for environment is set through Woodside's Environment and Biodiversity Policy. In recognition of the intrinsic value of nature, Woodside's objective is to undertake activities in an environmentally sustainable way. This policy sets out Woodside's commitments (the principles) for managing the environment and biodiversity, and supporting sustainable development.

In addition, Woodside's Climate Policy acknowledges the advice from the Intergovernmental Panel on Climate Change (IPCC) and the objectives of the Paris Agreement. The policy identifies principles to achieve Woodside's objective of being a lower-carbon energy provider.

[3] This proposed Echo A / Upper E subsea tieback has not been developed to date.

These policies apply to Woodside's employees, contractors, and joint venture partners engaging in activities under Woodside's operational control.

ES3 DESCRIPTION OF RELEVANT REQUIREMENTS

The Goodwyn Area Infill Development is in Australian Commonwealth waters and falls under Commonwealth jurisdiction.

The principal piece of environmental legislation that is relevant to the Goodwyn Area Infill Development is the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGS Act). The OPGGS Act provides the legal framework for petroleum activities in offshore areas. Specific environmental obligations are set out in the OPGGS Act's associated regulations, including the Environment Regulations.

Under the Environment Regulations, a proponent must submit an OPP (this document) to NOPSEMA before commencing an offshore project; the purpose of an OPP is described above. The Environment Regulations define an offshore project as "one or more activities that are undertaken for the purpose of the recovery of petroleum, other than on an appraisal basis, including any conveyance of recovered petroleum by pipeline (whether or not the activity is undertaken for other purposes)".

In addition to an accepted OPP, other environmental approvals are required before a petroleum activity can be undertaken in an offshore area. Under the Environment Regulations, a titleholder must also submit an EP to NOPSEMA before commencing a petroleum activity. However, an EP for a petroleum activity that is, or is part of, an offshore project can only be submitted if:

- NOPSEMA has accepted an OPP that includes that petroleum activity, or
- the Commonwealth Environment Minister has
  - made a decision under the EPBC Act that an action that includes the petroleum activity is not a controlled action
  - made a decision that a particular provision of Part 3 of the EPBC Act is not a controlling provision for an action that is equivalent to or includes the petroleum activity because the Commonwealth Environment Minister believes the action will be taken in a particular manner, or
  - has approved the taking of an action that is equivalent to or includes the petroleum activity under the EPBC Act.

Several other requirements, including under legislation, guidelines, and management plans were also identified as relevant to the environmental management of the Goodwyn Area Infill Development; these are described within this OPP.

ES4 OFFSHORE PROJECT PROPOSAL PROCESS

Under the Environment Regulations, an OPP must appropriately describe the offshore project and the existing environment that may be affected by the offshore project, detail the environmental impacts and risks arising from the offshore project, evaluate them (appropriate to the nature and scale of each impact and risk) and demonstrate that they will be managed to an acceptable level.

The environmental impacts and risks for the offshore project were assessed in accordance with Woodside's Risk Management Process and associated procedures, following these key steps:

- establish the context
  - describe the project
  - describe the existing environment

  - identify relevant requirements
- identify impacts and risks
- analyse impacts and risks
  - evaluate consequences (for impacts and risks)
  - determine likelihood and risk rating (for risks)
- treat impacts and risks
  - identify key control measures
- demonstrate acceptability.

As part of the OPP process, Woodside developed acceptable level(s) for the Goodwyn Area Infill Development based on considering the relevant contexts, including but not limited to:

- principles of ESD
- relevant requirements, such as
  - Australian legislation, government policies, or environmental management guidelines
  - management plans relevant to matters protected under Part 3 of the EPBC Act (e.g. recovery plans, conservation management plans, marine park management plans)
- internal context, such as Woodside's processes and procedures
- external context, such as advice from stakeholders.

As part of the demonstration of acceptability, the predicted level of impact and risk was compared against the acceptable level(s) to determine if they can be met, or if additional management (i.e. additional key control measures) may be required to further reduce the impact or risk so that it does not exceed the acceptable level(s).

ES5 DESCRIPTION OF THE PROJECT

Using multiple subsea tiebacks to existing GWF subsea infrastructure, the Goodwyn Area Infill Development intends to develop incremental volumes of gas and condensate to partially fill ullage at the GWA platform. The Goodwyn Area Infill Development includes both existing and previously undeveloped gas reservoirs within petroleum titles west and south-west of the GWA platform. Reservoirs within scope of the Goodwyn Area Infill Development include (but are not limited to): Echo Spur, , Tidepole East, Wilcox, Yodel Updip, and Yodel South. Additional reservoirs, not yet fully defined, may be considered as part of future tiebacks opportunities. While the gas reservoirs that may form part of future tieback opportunities are not yet fully defined, they will be accessed via the petroleum titles listed in Table ES-1, and hydrocarbon characteristics are expected to be within the range of reservoir characteristics (i.e. yield similar products) described in the OPP.

Existing operations such as the processing well fluids at the GWA platform, transferring these to the KGP for final processing, and exporting to domestic and international markets are not within scope of this OPP and do not form part of the project description (refer to the *Existing Environmental Approvals for the GWA Facility and KGP* within Section ES1).

The Project Area defines the spatial boundary for the offshore project and incorporates the petroleum titles relevant to the Goodwyn Area Infill Development (Figure ES-1). At its closest, the Project Area is ~30 km north of the Montebello Islands and ~140 km north-west of Karratha. All planned petroleum activities associated with the offshore project will be undertaken within the Project Area.

Key petroleum activities associated with the Goodwyn Area Infill Development include:

- drilling and completions

  - geotechnical sampling (if required to inform MODU mooring)
  - drilling operations (for up to 8 production wells)
  - formation evaluation
  - well completion
  - well unloading
- subsea installation and pre-commissioning
  - installing Xmas trees, flowlines, electrohydraulic umbilicals, and other infield infrastructure
  - pre-commissioning
- start-up and operations
  - initial start-up of wells and subsea infrastructure
  - subsea IMMR
- decommissioning
  - plug and abandon wells
  - removing property
- field support activities
  - operating MODUs, vessels, helicopters, and remotely operated vehicles.

Woodside is currently undertaking concept select engineering for the Goodwyn Area Infill Development, with front-end engineering design (FEED) scheduled to start during 2024. The Goodwyn Area Infill Development will comprise multiple development phases over its life. The initial phase is planned to start during 2025/2026, with first gas in 2026. The timing of subsequent development phases will depend on reservoir performance and project requirements. The indicative EOFL for the Goodwyn Area Infill Development is ~2040, to align with the currently approved EOFL for the existing GWA Facility operations.

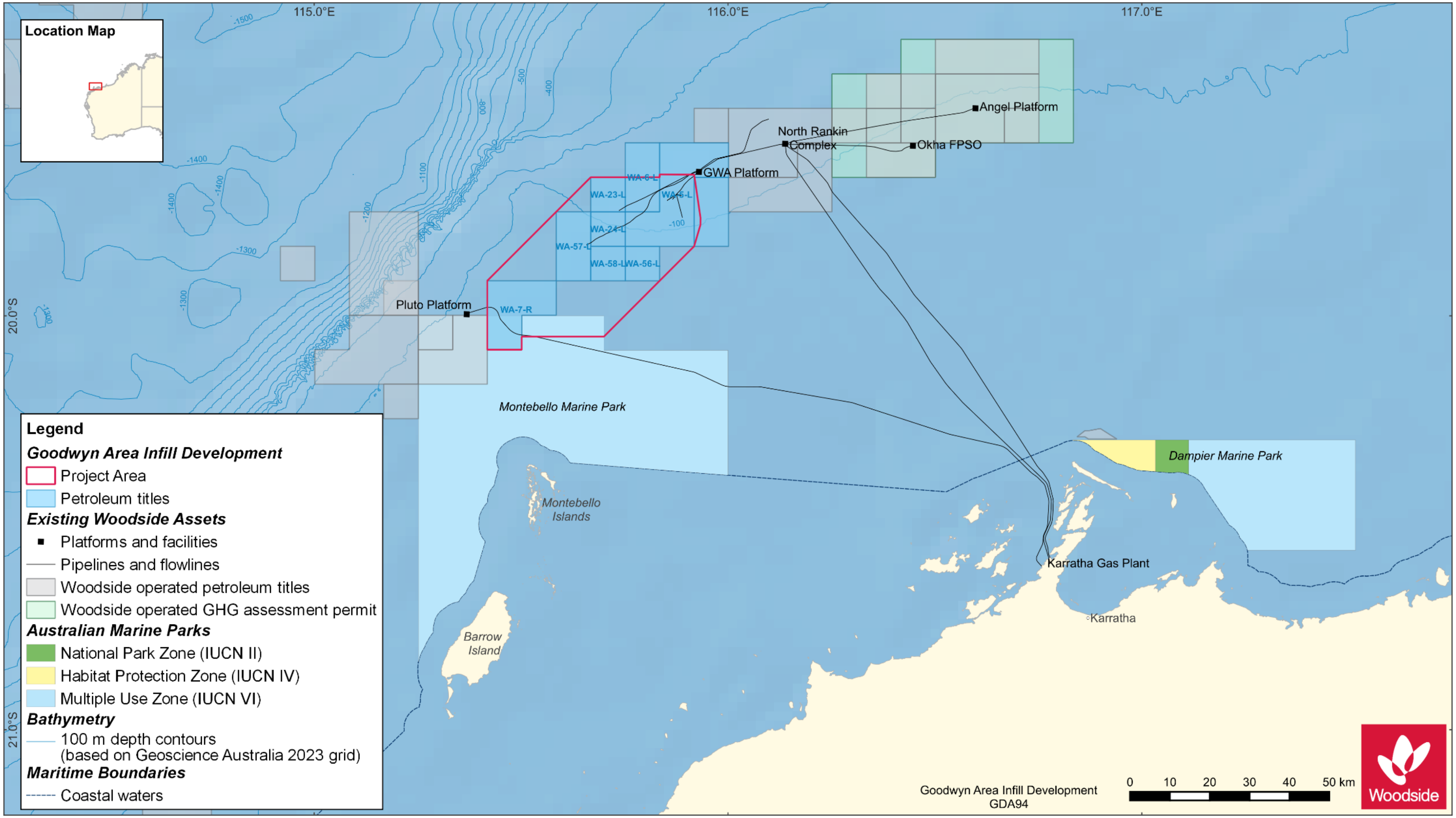


Figure ES-1: Location of Goodwyn Area Infill Development

ES6 ALTERNATIVES ANALYSIS

Woodside identified these project alternatives:

- subsea tieback to the GWA platform (all reservoirs developed via tiebacks to existing GWF infrastructure and well fluids transported to GWA platform)
- subsea tieback to the GWA and Pluto platforms (Wilcox reservoir developed via a tieback directly to Pluto platform, and all other reservoirs developed via tiebacks to existing GWF infrastructure with well fluids transported to GWA platform)
- subsea tieback to the GWA platform and Pluto trunkline (Wilcox reservoir developed via subsea tieback or hot top into the existing Pluto trunkline, and all other reservoirs developed via tiebacks to existing GWF infrastructure with well fluids transported to GWA platform)

  (together, the Feasible Project Alternatives)
- subsea tieback to a greenfield facility (Greenfield Facility Development Alternative)
- no development, including consideration of limiting development of wells near the Montebello Marine Park (No Development Alternative).

The Greenfield Facility Development Alternative was not considered a feasible alternative, as there is an insufficient resource base in the target reservoirs to support a standalone development. The No Development Alternative was also not considered a feasible alternative as the NWSJV has development obligations for commercially viable reservoirs under its production licence and retention lease agreements. Although the reservoir targets being pursued by the Goodwyn Area Infill Development are economically challenged, it is expected that commercial viability can be achieved for some, or all, of the targets under a tie-back development.

Woodside did a qualitative comparative assessment of the Feasible Project Alternatives. This comparative assessment considered key environmental, technical, safety, and economic impacts and risks. Based on these impacts and risks, Woodside's preferred project alternative is subsea tieback to the GWA platform (i.e. all reservoirs developed via tiebacks to existing GWF infrastructure and well fluids transported to GWA platform). This alternative is the subject of this Goodwyn Area Infill Development OPP.

Although there were no material differences in the environmental impacts or risks associated with the Feasible Project Alternatives, the technical feasibility and safety risks were considered lower and less complex for the preferred alternative (subsea tieback to the GWA platform). Woodside considered that the preferred project alternative will also maximise use of existing infrastructure, maintain ullage at the GWA platform as the existing producing fields decline, and continue to support domestic and export markets until the approved EOFL for the existing GWA Facility operations.

A comparative assessment of feasible activity alternatives that were evident at the current phase (concept select) of engineering was also done, including:

- types of MODU
- types of piling-based mooring systems
- top-hole locations for drilling within vicinity of marine parks
- types of drilling fluids
- drilling discharges management
- hydrotest fluid discharge management
- produced water disposal
- carbon management

- MEG injection.

These assessments typically showed that a final decision based on technical feasibility and/or safety risk would be determined during FEED, and therefore multiple feasible activity alternatives are carried forward within this OPP.

ES7 DESCRIPTION OF THE EXISTING ENVIRONMENT

The description of the existing environment relevant to the Goodwyn Area Infill Development is presented for:

- Project Area—the spatial extent where planned activities will occur
- Environment that May Be Affected (EMBA)—the largest spatial extent where unplanned events could have an environmental consequence on the surrounding environment.

The Project Area is on the Australian continental shelf within Commonwealth waters, and within the North-west Marine Region (NWMR). The EMBA extends into the South-west Marine Region (SWMR) (Figure ES-2).

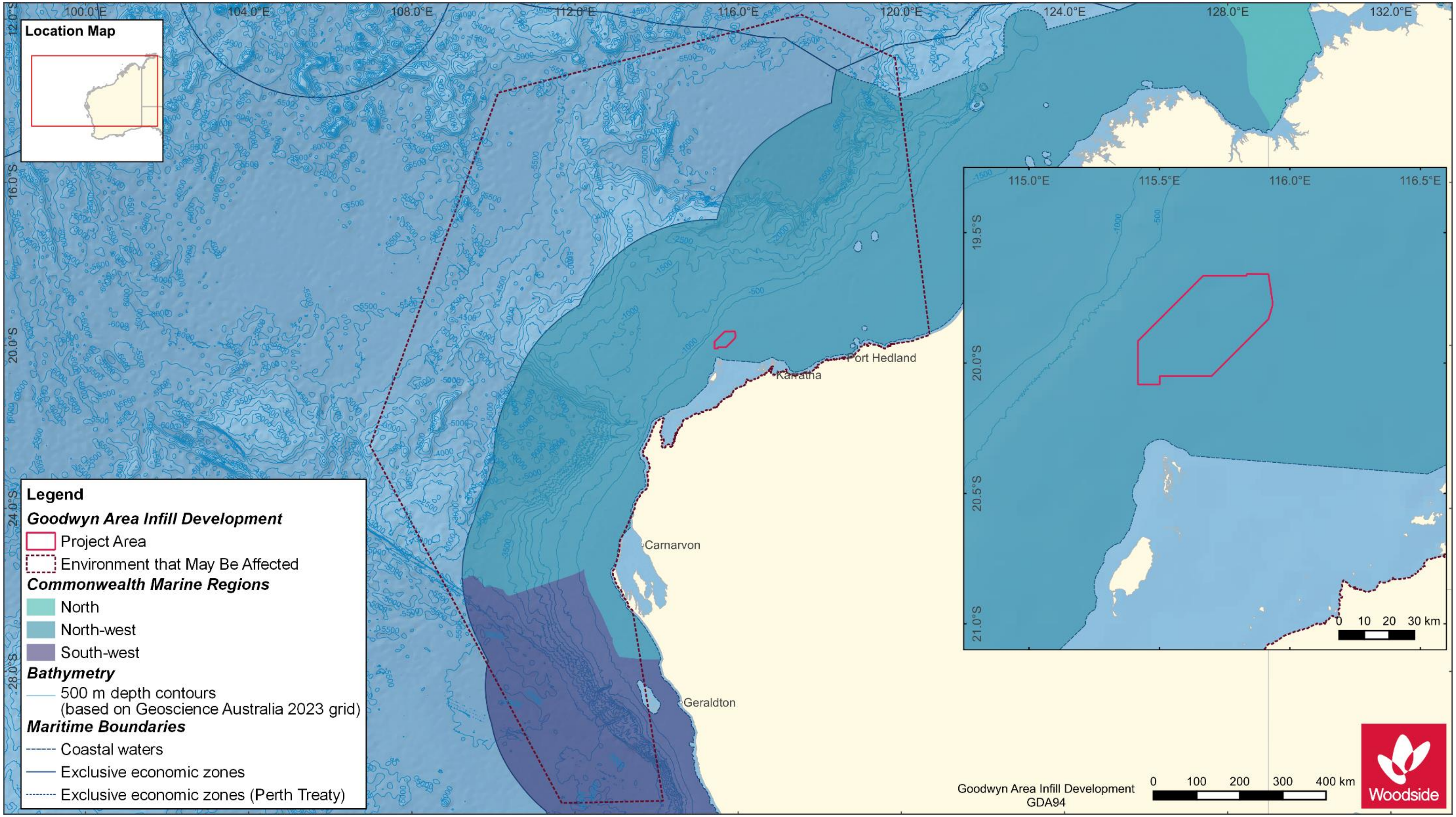


Figure ES-2: Project Area and EMBA for the Goodwyn Area Infill Development

Physical Environment

Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA), the Project Area occurs within the Northwest Shelf Province bioregion. This bioregion is a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells, and internal tides. Its waters derive from the Indonesian Throughflow, are warm and oligotrophic, and circulate throughout the bioregion via branches of the South Equatorial and Eastern Gyral currents.

The bathymetry within the Project Area is generally flat, which is consistent with the broader Northwest Shelf Province shelf region. Based on classifications by Geoscience Australia, the seabed geomorphology within the vicinity of the Project Area comprises slope, shelf, terrace, and pinnacle geomorphic units. The two shallower pinnacle units (with features in <30 m water depth) correspond with Rankin Bank and Wilcox Shoal.

Habitat and Biological Communities

Habitats within the NWMR range from nearshore and coastal primary producer habitats (e.g. seagrass, coral communities, mangroves) to offshore soft sediment seabed habitats and submerged and emergent reef systems. These habitats support biological communities that range from low-density sessile and mobile benthos, such as sponges, molluscs, and echinoids in offshore soft sediment habitat to complex, diverse, remote coral reef systems.

The predominant benthic habitat within the Project Area is expected to be soft sediment with sparse infauna and epifauna communities; this habitat is broadly represented throughout the NWMR. Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate. These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans.

Rankin Bank has a diverse range of habitats (e.g. consolidated reef and algae, hard corals, unconsolidated sand/silt) and benthic communities (e.g. macroalgae, soft corals, sponges, other invertebrates), and supports a diverse fish assemblage. Rankin Bank is considered to represent habitats that are likely to play an important role in the productivity of the Pilbara region. Wilcox Shoal is currently unsurveyed, but the bathymetry indicates that the upper reaches of the shoal may support a high cover of benthic organisms comprising mixed hard and soft corals, transitioning to a deeper water benthic community comprising soft corals and mixed biota (sponges, other sessile invertebrate biota).

No threatened ecological communities (section 181 of the EPBC Act), critical habitats (section 207A(1) of the EPBC Act), or wetlands of international significance (Ramsar wetlands) were identified within the Project Area.

Protected Species

A total of 113 EPBC Act listed species considered to be matters of national environmental significance (MNES) were identified as potentially occurring within the EMBA, of which a subset of 44 species were identified as potentially occurring within the Project Area.

Biologically important area (BIAs) are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour (e.g. breeding, foraging, resting, migration). These BIAs for regionally significant marine species intersect with the Project Area:

- foraging BIA for whale sharks
- internesting buffer BIA for flatback turtles
- breeding BIA for wedge-tailed shearwaters.

Habitat critical to the survival of a species refers to areas that are necessary for activities such as foraging, breeding, roosting, or dispersal; for long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for reintroducing populations or recovery of the species. This habitat critical to the survival of a species intersects with the Project Area:

- internesting habitat critical for the survival of flatback turtles.

Several additional BIAs and habitat critical for the survival of a species intersect with the EMBA and are described in this OPP.

Key Ecological Features

Key ecological features (KEFs) are elements of the Commonwealth marine environment that are considered important for a marine region's biodiversity or ecosystem function and integrity. One KEF intersects with the Project Area:

- ancient coastline at 125 m depth contour.

Several additional KEFs intersect with the EMBA and are described in this OPP.

Protected Places

The Commonwealth Montebello Marine Park intersects with the southern extent of the Project Area. The Montebello Marine Park is categorised as a Multiple Use Zone (IUCN VI). No other protected places (including World, National, or Commonwealth heritage listed places) are known to occur within the Project Area.

Several protected places, including World Heritage properties, National Heritage places, Commonwealth Heritage places, Australian Marine Parks, State marine protected areas, Indigenous Protected Areas, wetlands of international importance (Ramsar wetlands), and underwater cultural heritage sites intersect with the EMBA and are described in this OPP.

In accordance with the Environment Regulations the Goodwyn Area Infill Development does not involve a petroleum activity or part of a petroleum activity being undertaken in any part of a declared World Heritage Property. The closest World Heritage Property is The Ningaloo Coast, ~200 km south-west of the Project Area.

Socioeconomic and Cultural Environment

Woodside recognises the 'environment' (for the purpose of the evaluation required under the Environment Regulations) includes:

- the heritage value of places
- the social, economic, and cultural features of the broader environment.

Woodside understands that communal cultural connection may exist between First Nations people and land and waters, and that there is the potential for marine ecosystems to include cultural features as well as environmental values. This is one aspect of the broader concept of 'Sea Country', which can be defined as the area of sea over which First Nations people or groups have interests, cultural value, connection and use. 'Country' refers to more than just a geographical area: it is shorthand for all the values, places, resources, stories, and cultural obligations associated with that geographical area. Engagement on other Woodside activities on the North West Shelf (NWS) have confirmed that cultural values of marine systems do exist for different First Nations groups.

Woodside considers the 'Ancient Landscape', occurring between the present mainland and the ancient coastline at 125 m water depth KEF, as an area where potential archaeological material may exist on the seabed because it covers the full extent of possible First Nations occupation. At the time of writing, Woodside understands that there is no First Nations archaeology known to exist or any areas subject to declarations or prescriptions under the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth), *Underwater Cultural Heritage Act 2018* (Cth), or EPBC Act, located within the Project Area or EMBA.

Socioeconomic features present within the Project Area and/or EMBA include:

- commercial fisheries
  - low levels of effort associated with three State-managed commercial fisheries (an no Commonwealth-managed fisheries) are expected within the Project Area
  - several Commonwealth- and State-managed commercial fisheries are expected to be active within the EMBA
- tourism and recreation
  - limited tourism and recreation activities are expected within the Project Area; however, some recreational fishing may occur in the southern extent (e.g. around banks or shoals)
  - various tourism and recreation activities are likely to occur in nearshore mainland areas of the EMBA (e.g. recreational fishing, diving, and marine fauna watching)
- commercial shipping
  - one of the NWS shipping fairways intersects with the eastern extent of the Project Area
  - most commercial shipping traffic within the vicinity of the Project Area is expected to be associated with this fairway or the adjacent oil and gas facilities
- petroleum activities
  - the Northern Carnarvon Basin is one of the most heavily explored and developed petroleum basins in Australia
  - in addition to the NWS Project, other petroleum projects within the vicinity of the Project Area include Woodside’s Pluto LNG Project, Chevron Australia’s Wheatstone Project and Gorgon Gas Development, and Santos’ Varanus Island Hub.

ES8 CONSULTATION

Stakeholder consultation and engagement is an integral component of the environmental assessment and authorisation process for petroleum activities in offshore areas. With more than 30 years of operating experience on the NWS, Woodside has a strong history of working with local communities, relevant regulators, and a broad range of persons and organisations—we understand the potential risks and impacts from our proposed activities and continually develop appropriate measures to manage them.

Woodside’s objectives for stakeholder consultation are to:

- improve stakeholder awareness and understanding of the Goodwyn Area Infill Development
- provide stakeholders with opportunities to obtain information about the Goodwyn Area Infill Development including the physical, ecological, socioeconomic, and cultural environment that may be affected, the potential impacts or risks that may occur, and the prevention and mitigation measures proposed to avoid or minimise those impacts
- gain feedback from stakeholders on their concerns about the development of Goodwyn Area Infill Development and where possible, address stakeholder concerns through further activities, or by implementing additional mitigation measures.

Woodside is undertaking a phased program of consultation:

- **Phase 1:** preliminary consultation undertaken during the impact and risk assessment process and preparation of the OPP
- **Phase 2**: formal consultation undertaken during the public comment process of the draft OPP
- **Phase 3**: ongoing consultation during project planning and execution.

Preliminary consultation (Phase 1) commenced in 2023 and is built on the broader consultation and engagement process that Woodside has in place for the NWS region. Phase 1 consultation activities included these tasks:

- review feedback from Goodwyn Area Infill Geophysical and Geotechnical Survey EP and other NWS Woodside EPs with similar EMBAs
- identify any new stakeholders not identified in previous EP engagements with similar EMBAs
- engage with NOPSEMA and Director of National Parks
- engage First Nations stakeholders as part of NWS Project consultation activities.

ES9 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

Table ES-1 and Table ES-3 summarise the outcomes of the environmental impact and risk assessment for planned activities and unplanned events, respectively, for the Goodwyn Area Infill Development.

By adopting key control measures (CM), Woodside determined that each environmental impact and risk associated with the Goodwyn Area Infill Development will be managed to an acceptable level.

Table ES-2: Planned activities—Summary of environmental impact assessment

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
Physical Presence: Interaction with other Marine Users	Potential changes to the functions, interests, or activities of other users	Commercial fisheries	No lasting effect (F)	**CM-01**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth) and any subsequent marine orders **CM-02**: If property is accepted to be decommissioned in situ, this activity must comply with the *Environmental Protection (Sea Dumping) Act 1981* (Cth) **CM-03**: Establish and maintain a 500 m safety exclusion zone around the MODU and installation vessel/s for the duration of the relevant petroleum activity **CM-04**: Remove all property above the mudline unless a comparative assessment demonstrates an equal or better environmental outcome for an alternative decommissioning approach, and this has been accepted within an EP submitted under the Environment Regulations	Acceptable	**EPO-01**: No interference with other marine users to a greater extent than is necessary for the exercise of rights and performance of duties as conferred to the titleholder
		Tourism and recreation	No lasting effect (F)			
		Commercial shipping	No lasting effect (F)			
Physical Presence: Disturbance to the Seabed	Change to water quality	Physical environment	No lasting effect (F)	**CM-02**: (see above) **CM-04**: (see above) **CM-05**: Undertake project-specific Mooring Design Analysis **CM-06**: Undertake project-specific Basis of Well Design, which includes assessing seabed sensitivity **CM-07**: Consider and implement appropriate adaptive management measures during the EP process to reduce impacts on banks and shoals to ALARP **CM-08**: Subsea installation activities will not occur on identified shoals within the Project Area **CM-09**: Top hole locations will not occur within 500 m of identified shoals within the Project Area	Acceptable	**EPO-02**: No adverse effects greater than a D consequence (minor, not affecting ecosystem function) to benthic habitats and communities from planned seabed disturbance during the petroleum activity **EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity
	Potential changes to habitats and biological communities	Offshore habitats and biological communities	Minor (D)			
		KEFs	Minor (D)			
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	Minor (D)			

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
Routine Emissions: Light Generation	Potential changes to fauna behaviour	Fish, sharks, and rays	No lasting effect (F)	**CM-10**: Limit lighting to the minimum required for navigational and safety requirements, except for emergency events **CM-11**: Manage lighting in accordance with Woodside's Offshore Seabird Management Plan **CM-12**: Consider and implement appropriate light mitigation and management measures (e.g. as described in the National Light Pollution Guidelines for Wildlife) during the EP process to reduce impacts to marine fauna to ALARP	Acceptable	**EPO-03**: (see above) **EPO-04**: No adverse effects greater than an F consequence (localised, no lasting effect) to marine fauna from artificial light emissions during the petroleum activity **EPO-05**: The petroleum activity will not be undertaken in a manner that is inconsistent with any threatened species or community recovery plan, or threat abatement plan, as made or adopted under the EPBC Act
		Marine reptiles	No lasting effect (F)			
		Seabirds and migratory shorebirds	No lasting effect (F)			
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	No lasting effect (F)			
Routine Acoustic Emissions: Continuous Sound Generation	Potential changes to fauna behaviour	Planktonic communities	No lasting effect (F)	**CM-13**: Vessels and helicopters must comply with legislative requirements for interacting with cetaceans, including Part 8 Division 8.1 of the EPBC Regulations 2000 (Cth) **CM-14**: Consider and implement appropriate acoustic mitigation and adaptive management measures during the EP process to reduce impacts to marine fauna to ALARP	Acceptable	**EPO-03**: (see above) **EPO-05**: (see above) **EPO-06**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to marine fauna from underwater sound emissions during the petroleum activity
		Fish, sharks, and rays	No lasting effect (F)			
		Marine mammals	Slight (E)			
	Potential injury or mortality to fauna	Planktonic communities	No lasting effect (F)			
		Fish, sharks, and rays	No lasting effect (F)			
		Marine mammals	Slight (E)			
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	Slight (E)			

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
Routine Acoustic Emissions: Impulsive Sound Generation	Potential changes to fauna behaviour	Planktonic communities	No lasting effect (F)	**CM-14**: (see above) **CM-15**: Implement Woodside's Vertical Seismic Profile Procedure	Acceptable	**EPO-03**: (see above) **EPO-05**: (see above) **EPO-06**: (see above)
		Fish, sharks, and rays	No lasting effect (F)			
		Marine reptiles	Slight (E)			
		Marine mammals	Slight (E)			
	Potential injury or mortality to fauna	Planktonic communities	No lasting effect (F)			
		Fish, sharks, and rays	Slight (E)			
		Marine reptiles	Slight (E)			
		Marine mammals	Slight (E)			
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	Slight (E)			
Routine and Non-routine Emissions: Atmospheric	Change in air quality	Physical environment	No lasting effect (F)	**CM-01**: (see above) **CM-16A**: Comply with legislative requirements for emissions reporting, including National Pollutant Inventory (NPI) **CM-23**: Maintain flare on GWA platform to maximise efficiency of combustion and minimise venting, incomplete combustion waste products, and smoke emissions	Acceptable	**EPO-07**: No adverse effects greater than an F consequence (localised, no lasting effect) to air quality from atmospheric emissions during the petroleum activity
Routine and Non-routine Emissions: Greenhouse Gases	N/A	Habitat and biological communities	N/A	**CM-01**: (see above) **CM-16B**: Comply with legislative requirements for emissions reporting, including National Greenhouse and Energy Reporting (NGER) scheme **CM-17**: Comply with emissions intensity requirements for reservoir carbon dioxide from new gas fields as described under Division 11,	Acceptable	**EPO-08**: Indirect GHG Emissions associated with the Goodwyn Area Infill Development and that are directly within operator influence, shall assist in NWS
		Protected species				
		KEFs				
		Protected places				

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
		Socioeconomic and cultural environment		section 35A in Part 19 of Schedule 1 of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth) **CM-18**: Apply for and manage NWS Project GHG emissions to within the relevant baseline under the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth) **CM-19**: Contracting strategy and evaluation for hire of vessels includes consideration of vessel emissions parameters and low carbon/alternate fuels **CM-20**: Maintain a program to monitor market developments related to the contribution of natural gas in the energy transition **CM-21**: Forecast, measure, monitor and/or estimate facility GHG emissions (in accordance with NGER/NPI) to inform optimisation management practices and minimise environmental impact of GWA platform GHG emissions **CM-22**: Implement relevant methane management measures at GWA platform **CM-23**: (see above)		Project achieving GHG reductions under reformed Safe Guard Mechanism (inclusive of legislated net zero emissions by 2050). **EPO-09**: Woodside to support customers and suppliers to reduce their GHG emissions by Woodside complying with relevant Corporate Woodside policies, including those designed to monitor market developments related to hydrocarbons in the energy transition.
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	Change to water quality	Physical environment	No lasting effect (F)	**CM-24**: Implement Woodside’s Engineering Standard Pipelines Flooding, Cleaning, Gauging and Hydrotesting **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline **CM-26**: Implement Woodside's Engineering Operating Standard (Subsea Isolation) Procedure	Acceptable	**EPO-03**: (see above) **EPO-10**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality from routine and non-routine hydrocarbon and chemical discharges during the petroleum activity
	Potential changes to the values and sensitivities of protected places	Australian Marine Park	No lasting effect (F)			
Routine and Non-routine	Change to water quality	Physical environment	No lasting effect (F)	**CM-25**: (see above)	Acceptable	**EPO-03**: (see above)

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	Potential injury or mortality to fauna	Planktonic communities	No lasting effect (F)	**CM-27**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth), *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth), and any subsequent marine orders		**EPO-11**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality and biological communities from routine and non-routine MODU/vessel discharges during the petroleum activity
	Potential changes to the values and sensitivities of protected places	Australian Marine Park	No lasting effect (F)			
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	Change to water quality	Physical environment	No lasting effect (F)	**CM-07**: (see above) **CM-25**: (see above) **CM-28**: Implement Woodside’s Drilling Fluid Best Practice guidelines **CM-29**: Implement Woodside's Reservoir, Drilling and Completions Fluids Guideline **CM-30**: Where non–water-based muds (NWBM) are selected for use, implement overburden Drilling Fluids Environmental Requirements process **CM-31**: Solids control equipment (SCE) used to treat drill cuttings returned to the MODU prior to discharge **CM-32**: Discharge drill cuttings from the MODU below the waterline **CM-33**: Maintain average oil on cuttings (OOC) at <6.9% by weight on wet cuttings (for sections drilled with NWBM) **CM-34**: Prohibit bulk overboard discharge of NWBM **CM-35**: No top-hole locations within the Montebello Marine Park **CM-36**: Limit stock barite to a maximum of 1 mg/kg dry weight of mercury, and a maximum 3 mg/kg dry weight of cadmium	Acceptable	**EPO-03**: (see above) **EPO-12**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality from routine and non-routine drill cuttings and drilling fluid discharges during the petroleum activity **EPO-13**: No adverse effects greater than a D consequence (minor, not affecting ecosystem function) to benthic habitats and communities from routine and non-routine drill cuttings and drilling fluid discharges during the petroleum activity
	Change to sediment quality	Physical environment	No lasting effect (F)			
	Potential changes to habitats and biological communities	Offshore habitats and biological communities	Minor (D)			
		KEF	Minor (D)			
	Potential changes to the values and sensitivities of protected places	Australian Marine Park	Slight (E)			

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	Change to water quality	Physical environment	No lasting effect (F)	**CM-25**: (see above) **CM-28**: (see above) **CM-29**: (see above) **CM-35**: (see above) **CM-36**: (see above) **CM-37**: Consider options for using excess bulk cement, bentonite, or barite, and implement as appropriate during the EP process **CM-38**: During well unloading and completion activities (to MODU), process any produced water through the well test water filtration treatment package before discharging to the environment	Acceptable	**EPO-14**: No adverse effects greater than an F consequence (localised, no lasting effect) to water or sediment quality from routine and non-routine cement and other drilling related discharges during the petroleum activity **EPO-15**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to benthic habitats and communities from routine and non-routine cement and other drilling related discharges during the petroleum activity
	Change to sediment quality	Physical environment	No lasting effect (F)			
	Potential changes to habitats and biological communities	Offshore habitats and biological communities	Slight (E)			
		KEF	Slight (E)			
Downstream Discharges: Produced Water	Change to water quality	Physical environment	Slight (E)	**CM-25**: (see above) **CM-39**: Implement Woodside's Offshore Marine Discharges Adaptive Management Plan **CM-40**: Non-routine (potential high oil in water [OIW]) produced water (PW) discharge activities will not occur concurrently. **CM-41**: Temporary OIW skid used during commissioning (initial start-up)	Acceptable	**EPO-16**: No impact to ecosystem integrity from PW outside the Approved Mixing Zone boundary
	Change to sediment quality	Physical environment	Slight (E)			
	Potential changes to habitats and biological communities	Planktonic communities	Slight (E)			
	Potential injury or mortality to fauna	Fish, sharks and rays	Slight (E)			
		Marine reptiles	Slight (E)			
		Marine mammals	Slight (E)			

Aspect	Impacts	Receptors	Consequence	Adopted key control measures	Acceptability	EPOs
All	Potential changes to cultural values or features	Cultural features and heritage values	No lasting effect (F)	**CM-54**: The offshore project must comply with legislative requirements, including the *Underwater Cultural Heritage Act 2018* (Cth) and *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) **CM-55**: Undertake a desktop assessment to identify any indicators of underwater cultural heritage within proposed areas of seabed disturbance for the Goodwyn Area Infill Development **CM-56**: Engage with relevant cultural authorities that may be affected in the unlikely event of an unplanned hydrocarbon release **CM-57**: Implement a program of ongoing consultation with First Nations people whose functions, interests or activities may be affected by the petroleum activities to identify and reduce impacts to cultural features and heritage values **CM-58**: Consider and implement a 'living heritage' management approach during the EP process to reduce impacts to identified cultural features and heritage values	Acceptable	**EPO-24**: Prevent adverse changes to underwater cultural heritage (as protected under the *Underwater Cultural Heritage Act 2018* [Cth]), or to declared areas or objects of particular significance (as protected under the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* [Cth]) from the petroleum activity **EPO-25**: Woodside will support First Nations capacity for ongoing engagement and consultation on EPs for the purpose of avoiding impacts to cultural features and heritage values

Table ES-3: Unplanned events—Summary of environmental risk assessment

Aspect	Risks	Receptors	Consequence	Adopted key control measures	Likelihood	Risk rating	Acceptability	EPOs
Physical Presence: Interaction with Marine Fauna	Potential injury or mortality to fauna	Fish, sharks, and rays	Slight (E)	**CM-13**: (see above)	Highly unlikely (1)	Low	Acceptable	**EPO-17**: No vessel strikes on EPBC Act listed cetaceans or other marine megafauna during the petroleum activity
		Marine reptiles	Slight (E)			Low		
		Marine mammals	Slight (E)			Low		
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	Slight (E)			Low		
Physical Presence: Introduction of Invasive Marine Species	Potential changes to ecosystems	Offshore habitats and biological communities	Slight (E)	**CM-42**: Vessels must comply with legislative requirements, including *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* (Cth), *Biosecurity Act 2015* (Cth), any subsequent marine orders, and any national best practice guidance **CM-43**: Implement Woodside's Invasive Marine Species Management Plan	Highly unlikely (1)	Low	Acceptable	**EPO-18**: No introduction and establishment of an invasive marine species (IMS) into the Project Area as a result of the petroleum activity
		KEFs	Slight (E)			Low		
Physical Presence: Unplanned Seabed Disturbance	Change to water quality	Physical environment	No lasting effect (F)	**CM-05**: (see above) **CM-44**: Station-keeping systems and mooring system testing implemented as per project-specific Mooring Design Analysis	Highly unlikely (1)	Low	Acceptable	**EPO-19**: No unplanned seabed disturbance within the Project Area resulting in greater than a D consequence (minor, not affecting ecosystem function) during the petroleum activity
	Potential changes to habitats and biological communities	Offshore habitats and biological communities	Minor (D)			Moderate		
		KEFs	Slight (E)			Low		
	Potential changes to the values and	Australian Marine Parks	Slight (E)			Low		

Aspect	Risks	Receptors	Consequence	Adopted key control measures	Likelihood	Risk rating	Acceptability	EPOs
	sensitivities of protected places							
Unplanned Release: Hazardous and Non-hazardous Solid Wastes	Change to water quality	Physical environment	No lasting effect (F)	**CM-01**: (see above) **CM-45**: Implement waste management procedures which provide for safe handling and transportation, segregation and storage, and appropriate classification of all waste generated	Unlikely (2)	Low	Acceptable	**EPO-20**: No unplanned release of hazardous or non-hazardous solid waste within the Project Area resulting in greater than an E consequence (slight, not affecting ecosystem function) during the petroleum activity
	Change to sediment quality	Physical environment	No lasting effect (F)			Low		
	Potential injury or mortality to fauna	Fish, sharks, and rays	Slight (E)			Moderate		
		Marine reptiles	Slight (E)			Moderate		
		Marine mammals	Slight (E)			Moderate		
		Seabirds and migratory shorebirds	Slight (E)			Moderate		
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	Slight (E)			Moderate		
Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment)	Change to water quality	Physical environment	Slight (E)	**CM-25**: (see above) **CM-27**: (see above) **CM-46**: Implement Woodside's Marine Offshore Vessel Assurance Procedure **CM-47**: Consider options for the storage, handling, and transfer of hydrocarbons and chemicals, and implement as appropriate during the EP process	Unlikely (2)	Moderate	Acceptable	**EPO-21**: No minor loss of containment of hydrocarbons or chemicals within the Project Area resulting in greater than an E consequence (slight, not affecting ecosystem function), during petroleum activities
	Potential changes to habitats and biological communities	Planktonic communities	Slight (E)			Moderate		
	Potential injury or mortality to fauna	Fish, sharks, and rays	Slight (E)			Moderate		
		Marine reptiles	Slight (E)			Moderate		
		Marine mammals	Slight (E)			Moderate		

Aspect	Risks	Receptors	Consequence	Adopted key control measures	Likelihood	Risk rating	Acceptability	EPOs
	Potential changes to the values and sensitivities of protected places	Australian Marine Parks	Slight (E)			Moderate		
Unplanned Hydrocarbon Release: Gas and Condensate	Change to water quality	Physical environment	Minor (D)	**CM-48**: In accordance with the Resource Management and Administration Regulations, a NOPSEMA-accepted Well Operations Management Plan must be in place before commencing the petroleum activity **CM-49**: In accordance with the Safety Regulations, a NOPSEMA-accepted Safety Case for NWS pipelines must be in place before commencing the petroleum activity **CM-50**: In accordance with the Environment Regulations, a NOPSEMA-accepted Oil Pollution Emergency Plan must be in place before commencing the petroleum activity **CM-51**: A project-specific Source Control Emergency Response Plan must be in place before commencing the petroleum activity **CM-52**: A baseline environmental survey of Wilcox Shoal must be in	Highly unlikely (1)	Moderate	Acceptable	**EPO-22**: Woodside will manage its activities to prevent a significant loss of containment. During the petroleum activity a risk of well loss of containment to the environment will be limited to high[4]
	Change to sediment quality	Physical environment	Minor (D)			Moderate		
	Change to air quality	Physical environment	No lasting effect (F)			Low		
	Potential changes to habitats and biological communities	Plankton communities	Slight (E)			Low		
		Offshore habitats and biological communities	Major (B)			Moderate		
		Nearshore and coastal habitats and biological communities	Major (B)			Moderate		
		KEFs	Minor (D)			Moderate		
	Potential changes to fauna behaviour Potential injury or mortality to fauna	Fish, sharks and rays	Moderate (C)			Moderate		
		Marine reptiles	Major (B)			Moderate		
		Marine mammals	Moderate (C)			Moderate		
		Seabirds and migratory shorebirds	Moderate (C)			Moderate		

[4] Refer to Section 4.5.2.2

Aspect	Risks	Receptors	Consequence	Adopted key control measures	Likelihood	Risk rating	Acceptability	EPOs
	Potential changes to the values and sensitivities of protected places	AMPs	Major (B)	place before commencing the petroleum activity		Moderate		
		State marine protected areas	Major (B)			Moderate		
	Potential changes to the functions, interests, or activities of other users	Commercial fisheries and aquaculture	Minor (D)			Moderate		
		Traditional fisheries	Minor (D)			Moderate		
		Tourism and recreation	Minor (D)			Moderate		
		Petroleum activities	No lasting effect (F)			Low		
Unplanned Hydrocarbon Release: Marine Fuel	Change to water quality	Physical environment	Minor (D)	**CM-27**: (see above) **CM-46**: (see above) **CM-50**: (see above) **CM-52**: (see above) **CM-53**: Where required under the WMS, a project-specific Simultaneous Operations (SIMOPS) Plan must be in place before commencing the petroleum activity	Highly unlikely (1)	Moderate	Acceptable	**EPO-23**: Woodside will manage its activities to prevent a significant loss of containment. During the petroleum activity a risk of hydrocarbons released to the environment, from a vessel collision, to the environment will be limited to moderate[5]
	Change to sediment quality	Physical environment	Minor (D)			Moderate		
	Potential changes to habitats and biological communities	Plankton communities	Slight (E)			Low		
		Offshore habitats and biological communities	Slight (E)			Low		
		Nearshore and coastal habitats and biological communities	Slight (E)			Low		
		KEFs	Slight (E)			Low		

[5] Refer to Section 4.5.2.2

Aspect	Risks	Receptors	Consequence	Adopted key control measures	Likelihood	Risk rating	Acceptability	EPOs
	Potential changes to fauna behaviour Potential injury or mortality to fauna	Fish, sharks and rays	Minor (D)			Moderate		
		Marine reptiles	Minor (D)			Moderate		
		Marine mammals	Minor (D)			Moderate		
		Seabirds and migratory shorebirds	Minor (D)			Moderate		
	Potential changes to the values and sensitivities of protected places	AMPs	Minor (D)			Moderate		
		State marine protected areas	Minor (D)			Moderate		
	Potential changes to the functions, interests, or activities of other users	Commercial fisheries and aquaculture	Slight (E)			Low		
		Traditional fisheries	Slight (E)			Low		
		Tourism and recreation	Slight (E)			Low		
		Petroleum activities	No lasting effect (F)			Low		
All	Potential changes to cultural values or features	Cultural features and heritage values	No lasting effect (F)	**CM-54**: (see above) **CM-55**: (see above) **CM-56**: (see above) **CM-57**: (see above) **CM-58**: (see above)	Highly unlikely (1)	Low	Acceptable	**EPO-24**: (see above) **EPO-25**: (see above)

ES10 CUMULATIVE IMPACT ASSESSMENT

For the cumulative impact assessment within this OPP, Woodside has adopted these definitions:

- holistic impacts—connections and interactions between impacts, and the overall impact of the offshore project on the environment as a whole
- cumulative impacts—the successive, incremental, and interactive impacts on the environment of the offshore project with one or more past, present, and reasonably foreseeable future activities.

Woodside has identified and evaluated potential holistic effects from the different aspects associated with planned activities from the offshore project (i.e. holistic impacts), and potential cumulative effects from planned activities associated with the offshore project in combination with other relevant marine activities (i.e. cumulative impacts).

The key control measures and EPOs as defined in Table ES-2 and Table ES-3 were considered appropriate to manage the environmental impacts and risks, including holistic and cumulative impacts, associated with the Goodwyn Area Infill Development to an acceptable level.

ES11 ENVIRONMENTAL PERFORMANCE FRAMEWORK

The Goodwyn Area Infill Development will be undertaken in accordance with this OPP and subsequent activity-specific EPs.

The environmental performance framework for the offshore project identifies key processes that are in place to direct, review, and manage the offshore project so environmental impacts and risks are managed to an acceptable level, and that the EPOs outlined in this OPP are achieved. Key processes within the framework include ongoing monitoring, assurance, and reporting requirements.

1 INTRODUCTION

1.1 Overview

The Goodwyn A (GWA) Facility (GWA Facility) comprises a subsea hydrocarbon system (i.e. production wells and associated infield infrastructure) and a platform. The GWA platform is an integrated production (gas and condensate), utilities, and accommodation platform. Fluids processed at the GWA platform are recovered from a series of fields and exported to the Karratha Gas Plant (KGP) via an interfield line (IFL) and export trunkline (2TL). Existing fields and subsea tiebacks supplying hydrocarbons to the GWA platform include:

- Goodwyn
- Echo, and Yodel
- Perseus, and Searipple
- Greater Western Flank (GWF)
  - Phase 1: Goodwyn 'H' (Goodwyn GH), and Tidepole
  - Phase 2: Keast, Dockrell, Sculptor, Rankin, Lady Nora, and Pemberton
  - Phase 3: Goodwyn GH.

The GWA Facility is operated by Woodside Energy Limited (Woodside) on behalf of the North West Shelf Joint Venture (NWSJV) between Woodside Energy Ltd, BP Developments Australia Pty Ltd, Woodside Energy (North West Shelf) Pty Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, CNOOC NWS Private Ltd, and Shell Developments (Australia) Pty Ltd.

On behalf of the NWSJV, Woodside proposes to undertake the Goodwyn Area Infill Development (the 'offshore project'[6]). Using multiple subsea tiebacks (within scope of this proposal) to existing GWF subsea infrastructure (out of scope of this proposal), the Goodwyn Area Infill Development intends to develop incremental volumes of gas and condensate to partially fill ullage (unused gas production capacity) at the GWA platform as the production from existing wells and fields declines. The Goodwyn Area Infill Development will target both existing and previously undeveloped gas reservoirs within petroleum titles to the west and south-west of the GWA platform (Table 1-1, Figure 1-1; Figure 1-2). The Goodwyn Area Infill Development is located entirely within Commonwealth waters[7].

Well fluids from the Goodwyn Area Infill Development will be processed at the GWA platform before being exported via the IFL and 2TL export trunkline to the KGP for final processing, then exported to domestic and international markets. The Goodwyn Area Infill Development will be operated from the GWA platform and use existing processing facilities, and existing subsea production and topsides control hardware. Note: Existing infrastructure and operations at the GWA Facility, transport of well fluids from the GWA platform to KGP via the IFL and 2TL, and existing infrastructure and operations at KGP do not form part of this offshore project as they are covered under other existing environmental approvals (refer to Section 1.4.2.1).

Woodside is targeting a final investment decision (FID) for the Goodwyn Area Infill Development in 2024. A phased development program is proposed for the Goodwyn Area Infill Development, with Phase 1 anticipated to start during 2025/2026, and deliver first gas in 2026. Achieving these milestones is subject to several factors including NWSJV approvals, regulatory approvals, and commercial arrangements being finalised.

[6] In accordance with the Environment Regulations, an offshore project means "one or more activities that are undertaken for the purpose of the recovery of petroleum, other than on an appraisal basis, including any conveyance of recovered petroleum by pipeline (whether or not the activity is undertaken for other purposes)".

[7] Commonwealth waters start at the seaward boundary of coastal waters (3 nautical miles (nm) from the territorial sea baseline) and extend to the outer boundary of the Australia's exclusive economic zone (EEZ).

Table 1-1: Overview of the Goodwyn Area Infill Development

Item	Description
Proponent	Woodside, for and on behalf of the NWSJV
Location	~140 km north-west of Karratha, Western Australia (WA)
Water depths	~70–160 m for areas of proposed subsea infrastructure ~20–180 m for full extent of Project Area
Petroleum titles	The offshore project provides for a phased development which may incorporate these petroleum titles and gas reservoirs: • WA-5-L (Echo Spur, Tidepole East) • WA-24-L (, Yodel Updip, Yodel South) • WA-7-R (Wilcox) The offshore project also provides for potential future development of gas reservoirs within these petroleum titles (above) and/or others (WA-6-L, WA-23-L, WA-56-L, WA-57-L, WA58-L) within the Project Area
Petroleum activities	• drilling and completions – geotechnical sampling (if required to inform MODU mooring) – drilling operations (for up to 8 production wells) – formation evaluation – well completion – well unloading • subsea installation and pre-commissioning – installing Xmas trees, flowlines, electrohydraulic umbilicals, and other infield infrastructure – pre-commissioning • start-up and operations – initial start-up of wells and subsea infrastructure – subsea inspection, monitoring, maintenance, and repair [IMMR] • decommissioning – plugging and abandoning wells – removing property • field support – operating mobile offshore drilling units [MODUs], vessels, helicopters, and remotely operated vehicles [ROVs])
Anticipated hydrocarbon	Gas and condensate
End of field life (EOFL)	2040

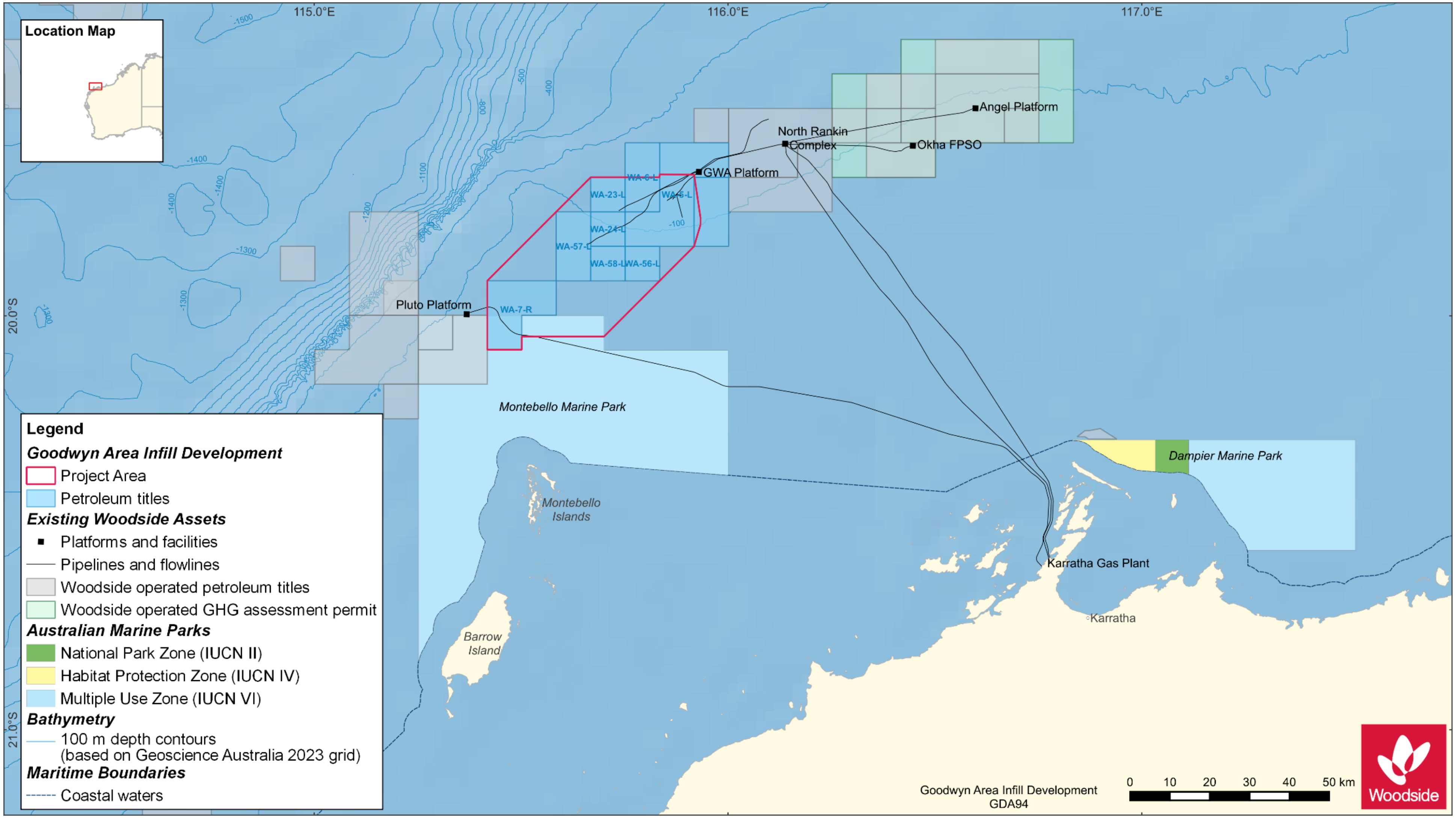
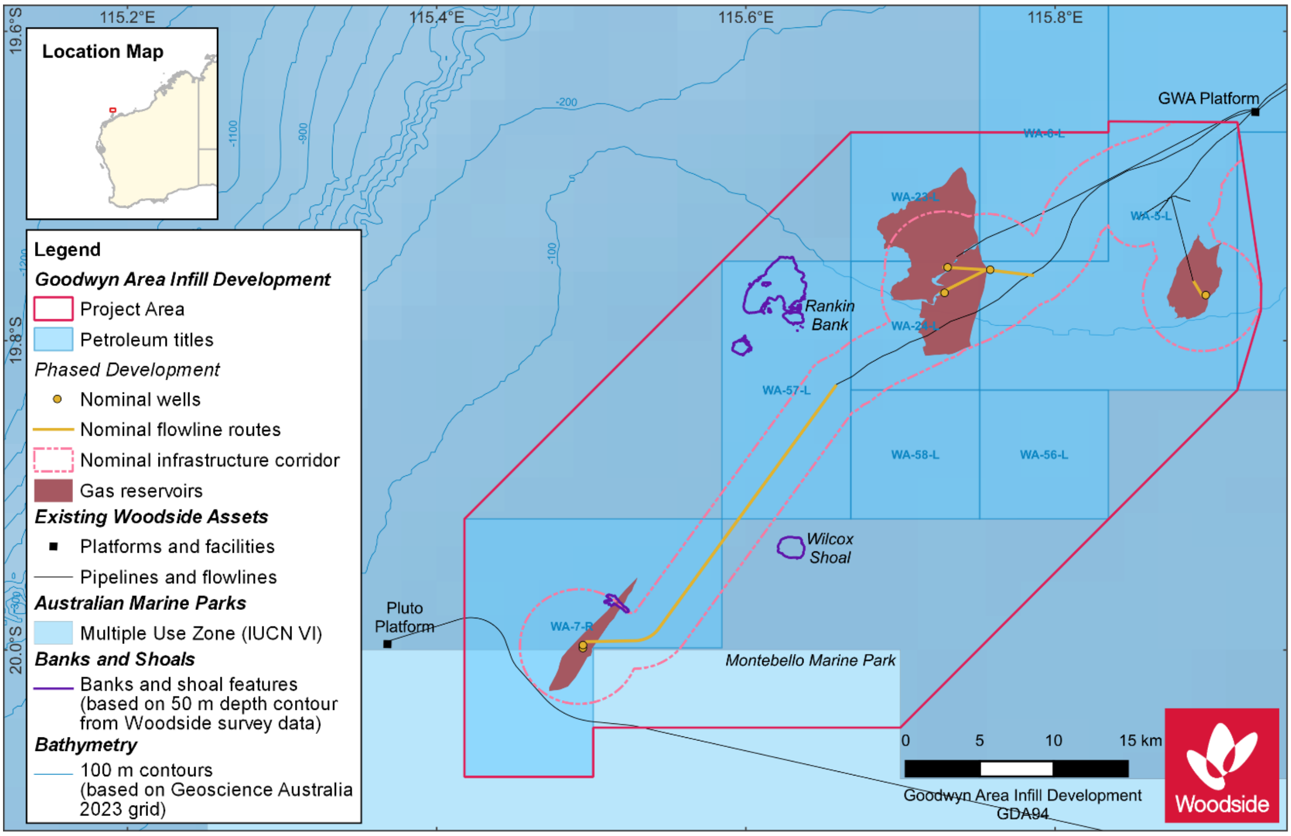


Figure 1-1: Location of the Goodwyn Area Infill Development



Note: The wells and flowline routes shown in the above figure are nominal locations only and are subject to change. The final selection of wells and flowline routes for the Goodwyn Area Infill Development will be determined during front-end engineering design (FEED).

Figure 1-2: Nominal locations for the production wells, flowlines, and infrastructure corridor for the phased development

1.2 Proponent

Woodside is the proponent for this offshore project, on behalf of the NWSJV.

Woodside is a global energy company, founded in Australia. Woodside's operations are characterised by strong safety and environmental performance in remote and challenging locations. Wherever Woodside works, it is guided by its values of integrity, respect, working together, ownership, sustainability, and courage.

Since 1984 Woodside has been operating, on behalf of the NWSJV, the North West Shelf Project (NWS Project), which is one of Australia's largest resource developments, and one of the world's largest producers of liquified natural gas (LNG).

Woodside has an excellent track record of efficient and safe production. Woodside strives for excellence in safety and environmental performance and continues to strengthen relationships with customers, partners, co-venturers, governments, and communities. Further information about Woodside can be found at www.woodside.com

In accordance with regulation 7(2)(a) of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (Commonwealth [Cth]) (referred to as the Environment Regulations), details of the proponent and contact details are provided below:

Woodside Energy Limited

11 Mount Street

Perth, Western Australia

T: 08 9348 4000

E: feedback@woodside.com

ACN: 63 005 482 986

1.3 Purpose of the Offshore Project Proposal

This Offshore Project Proposal (OPP) has been prepared in accordance with the Environment Regulations, as administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

In accordance with the Environment Regulations, the purpose of this OPP is to:

- appropriately identify and evaluate the environmental impacts and risks of the offshore project (including from both planned activities and unplanned events)
- demonstrate that the environmental impacts and risks of the offshore project will be managed to an acceptable level[8]
- demonstrate that the offshore project will be carried out in a manner consistent with the principles of ecologically sustainable development (ESD), as defined in section 3A of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).

The OPP defines project-specific environmental performance outcomes (EPOs) that are consistent with the principles of ESD and are the basis for monitoring, auditing, and managing the offshore project, which will be undertaken by Woodside. The environmental performance framework specified in this OPP provides Woodside and NOPSEMA with the required level of assurance that impacts and risks associated with the offshore project will be managed to an acceptable level.

1.4 Scope of the Offshore Project Proposal

1.4.1 In Scope

The scope of this OPP covers the petroleum activities (Table 1-1) in Commonwealth waters that comprise the Goodwyn Area Infill Development (the offshore project).

The offshore project is described in further detail in Section 5. The Project Area, as defined in Section 5.1.2, defines the spatial boundary of planned activities associated with the offshore project.

This OPP addresses potential environmental impacts from planned petroleum activities and potential environmental risks from unplanned events that may originate from petroleum activities associated with the Goodwyn Area Infill Development within the Project Area. The impact and risk assessment within the OPP also considered downstream emissions and discharges associated with the Goodwyn Area Infill Development and within the operator’s influence.

1.4.2 Out of Scope

These activities are not in the scope of this OPP:

- exploration and appraisal activities associated with previously undeveloped resources; as per the Environment Regulations, these petroleum activities will be subject to a separate EP development and assessment process
- transit to and from the Project Area by project vessels (as well as port activities associated with these vessels) or helicopters; vessels or helicopters supporting the offshore project operating outside the Project Area (e.g. transiting to and from port) are subject to applicable maritime or

[8] An acceptable level is the maximum level of change in environmental parameters before the environmental effects become unacceptable (NOPSEMA 2024a).

aviation regulations and they are not performing the petroleum activity[9], and therefore they are not managed by this OPP.

- existing operations at the GWA Facility (including the IFL)[10], and other relevant NWS Project assets (e.g. the 2TL export trunkline and KGP) are out of scope of this OPP as they subject to other existing environmental assessments and approvals (Section 1.4.2.1)
- potential minor topside modifications to the GWA platform; as per the Environment Regulations, these petroleum activities may be subject to a separate revision and assessment of the GWA Facility Operations Environment Plan (EP).

1.4.2.1 Existing Environmental Approvals

This OPP does not include the existing infrastructure and operations of the GWA Facility and NWS Project. These facilities are approved and are operating under existing approvals, as described below, and are not within the scope of this OPP. These existing operations (and any approved changes) will continue regardless of the proposed Goodwyn Area Infill Development.

On behalf of the NWSJV, Woodside operates the NWS Project. The NWS Project is one of the world's largest LNG producers, supplying Australian and international markets with gas from offshore gas and condensate fields in the Carnarvon Basin, off the Pilbara coast of WA. The NWS Project is also one of the largest producers of domestic gas in WA. The NWS Project commenced in 1984 with the commissioning of the KGP.

Since then the KGP has undergone several expansions and additional facilities have been installed. The NWS Project includes processing, storage, and offloading facilities associated with operations at the KGP, as well as two export trunklines (1TL and 2TL) that extend from the North Rankin Complex in Commonwealth waters to the onshore KGP[11]. At present, pursuant to Ministerial Statements granted under the *Environmental Protection Act 1986* (WA) (EP Act), the existing NWS Project is approved to process natural gas and associated fluids from NWSJV field resources to produce and supply up to 18.5 mtpa of LNG at the KGP until ~2030.

Woodside is currently proposing, and seeking environmental approval, to operate the NWS Project to around 2070 as an LNG facility that is commercially capable of accepting gas for processing from other resource owners (ORO) as well as any remaining or new NWSJV field resources. The NWS Project Extension has been assessed by the Environmental Protection Authority (EPA) under the EP Act, with the EPA's assessment report published in June 2022 (EPA Report 1727)[12].

The GWA Facility is one of the NWSJV assets that supply natural gas and associated fluids to the KGP. The GWA Facility commenced production in 1995. The GWA Facility, including the existing fields and subsea tiebacks operate under existing environmental approvals.

A referral was submitted under the EPBC Act in 2003 to convert one of the GWA platform's high-pressure trains to low-pressure operation so as to access low-pressure reserves and meet gas contract commitments. This referral also incorporated associated topside modifications, including upgrading water-handling facilities to treat the potential increase in produced water (PW), gas and condensate dehydration system, and power generation turbines. The proposal was determined to be 'not a controlled action' (EPBC 2003/914).

[9] In accordance with the Environment Regulations, a petroleum activity means "operations or works in an offshore area undertaken for the purpose of: (a) exercising a right conferred on a petroleum titleholder under the Act by a petroleum title; or (b) discharging an obligation imposed on a petroleum titleholder by the Act or a legislative instrument under the Act".

[10] This includes all impacts and risks associated with the petroleum activities (e.g. those resulting from emissions or discharges) within scope of the GWA Facility Operations EP.

[11] The operation of the 2TL export trunkline is within scope of the WA Department of Energy, Mines, Industry Regulation and Safety (DEMIRS)-accepted North West Shelf Trunklines State Waters Operations Environment Plan (EP) and the NOPSEMA-accepted North Rankin Complex Facility Operations EP.

[12] The EPA's assessment report is currently subject to appeals which are being managed by the Office of the Appeals Convenor.

Existing subsea tiebacks to the GWA platform have been previously referred under the EPBC Act as follows:

- January 2001: Echo–Yodel tie-ins were approved with conditions under section 23 and 24A of the EPBC Act by the then Minister for the Environment and Heritage (EPBC 2000/11)
- February 2004: Perseus–Searipple tie-ins (Perseus over Goodwyn Development) was determined to be 'not a controlled action' (EPBC 2004/1326)
- April 2005: an additional development to the Echo–Yodel fields (Echo A / Upper E) was determined to be 'not a controlled action' (EPBC 2005/2042)[13]
- January 2006: Western Flank Gas subsea development was determined to be 'not a controlled action' (EPBC 2005/2464); this development incorporates GWF Phase 2 and Phase 3
  - GWF Phase 2 comprised development of the Keast, Dockrell, Sculptor, Rankin, Lady Nora, and Pemberton reservoirs, including the construction and installation of wells and supporting subsea infield infrastructure, and a pipeline to the GWA platform
  - GWF Phase 3 comprised further development of the Goodwyn GH reservoir, including the construction and installation of wells and supporting subsea infield infrastructure
- August 2011: GWF Phase 1 Gas Development was determined to be 'not a controlled action if undertaken in a particular manner' (EPBC 2011/5980)
  - GWF Phase 1 comprised development of the Goodwyn GH and Tidepole reservoirs within WA-5-L, including the construction and installation of wells, supporting subsea infield infrastructure, and a pipeline to the GWA platform.

On 27 February 2014 the process for streamlined environmental approvals for offshore petroleum and greenhouse gas (GHG) storage activities in Commonwealth waters came into effect. Following a strategic assessment of NOPSEMA's environmental management authorisation process under section 146 of the EPBC Act, the then Federal Minister for the Environment endorsed NOPSEMA's process as set out in the *Program Report—Strategic Assessment of the environmental management authorisation process for petroleum and greenhouse gas storage activities administered by the National Offshore Petroleum Safety and Environmental Management Authority under the Offshore Petroleum and Greenhouse Gas Storage Act 2006* dated February 2014 as a program (the Program) (Australian Government 2014) that meets the requirements of Part 10 of the EPBC Act.

Subsequently, on 27 February 2014, the Minister also approved a class of actions under section 146B of the EPBC Act which, if undertaken in accordance with the endorsed Program, will not require separate referral, assessment, and approval under the EPBC Act (Class Approval). The Class Approval is valid until 31 December 2040.

Petroleum activities that are within scope, and undertaken in accordance with, the NOPSEMA-accepted GWA Facility Operations EP are covered by the Class Approval issued by the Minister for the Environment under section 146B of the EPBC Act on 27 February 2014.

1.5 Structure of the Offshore Project Proposal

The structure of this OPP reflects the process and requirements of the Environment Regulations, as outlined in Table 1-2.

[13] This proposed Echo A / Upper E subsea tieback has not been developed to date.

Table 1-2: OPP process phases, applicable Environment Regulations, and relevant section of the OPP

Criteria for acceptance	Content requirements	Elements	Relevant section
Regulation 9(4)(a) and Regulation 13(4)(c): appropriately identifies and evaluates the environmental impacts and risks of the project	Regulation 7(5)(a): details of the environmental impacts and risks of the activities that are part of the project Regulation 7(5)(b): an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk	Impact and risk assessment process Identify and evaluate the impacts and risks	Section 4 Section 9 Section 10
Regulation 13(4)(d): demonstrates that the environmental impacts and risks of the project will be managed to an acceptable level		Define acceptable levels of impact and risk Demonstrate acceptability	Section 4 Section 9 Section 10
Regulation 9(4)(b) : sets out environmental performance outcomes that are: (i) consistent with the principles of ecologically sustainable development; and (ii) relevant to the identified environmental impacts and risks for the project	Regulation 7(2)(e): the environmental performance outcomes for each activity that is part of the project Regulation 7(5)(a) Regulation 7(5)(b)	Identify and evaluate the impacts and risks Identify EPOs	Section 4 Section 9 Section 10
Regulation 13(4)(e): sets out appropriate environmental performance outcomes for each activity that are consistent with the principles of ecologically sustainable development			
Regulation 9(4)(c) and Regulation 13(4)(f): does not involve an activity or part of an activity being undertaken in any part of a declared World Heritage property	Regulation 7(2)(b): a summary of the project, including the following: (i) a description of each activity that is part of the project (ii) the location or locations of each activity (iii) a proposed timetable for carrying out the project (iv) a description of the facilities that are proposed to be used to undertake each activity (v) a description of the actions proposed to be taken, following completion of the project, in relation to those facilities Regulation 7(2)(c): a description of the existing environment that may be affected by the project	No activity, or part of the activity, undertaken in any part of a declared World Heritage property	Section 5 Section 7

Criteria for acceptance	Content requirements	Elements	Relevant section
	Regulation 7(2)(d): details of the relevant values and sensitivities (if any) of that environment		
Regulation 9(4)(d): sufficiently addresses the matters required by regulations 6 and 7	Regulation 6(1): before commencing an offshore project, a person must submit an offshore project proposal for the project to NOPSEMA Regulation 6(4): the proposal must be in writing	Develop and submit an OPP before commencing an offshore project	This OPP
	Regulation 7(2)(a) the proponent's name and contact details Regulation 7(2)(b) Regulation 7(2)(c) Regulation 7(2)(d) Regulation 7(2)(e) Regulation 7(2)(f): a description of any feasible alternative to the project, or an activity that is part of the project, including: (i) a comparison of the environmental impacts and risks arising from the project or activity and the alternative; and (ii) an explanation, in adequate detail, of why the alternative was not preferred Regulation 7(3): without limiting paragraph (2)(d), relevant values and sensitivities may include any of the following: (a) the world heritage values of a declared World Heritage property (b) the national heritage values of a National Heritage place (c) the ecological character of a declared Ramsar wetland (d) the presence of a listed threatened species or listed threatened ecological community (e) the presence of a listed migratory species	Proponent details Describe the project and feasible alternatives Describe the existing environment Impact and risk assessment process Define acceptable levels of impact and risk Identify and evaluate the impacts and risks Demonstrate acceptability Identify EPOs Identify and demonstrate how relevant requirements are met	Section 1.2 Section 3 Section 4 Section 5 Section 6 Section 7 Section 9 Section 10

Criteria for acceptance	Content requirements	Elements	Relevant section
	(f) any values and sensitivities that exist in, or in relation to, part or all of: (i) a Commonwealth marine area; or (ii) Commonwealth land Regulation 7(4)(a): describe the requirements, including legislative requirements, that apply to the project and are relevant to the environmental management of the project Regulation 7(4)(b): describe how those requirements will be met Regulation 7(5)(a) Regulation 7(5)(b)		
Regulation 13(4)(a): adequately addresses comments given during the period for public comment	Regulation 11(c): if the proponent received a copy of comments on the proposal—must include with the resubmitted proposal: (i) a summary of all comments received (ii) an assessment of the merits of each objection or claim in those comments about the project or any activity that is part of the project (iii) a statement of the proponent's response or proposed response, to each objection or claim, including a demonstration of the changes, if any, that have been made to the proposal as a result of an objection or claim	Consultation	The content requirements for this criteria will be addressed within Section 8, after the OPP public comment period has ended
Regulation 13(4)(b): is appropriate for the nature and scale of the project	Regulation 7(2)(b) Regulation 7(2)(c) Regulation 7(2)(d) Regulation 7(2)(e) Regulation 7(2)(f): Regulation 7(5)(a) Regulation 7(5)(b)	The 'nature and scale' principle applies throughout the OPP	Section 4 Section 5 Section 6 Section 7 Section 8 Section 9 Section 10 Section 11

2 WOODSIDE MANAGEMENT SYSTEM

2.1 Overview

The Woodside Management System (WMS) provides a structured framework of documentation to set common expectations governing how employees and contractors at Woodside will work. Many of the standards presented in Section 9 are drawn from the WMS documentation, which comprises four elements: Compass and Policies, Expectations, Processes and Procedures, and Guidelines, as outlined below (and illustrated in Figure 2-1):

- **Compass and Policies**: Set the enterprise-wide direction for Woodside by governing behaviours, actions, and business decisions and ensuring we meet our legal and other external obligations
- **Expectations**: Set essential activities or deliverables required to achieve the objectives of the Key Business Activities and are the basis for developing processes and procedures
- **Processes and Procedures**: Processes identify the set of interrelated or interacting activities that transforms inputs into outputs, to systematically achieve a purpose or specific objective. Procedures specify what steps, by whom, and when required to carry out an activity or a process
- **Guidelines**: Provide recommended practice and advice on how to perform the steps defined in Procedures, together with supporting information and associated tools. Guidelines provide advice on how activities or tasks may be performed; information to consider; or how to use tools and systems.

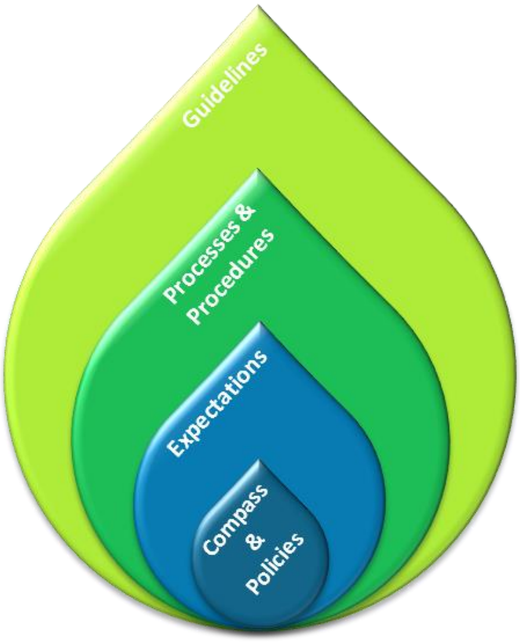


Figure 2-1: Four major elements of the WMS Seed

The WMS is organised within a Business Process Hierarchy, which is based on Key Business Activities to ensure the system remains independent of organisation structure, is globally applicable, and is scalable wherever required. These Key Business Activities are grouped into Management, Support and Value Stream activities, as shown in Figure 2-2. The Value Stream activities capture, generate, and deliver value through the exploration and production lifecycle. The Management activities influence all areas of the business, while Support activities may influence one or more value stream activities.

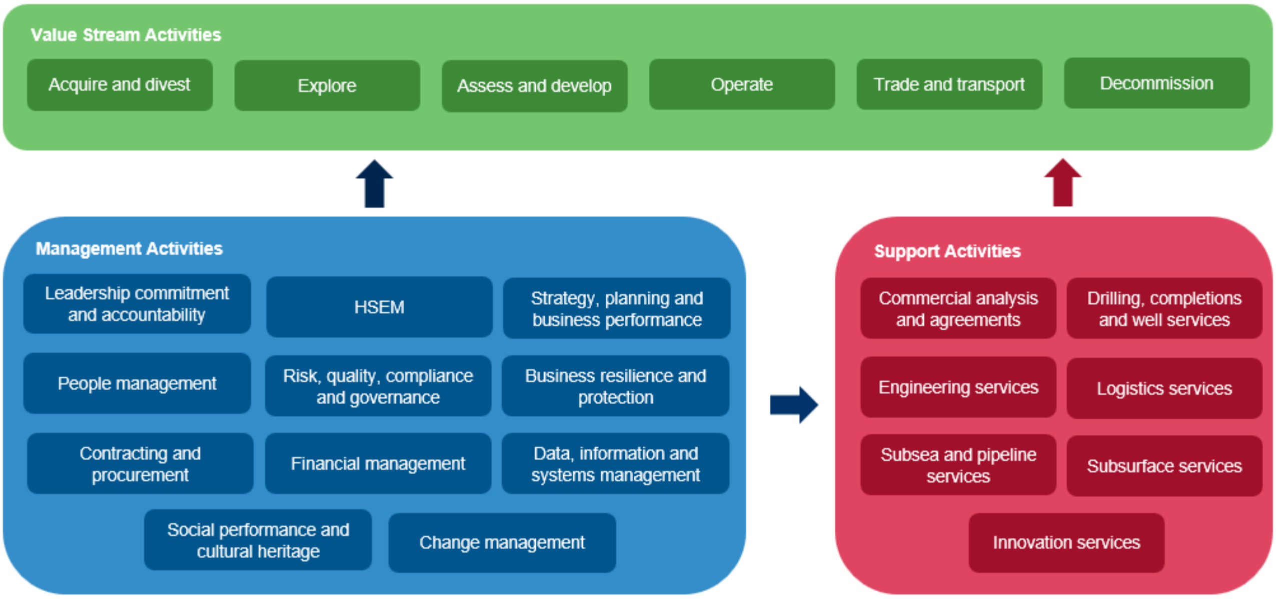


Figure 2-2: WMS business process hierarchy

2.2 Environmental Policies

The overall direction for environment is set through Woodside's Environment and Biodiversity Policy (Appendix A). This policy sets out Woodside's commitments (the principles) for managing environment and biodiversity, with an objective of recognising the intrinsic value of nature and the importance of conserving biodiversity and ecosystem services to support the sustainable development of our society.

In addition, Woodside's Climate Policy (Appendix A) identifies principles to achieve Woodside's objective of being a lower-carbon energy provider during the energy transition. For Woodside, a lower carbon portfolio is one from which the net equity Scope 1 and 2 GHG emissions, which includes the use of offsets, are being reduced towards targets, and into which new energy products and lower carbon services are planned to be introduced as a complement to existing and new investments in oil and gas. Woodside's Climate Policy sets out the principles that we believe will assist us achieve this aim.

These policies apply to Woodside's employees, contractors, and joint venture partners engaging in activities under Woodside's operational control. Woodside managers are also responsible for promotion of these policies in non-operated joint ventures.

2.3 Relationship of the WMS to the OPP

The objectives under the WMS define the mandatory performance requirements that apply to Woodside activities and the performance of its employees and contractors within their area of responsibilities. The management commitments made in this OPP and subsequent EPs will be implemented through a management framework specific to the Goodwyn Area Infill Development, but integrated into the WMS.

3 DESCRIPTION OF RELEVANT REQUIREMENTS

The Goodwyn Area Infill Development is located in Australian Commonwealth waters and falls under Commonwealth jurisdiction. In accordance with regulation 7(4) of the Environment Regulations, a description of the requirements, including legislative requirements, that apply to the offshore project and are relevant to the environmental management of the offshore project are provided below.

3.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Cth)

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGS Act) provides the legal framework for petroleum activities in Commonwealth waters (i.e. those waters beyond three nautical miles (nm) of the territorial sea baseline to the outer extent of the continental shelf and Australian Exclusive Economic Zone (EEZ) at 200 nm). Specific environmental, resource management, and safety obligations are set out in the Act's associated regulations, including:

- Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (Environment Regulations)
- Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 (Resource Management and Administration Regulations)
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 (Safety Regulations).

The object of the Environment Regulations is to ensure that any petroleum activity carried out within an offshore area[14] is:

- carried out in a manner consistent with the principles of ESD as set out in section 3A of the EPBC Act
- carried out in a manner by which the environmental impacts and risks of the petroleum activity will be reduced to as low as reasonably practicable (ALARP)
- carried out in a manner by which the environmental impacts and risks of the petroleum activity will be of an acceptable level.

3.1.1 Offshore Project Proposal

Under the OPGGS Act, the Environment Regulations apply to offshore projects in Commonwealth waters and are administered by NOPSEMA.

An OPP must

- be appropriate to the nature and scale of the offshore project
- identify and evaluate the environmental impacts and risks of the offshore project
- demonstrate that the environmental impacts and risks of the offshore project will be managed to an acceptable level
- set appropriate EPOs that are consistent with principles of ESD

The criteria for acceptance of an OPP and the associated regulatory content requirements are shown in Table 1-2.

Under Part 2 of the Environment Regulations, before commencing an offshore project, an OPP for the project must be submitted to NOPSEMA—this document has been prepared to meet this requirement.

[14] In accordance with the OPGGS Act, an 'offshore area' is defined as (a) starts 3 nm from the baseline from which the breadth of the territorial sea is measured, and (b) extends seaward to the outer limits of the continental shelf.

3.1.2 Environment Plan

EPs are also required under the OPGGS Act and Environment Regulations for petroleum activities in Commonwealth waters.

In accordance with regulation 26(3) of the Environment Regulations, a titleholder may only submit an EP for a petroleum activity that is, or is part of, an offshore project, only if NOPSEMA has accepted an OPP that includes that petroleum activity, or the Commonwealth Environment Minister has:

- made a decision under the EPBC Act that an action that includes the petroleum activity is not a controlled action
- made a decision that a particular provision of Part 3 of the EPBC Act is not a controlling provision for an action that is equivalent to or includes the petroleum activity because the Commonwealth Environment Minister believes the action will be taken in a particular manner, or
- has approved the taking of an action that is equivalent to or includes the petroleum activity under the EPBC Act.

An EP must:

- be appropriate for the nature and scale of the activity
- demonstrate that the environmental impacts and risks of the petroleum activity will be reduced to ALARP
- demonstrate that the environmental impacts and risks of the petroleum activity will be managed to an acceptable level
- provides for appropriate EPOs, environmental performance standards (EPSs), and measurement criteria
- include an appropriate implementation strategy and monitoring, recording, and reporting arrangements.

The criteria for acceptance of an EP are further described in regulation 34 of the Environment Regulations.

Under the Environment Regulations, a titleholder is required to have in place an accepted EP before commencing a petroleum activity. EPs for the petroleum activities associated with the Goodwyn Area Infill Development will be submitted after this OPP has been accepted by NOPSEMA.

3.2 Environment Protection and Biodiversity Conservation Act 1999 (Cth)

One of the objectives EPBC Act is to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places in Australia. These are some of the matters of national environmental significance (MNES) protected under Part 3 of the EPBC Act. The EPBC Act sets a regime that requires actions which a person thinks will have, or are likely to have, significant impacts on MNES to be referred under the EPBC Act. These actions may be determined to be 'controlled actions' and require assessment and approval by the Commonwealth Minister for the Environment under the EPBC Act. The EPBC Act also aims to ensure actions taken on (or affecting) Commonwealth land or waters are consistent with the principles of ESD.

In relation to offshore petroleum activities in Commonwealth waters covered by the Class Approval issued by the Commonwealth Minister for the Environment under section 146B of the EPBC Act on 27 February 2014, relevant requirements under the EPBC Act have been administered by NOPSEMA since February 2014, via the Program (Australian Government 2014). The effect of streamlining is that offshore petroleum activities covered by the Class Approval are no longer subject to separate authorisation processes under both the OPGGS Act and the EPBC Act.

3.3 Other Relevant Commonwealth Legislation

Other Commonwealth legislation relevant to the environmental management of the offshore project is outlined in Table 3-1.

Table 3-1: Other relevant Commonwealth legislation

Commonwealth Legislation	Legislation Summary	Relevance to Goodwyn Area Infill Development
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (ATSIHP Act)	The purpose of this Act is the preservation and protection of areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal traditions.	There are no planned activities associated with this offshore project that will result in interference with any known significant Aboriginal area or object. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Air Navigation Act 1920 *Civil Aviation Act 1988*	These Acts relate to the management of air navigation, including prevention of accidents and incidents.	Applies to helicopter and other aircraft activities undertaken during all phases of the offshore project. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Australian Maritime Safety Authority Act 1990	This Act establishes a legal framework for the Australian Maritime Safety Authority (AMSA), which represents the Australian Government and international forums in developing, implementing and enforcing international standards including those governing ship safety and marine environment protection. AMSA is responsible for administering the marine orders in Commonwealth waters.	The Act applies to offshore petroleum activities that have the potential to affect maritime safety and/or result in environmental damage including pollution associated with the vessel operations. This is also relevant to oil spills from vessels during petroleum activities. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Australian Radiation Protection and Nuclear Safety Act 1998	This Act relates to the protection of the health and safety of people, and the protection of the environment from the harmful effects of radiation.	Radioactive traces may be used during formation evaluation. These sealed radioactive sources are lowered into the well as part of the well logging tools and removed. Any use of radioactive materials must comply with this Act. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Biosecurity Act 2015 Biosecurity Regulation 2016	This Act provides the Commonwealth with powers to take quarantine measures, and implement related programs as are necessary to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. This Act includes mandatory controls on the use of seawater as ballast in ships and the declaration of sea	The offshore project will comply with biosecurity requirements in accordance with this Act. This will include biofouling and ballast water requirements for vessels, offshore facilities (i.e. MODU), and associated in-water equipment. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.

Commonwealth Legislation	Legislation Summary	Relevance to Goodwyn Area Infill Development
	vessels voyaging out of and into Commonwealth waters. The Regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers.	
Climate Change Act 2022	This Act sets out Australia's GHG emissions reduction targets, provides for annual climate change statements, and confers advisory functions on the Climate Change Authority.	Applies to national GHG emissions and associated reduction targets. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Environment Protection (Sea Dumping) Act 1981 Environment Protection (Sea Dumping) Regulations 1983	This Act and associated regulations protect the environment by regulating dumping matter into the sea, incineration of waste at sea and placement of artificial reefs.	Sea dumping permits will be in place where required. Sea dumping activities will be undertaken in accordance with the Act and under permit as required. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Hazardous Waste (Regulation of Exports and Imports) Act 1989	The main purpose of this Act is to regulate the import, export, and transport of hazardous waste. It aims to ensure adequate disposal of hazardous waste to minimise impacts to humans and the environment within and outside Australia.	The offshore project will comply with the requirements of this Act with regard to export of hazardous waste. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Industrial Chemicals Act 2019	This Act provides for a national scheme to regulate the introduction of industrial chemicals into Australia. and aids in the protection of human health and the environment via restrictions and/or management recommendations for industrial chemical use.	All chemicals used in association with this offshore project will comply with the requirements of this Act. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
National Environment Protection Measures (Implementation) Act 1998 National Environment Protection Measures (Implementation) Regulations 1999	This Act and associated regulations provide for the implementation of National Environment Protection Measures (NEPMs) to protect, restore and enhance the quality of the environment in Australia and ensure that the community has access to relevant and meaningful information about pollution. The National Environment Protection Council has made NEPMs relating to ambient air quality, the movement of controlled waste between states and territories, the national pollutant inventory, and used packaging materials.	Woodside will meet any requirements of this Act including submitting reports as required. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
National Greenhouse and Energy Reporting Act 2007 National Greenhouse and Energy Reporting Regulations 2008	This Act and associated regulations and rule establishes the legislative framework for the National Greenhouse and Energy Reporting (NGER) scheme for Australian	Woodside will meet any requirements of this Act (and associated regulations and rule) including submitting reports as required.

Commonwealth Legislation	Legislation Summary	Relevance to Goodwyn Area Infill Development
National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015	corporations to report GHG emissions and energy consumption and production.	Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Navigation Act 2012	This Act regulates navigation and shipping, including Safety of Life at Sea (SOLAS), and will apply to some activities of the mobile offshore drilling unit (MODU) and project vessels. This Act is the primary legislation that regulates ship and seafarer safety, shipboard aspects of marine environment protection and pollution prevention.	Vessel operations undertaken as a part of this activity will adhere to MARPOL and the various marine orders (as appropriate to vessel class) enacted under this Act. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Navigation Act 2012 *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* *Protection of the Sea (Harmful Antifouling Systems) Act 2006* Marine Order 30—Prevention of collisions Marine Order 57—Helicopter operations Marine Order 91—Marine pollution prevention—oil Marine Order 93—Marine pollution prevention—noxious liquid substances Marine Order 94—Marine pollution prevention—packaged harmful substances Marine Order 95—Marine pollution prevention—garbage Marine Order 96—Marine pollution prevention—sewage Marine Order 97—Marine pollution prevention—air pollution	These Acts give effect to the requirements under the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) in Australia.	Vessel operations undertaken as a part of this activity will adhere to MARPOL73/78 and the various marine orders (as appropriate to vessel class) enacted under these Acts. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995	This Act and associated regulations provide for measures to protect ozone in the atmosphere by controlling and ultimately reducing the manufacture, import and export of ozone depleting substances (ODSs) and synthetic GHGs, and replacing them with suitable alternatives.	The Act will only apply to Woodside if it manufactures, imports or exports ODSs. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Underwater Cultural Heritage Act 2018 (UCH Act)	This Act came into effect on 1 July 2019 and replaces the *Historic Shipwrecks Act 1976*. This new Act continues the protection of Australia's shipwrecks, and has broadened to include protection of sunken aircraft and other types of underwater cultural heritage (UCH).	There are no planned activities associated with this offshore project that will result in interference with any known UCH sites listed under the Act. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.

3.4 Commonwealth Policies and Guidelines

Commonwealth policies or guidelines relevant to the environmental management of the offshore project are outlined in Table 3-2.

Table 3-2: Other relevant Commonwealth policies and guidelines

Policy or Guideline	Summary	Relevance to Goodwyn Area Infill Development
Department of Agriculture, Fisheries and Forestry (DAFF)		
Anti-fouling and in-water cleaning guidelines (DotE 2015a)	This guideline provides best practice approaches to applying, maintaining, removing, and disposing of anti-fouling coatings. They are also used for managing biofouling and invasive aquatic species. This guideline applies to all vessels and movable structures in Australian aquatic environments (marine, estuarine and freshwater) regardless of whether they have an anti-fouling coating.	The offshore project will consider this guideline and best practice approaches. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Australian Ballast Water Management Requirements (DAWE 2020)	The requirements set out the obligations on vessel operators with regards to the management of ballast water when operating within Australian territorial seas[1]. These requirements include legislative obligations under the *Biosecurity Act 2015* (Cth) and International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (Ballast Water Management Convention). The requirements provide guidance for vessel operators on best practice policies and apply to all vessels operating internationally and domestically in Australia.	The offshore project will consider this guidance and comply with any legislative requirements (as per Table 3-1). The offshore project does not occur within Australian territorial seas. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Australian Biofouling Management Requirements (DAWE 2022)	The requirements set out vessel operator obligations for managing biofouling when operating vessels under biosecurity control within Australian territorial seas. DAFF's powers to manage biosecurity risk associated with biofouling are contained in the *Biosecurity Act 2015* (Cth) and associated legislation. The requirements provide guidance for vessel operators on best practice and applies to operators of all international vessels that are subject to biosecurity control while in Australian territorial seas.	The offshore project will consider this guidance and comply with any legislative requirements (as per Table 3-1). The offshore project does not occur within Australian territorial seas. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Department of Climate Change, Energy, the Environment and Water (DCCEEW)		
EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales: Industry guidelines (DEWHA 2008a)	The aim of this policy statement is to: • provide practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic survey operations • provide a framework that minimises the risk of biological consequences from acoustic disturbance from seismic survey sources to whales in biologically important habitat areas or during critical behaviours • provide guidance to both proponents of seismic surveys and operators conducting	The offshore project will consider this policy statement and acoustic management approaches. Seismic surveys are not within the scope of the offshore project. Not linked to key control measures for the management of any impacts and/or risks under this OPP.

Policy or Guideline	Summary	Relevance to Goodwyn Area Infill Development
	seismic surveys about their legal responsibilities under the EPBC Act.	
EPBC Act Policy Statement 3.21 – Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DotEE 2017)	This policy statement is intended to provide a guide for stakeholders in assessing the likelihood of a proposed action having a significant impact on one or more migratory shorebird species in Australia. This policy statement is a key action under the Wildlife Conservation Plan for Migratory Shorebirds (Table 3-3).	The offshore project will consider this policy statement and significant impact guidance within the impact and risk evaluations. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
The Interim Engaging with First Nations People and Communities on Assessments and Approvals under Environment Protection and Biodiversity Conservation Act 1999 (DCCEEW 2023h)	This interim guidance outlines the statutory obligations that apply to proponents engaging with First Nations people and communities under the EPBC Act.	The offshore project will consider this interim guideline and recommended approaches. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
(Draft) Guidelines for working in the near and offshore environment to protect Underwater Cultural Heritage (DCCEEW 2023f)	These draft guidelines aim to: • provide direction on addressing legislative obligations for proponents of near and offshore developments • promote best practice for identifying, assessing, and protecting UCH in Australian waters.	The offshore project will consider this draft guideline and recommended management approaches. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
National biofouling management guidelines for the petroleum production and exploration industry (MPSC 2009)	This guidance provides recommendations for the management of biofouling hazards by the petroleum industry.	The offshore project will consider this guideline and recommended management approaches. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
National Light Pollution Guidelines for Wildlife (DCCEEW 2023k)	The guidelines raise awareness of the impacts of artificial light on wildlife. The guidelines provide: • a framework for how to assess and manage the light pollution impacts on wildlife • detailed guidance for how to manage artificial light • detailed advice on how to protect specific wildlife, including marine turtles, seabirds, migratory shorebirds, and ecological communities.	The offshore project will consider these guidelines and management approaches within the impact and risk evaluations. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.
Department of Industry, Science, Energy and Resources (DISER)		
Offshore petroleum decommissioning guideline (DISER 2022b)	The guideline aims to clarify the application, operation, and interaction between the OPGGS Act (and associated regulations) and other Commonwealth legislation, for the decommissioning offshore petroleum property in Commonwealth waters. This guideline helps offshore petroleum titleholders plan and seek the regulatory approvals necessary to undertake a	The offshore project will consider these guidelines within the decommissioning strategy of the project description. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP.

Policy or Guideline	Summary	Relevance to Goodwyn Area Infill Development
	decommissioning activity, and to understand the expectations of relevant decision-makers.	
NOPSEMA		
Environmental bulletin – Oil spill modelling (NOPSEMA 2019)	The bulletin provides clarification on the application and interpretation of oil spill modelling.	The offshore project will consider this guidance within the impact and risk evaluations of the OPP. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Information paper – Acoustic impact evaluation and management (NOPSEMA 2024b)	The paper's primary focus is on evaluating and managing the environmental impacts due to sound emissions from marine seismic surveys, however, is relevant to environmental impacts from other petroleum activities.	The offshore project will consider this guidance within the impact and risk evaluations of the OPP. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Information paper – Reducing marine pest biosecurity risks through good practice biofouling management (NOPSEMA 2024c)	The intent of this paper is to clarify biosecurity requirements relevant to offshore activities, and provide advice on good practice that is consistent with expectations for managing biofouling within the Australian marine environment.	The offshore project will consider this guidance within the impact and risk evaluations of the OPP. Not linked to key control measures for the management of any impacts and/or risks under this OPP.
Policy – Section 572 maintenance and removal of property (NOPSEMA 2022)	This policy sets out the principles that NOPSEMA will apply in the administration of section 572 of the OPGGS Act. The policy includes expectations for the information to be included in an OPP in regard to section 572 of the Act.	The offshore project will consider these guidelines within the decommissioning strategy of the project description. Applicable requirements are linked to key control measures for the management of relevant impacts and/or risks under this OPP

1. *The territorial sea is a belt of water not exceeding 12 nm in width measured from the territorial sea baseline.*

3.5 Management Plans

3.5.1 Marine Bioregional Plans

Marine Bioregional Plans aim to strengthen the operation of the EPBC Act to help ensure that the marine environment remains healthy and resilient. These plans describe the marine environment and conservation values within each region, set broad biodiversity objectives, identify priorities and strategies to address these priorities (DCCEEW 2021e). Marine Bioregional Plans:

- support strategic, consistent and informed decision-making under Commonwealth environment legislation in relation to Commonwealth marine areas
- support efficient administration of the EPBC Act to promote the ecologically sustainable use of the marine environment and its resources
- provide a framework for strategic intervention and investment by government to meet policy objectives and statutory responsibilities.

Marine Bioregional Plans improve the understanding of Australian oceans by providing a consolidated picture of the biophysical characteristics and the diversity of marine life (DCCEEW 2021e). The are currently four Marine Bioregional Plans that have been developed (South-west, North-west, North, and Temperate East).

3.5.2 Recovery Plans, Conservation Advice, and Threat Abatement Plans

Under section 139(1)(b) of the EPBC Act, the Commonwealth Minister for Environment and Water (the Minister) must not, when deciding whether or not to approve the taking of an action and what conditions should attach to any approval, act inconsistently with a recovery plan for a listed threatened species or ecological community or a threat abatement plan for a species or community protected under the Act. Similarly, under section 268 of the EPBC Act: ‘[a] Commonwealth agency must not take any action that contravenes a recovery plan or a threat abatement plan’. Under section 139(2) of the EPBC Act, the Minister must also have regard to any approved conservation advice for a listed threatened species or community.

In relation to offshore petroleum activities in Commonwealth waters, these requirements are now administered by NOPSEMA in accordance with commitments set out in the Program (Australian Government 2014).

Relevant recovery plans or threat abatement plans relevant to the scope of this OPP have been identified. Table 3-3 lists the objectives and (where relevant) the action areas of these plans, and also identifies whether these objectives/action areas are applicable to government, the titleholder, and/or the offshore project.

For those objectives/action areas applicable to the offshore project, the relevant actions of each plan have been identified, and an evaluation has been conducted as to whether impacts and risks resulting from the offshore project are not inconsistent with that action. These assessments are included as part of the Demonstration of Acceptability presented for each aspect in Section 9.

Table 3-3: Identification of relevant Recovery Plans, Conservation Advice, and Threat Abatement Plans objectives and action areas

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
National Recovery Plan for the Australian Fairy Tern (CoA 2022b)			
Recovery Plan objective: By 2030, sustain a positive population trend (compared to 2020 baseline counts) in the number of mature individuals of the Australian fairy tern in both the eastern and western populations	Y		
Strategies to achieve objectives			
Manage and protect known Australian fairy tern breeding populations at the landscape scale	Y		
Develop and apply techniques to measure changes in population trend(s) in order to measure the efficacy of recovery actions	Y		
Reduce, or eliminate threats at breeding, non-breeding and foraging sites	Y		
Undertake research and monitoring to improve understanding of breeding, non-breeding and foraging attributes in order to better target management actions and habitat restoration	Y		
Engage community stakeholders in Australian fairy tern conservation	Y		
Coordinate, review and report on recovery progress	Y		
Recovery Plan for the Australian Sea Lion (DSEWPaC 2013b)			
Overarching objective			
The overarching objective of this recovery plan is to halt the decline and assist the recovery of the Australian sea lion throughout its range in Australian waters by increasing the total population size while maintaining the number and distribution of breeding colonies with a view to: • improving the population status, leading to future removal of the Australian sea lion from the threatened species list of the EPBC Act • ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future	Y	Y	Y
Specific objectives			
Mitigate interactions between fishing sectors (commercial, recreational and Indigenous) and the Australian sea lion to enable the recovery of all breeding colonies	Y		
Mitigate the impacts of marine debris on Australian sea lion populations	Y	Y	
Mitigate the impacts of aquaculture operations on Australian sea lion populations	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Investigate and mitigate other potential threats to Australian sea lion populations, including disease, vessel strike, pollution and tourism	Y		
Continue to develop and implement research and monitoring programs that provide outputs of direct relevance to the conservation of the Australian sea lion	Y		
Increase community involvement in, and awareness of, the recovery program	Y		
Conservation Management Plan for the Blue Whale (CoA 2015a)			
Long-term recovery objective: Minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list	Y	Y	Y
Interim recovery objectives			
The conservation status of blue whale populations is assessed using efficient and robust methodology	Y		
The spatial and temporal distribution, identification of biologically important areas (BIAs), and population structure of blue whales in Australian waters is described	Y		
Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place	Y		
Anthropogenic threats are demonstrably minimised	Y	Y	Y
Action areas			
A. Assessing and addressing threats			
A.1: Maintain and improve existing legal and management protection	Y		
A.2: Assessing and addressing anthropogenic noise	Y	Y	Y
A.3: Understanding impacts of climate variability and change	Y		
A.4: Minimising vessel collisions	Y	Y	Y
B. Enabling and measuring recovery			
B.1: Measuring and monitoring population recovery	Y		
B.2: Investigating population structure	Y		
B.3: Describing spatial and temporal distribution and defining biologically important habitat	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Recovery Plan for the Grey Nurse Shark (DotE 2014b)			
Overarching objective			
To assist the recovery of the grey nurse shark in the wild, throughout its range in Australian waters, with a view to: • improving the population status, leading to future removal of the grey nurse shark from the threatened species list of the EPBC Act • ensuring that anthropogenic activities do not hinder the recovery of the grey nurse shark in the near future, or impact on the conservation status of the species in the future	Y	Y	Y
Specific objectives			
Develop and apply quantitative monitoring of the population status (distribution and abundance) and potential recovery of the grey nurse shark in Australian waters	Y		
Quantify and reduce the impact of commercial fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range	Y		
Quantify and reduce the impact of recreational fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range	Y		
Where practicable, minimise the impact of shark control activities on the grey nurse shark	Y		
Investigate and manage the impact of ecotourism on the grey nurse shark	Y		
Manage the impact of aquarium collection on the grey nurse shark	Y		
Improve understanding of the threat of pollution and disease to the grey nurse shark	Y		
Continue to identify and protect habitat critical to the survival of the grey nurse shark and reduce the impact of threatening processes within these areas	Y		
Continue to develop and implement research programs to support the conservation of the grey nurse shark	Y		
Promote community education and awareness in relation to grey nurse shark conservation and management	Y		
Recovery Plan for Marine Turtles in Australia (CoA 2017b)			
Long-term recovery objective: Minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so they can be removed from the EPBC Act threatened species list	Y	Y	Y

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Interim recovery objectives			
Current levels of legal and management protection for marine turtle species are maintained or improved, both domestically and throughout the migratory range of Australia's marine turtles	Y		
The management of marine turtles is supported	Y		
Anthropogenic threats are demonstrably minimised	Y	Y	Y
Trends in nesting numbers at index beaches and population demographics at important foraging grounds are described	Y		
Action Areas			
A. Assessing and addressing threats			
A1. Maintain and improve efficacy of legal and management protection	Y		
A2. Adaptatively manage turtle stocks to reduce risk and build resilience to climate change and variability	Y		
A3. Reduce the impacts of marine debris	Y	Y	Y
A4. Minimise chemical and terrestrial discharge	Y	Y	Y
A5. Address international take within and outside Australia's jurisdiction	Y		
A6. Reduce impacts from terrestrial predation	Y		
A7. Reduce international and domestic fisheries bycatch	Y		
A8. Minimise light pollution	Y	Y	Y
A9. Address the impacts of coastal development/infrastructure and dredging and trawling	Y		
A10. Maintain and improve sustainable Indigenous management of marine turtles	Y		
B. Enabling and measuring recovery			
B1. Determine trends in index beaches	Y		
B2. Understand population demographics at key foraging grounds	Y		
B3. Address information gaps to better facilitate the recovery of marine turtle stocks	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
National Recovery Plan for Albatrosses and Petrels (DCCEEW 2022c)			
Objective of the Recovery Plan objective: To improve the conservation status of albatrosses and petrels so that these species are on a trajectory towards no longer being threatened in Australia's jurisdiction	Y	Y	Y
Overarching actions			
A: Assessing and addressing threats			
A.1: Ongoing protection of albatross and petrel species breeding sites and habitats in Australia's jurisdiction	Y		
A.2: Prevent introduction of alien species to breeding islands in Australia's jurisdiction	Y		
A.3: Identify whether competition with native species is causing population declines	Y		
A.4: Identify diseases likely to have a population-level effect on breeding populations	Y		
A.5: Avoid or minimise incidental catch (or bycatch) of seabirds during fishing operations in Australia's jurisdiction	Y		
A.6: Advocate for effective international measures for conserving albatrosses and petrels	Y		
A.7: Minimise the effects of marine debris, plastics and pollution	Y	Y	Y
B: Enabling and measuring recovery			
B.1: Monitor population and conservation status of breeding populations in Australia's jurisdiction	Y		
B.2: Monitor the effects of fishing on albatrosses and petrels in Australia's jurisdiction	Y		
B.3: Increase community understanding of and involvement in the conservation of albatrosses and petrels	Y		
B.4: Increase understanding of the effects of climate change on albatrosses and petrels in Australia, and identify ways to increase the resilience of the species to these effects	Y		
B.5: Implement statutory requirements	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Sawfish and River Sharks Multispecies Recovery Plan (CoA 2015b)			
Primary objective			
To assist the recovery of sawfish and river sharks in Australian waters with a view to: • improving the population status leading to the removal of the sawfish and river shark species from the threatened species list of the EPBC Act • ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future	Y	Y	Y
Specific objectives			
Reduce and, where possible, eliminate adverse impacts of commercial fishing on sawfish and river shark species	Y		
Reduce and, where possible, eliminate adverse impacts of recreational fishing on sawfish and river shark species	Y		
Reduce and, where possible, eliminate adverse impacts of Indigenous fishing on sawfish and river shark species	Y		
Reduce and, where possible, eliminate the impact of illegal, unregulated and unreported fishing on sawfish and river shark species	Y		
Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification on sawfish and river shark species	Y	Y	Y
Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life	Y	Y	Y
Reduce and, where possible, eliminate any adverse impacts of collection for public aquaria on sawfish and river shark species	Y		
Improve the information base to allow the development of a quantitative framework to assess the recovery of, and inform management options for, sawfish and river shark species	Y		
Develop research programs to assist conservation of sawfish and river shark species	Y		
Improve community understanding and awareness in relation to sawfish and river shark conservation and management	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation Management Plan for the Southern Right Whale (DSEWPaC 2012a)[15]			
Recovery objective			
Long-term recovery objective: Minimise anthropogenic threats to allow the conservation status of the southern right whale to improve so that it can be removed from the threatened species list under the EPBC Act.	Y	Y	Y
Interim recovery objectives			
Demonstrate that the number of southern right whales occurring off south-west Australia (nominally south-west Australian population) is increasing at or near the maximum biological rate	Y		
Demonstrate that the number of southern right whales occurring off south-east Australia (nominally south-east Australian population) is showing signs of increase	Y		
The nature and degree of difference between the south-eastern and south-western Australian populations of southern right whales is clearly understood	Y		
Current levels of legal and management protection for southern right whales are maintained or improved and an appropriate adaptive management regime is in place	Y		
Anthropogenic threats are demonstrably minimised	Y	Y	Y
Action areas			
A.1 Assessing and addressing threats			
Continue or improve existing legislative management actions	Y		
A.2. Assessing and addressing anthropogenic noise			
Improve the understanding of what impact anthropogenic noise may have on southern right whale populations by: • assessing anthropogenic noise in key calving areas • assessing responses of southern right whales to anthropogenic noise • if necessary, developing further mitigation measures for noise impacts	Y		

[15] A draft National Recovery Plan for the southern right whale (*Eubalaena australis*) was released for comment in early-2023; a final plan has not yet been released.

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
A.3. Reducing commercial fishing entanglements			
Minimise the risk of entanglements by: • where necessary, exploring with the crustacean and cephalopod (primarily octopus) fishing industries the option to develop codes of conduct that minimise interactions between commercial fishers and southern right whales • improve reporting for entanglement incidents for all fisheries likely to interact with southern right whales • investigate alternative fishing techniques and technologies to reduce the risk of entanglement	Y		
A.4. Preparing for potential impacts of climate variability and change			
Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica	Y	Y	Y
A.5. Addressing vessel collisions			
Develop a national ship strike strategy that quantifies vessel movements within the distribution ranges of southern right whales and outlines appropriate mitigation measures that reduce impacts from vessel collisions	Y		
A.6. Addressing infrastructure and coastal development impacts			
Principle actions addressing impacts of coastal development are covered under anthropogenic noise and shipping collisions. Improve management systems designed to minimise the impact of infrastructure development and operation and coastal development on southern right whales, by ensuring that existing information about coastal habitat requirements, environmental suitability of coastal locations, historic high use and emerging areas is available to coastal planning and approvals areas in all levels of government	Y		
B.1. Measuring and monitoring population recovery			
Continue to obtain and refine population abundance and trends for the south-west population and develop firm population and rate of increase estimates for the south-east population. This can be implemented by the following projects: • maintain long-term aerial survey and photo-identification monitoring of the south-west coastal region (Cape Leeuwin to Ceduna) on an annual basis • initiate long-term aerial survey and photo-identification monitoring of the south-east coastal region (Ceduna to Sydney including Tasmania) on an annual basis • build and populate a Right Whale Photo-Identification Catalogue • continue monitoring the population at Head of Bight • review the conservation status of southern right whales against threatened species listing criteria under the EPBC Regulations	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
B.2. Investigating two-population model			
Carry out comprehensive genetic and photographic identification studies to further investigate differences between the south-eastern and south-western populations of southern right whales within Australian waters including: • determining the nature and degree of differences between the south-eastern and south-western populations and implications for population recovery • ascertaining rates of genetic interchange amongst the south-east and south-west populations • ascertaining geographic range and habitat occupancy for the two populations • improving the understanding of interchange between populations from Australia and New Zealand waters	Y		
B.3. Understanding offshore distribution and migration			
Investigate the offshore distribution of southern right whales, specifically: • offshore distribution within Australian waters • movements between feeding and breeding grounds • winter distribution of the component of the population that does not migrate to the Australian coast.	Y		
B.4. Characterising behaviour and movements			
Extend behavioural studies and further review existing behavioural and fine-scale movement data to characterise behaviours and movements that may be affected by the known and potential threats identified in this plan	Y		
Recovery Plan for the White Shark (DSEWPaC 2013c)			
Objective			
The overarching objective of this recovery plan is to assist the recovery of the white shark in the wild throughout its range in Australian waters with a view to: • improving the population status leading to future removal of the white shark from the threatened species list of the EPBC Act • ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future.	Y		
Specific objectives			
Develop and apply quantitative measures to assess population trends and any recovery of the white shark in Australian waters and monitor population trends	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Quantify and minimise the impact of commercial fishing, including aquaculture, on the white shark through incidental (illegal and/or accidental) take	Y		
Quantify and minimise the impact of recreational fishing on the white shark through incidental (illegal and/or accidental) take	Y		
Where practicable, minimise the impact of shark control activities	Y		
Investigate and manage (and where necessary reduce) the impact of tourism	Y		
Quantify and minimise the impact of international trade in white shark products through implementation of CITES[16] provisions	Y		
Continue to identify and protect habitat critical to the survival of the white shark and minimise the impact of threatening processes within these areas	Y		
Continue to develop and implement relevant research programs to support the conservation of the white shark	Y		
Promote community education and awareness in relation to white shark conservation and management	Y		
Encourage the development of regional partnerships to enhance the conservation and management of the white shark across national and international jurisdictions	Y		
Conservation Advice for Asian Dowitcher (DCCEEW 2024e)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of Asian dowitcher throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in Asian dowitcher populations by working with relevant Range States to address threats in the East Asian-Australasian Flyway (EAAF)	Y		
Conservation and management priorities			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for Asian dowitcher conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for Asian dowitcher in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar site, biodiversity stewardship payments)	Y		

[16] International Convention on International Trade in Endangered Species of Wild Fauna and Flora.

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Unify existing management plans for important shorebird areas into a guided and partially standardised document. Subsequentially, develop management plans for each important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilized during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network, including inland wetlands and coastal sites	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands (and roost sites) to support populations of migratory shorebirds, including Asian dowitcher	Y		
Develop and, where necessary, implement floating roost sites that can support Asian dowitcher roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on Asian dowitcher feeding and roosting habitat within Australia	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of posters showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Identify key areas where Asian dowitcher take occurs	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Black-tailed Godwit (DCCEEW 2024g)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of black-tailed godwit throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in black-tailed godwit populations by working with relevant Range States to address threats in the East Asian-Australasian Flyway (EAAF)	Y		
Conservation and management priorities			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for black-tailed godwit conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for black-tailed godwit in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar site, biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and partially standardised document. Subsequentially, develop management plans for each important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species’ local-scale movement patterns and incorporate all important habitats utilized during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species’ migration network, including inland wetlands and coastal sites	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands (and roost sites) to support populations of migratory shorebirds, including black-tailed godwit	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Develop and, where necessary, implement floating roost sites that can support black-tailed godwit roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on black-tailed godwit feeding and roosting habitat within Australia	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of posters showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Identify key areas where black-tailed godwit take occurs	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Blue Petrel (TSSC 2015c)			
Conservation and management actions			
Continue to manage Macquarie Island and its surrounds in such a way that human disturbance is minimised	Y		
Continue strict quarantine management practices for Macquarie Island to reduce the risk of any invasive species (re)establishing on the island	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation Advice for Christmas Island White-tailed Tropicbird (DotE 2014a)			
Management actions			
Maintain controls for feral cats, black rats and crazy ants	Y		
Upgrade quarantine standards	Y		
Create a multi-stakeholder team with responsibilities for ensuring threatened species are conserved	Y		
Evaluate the effectiveness of management actions and the need to adapt them if necessary	Y		
Conservation Advice for Common Greenshank (DCCEEW 2024i)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of common greenshank throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in common greenshank populations by working with relevant Range States to address threats in the East Asian-Australasian Flyway (EAAF)	Y		
Conservation and management priorities			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for common greenshank conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for common greenshank in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar site, biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and partially standardised document. Subsequentially, develop management plans for each important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilized during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies and site managers	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Ensure that functional connectivity of sites is maintained throughout the species' migration network, including inland wetlands and coastal sites	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands (and roost sites) to support populations of migratory shorebirds, including common greenshank	Y		
Develop and, where necessary, implement floating roost sites that can support common greenshank roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on common greenshank feeding and roosting habitat within Australia	Y		
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for common greenshank	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of posters showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Identify key areas where common greenshank take occurs	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Curlew Sandpiper (DCCEEW 2023b)			
Primary conservation objectives			
Minimise further loss of habitat critical to the survival of curlew sandpiper throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in curlew sandpiper populations by working with relevant Range States to address threats in the East Asian-Australasian Flyway (EAAF)	Y		
Conservation and management actions			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for curlew sandpiper conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for curlew sandpiper in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar site, biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and partially standardised document. Subsequentially, develop management plans for each important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilized during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network, including inland wetlands and coastal sites	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands (and roost sites) to support populations of migratory shorebirds, including curlew sandpiper	Y		
Develop and, where necessary, implement floating roost sites that can support curlew sandpiper roosting in areas severely affected by human development	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Invasive marine species			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Identify and protect inland wetlands and coastal drought refuges in Australia	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on curlew sandpiper feeding and roosting habitat within Australia	Y		
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for curlew sandpiper	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of posters showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Identify key areas where curlew sandpiper take occurs	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation Advice for Dwarf Sawfish (DEWHA 2009)			
Regional priority actions			
Fishing pressure			
Raise awareness of the dwarf sawfish within the local, Indigenous and fishing communities, including species identification and handling techniques for bycatch specimens (i.e. using fact sheets and information brochures)	Y		
Work with fishers to develop appropriate codes of conduct for handling sawfish to reduce mortality	Y		
Protect remnant populations through the development of conservation agreements and covenants with the fishing community	Y		
Investigate the closure of some estuarine and coastal habitats to fishing	Y		
Habitat loss, disturbance and modification			
Identify populations and areas of high conservation priority	Y		
Conservation information			
Maintain liaison with Indigenous ranger groups and other appropriate groups patrolling waters in which populations occur	Y		
Conservation Advice for Eastern Curlew (DCCEEW 2023e)			
Primary conservation actions			
Minimise further loss of habitat critical to the survival of far eastern curlew throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in far eastern curlew populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		
Conservation and management actions			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for far eastern curlew conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for far eastern curlew in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including far eastern curlews	Y		
Develop and, where necessary, implement floating roost sites that can support far eastern curlew roosting in areas severely affected by human development	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on far eastern curlew's feeding and roosting habitat within Australia	Y		
Hunting			
Identify key areas where the legal and illegal take of far eastern curlew occurs	Y		
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Disturbance at feeding and roosting sites			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for far eastern curlews	Y		
Conservation Advice for Fin Whale (TSSC 2015b)			
Conservation actions			
Maintain and improve existing legal and management protection	Y		
Understanding impacts of climate variability and change	Y		
Assessing and addressing anthropogenic noise	Y	Y	Y
Minimising vessel collisions	Y	Y	Y
Conservation Advice for Great Knot (DCCEEW 2024b)			
Primary conservation actions			
Minimise further loss of habitat critical to the survival of great knot throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in great knot populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		
Conservation and management actions			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for great knot conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for great knot in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including great knot	Y		
Develop and, where necessary, implement floating roost sites that can support great knot roosting in areas severely affected by human development	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on great knot's feeding and roosting habitat within Australia	Y		
Hunting			
Identify key areas where the legal and illegal take of great knot occurs	Y		
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Disturbance at feeding and roosting sites			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for great knot	Y		
Conservation Advice for Greater Sand Plover (DCCEEW 2023c)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of greater sand plover throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in greater sand plover populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		
Conservation and management actions			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for greater sand plover conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for greater sand plover in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including greater sand plover	Y		
Develop and, where necessary, implement floating roost sites that can support greater sand plover roosting in areas severely affected by human development	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on greater sand plover's feeding and roosting habitat within Australia	Y		
Hunting			
Identify key areas where the legal and illegal take of greater sand plover occurs	Y		
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Disturbance at feeding and roosting sites			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for greater sand plover	Y		
Conservation Advice for Grey Plover (DCCEEW 2024h)			
Primary conservation outcome			
Minimise further loss of habitat critical to the survival of grey plover throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in grey plover populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation and management priorities			
Habitat loss caused by residential, commercial, and aquaculture development			
Strengthen international cooperation for grey plover conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for grey plover in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update/modify existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including grey plover	Y		
Develop and, where necessary, implement floating roost sites that can support grey plover roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on grey plover's feeding and roosting habitat within Australia	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for grey plover	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Encourage Range States of the East Asian – Australasian Flyway Partnership to actively prevent hunting in known migratory shorebird roosting and nesting sites	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Leaf-scaled Sea Snake (DSEWPaC 2011b)			
Regional priority actions			
Habitat loss, disturbances and modification			
Identify remnant populations of high conservation priority	Y		
Monitor known populations to identify key threats	Y		
Ensure there is no disturbance in areas where the leaf-scaled seasnake occurs, excluding necessary actions to manage the conservation of the species.	Y	Y	Y
Monitor changes to sea water temperatures and sea levels	Y		
Conservation information			
Raise awareness of the leaf-scaled seasnake within the local community and commercial fisheries, in particular fisheries activities off the WA coast	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Enable recovery of additional populations			
Investigate options for enhancing or establishing additional populations such as captive breeding and release	Y		
Conservation Advice for Lesser Sand Plover (TSSC 2016)			
Conservation and management actions			
Work with governments along the EAAF to prevent destruction of key breeding and migratory staging sites	Y		
Protect important habitat in Australia	Y		
Support initiatives to improve habitat management at key sites	Y		
Maintain and improve protection of roosting and feeding sites in Australia	Y		
Advocate for the creation and restoration of foraging and roosting sites	Y		
Incorporate requirements for lesser sand plover into coastal planning and management	Y		
Manage important sites to identify, control and reduce the spread of invasive species	Y		
Manage disturbance at important sites which are subject to anthropogenic disturbance when lesser sand plovers are present—e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures	Y		
Conservation Advice for Northern Siberian Bar-tailed Godwit (DCCEEW 2024f)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of Yakutian bar-tailed godwit throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in Yakutian bar-tailed godwit populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		
Conservation and management actions			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for Yakutian bar-tailed godwit conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Continue to identify important habitat for Yakutian bar-tailed godwit in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including Yakutian bar-tailed godwit	Y		
Develop and, where necessary, implement floating roost sites that can support Yakutian bar-tailed godwit roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on Yakutian bar-tailed godwit's feeding and roosting habitat within Australia	Y		
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for Yakutian bar-tailed godwit	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Identify key areas where the legal and illegal take of Yakutian bar-tailed godwit occurs	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Painted Button-quail (Houtman Abrolhos) (DCCEEW 2023d)			
Primary conservation objective			
By 2032, painted button-quail (Houtman Abrolhos) population maintained on Wallabi Islands resulting in a stable or increasing trend in number of mature individuals	Y		
By 2032, painted button-quail (Houtman Abrolhos) population restored to North Island	Y		
Conservation and management priorities			
Ensure strong quarantine protocols and invasion monitoring in place at all islands, including North Island to prevent rodent and cat invasion	Y		
Develop and implement a contingency plan for the control and eradication of introduced rats or cats on the islands	Y		
Continue ongoing weed control with the aim to eradicate golden crownbeard and Paterson's Curse	Y		
Develop and implement a suitable fire management strategy to prevent of ignitions and advance measures to limit spread of fires within the Houtman Abrolhos archipelago where the subspecies occurs	Y		
Provide maps of known occurrences to local fire services	Y		
Prohibit the lighting of fires by all visitors to the islands	Y		
Continue Tammar wallabies monitoring and eradication program on North Island	Y		
Once wallabies completely removed, undertake translocation of the painted button-quail (Houtman Abrolhos) to North Island if deemed feasible	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Develop and implement a management plan for the control and eradication of the introduced house mice on the islands	Y		
Clearly define pedestrian access (boardwalk, beach or walking trail)	Y		
Considerer tourism developments only where there are minimal impacts to the subspecies or where impacts can be mitigated	Y		
Conservation Advice for Red Knot (DCCEEW 2024a)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of red knot throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in red knot populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		
Conservation and management actions			
Habitat loss, disturbance and modifications impacts			
Strengthen international cooperation for red knot conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for red knot in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)			
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including red knot	Y		
Develop and, where necessary, implement floating roost sites that can support red knot roosting in areas severely affected by human development	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on red knot's feeding and roosting habitat within Australia	Y		
Hunting			
Identify key areas where the legal and illegal take of red knot occurs	Y		
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Disturbance at feeding and roosting sites			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for red knot	Y		
Conservation Advice for red-tailed tropicbird (DCCEEW 2023o)			
Primary conservation outcome			
A stable or increasing population trend within Australian territory is maintained to the extent that the subspecies is no longer eligible to be listed under the EPBC Act	Y		
Conservation and management priorities			
Nest predation by introduced species			
Complete the cat eradication program on Christmas Island	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Monitor levels of nest predation by rats, and carry out localised rat control when this predation crosses critical impact thresholds, e.g. 40% nest failure	Y		
Where applicable, continue cat and rat control programs on other breeding islands	Y		
Maintain and strengthen biosecurity measures to prevent disease and invasive species incursions	Y		
Nestling injury or death caused by ants			
Continue invasive ant control on Christmas Island, especially around nesting colonies, and tropical fire ant control on Ashmore Reef	Y		
Stakeholder engagement/community engagement			
Raise awareness and promote seabird conservation amongst the general public, especially through the tourism industry	Y		
Survey and monitoring priorities			
Monitor breeding islands to track population changes and breeding success in the Australian population. Monitoring of breeding success should be able to identify causes of breeding failure, with appropriate management responses enacted if failure rates reach defined trigger points (e.g. rat control when nest failure rate is above 40%)	Y		
Monitor the levels of threats, and their impacts on the subspecies, including rat and cat activity and density, weed invasion and ant presence at nesting sites	Y		
Undertake survey to assess the effectiveness of the current control programs on breeding islands (e.g. comparison of predation or nest failure rate before and after the implementation of control programs)	Y		
Information and research priorities			
Understand current and projected population constraints imposed by the marine environment, particularly as climate changes. For example, monitor changes in the foraging time and patterns of nesting birds, and their body condition, to track whether climate-related changes in resource availability are affecting the birds.	Y		
Conservation Advice for Ruddy Turnstone (DCCEEW 2024c)			
Primary conservation outcome			
Minimise further loss of habitat critical to the survival of ruddy turnstone throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in ruddy turnstone populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation and management priorities			
Habitat loss caused by residential, commercial, and aquaculture development			
Strengthen international cooperation for ruddy turnstone conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for ruddy turnstone in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)			
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including ruddy turnstone	Y		
Develop and, where necessary, implement floating roost sites that can support ruddy turnstone roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on ruddy turnstone's feeding and roosting habitat within Australia	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for ruddy turnstone	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Encourage Range States of the East Asian – Australasian Flyway Partnership to actively prevent hunting in known migratory shorebird roosting and nesting sites	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Sei Whale (TSSC 2015a)			
Conservation actions			
Maintain and improve existing legal and management protection	Y		
Understanding impacts of climate variability and change	Y		
Assessing and addressing anthropogenic noise	Y	Y	Y
Minimising vessel collisions	Y	Y	Y
Conservation Advice for Sharp-tailed Sandpiper (DCCEEW 2024d)			
Primary conservation outcome			
Minimise further loss of habitat critical to the survival of sharp-tailed sandpiper throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in sharp-tailed sandpiper populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation and management priorities			
Habitat loss caused by residential, commercial, and aquaculture development			
Strengthen international cooperation for sharp-tailed sandpiper conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for sharp-tailed sandpiper in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update/modify existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including sharp-tailed sandpiper	Y		
Develop and, where necessary, implement floating roost sites that can support sharp-tailed sandpiper roosting in areas severely affected by human development	Y		
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on sharp-tailed sandpiper's feeding and roosting habitat within Australia	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for sharp-tailed sandpiper	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Encourage Range States of the East Asian – Australasian Flyway Partnership to actively prevent hunting in known migratory shorebird roosting and nesting sites	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		
Conservation Advice for Short-nose Seasnake (DSEWPaC 2011a)			
Regional priority actions			
Habitat loss, disturbance and modification			
Identify remnant populations of high conservation priority	Y		
Monitor known populations to identify key threats	Y		
Ensure there is no anthropogenic disturbance in areas where the short-nosed seasnake occurs, excluding necessary actions to manage the conservation of the species	Y	Y	Y
Monitor changes to sea water temperatures and sea levels	Y		
Conservation information			
Raise awareness of the short-nosed seasnake within the local community and commercial fisheries, in particular fisheries activities off the WA coast	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Enable recovery of additional populations			
Investigate options for enhancing or establishing additional populations such as captive breeding and release	Y		
Conservation Advice for Terek Sandpiper (DCCEEW 2024j)			
Primary conservation objective			
Minimise further loss of habitat critical to the survival of terek sandpiper throughout Australia (including habitat predicted to become habitat critical in the future because of climate change)	Y		
Prevent further declines in terek sandpiper populations within the Australian jurisdiction by working with relevant Range States to address threats in the EAAF	Y		
Conservation and management priorities			
Habitat loss caused by residential, commercial, and aquaculture development			
Strengthen international cooperation for terek sandpiper conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention)	Y		
Continue to identify important habitat for terek sandpiper in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments)	Y		
Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds	Y		
Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period	Y		
Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers	Y		
Ensure that functional connectivity of sites is maintained throughout the species' migration network	Y		
Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including terek sandpiper	Y		
Develop and, where necessary, implement floating roost sites that can support terek sandpiper roosting in areas severely affected by human development	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Invasive species impacts			
Monitor the spread of cordgrass and mangroves throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass or encroached upon by mangroves (e.g., develop methods to prevent the further spread of cordgrass and mangroves)	Y		
Climate change and severe weather impacts			
Develop and implement a climate change adaptation plan for the species	Y		
Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species	Y		
Quantify the significance of sea level rise on terek sandpiper's feeding and roosting habitat within Australia	Y		
Human disturbance			
Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds	Y		
Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for terek sandpiper	Y		
Hunting			
Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF	Y		
Publish an updated field guide of shorebirds within the EAAF and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded	Y		
Identify key areas where terek sandpiper take occurs	Y		
Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Conservation Advice for Whale Shark (TSSC 2015f)			
Conservation and management actions			
Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea) and along the northward migration route that follows the northern WA coastline along the 200 m isobath	Y	Y	Y
Management of all domestic tourism industry interactions with whale sharks in accordance with the Western Australian 'Whale Shark Management with particular reference to Ningaloo Reef' Wildlife Management Program No. 57	Y		
Continued advocacy of threat mitigation actions for whale sharks in international fora including, but not limited to, regional fishery management organisations	Y		
Support for the development of eco-tourism industries in areas where traditional hunting of whale sharks occurs	Y		
Wildlife Conservation Plan of Migratory Shorebirds (CoA 2015c)			
Objectives			
Protection of important habitats for migratory shorebirds has occurred throughout the EAAF.	Y		
Wetland habitats in Australia, on which migratory shorebirds depend, are protected and conserved	Y		
Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated	Y	Y	Y
Knowledge gaps in migratory shorebird ecology in Australia are identified and addressed to inform decision makers, land managers and the public	Y		
Actions to achieve the specific objectives (anthropogenic threats)			
Develop and implement a community education and awareness program to reduce the effects of recreational disturbance on migratory shorebirds	Y		
Investigate the impacts of climate change on migratory shorebird habitat and populations in Australia	Y		
Investigate the significance of cumulative impacts on migratory shorebird habitat and populations in Australia	Y		
Investigate the impacts of hunting and shorebird prey harvesting on migratory shorebirds in Australia and the EAAF	Y		
Develop guidelines for wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	Titleholder	Offshore Project
Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes	Y	Y	Y
Marine Debris Threat Abatement Plan (CoA 2018)			
Objectives			
Contribute to long-term prevention of the incidence of marine debris	Y	Y	Y
Understand the scale of impacts from marine plastic and microplastic on key species, ecological communities and locations	Y		
Remove existing marine debris	Y		
Monitor the quantities, origins, types and hazardous chemical contaminants of marine debris, and assess the effectiveness of management arrangements for reducing marine debris	Y		
Increase public understanding of the causes and impacts of harmful marine debris, including microplastic and hazardous chemical contaminants, to bring about behaviour change	Y		
Actions to achieve the specific objectives (prevention of marine debris)			
Establish a threat abatement plan (TAP) team to coordinate actions for the life of the TAP	Y		
Limit the amount of single-use plastic material lost to the environment in Australia	Y		
Encourage development of a circular economy in Australia	Y		
Encourage innovation in recovery and waste treatment technologies	Y		
Improve management of abandoned, lost and discarded fishing gear	Y		
Improve shipping waste management	Y	Y	Y

3.5.3 Australian Marine Parks

Australian Marine Parks (AMPs) (Commonwealth reserves proclaimed under the EPBC Act in 2007 and 2013) are located in Commonwealth waters, and are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of National Parks (DNP) is a corporation established under the EPBC Act, and responsibilities include managing AMPs (supported by Parks Australia). Other parts of the Australian Government must not perform functions or exercise powers in relation to these parks that are inconsistent with management plans for the parks (section 362 of the EPBC Act).

In alignment with the EPBC Act, each AMP is assigned an International Union for Conservation of Nature (IUCN) category (or multiple categories); and each category has a set of Australian IUCN management principles associated with it (as defined in Schedule 8 of the EPBC Regulations 2000). The IUCN categories and management principles associated with AMPs relevant for this offshore project (as identified in Section 7.8.6) are described in Table 3-4.

Table 3-4: Australian IUCN reserve management principles

Category II: National Park:	Category IV: Habitat/Species Management Area	Category VI: Managed Resource Protected Areas
3.01 The reserve or zone should be protected and managed to preserve its natural condition according to the following principles. 3.02 Natural and scenic areas of national and international significance should be protected for spiritual, scientific, educational, recreational or tourist purposes. 3.03 Representative examples of physiographic regions, biotic communities, genetic resources, and native species should be perpetuated in as natural a state as possible to provide ecological stability and diversity. 3.04 Visitor use should be managed for inspirational, educational, cultural and recreational purposes at a level that will maintain the reserve or zone in a natural or near natural state. 3.05 Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur. 3.06 Respect should be maintained for the ecological, geomorphologic, sacred and aesthetic attributes for which the reserve or zone was assigned to this category. 3.07 The needs of Indigenous people should be taken into account, including subsistence resource use, to the extent that they do not conflict with these principles. 3.08 The aspirations of traditional owners of land within the reserve or zone, their continuing land	5.01 The reserve or zone should be managed primarily, including (if necessary) through active intervention, to ensure the maintenance of habitats or to meet the requirements of collections or specific species based on the following principles. 5.02 Habitat conditions necessary to protect significant species, groups or collections of species, biotic communities or physical features of the environment should be secured and maintained, if necessary, through specific human manipulation. 5.03 Scientific research and environmental monitoring that contribute to reserve management should be facilitated as primary activities associated with sustainable resource management. 5.04 The reserve or zone may be developed for public education and appreciation of the characteristics of habitats, species or collections and of the work of wildlife management. 5.05 Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur. 5.06 People with rights or interests in the reserve or zone should be entitled to benefits derived from activities in the reserve or zone that are consistent with these principles. 5.07 If the reserve or zone is declared for the purpose of a botanic garden, it should also be	7.01 The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. 7.02 The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. 7.03 Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. 7.04 Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.

Category II: National Park:	Category IV: Habitat/Species Management Area	Category VI: Managed Resource Protected Areas
management practices, the protection and maintenance of cultural heritage and the benefit the traditional owners derive from enterprises, established in the reserve or zone, consistent with these principles should be recognised and taken into account.	managed for the increase of knowledge, appreciation and enjoyment of Australia's plant heritage by establishing, as an integrated resource, a collection of living and herbarium specimens of Australian and related plants for study, interpretation, conservation and display.	

In addition to the identified management principles, activities must be undertaken in a manner that is consistent with the objectives of the zone and the values of the marine park (including natural, cultural, heritage and socioeconomic values) (DNP 2018a):

- the objective of the National Park Zone (IUCN II) 'is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible'
- the objective of the Habitat Protection Zone (IV) 'is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats'
- the objective of the Recreational Use Zone (IUCN IV) 'is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while providing for recreational use'
- the objective of the Multiple Use Zone (VI) 'is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species'
- the objective of the Special Purpose Zone (Trawl) (VI) 'is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species, while applying special purpose management arrangements for specific activities'.

The southern extent of the Project Area intersects with the Montebello Marine Park (Section 7.8.6). The Montebello Marine Park is categorised as a Multiple Use Zone (IUCN VI). Mining operations[17] may be undertaken within a Multiple Use Zone if authorised by:

- a policy, plan or program endorsed under Part 10 of the EPBC Act ('strategic assessment') and conducted in accordance with that authorisation
- a class approval issued under the North-West Marine Parks Network Management Plan (DNP 2018a).

A class approval, dated 28 June 2018, permitting mining operations and GHG activities was issued specifically under the North-west Marine Parks Network Management Plan (DNP 2018c), which includes the Montebello Marine Park Multiple Use Zone as an Approved Zone.

3.6 World Heritage Properties

Australian World Heritage management principles are prescribed in Schedule 5 of the EPBC Regulations 2000. Management principles that are considered relevant to the scope of this OPP are listed in Table 3-5.

In accordance with the Environment Regulations the Goodwyn Area Infill Development does not involve a petroleum activity or part of a petroleum activity being undertaken in any part of a declared

[17] Mining operations are defined in section 355(2) of the EPBC Act, and include offshore petroleum activities, transportation of minerals by pipeline, and oil spill response.

World Heritage Property. The closest World Heritage Property is The Ningaloo Coast, ~200 km south-west of the Project Area (Section 7.8.1).

Table 3-5: Relevant management principles under Schedule 5—Australian World Heritage management principles of the EPBC Act

Number	Principle	Relevant Section of the OPP
3	**Environmental impact assessment and approval**	
3.01	This principle applies to the assessment of an action that is likely to have a significant impact on the World Heritage values of a property (whether the action is to occur inside the property or not).	3.01 and 3.02: Assessment of significant impact on World Heritage values is included in Section 9. Principles are met by the submitted OPP.
3.02	Before the action is taken, the likely impact of the action on the World Heritage values of the property should be assessed under a statutory environmental impact assessment and approval process.	
3.03.	The assessment process should: (a) identify the World Heritage values of the property that are likely to be affected by the action; and (b) examine how the World Heritage values of the property might be affected; and (c) provide for adequate opportunity for public consultation	3.03(a) and 3.03(b): World Heritage values are identified in Section 7 and considered in the assessment of impacts and risks in Section 9. 3.03(c): Public comment period is a requirement of an OPP as detailed in Section 8.
3.04	An action should not be approved if it would be inconsistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property	3.04, 3.05, and 3.06: Principles are considered to be met by the acceptance of this OPP.
3.05	Approval of the action should be subject to conditions that are necessary to ensure protection, conservation, presentation or transmission to future generations of the World Heritage values of the property	
3.06	The action should be monitored by the authority responsible for giving the approval (or another appropriate authority) and, if necessary, enforcement action should be taken to ensure compliance with the conditions of the approval	

Note that Section 1 – General Principles and Section 2 – Management Planning of Schedule 5 are not considered relevant to the scope of this OPP and, therefore, have not been included.

3.7 International Agreements

Australia is a signatory to several international conventions and agreements relevant to environmental protection. Those relevant to Commonwealth legislation that may apply to Goodwyn Area Infill Development include:

- Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and Their Environment (commonly referred to as the China Australia Migratory Bird Agreement or CAMBA)
- Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment (commonly referred to as the Japan Australia Migratory Bird Agreement or JAMBA)
- Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds (commonly referred to as the Republic of Korea Australia Migratory Bird Agreement or ROKAMBA)
- Agreement on the Conservation of Albatrosses and Petrels (ACAP)
- Convention on the International Maritime Organisation 1948

- International Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (Basel Convention)
- International Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)
- International Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- International Convention for the Prevention of Pollution from Ships (commonly known as MARPOL 73/78)
- International Convention on Harmful Anti Fouling Systems 2001 (AFS Convention)
- International Convention on Civil Liability for Oil Pollution Damage 1969 (renewed in 1992) (CLC Convention)
- International Convention on the Control and Management of Ship's Ballast Water and Sediment (Ballast Water Management Convention)
- Kyoto Protocol 1997
- Minamata Convention on Mercury 2013
- Montreal Protocol on Substances that Deplete the Ozone Layer 1987
- Paris Agreement 2015
- Protocol to International Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter 1996
- Rotterdam Convention, a multilateral treaty to promote shared responsibilities in relation to importing hazardous chemicals
- The Convention on the International Regulations for Preventing Collisions at Sea 1972
- United Nations Convention on the Law of the Sea 1982
- United Nations Framework Convention on Climate Change 1992
- UN 2030 Agenda for Sustainable Development.

4 OFFSHORE PROJECT PROPOSAL PROCESS

4.1 Overview

This section outlines the process Woodside used to prepare this OPP, once the project was defined as an offshore project. The process describes the environmental impact and risk management methodology used to identify and evaluate impacts and risks to meet acceptability requirements, and develop EPOs.

Regulation 7(5) of the Environment Regulations requires the OPP to include details of the environmental impacts and risks for the offshore project, and evaluate these impacts and risks, appropriate to the nature and scale of each impact and risk. The objective of the impact and risk assessment process described in this section is to identify the impacts and risks associated with the offshore project so they can be evaluated, and apply appropriate key control measures to demonstrate the project will managed to an acceptable level.

Environmental impacts and risks identified and evaluated include those directly and indirectly associated with the offshore project, including potential emergency and accidental events (i.e. an unplanned event). In this OPP, potential impacts from planned activities are termed ‘impacts’, while ‘risks’ are associated with unplanned events (with the potential for an environmental impact if the risk is realised).

4.2 Environmental Risk Management Methodology

4.2.1 Woodside Risk Management Process

Woodside recognises that risk is inherent to its business and that effectively managing risk is vital to deliver company objectives, success, and continued growth. Woodside is committed to managing risk proactively and effectively. The objective of Woodside’s risk management system is to provide a consistent process for recognising and managing risks across Woodside’s business. Achieving this objective includes ensuring risks consider impacts across these key areas of exposure: health and safety, environment, finance, reputation and brand, legal and compliance, and social and cultural. Appendix A contains a copy of Woodside’s Risk Management Policy.

The environmental risk management methodology used in this OPP is based on Woodside’s Risk Management Process, which aligns to industry standards, such as International Organization for Standardization (ISO) 31000 (SA 2018). The WMS risk management processes and procedures, guidelines, and tools provide guidance and specific techniques for managing risk that are tailored for particular areas of risk within certain business processes. Procedures applied for environmental risk management include:

- Health, Safety and Environment Management Procedure
- Impact Assessment Procedure.

The impact and risk management methodology provides a framework to demonstrate that impacts and risks are identified and assessed to be at an acceptable level, as required by the Environment Regulations. Figure 4-1 shows the key steps of Woodside’s Risk Management Process; Sections 4.3 to 4.11 describe each step and how they are applied to the scopes of this offshore project.

Figure 4-1: Woodside's Risk Management Process

4.2.2 Health, Safety and Environment Management Procedure

The Health, Safety and Environment Management Procedure provides the structure for managing health, safety, and environment (HSE) impacts and risks across Woodside, defines the decision authorities for company-wide HSE management activities and deliverables, and supports continuous improvement in HSE management.

4.2.3 Impact Assessment Procedure

To support effective environmental risk assessment, Woodside's Impact Assessment Procedure (Figure 4-2) outlines the steps to meet the required environment, health, and social standards by ensuring impact assessments are undertaken appropriate to the nature and scale of the activity, the regulatory context, the receiving environment, interests, concerns and rights of stakeholders, and the applicable framework of standards and practices.

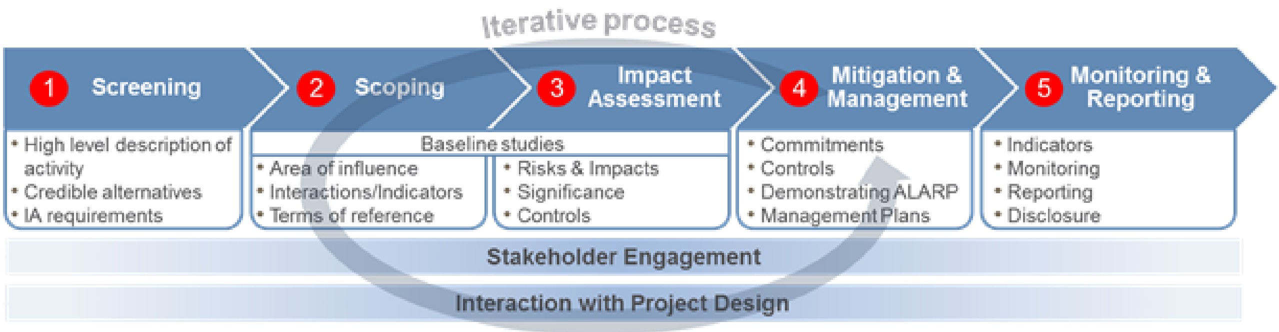


Figure 4-2: Woodside's Impact Assessment Process

4.3 Establish the Context

4.3.1 Define the Project

This first stage of the OPP process involves evaluating whether the project meets the definition of an 'offshore project' as defined in the Environment Regulations. The project is described in relation to:

- what is to be undertaken (i.e. each petroleum activity that is part of project)
- the location or locations of each petroleum activity
- how it is planned to be undertaken, including operational details for each petroleum activity, actions following completion of the project, and proposed timeframes for the project.

The 'what' and 'how' are described in the context of 'environmental aspects'[18] to inform the impact and risk assessment for planned (routine and non-routine) activities and unplanned (accidents, incidents, or emergency conditions) events.

The project is described in Section 5 and is referred to as the offshore project.

4.3.2 Define the Existing Environment

The context of the existing environment is described and determined by considering the nature and scale of the project (size, type, timing, duration, complexity, and intensity of all project-related activities), as described in Section 5. The purpose of this step is to describe the existing environment that may be affected (EMBA)—directly or indirectly—by the project's planned activities or unplanned events[19].

The Description of the Existing Environment (Section 7) is structured into subsections that define the physical, biological, socioeconomic, and cultural attributes of the area of interest, in accordance with the definition of environment in regulation 5 of the Environment Regulations. These subsections refer to relevant values and sensitivities as defined in regulation 7(3) of the Environment Regulations:

- the world heritage values of a declared World Heritage property
- the national heritage values of a National Heritage place
- the ecological character of a declared Ramsar wetland
- the presence of a listed threatened species or listed threatened ecological community
- the presence of a listed migratory species
- any values and sensitivities that exist in, or in relation to, part or all of:
  - a Commonwealth marine area
  - Commonwealth land.

Woodside groups environmental values into the following categories, which have been selected to address key physical and biological attributes, as well as social and cultural values of the existing environment, and are used throughout the impact and risk assessment method:

- soil and groundwaters

[18] An environmental aspect is an element of the petroleum activity that can interact with the environment.

[19] For each source of risk, the credible worst-case scenario (in conjunction with impact thresholds) is used to determine the spatial extent of the EMBA. The worst-case unplanned event is considered to be an unplanned hydrocarbon release, further defined for each activity through the risk assessment process. Interpreting stochastic oil spill modelling determines the EMBA for the unplanned hydrocarbon release, which defines the spatial scale of the environment that may be potentially affected by the offshore project, and in turn provides context to the 'nature and scale' of the existing environment.

- marine sediment
- water quality
- air quality (including odour)
- ecosystems and habitats
- species
- socioeconomic and cultural

4.3.3 Relevant Requirements

The relevant requirements in the context of legislation, other environmental approval requirements, conditions and standards that apply to the offshore project are identified and reviewed and are presented in Section 3.

4.4 Impact and Risk Identification

Relevant environmental aspects were identified to support the process of identifying environmental impacts and risks associated with the offshore project.

The environmental impact and risk assessment presented in this OPP was informed by an environmental impact and risk identification (ENVID) workshop, desktop environmental assessments, and modelling studies.

The ENVID workshop was undertaken by a multidisciplinary team comprising relevant operational and environmental personnel with sufficient breadth of knowledge, training, and experience to reasonably assure that impacts and risks were identified, and their potential environmental consequences assessed. During the workshop, impacts and risks were identified for both planned activities and unplanned events, and recorded in a register. During the ENVID workshop, impact and risks identified as not applicable (not credible) were removed from the assessment.

4.5 Impact and Risk Analysis

Impact and risk analysis involves defining the particular impact or risk and assessing appropriate key control measures, as well as considering previous risk assessments for similar activities, relevant studies, past performance, external stakeholder consultation feedback, and the existing environment.

These key steps were undertaken for each identified impact of risk during the analysis:

- assess the consequence (for impacts and risks)
- identify the decision type in accordance with the decision support framework
- identify appropriate key control measures for the offshore project that align with the decision type
- assess the risk rating (for risks).

4.5.1 Decision Support Framework

To support the impact and risk assessment process, and Woodside's determination of acceptability (Section 4.8), Woodside's risk management processes and procedures include the use of a decision support framework based on principles set out in the Guidelines on Risk Related Decision Making (OEUK 2014). This framework is integrated into the ENVID workshop to determine the level of supporting evidence that may be required to draw sound conclusions regarding impact consequence and risk rating, and whether they are acceptable (Figure 4-3). Application of the decision support framework confirms:

- petroleum activities associated with the offshore project do not pose an unacceptable environmental impact or risk
- appropriate effort is applied to manage impacts and risks based on the uncertainty of the impact or risk, the complexity, and the consequence or risk rating (i.e. potential higher-order environmental impacts or risks are subject to further evaluation/assessment).

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

This framework enables Woodside to appropriately understand an impact or risk, and determine if the impact or risk is acceptable.

4.5.1.1 Decision Type A

Decision type A impacts and risks are well understood and associated with an established practice. Decision support is generally recognised as good industry practice (and are often embodied in legislation, codes and standards) and utilises professional judgment.

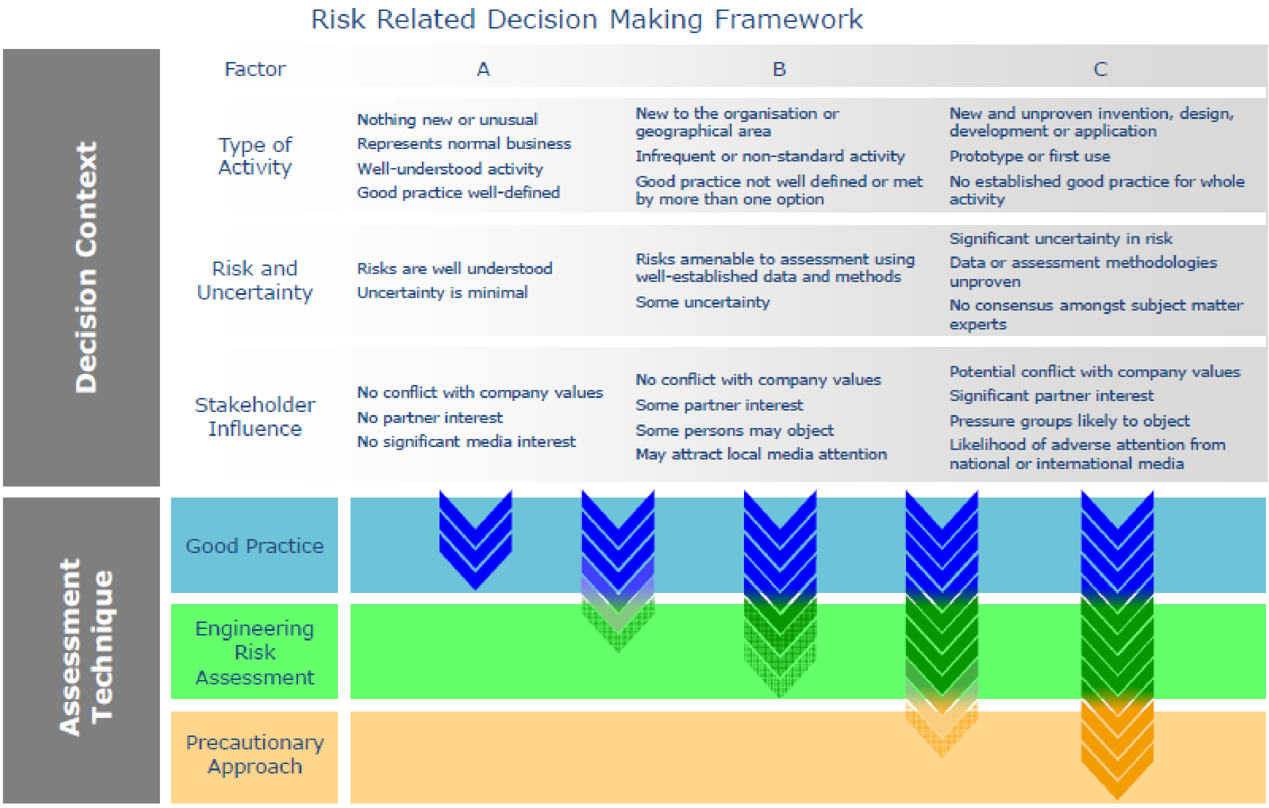
4.5.1.2 Decision Type B

Decision type B impacts and risks typically involve greater uncertainty and complexity and can include potential higher-order impacts or risks. These activities may deviate from established practice or have some lifecycle implications and typically require further engineering risk assessment to support the decision and ensure that the impact or risk is acceptable. Engineering risk assessment tools may include:

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

4.5.1.3 Decision Type C

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



Source: (OEUK 2014)

Figure 4-3: Risk-related decision-making framework

4.5.1.4 Decision Support Framework Tools

These framework tools are applied, as appropriate, to help identify key control measures for the offshore project based on the decision types described above:

- **Legislation, Codes and Standards** – identifies the requirements of legislation, codes and standards that are to be complied with for the activity
- **Good Industry Practice** – identifies further engineering control standards and guidelines that may be applied by Woodside above that required to meet the legislation, codes and standards
- **Professional Judgement** – uses relevant personnel with the knowledge and experience to identify alternative controls. Woodside applies the hierarchy of control as part of the risk assessment to identify any alternative measures to control the risk
- **Risk-based Analysis** – assesses the results of probabilistic analyses such as modelling, quantitative risk assessment and/or cost–benefit analysis to support the selection of control measures identified during the risk assessment process
- **Company Values** – identifies values identified in Woodside's code of conduct, policies and the Woodside Compass. Views, concerns and perceptions are to be considered from internal Woodside stakeholders directly affected by the planned impact or potential risk
- **Societal Values** – identifies and addresses the views, concerns and perceptions of relevant stakeholders.

Note: Key control measures are identified within the OPP phase for an offshore project; additional control measures may also be identified and adopted during the development of subsequent EPs (Section 4.6).

4.5.2 Impact and Risk Classification

Environmental impacts and risks are assessed to determine the potential consequence. The consequence considers the magnitude of the impact or risk and the sensitivity of the potentially impacted receptor. Risks are further assessed qualitatively and/or quantitatively in terms of likelihood and residual risk rating.

4.5.2.1 Impacts

Environmental impacts are assessed to determine the potential consequence (Table 4-1) outlined in Woodside's Risk Management Process. The consequence considers the magnitude of the impact or risk and the sensitivity of the potentially impacted receptor.

Table 4-1: Woodside (environment and social and cultural) consequence levels

Environment	Social and Cultural	Consequence Level
Catastrophic, long-term impact (>50 years) on highly valued ecosystem, species, habitat or physical or biological attribute	Catastrophic, long-term impact (>20 years) to a community, social infrastructure, or highly valued area/item of international cultural significance	***A***
Major, long-term impact (10–50 years) on highly valued ecosystem, species, habitat or physical or biological attribute	Major, long-term impact (5–20 years) to a community, social infrastructure, or highly valued area/item of national cultural significance	***B***
Moderate, medium-term impact (2–10 years) on ecosystem, species, habitat or physical or biological attribute	Moderate, medium-term impact (2–5 years) to a community, social infrastructure, or highly valued area/item of national cultural significance	***C***
Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystem function), physical or biological attribute	Minor, short-term impact (1–2 years) to a community, or highly valued area/item of cultural significance	***D***
Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attribute	Slight, short-term impact (<1 year) to a community, or area/item of cultural significance	***E***
No lasting effect (<1 month); localised impact not significant to environmental receptor	No lasting effect (<1 month); localised impact not significant to area/item of cultural significance	***F***

4.5.2.2 Risks

The risk rating process assigns a level of risk to each risk event, measured in terms of consequence and likelihood. The assigned risk rating is determined with controls in place, therefore; the risk rating is determined after identifying the decision type and appropriate control measures.

The risk rating process considers the potential environmental consequences and, where applicable, the social and cultural consequences of the risk.

The risk rating process is undertaken using the steps described in the subsections below.

4.5.2.2.1 Select the Consequence Level

Determine the worst-case credible consequence (Table 4-1) associated with the selected event, assuming all controls (preventive and mitigative) are absent or have failed. If more than one potential consequence applies, select the highest severity consequence level.

4.5.2.2.2 Select the Likelihood Level

Determine the description that best fits the chance of the selected consequence occurring, assuming reasonable effectiveness of the prevention and mitigation controls (Table 4-2).

Table 4-2: Woodside likelihood levels

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

4.5.2.2.3 Calculate the Risk Rating

The risk rating is derived from the consequence and likelihood levels above, in accordance with the matrix shown in Figure 4-4. A likelihood and risk rating are only applied to environmental risks (unplanned events), not environmental impacts from planned activities.

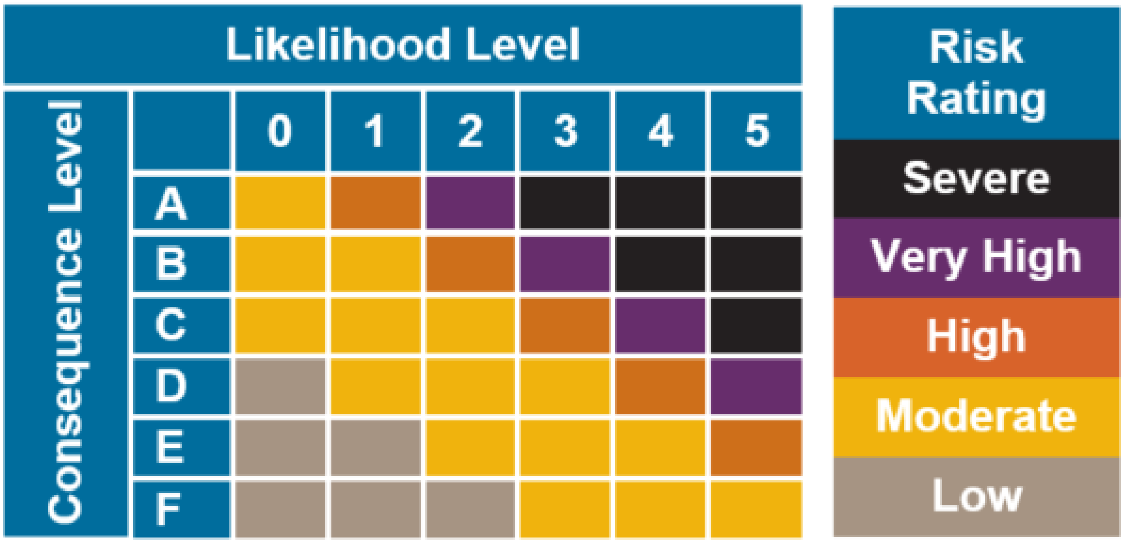


Figure 4-4: Woodside risk ratings

4.6 Key Control Measures

In the process of evaluating impacts and risks, any adopted key control measures required to manage the impacts and risks to acceptable levels are identified and captured as commitments to be implemented for the offshore project.

At the OPP phase, the adopted key control measures reflect the commitments that are required to be implemented to meet the criteria for acceptance. This includes any practices that will reduce the impacts and risks in order to meet the identified EPOs, any relevant legal requirements (related specifically to the impact/risk), internal company requirements, and any requirements that are identified through the consultation process.

Further review and potential adoption of additional controls will be undertaken in subsequent phases of the offshore project (e.g. when preparing EPs for specific petroleum activities within the scope of this OPP). Although the overarching EPOs will be carried through from this OPP to the activity-specific EPs, the controls and corresponding EPSs to reduce impacts and risks to ALARP will be identified and implemented during these subsequent phases.

4.7 Acceptable Levels

Regulation 13(4)(d) of the Environment Regulations requires the OPP to demonstrate that the environmental impacts and risks of the project will be managed to an acceptable level.

An acceptable level has been described as "the specified amount of an environmental impact and risk that the project may have" and "is the maximum level of change in environmental parameters before the environmental effects become unacceptable" (NOPSEMA 2024a). The acceptable level(s) of environmental impact and risk should be defined before the evaluation of those impacts and risks can take place, and the EPOs established (NOPSEMA 2024a).

In alignment with NOPSEMA's OPP Decision Making Guideline and OPP Content Requirements (NOPSEMA 2024e; 2024a), Woodside has developed acceptable level(s) for the Goodwyn Area Infill Development (Table 4-3) based on the consideration of relevant context, including but not limited to:

- principles of ESD
  - in particular the Biodiversity and Intergenerational Principles (refer to descriptions of the principles in Section 4.8.3)
- relevant requirements, such as
  - Australian legislation, government policies, or environmental management guidelines
  - management plans relevant to matters protected under Part 3 of the EPBC Act (e.g. recovery plans, conservation management plans, marine park management plans)
- internal context, such as Woodside processes and procedures
- external context, such as advice from stakeholders.

During the impact and risk assessment (Section 9), the predicted level of impact and risk will be compared against the acceptable level(s) to determine if they can be met, or if additional management (i.e. additional key control measures; Section 4.6) may be required to further reduce the impact or risk so that they do not exceed the acceptable level(s).

Table 4-3: Acceptable levels for the Goodwyn Area Infill Development

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
Planned Activities			
Physical Presence: Interaction with other Marine Users	Commercial fisheries	• **AL-01:** No interference with fishing within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder	The acceptable level is not inconsistent with section 280(2)(b) of the OPGGS Act regarding the interference with fishing within a petroleum title. This acceptable level of environmental impact does not have the potential to affect intergenerational equity as natural resources, environmental quality, and productivity of the environment are maintained for future generations. As such this acceptable level is consistent with the Intergenerational Principle of ESD.
	Commercial shipping	• **AL-02**: No interference with navigation within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder	The acceptable level is not inconsistent with section 280(2)(a) of the OPGGS Act regarding the interference with navigation within a petroleum title. This acceptable level of environmental impact does not have the potential to affect intergenerational equity as natural resources, environmental quality, and productivity of the environment are maintained for future generations. As such this acceptable level consistent with the Intergenerational Principle of ESD.
	Petroleum activities Tourism and recreation	• **AL03**: No interference with other lawful marine users within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder	The acceptable level is not inconsistent with section 280(2)(d) of the OPGGS Act regarding the interference with other petroleum activities within a petroleum title. This acceptable level of environmental impact does not have the potential to affect intergenerational equity as natural resources, environmental quality, and productivity of the environment are maintained for future generations. As such this acceptable level consistent with the Intergenerational Principle of ESD.
Physical Presence: Disturbance to the Seabed	Physical environment Offshore habitats and biological communities Key ecological features	• **AL-04**: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	Consistent with the objectives of the EPBC Act, and in the context of the principles of ESD (as defined in the EPBC Act), the Marine Bioregional Plan for the NWMR (DSEWPaC 2012b) sets the following objectives for the region: • conserving biodiversity and maintaining ecosystem health • ensuring the recovery and protection of threatened species • improving understanding of the region’s biodiversity and ecosystems and the pressures they face. The acceptable level is not inconsistent with the objectives for the management of the NWMR. As the objectives of the Marine Bioregional Plan for the NWMR take into consideration the Biodiversity Principle of ESD, this acceptable level is also consistent with that principle of ESD.

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
	Australian Marine Parks	• **AL-05**: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	The objectives of the North-west Marine Parks Network Management Plan (DNP 2018a) are to provide for: • the protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the north-west network • ecologically sustainable use and enjoyment of the natural resources within marine parks in the north-west network (where this is consistent with first objective). The acceptable level is not inconsistent with the objectives for the management of the north-west network of Australian marine parks. As the objectives of the North-west Marine Parks Network Management Plan take into consideration the Biodiversity and Intergenerational Principles of ESD, this acceptable level is also consistent with those principles of ESD.
Routine Emissions: Light Generation	Fish, sharks, and rays Marine reptiles Seabirds and migratory shorebirds	• **AL-06**: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery • **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival • **AL-08**: No adverse effect from the petroleum activity that is inconsistent with any threatened species recovery plan made or adopted under the EPBC Act	Recovery plans and conservation advices are developed to assist with planning for the recovery of an EPBC Act listed threatened species or community. The long-term objective of recovery plans are similar, with the intent of minimising anthropogenic threats such that their conservation status can improve and be removed from the EPBC Act threatened species list (Table 3-3). The acceptable levels (**AL-06** and **AL-07**) have been developed such that they are not inconsistent with the long-term objectives of recovery plans or conservation advices. As the objectives of recovery plans and conservation advices take into consideration the Biodiversity Principle of ESD, these acceptable levels are also consistent with that principle of ESD. Light pollution has been identified as a key threat to marine turtles in Australia (CoA 2017b). The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies these relevant management actions: • A1.5—manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival • A1.6—manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue • A8.1—artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats. Under the EPBC Act an action must not be inconsistent with a recovery plan or threat abatement plan. The acceptable level (**AL-08**) has been developed such that the petroleum activity will be managed in such a way that it is not inconsistent with the requirements of the recovery plan. The specific management actions (as shown above) from the in-force recovery plan for marine turtles are also further addressed in the

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
			‘demonstration of acceptability’ within the environmental impact and risk assessment for each aspect (see Section 9).
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Routine Acoustic Emissions: Continuous Sound Generation Routine Acoustic Emissions: Impulsive Sound Generation	Planktonic communities Fish, sharks, and rays Marine reptiles Marine mammals	• **AL-06**: (see above) • **AL-07**: (see above) • **AL-08**: (see above)	Refer to source and justification description above for **AL-06** and **AL-07**. Noise interference has been identified as a key threat to marine turtles in Australia (CoA 2017b). The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies these relevant management actions: • A1.5—manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival • A1.6—manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue Noise interference has also been identified as a key threat to blue whales (CoA 2015a). The Conservation Management Plan for the Blue Whale (CoA 2015a) identifies these relevant management actions: • A2.3—anthropogenic noise in BIAs will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area. It is understood that in the context of the Conservation Management Plan for the Blue Whale (CoA 2015a), the term injury refers to both temporary and permanent hearing impairments (DAWE and NOPSEMA 2021). Under the EPBC Act an action must not be inconsistent with a recovery plan or threat abatement plan. The acceptable level (**AL-08**) has been developed such that the petroleum activity will be managed in such a way that it is not inconsistent with the requirements of the recovery plan. The specific management actions (as shown above) from the in-force recovery plan for marine turtles and blue whales are also further addressed in the ‘demonstration of acceptability’ within the environmental impact and risk assessment for each aspect (see Section 9).
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Routine and Non-routine Emissions: Atmospheric	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**. As additional context, a “substantial impact” is described in the Marine Bioregional Plan for the NWMR (DSEWPaC 2012b) as including a “substantial change in air or water quality, which may adversely impact biodiversity, ecological function or integrity, social amenity or human health”.

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
			The acceptable level is not inconsistent with the objectives for the management of the NWMR.
Routine and Non-routine Emissions: Greenhouse Gases	Habitats and biological communities Protected species Key ecological features Protected places Socioeconomic and cultural environment	• **AL-09**: Meet the objectives and principles of Woodside's Climate Policy	Woodside has a Climate Policy (Section 2.2; Appendix A) that includes a commitment to near, mid, and long-term net emissions reduction targets. In alignment with the Climate Policy, Woodside has announced targets for near- and medium- term emissions reductions—to reduce net equity Scope 1 and 2 GHG emissions by 15% by 2025, and 30% by 2030, below a starting base representative of annual average gross equity emissions for 2016-2020 (Woodside 2023a). Woodside has also announced an aspiration of net zero equity Scope 1 and 2 GHG emissions by 2050 or sooner (Woodside 2023a). In addition, Woodside has now set a Scope 3 emissions abatement target—to take FID on 5 Mtpa CO_2-e new energy products and lower carbon services by 2030 (Woodside 2024). The acceptable level (**AL-09**) has been developed such that the Goodwyn Area Infill Development is implemented to be consistent with the objectives and principles of the Climate Policy. In relation to the Goodwyn Area Infill Development, the acceptable level (**AL-09**) is considered relevant to GHG emissions identified and quantified within this OPP. Note: The boundary used for the GHG emissions inventory presented within this OPP is specific to the Goodwyn Area Infill Development and is therefore different to GHG inventory boundaries used for other facilities (e.g. GWA Facility, NWS Project) and the broader Woodside portfolio. As such, what is considered a direct or indirect GHG emission, or Scope 1 or Scope 3 GHG emission, depends upon the boundary being applied, and classifications can change under differing boundary definitions. Refer to Section 9.1.7 for further descriptions of the GHG emission inventory and definitions used in this OPP for the Goodwyn Area Infill Development.
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water,	Physical environment Planktonic communities	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
Cooling Water, and Brine			
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Offshore habitats and biological communities		
	Key ecological features		
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Offshore habitats and biological communities		
	Key ecological features		
Downstream Discharges: Produced Water	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Planktonic communities		
	Fish, sharks, and rays	• **AL-06**: (see above) • **AL-07**: (see above)	Refer to source and justification description above for **AL-06** and **AL-07**.
	Marine reptiles		
	Marine mammals		
Unplanned Events			
Physical Presence: Interaction with Marine Fauna	Fish, sharks, and rays	• **AL-06**: (see above) • **AL-07**: (see above)	Refer to source and justification description above for **AL-06** and **AL-07**. Vessel disturbance has been identified as a key threat to EPBC Act listed species (e.g. marine turtles (CoA 2017b) and blue whales (CoA 2015a)); however no specific management actions regarding vessel interactions with marine fauna were identified. As such, existing acceptable levels (**AL-06** and **AL-07**) are considered to appropriately provide for all marine fauna.
	Marine reptiles		
	Marine mammals		
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Physical Presence: Introduction of	Offshore habitats and biological communities	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
Invasive Marine Species	Key ecological features		
Physical Presence: Unplanned Seabed Disturbance	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Offshore habitats and biological communities		
	Key ecological features		
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Unplanned Release: Hazardous and Non-hazardous Solid Wastes	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Fish, sharks, and rays	• **AL-06**: (see above) • **AL-07**: (see above)	Refer to source and justification description above for **AL-06** and **AL-07**. Marine debris has been identified as a key threat to other EPBC Act listed species (e.g. marine turtles (CoA 2017b) and blue whales (CoA 2015a)); however no specific management actions regarding marine debris interaction with marine fauna were identified. As such, existing acceptable levels (**AL-06** and **AL-07**) are considered to appropriately provide for all marine fauna.
	Marine reptiles		
	Marine mammals		
	Seabirds and migratory shorebirds		
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment)	Physical environment	• **AL-04**: (see above)	Refer to source and justification description above for **AL-04**.
	Fish, sharks, and rays	• **AL-06**: (see above) • **AL-07**: (see above)	Refer to source and justification description above for **AL-06** and **AL-07**.
	Marine reptiles		
	Marine mammals		
	Seabirds and migratory shorebirds		
	Australian Marine Parks	• **AL-05**: (see above)	Refer to source and justification description above for **AL-05**.
Unplanned Hydrocarbon Release: Gas and Condensate	Physical environment	• **AL-10**: The risk rating for environmental receptors from major	As described in Section 4.1, 'risks' are associated with unplanned events (with the potential for an environmental impact if the risk is realised). The acceptable level (**AL-10**) has been developed to focus on prevention through management of the risk level rather than specifying an acceptable level of impact (or consequence) should the event occur. It is considered that limiting the residual risk to environmental receptors to 'high'
	Planktonic communities		
	Offshore habitats and biological communities		

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
Unplanned Hydrocarbon Release: Marine Fuel	Nearshore and coastal habitats and biological communities Key ecological features Fish, sharks, and rays Marine reptiles Marine mammals Seabirds and migratory shorebirds Australian Marine Parks State marine protected areas Commercial fisheries and aquaculture Traditional fisheries Tourism and recreation Petroleum activities	unplanned hydrocarbon releases is less than or equal to high[20]	(see risk ratings matrix in Figure 4-4) is acceptable as this represents a level at which the potential risks associated with an unplanned event can be managed via legislative, industry guidelines, and/or internal Woodside procedures (i.e. all matters that can be taken into consideration when defining an acceptable level; Section 4.7), and such that the likelihood of the unplanned event resulting in the worst-case environmental consequence is controlled within 'remote' or 'highly unlikely' (see likelihood levels in Table 4-2). An acceptable level (**AL-10**) incorporating a risk rating is also considered consistent with NOPSEMA (2024a) guidance that states that an acceptable level "is the specified amount of environmental… risk that the project may have". The context (legislative, industry guidelines, and/or internal Woodside procedures) used to define the acceptable level are also further addressed in the 'demonstration of acceptability' within the environmental risk assessments for each unplanned hydrocarbon release aspect (see Sections 9.2.6 and 9.2.7). With the acceptable level focussed on prevention, and that any unplanned hydrocarbon release event causing environmental harm has a low probability of occurrence, the principles of ESD are considered to be met (i.e. by having the risk management requirements in place to prevent and mitigate an unplanned event, no environmental change that would alter biodiversity or intergenerational equity would occur).
Cultural Features and Heritage Values			
All	Cultural features and heritage values	• **AL-11:** No adverse effect on underwater cultural heritage such that it prevents the long-term protection of values as conferred by the *Underwater Cultural Heritage Act 2018* (Cth)	The UCH Act is Australia's primary UCH legislation. The UCH Act provides protection from disturbance or adverse impact to archaeological remains located in Australia's near and offshore environment (DCCEEW 2023f). The acceptable level (**AL-16**) is not inconsistent with the UCH Act. Note: Although no protected UCH is currently known to exist in the Project Area, this acceptable level (**AL-16**) is intended to apply should the position change. This acceptable level (**AL-11**) has also been developed such that the Goodwyn Area Infill Development is implemented to be consistent with the objectives and principles of the First Nations Communities Policy (Appendix A).

[20] Refer to Section 4.5.2.2.3 for risk ratings.

Aspect	Receptor (or Receptor Group)	Acceptable Level/s	Source and Justification
		• **AL-12:** No adverse effect on declared areas or objects of particular significance such that it prevents the long-term protection of values as conferred by the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth)	The ATSIHP Act an be used by Aboriginal and Torres Strait Islander people to make applications to protect places and objects of particular significance from injury or desecration (DCCEEW 2023n). The Commonwealth Minister for the Environment and Water can use the ATSIHP Act to make a declaration to protect an area or object for a specified period of time. The acceptable level (**AL-17**) is not inconsistent with the ATSIHP Act. Note: Although no declarations under the ATSIHP Act currently apply to the Project Area, this acceptable level (**AL-17**) is intended to apply should the position change. This acceptable level (**AL-12**) has also been developed such that the Goodwyn Area Infill Development is implemented to be consistent with the objectives and principles of the First Nations Communities Policy (Appendix A).
		• **AL-13:** No interference with native title rights or interests[21] within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder	The acceptable level is not inconsistent with section 280(2)(e) of the OPGGS Act regarding the interference with other petroleum activities within a petroleum title. Note: Although no determination of native title has been made and no native title claims have been lodged over the Project Area, this acceptable level (**AL-18**) is intended to apply should the position change. This acceptable level (**AL-13**) has also been developed such that the Goodwyn Area Infill Development is implemented to be consistent with the objectives and principles of the First Nations Communities Policy (Appendix A).

[21] Where native title rights and interests is defined under section 233 of the *Native Title Act 1993* (Cth).

4.8 Demonstration of Acceptability

Woodside has developed a set of acceptability criteria that allows them to determine the acceptability of an impact or risk. If an impact or risk is not considered acceptable, further control measures are required to lower the risk, or alternative development options considered. Woodside's acceptability criteria consider:

- comparison of predicted impact or risk against the defined acceptable level
- impact and risk classification and decision type
- principles of ESD
- internal context
- external context
- other requirements.

These criteria are described in the following subsections.

4.8.1 Comparison with Acceptable Level

In alignment with NOPSEMA's OPP Decision Making Guideline (NOPSEMA 2024e), the predicted residual impact or risk will be compared with the acceptable levels (as defined in Section 4.7).

4.8.2 Impact and Risk Classification, and Decision Type

Woodside has applied the approach that lower-order impacts or risks (Table 4-4) assessed as decision type A are 'broadly acceptable'. These impacts and risks are considered to be managed to an acceptable level by meeting legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines.

Higher-order impact or risks, assessed as a decision type B or C, require further evaluation and justification via the other acceptability criteria.

Table 4-4: Lower- and higher-order impacts and risks

Order	Impact (Consequence)	Risk (Risk Rating)	Decision Type
Lower-order	No lasting effect (F), Slight (E), or Minor (D)	Low, Moderate	A
Higher-order	Moderate (C), Major (B), or Catastrophic (A)	High, Very High, Severe	B or C

4.8.3 Principles of Ecologically Sustainable Development

As defined in section 3A of the EPBC Act, the principles of ESD are:

- decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations
- if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
- improved valuation, pricing and incentive mechanisms should be promoted.

Table 4-5 describes how each principle of ESD is applied when demonstrating acceptability for this OPP.

Table 4-5: Application of the principles of ESD

Principle of ESD	Application
Integration Principle Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	Evaluation that the impacts and risk to the environment (including ecological, social, economic, and cultural features, as per the definition in regulation 5 of the Environment Regulation) have been identified and evaluated, that the evaluation included any relevant objects or claims from consultation, and that residual impacts and risks can be managed to an acceptable level.
Precautionary Principle If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	For consideration of this principle, Woodside has assigned an impact consequence of Moderate or above, and a risk rating of High and above, to be the equivalent of serious or irreversible environmental damage. Where these higher-order impact and risks exist, an evaluation is done of the scientific uncertainty associated with the predicted impact or risk, and consideration of how this is accounted for in proposed management measures (including how to manage residual scientific uncertainty during the project).
Intergenerational Principle That the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	Evaluation that the predicted impacts and risks will be managed to an acceptable level that will not forego the health, diversity, or productivity of the environment for future generations.
Biodiversity Principle The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Evaluation that the predicted impacts and risks (including those to the MNES identified within regulation 7(3) of the Environment Regulations) will be managed to an acceptable level that will not affect the conservation of biological diversity and ecological integrity.
Valuation Principle Improved valuation, pricing and incentive mechanisms should be promoted.	The titleholder/s of the relevant petroleum titles will bear the cost of environmental management for the Goodwyn Area Infill Development. This principle is not considered separately for each aspect within the impact and risk assessment section of the OPP.

4.8.4 Internal Context

Woodside's internal requirements must be implemented when undertaking the offshore project. These requirements may focus on: how particular activities are done (e.g. vertical seismic profile [VSP]); particular impacts or risks (e.g. invasive marine species [IMS]); protecting certain receptors, and such requirements may be captured under the proponent's HSE Management System.

The WMS (described in Section 2) defines how Woodside will deliver its business objectives and the boundaries within which all Woodside employees and contractors are expected to work. The objectives under the WMS define the mandatory performance requirements that apply to all Woodside activities, and the performance of its employees and contractors within their area of responsibilities. Where relevant, Woodside's internal requirements are identified as controls (Section 9).

4.8.5 External Context

In addition to legal or other requirements, stakeholder expectations need to be understood to establish context for the area where the project is to take place. Stakeholder expectations may be well understood and based on previous experience, consultation, or general advice they have made available. Alternatively, they may be identified during project stakeholder consultation activities, and as such need to be tracked and their views and concerns considered for the impact and risk assessment.

During its long history of operating on the North West Shelf (NWS), Woodside has established strong stakeholder relationships and an appreciation for stakeholder views with respect to petroleum activities in the region. When establishing acceptable levels for impacts and risks, Woodside considers the expectations of potentially impacted stakeholders, and factors this into decision-making for the level of potential impact and risk of activities.

Woodside has undertaken preliminary consultation with identified relevant stakeholders (Section 8), incorporating outcomes into this OPP where applicable, and will continue to consider the views of stakeholders who provide comment on the Goodwyn Area Infill Development OPP through the formal consultation (public comment) process and other means of ongoing consultation.

4.8.6 Other Requirements

The proposed key control measures for the project are consistent with relevant legislative and other relevant requirements related to environmental management as described in Section 3.

4.9 Environmental Performance Outcomes

As defined in regulation 5 of the Environment Regulations, an EPO “for an activity, means a measurable level of performance required for the management of environmental aspects of the activity to ensure that environmental impacts and risks of the activity will be of an acceptable level”.

Regulation 7(2)(e) of the Environment Regulations requires the OPP to set out EPOs for the offshore project, and, in accordance with regulation 9(4)(b) and 13(4)(e), that these EPOs are:

- consistent with the principles of ESD
- relevant to the identified environmental impacts and risks for the project.

In alignment with NOPSEMA’s OPP Decision Making Guideline (NOPSEMA 2024e), Woodside has developed EPOs for the Goodwyn Area Infill Development (Section 9) that apply to managing the project’s environmental aspects, and will provide for environmental performance that is equal to or better than the defined acceptable level. The acceptable level or the predicted environmental impact and/or risk is encompassed within the defined EPOs (as per NOPSEMA’s OPP Content Requirements; NOPSEMA 2024a).

Where qualitative terms (e.g. adverse effects) are used in EPOs, they are supported by detailed environmental impact and risk assessments such that they can be interpreted as meaning an ‘*impact greater than the predicted consequence in this OPP’* or ‘*risk greater than that predicted in this OPP*’.

The EPOs for the Goodwyn Area Infill Development are consistent with the principles of ESD because:

- the acceptable levels (defined in Section 4.7) take into consideration the principles of ESD
- the demonstration of acceptability process (described in Section 4.8), which is applied to each aspect in Section 9, also takes into consideration the principles of ESD
- the EPOs have been set at a level of environmental performance that is equal to or better than the defined acceptable level(s).

4.10 Implement, Monitor, Review, and Report

An environmental performance framework for the offshore project describes the specific measures and arrangements to be implemented for the duration of the project. The strategy is based on the principles of Australian Standard / New Zealand Standard (AS/NZS) ISO 14001 Environmental Management System (SA/SNZ 2016), and demonstrates:

- key control measures are effective in managing the environmental impacts and risks of the offshore project to acceptable levels
- EPOs set out in the OPP are met through monitoring, recording, auditing, managing non-conformance, and reviewing
- environmental reporting requirements are met, including reportable incidents.

The environmental performance framework is presented in Section 11.

4.11 Consultation

This OPP must be made public, with a public comment period of at least four weeks, in accordance with regulation 9(5) of the Environment Regulations.

In accordance with regulation 11 of the Environment Regulations, Woodside must respond and prepare a written response to any comments received during the public comment period, including an assessment of the merits of each objection or claim, and a demonstration of changes, if any, that are made to the OPP as a result of an objection or claim. This response will be included in subsequent revisions of the OPP (i.e. after the public comment period).

In addition to the regulatory requirement for public comment, Woodside voluntarily carried out some additional preliminary consultation when developing this OPP.

Further details on the consultation approach for this OPP are provided in Section 8.

5 DESCRIPTION OF THE PROJECT

5.1 Project Overview

Using multiple subsea tiebacks to existing GWF subsea infrastructure, the Goodwyn Area Infill Development intends to develop incremental volumes of gas and condensate to partially fill ullage (unused gas production capacity) at the GWA platform. The Goodwyn Area Infill Development will target both existing and previously undeveloped gas reservoirs within petroleum titles to the west and south-west of the GWA platform (Table 5-1, Figure 5-1).

As described in Section 1.4, processing well fluids at the GWA platform, transferring to the KGP for final processing, and exporting to domestic and international markets are not within scope of this OPP, and as such do not form part of this Section's offshore project description.

The project description provided in the below sections is based on the use of currently available equipment and technology. If advancements occur that would affect the selection of equipment of techniques described here, any proposed changes will be described within subsequent EPs.

Table 5-1: Key characteristics for the Goodwyn Area Infill Development

Item	Description
Proponent	Woodside, for and on behalf of the NWSJV
Location	~140 km north-west of Karratha, WA
Water depths	~70–160 m for areas of proposed subsea infrastructure ~20–180 m for full extent of Project Area
Petroleum titles	The offshore project provides for a phased development which may incorporate these petroleum titles and gas reservoirs: • WA-5-L (Echo Spur, Tidepole East) • WA-24-L (Yodel Updip, Yodel South) • WA-7-R (Wilcox) The offshore project also provides for potential future development of gas reservoirs within these petroleum titles (above) and/or others (WA-6-L, WA-23-L, WA-56-L, WA-57-L, WA-58-L) within the Project Area
Petroleum activities	• drilling and completions – geotechnical sampling (if required to inform MODU mooring) – drilling operations (for up to 8 production wells) – formation evaluation – well completion – well unloading • subsea installation and pre-commissioning – installing Xmas trees, flowlines, electrohydraulic umbilicals, and other infield infrastructure – pre-commissioning • start-up and operations – initial start-up of wells and subsea infrastructure – subsea IMMR • decommissioning – plugging and abandoning wells – removing property • field support – operating MODUs, vessels, helicopters, and ROVs
Production wells	It is anticipated that the Goodwyn Area Infill Development may include: • up to 6 production wells drilled across multiple phases

Item	Description
	• allowance for up to an additional 2 production wells (as part of potential future developments)
Subsea infrastructure	It is anticipated that the Goodwyn Area Infill Development will include various infield infrastructure including (but not limited to): • wellheads, and Xmas trees • flowlines, electro-hydraulic umbilicals (EHUs), manifolds, pipeline end terminations (PLETs), flowline end terminations (FLETs), in-line trees (ILTs), umbilical termination assemblies (UTAs), electrical flying leads (EFLs), hydraulic flying leads (HFLs), flexible pipe jumpers, rigid spools, subsea intensifiers, cooling skids, pressure protection systems, and accumulator modules
Anticipated hydrocarbon	Gas and condensate
Design life	~20 years (wells), ~10 years (subsea infrastructure)
EOFL	2040

5.1.1 Schedule

Woodside is currently undertaking concept select engineering, and is currently targeting FID for the Goodwyn Area Infill Development in 2024. The initial phase of development is currently planned to start during 2025/2026, with first gas currently planned in 2026 (Table 5-2). Achieving these milestones is subject to several factors including NWSJV approvals, regulatory approvals, and commercial arrangements being finalised.

The indicative schedule for the phased development approach for the Goodwyn Area Infill Development is based on:

- where a phase includes development of multiple reservoirs
  - concurrent drilling activities will not occur
  - drilling and subsea installation activities may occur concurrently
- the number of wells to be developed within Phase 1 is ~2–5
- the number of wells in subsequent development phases has not been determined, and will depend on reservoir analysis and project requirements.

Activities associated with the Goodwyn Area Infill Development will occur concurrently with existing GWA Facility operations.

Table 5-2: Woodside's preliminary schedule for the Goodwyn Area Infill Development

Phase	Approximate Timing
Concept select	2022–2023
Front end engineering design (FEED)	Start during 2024
FID	2024
Drilling and subsea installation	Start during 2025/2026 (Phase 1) Start during 2027 (Phase 2) The timing of Phase 3 and any subsequent development phases will depend on reservoir analysis and project requirements
First gas	2026
EOFL decommissioning[1]	2040 (estimate only)

1. Decommissioning may occur in stages; an activity will require the submission and acceptance of an EP as per the requirements of the Environment Regulations.

5.1.2 Project Area

The Project Area defines the spatial boundary for the offshore project and incorporates the petroleum titles relevant to the Goodwyn Area Infill Development (Figure 5-1).

The Project Area has been defined such that sufficient buffers around planned activities (e.g. around a MODU during drilling; around construction vessels during installation, etc.) have been incorporated into this spatial extent. The Project Area also accommodates vessel movements during drilling, installation, commissioning, and operation (Note: Transit to and from the Project Area is out of scope as this is not characterised as a petroleum activity; Section 1.4.2). The Project Area also incorporates a 500 m safety exclusion zone that will be requested around the MODU and installation vessels for the duration of activities.

Planned activities associated with the offshore project (as described within this Section 5) will be undertaken wholly within the Project Area.

5.1.3 Location

Petroleum activities and associated infrastructure for the Goodwyn Area Infill Development occur in Commonwealth waters.

At its closest, the Project Area is ~30 km north of the Montebello Islands and ~140 km north-west of Karratha (Figure 5-1; boundary coordinates are shown in Table 5-3 and Figure 5-2). The water depths within the Project Area range between ~20 m and ~180 m (Note: Subsea infrastructure will be located in water depths of ~70 m and ~160 m; Table 5-1).

A nominal infrastructure corridor for the phased development has been developed to define the area within which subsea infrastructure and other seabed disturbance (e.g. from MODU mooring systems) may occur. The phased development nominal infrastructure corridor is based on a 4 km radius buffer around nominal well locations, a 2 km buffer either side of nominal flowline/EHU routes, and a 2 km buffer around existing GWF flowlines/EHUs. Figure 5-1 and Figure 5-2 show the nominal infrastructure corridor for the phased development (Section 5.2.1). The final subsea infrastructure locations are dependent on the outcomes of further studies and detailed engineering but are intended to occur within the Project Area.

The phased development nominal infrastructure corridor (as described above) may not include subsea infrastructure or seabed disturbance that may be associated with other future infill developments within the Project Area (Table 5-1; Section 5.2.2). The gas reservoirs that may form part of future tieback opportunities are not yet fully defined, and consequently a separate proposed infrastructure corridor has not yet been developed for those future developments. However, as those gas reservoirs will be accessed via the petroleum titles listed in Table 5-1, the subsea infrastructure for future tieback opportunities will also fall within these petroleum titles. All seabed disturbance (for both the phased development as well as any future development) is intended to occur within the broader Project Area.

Table 5-3: Boundary coordinates for the Project Area

Point identification	Latitude[1]	Longitude[1]
A	19° 39' 31.8" S	115° 55' 4.9" E
B	19° 45' 46.9" S	115° 56' 0.3" E
C	19° 46' 48.9" S	115° 55' 59.9" E
D	19° 49' 55.2" S	115° 55' 4.7" E
E	20° 03' 0.9" S	115° 42' 0.0" E
F	20° 03' 0.9" S	115° 30' 4.7" E
G	20° 04' 55.3" S	115° 30' 4.7" E

Point identification	Latitude[1]	Longitude[1]
H	20° 04' 55.3" S	115° 25' 4.7" E
I	19° 54' 55.3" S	115° 25' 4.7" E
J	19° 39' 55.2" S	115° 40' 4.7" E
K	19° 39' 55.2" S	115° 50' 4.7" E
L	19° 39' 30.0" S	115° 50' 4.7" E

1. Coordinate reference system is GDA94.

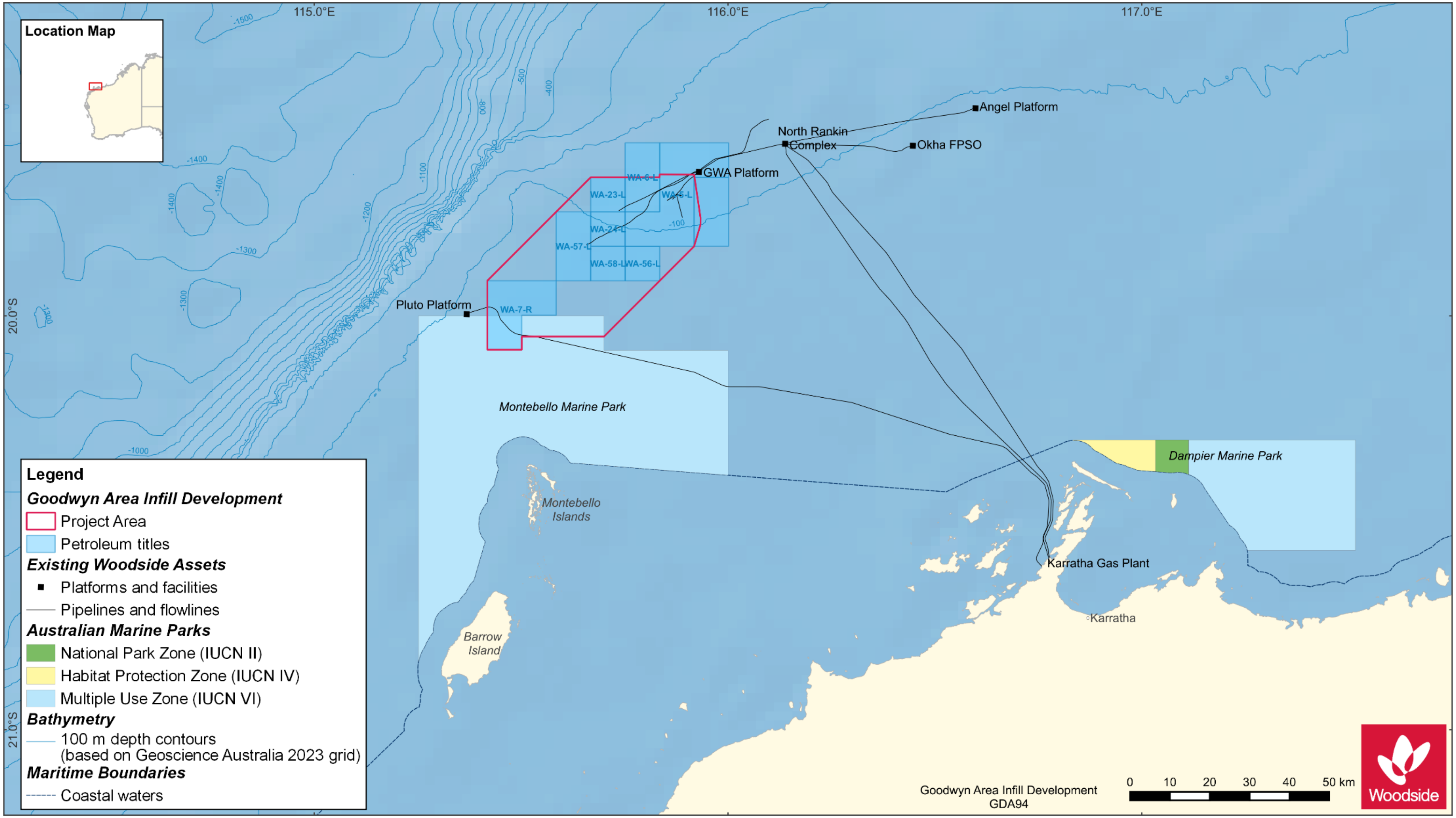
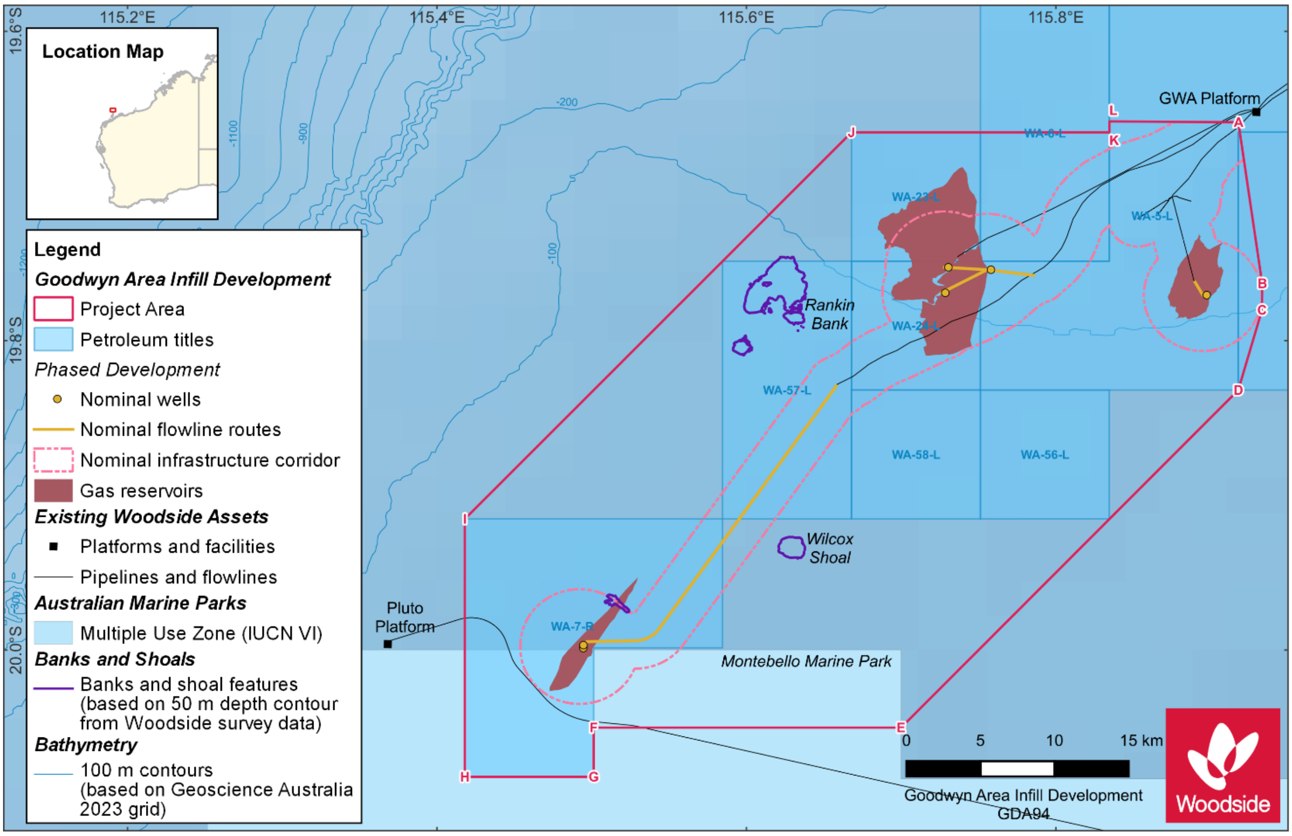


Figure 5-1: Goodwyn Area Infill Development—Project Area



Note: The wells and flowline routes shown in the above figure are nominal locations only and are subject to change. The final selection of wells and flowline routes for the Goodwyn Area Infill Development will be determined during FEED.

Figure 5-2: Nominal locations for the production wells, flowlines, and infrastructure corridor for the phased development

5.1.4 Hydrocarbon Characteristics

The gas resources associated with the Goodwyn Area Infill Development are classified as 'wet' gases, with condensate to gas ratios (CGRs) estimated to range ~48–192 stb/MMscf (Table 5-4).

The maximum estimated nitrogen (N_2) and carbon dioxide (CO_2) concentrations in the gas vary between reservoirs (Table 5-4). Similarly, the maximum design assumption for hydrogen sulfide (H_2S), a potential contaminant, concentrations also vary between the reservoirs (Table 5-4).

Note: There is some uncertainty in fluid composition for previously unpenetrated reservoirs; however these are expected to be within the range of characteristics for other existing NWS Project reservoirs.

Table 5-4: Indicative hydrocarbon characteristics (phased development reservoirs)

Item	Gas Gravity	iCGR (stb/MMscf)	Maximum N_2 (mol%)	Maximum CO_2 (mol%)	Maximum H_2S (ppm)[1]
Tidepole East	0.8	48	0.83	2.26	1.5
Wilcox	0.89	75	0.88	4.6	7
Yodel Updip	0.70	109	2.3	1.7	1
Yodel South	0.70	119	2.64	1.97	<2
NWS range	0.70-0.89	40-180	0.8-2.8	1.4-4.6	1-9.5

1. *Design assumption concentration presented for H_2S.*

5.2 Development Infrastructure

5.2.1 Phased Development

The phased development will target existing and previously undeveloped gas reservoirs within petroleum titles to the west and south-west of the GWA platform. The preliminary schedule for development is shown in Table 5-2, with Phase 1 and Phase 2 drilling and subsea installation activities proposed to commence in 2025/2026 and 2027 respectively. Future phases of development will depend on reservoir performance and project requirements.

The key infrastructure components of the Goodwyn Area Infill Development include the wells and associated subsea infrastructure (e.g. manifolds, flowlines, EHUs), which are described in the subsections below.

5.2.1.1 Wells

The Goodwyn Area Infill Development intends multiple drilling phases over the life of the offshore project. Initially a single well is planned for each target reservoir. As a stronger understanding of the reservoir is developed through production, additional wells will be considered. Based on currently available information, reservoirs that may include additional wells are Wilcox.

Although the exact location of the production wells has not yet been determined, they will be located within the petroleum titles as identified in Table 5-1 and Figure 5-1. Their location will depend on reservoir target areas, seabed bathymetry, and features to optimise reservoir recovery. Pressure and saturation changes in the reservoir will be monitored over the life of the offshore project, and used to inform decisions regarding reservoir management.

Each well will be topped by a wellhead, which can be used to suspend the production well casing and provides a structural foundation for the Xmas tree. Each wellhead is fitted with a subsea Xmas tree which:

- controls the flow of reservoir fluids from the well to the flowlines and provides a well shutoff mechanism
- manages chemical injection.

5.2.1.2 Subsea Infrastructure

The Xmas trees are connected to flowlines either directly or via interim structures (e.g. manifolds, FLETs), with connecting well jumpers to allow reservoir fluids to be carried. All the proposed Goodwyn Area Infill Development wells will ultimately tie-back to existing GWF subsea infrastructure.

Infield infrastructure for the Goodwyn Area Infill Development may include flowlines, EHUs, manifolds, PLETs, FLETs, ILTs, UTAs, EFLs, HFLs, flexible pipe jumpers, rigid spools, subsea intensifiers, cooling skids, pressure protection systems, and accumulator modules. Stabilisation (e.g. mattresses, grout bags, sand bags) may also be required.

The estimated infrastructure footprint for the phased development (i.e. up to 6 wells over multiple phases; Table 5-1 and Table 5-2) is ~0.035 km^2 (Table 5-5). This estimated footprint is based on current design (which has a focus on Phase 1 requirements) and using the nominal wells and flowline routes as shown in Figure 5-2; this infrastructure footprint is the direct disturbance footprint of installed infrastructure on the seabed. Note: A 15% contingency has been added to represent a conservative worst-case extent (allowing for flowline route variation between Wilcox and LPA). The final infrastructure footprint will be dependent on the outcomes of further studies and detailed engineering. An estimated infrastructure disturbance area for the phased development is ~1.79 km^2 (Table 5-5); this disturbance area takes into consideration that displacement of the flowlines and/or EHUs may occur over time (no displacement of other infrastructure is expected to occur).

The Goodwyn Area Infill Development subsea infrastructure is powered, monitored, and controlled from the GWA platform using the network of existing EHUs and subsea distribution units (SDUs).

Table 5-5: Approximate subsea infrastructure footprint and infrastructure disturbance area during phased development

Subsea Infrastructure	Approximate Infrastructure Footprint (km^2)	Approximate Infrastructure Disturbance Area (km^2)
Flowlines, EHUs and associated structures (e.g. UTA, FLET, etc.)	~0.022	~1.547
Manifold and associated connections/equipment (e.g. UCON termination head, EFLs, HFLs, rigid spools, pressure protection systems, etc.)	~0.002	~0.002
Wellheads, Xmas trees, and associated connections/equipment (e.g. UCON termination heads, EFLs, HFLs, well jumpers, etc.)	~0.006	~0.006
Total	***~0.030***	***~1.555***
Total (with 15% contingency)	***~0.035***	***~1.788***

5.2.2 Future Development

The Goodwyn Area Infill Development has been defined to accommodate other future tieback opportunities from gas resources owned by Woodside within the Project Area (Table 5-1). While the gas reservoirs that may form part of future tieback opportunities are not yet fully defined, they will be accessed via the petroleum titles listed in Table 5-1, and hydrocarbon characteristics are expected to be within the range of reservoir characteristics (i.e. yield similar products) described in the OPP for the phased tieback opportunities (see Section 5.1.4 0).

The infrastructure to support these potential future development opportunities is likely to comprise production wells and subsea infrastructure (similar to that described above for the phased development), and ultimately tied back to existing GWF subsea infrastructure. The estimated infrastructure footprint for future development (i.e. up to an additional 2 wells; Table 5-1) is ~0.005 km^2 (Table 5-6). This estimated footprint is based on current design for the phased development. The final infrastructure footprint will be dependent on the outcomes of further studies and detailed engineering for any future development. An estimated infrastructure disturbance area, which takes into consideration that displacement of the flowlines and/or EHUs may occur over time, is ~0.20 km^2 (Table 5-6).

Although the design of these future opportunities is not yet matured, these activities are within the scope of this OPP (as described in Sections 5.2.1.1 and 5.2.1.2).

The intent of the both the phased and future developments are the same: to develop incremental volumes of gas and condensate to partially fill ullage at the GWA platform. The allowance for an additional 2 production wells (and associated subsea infrastructure) for future development will not extend the indicative EOFL (2040) for the Goodwyn Area Infill Development.

Table 5-6: Approximate subsea infrastructure footprint and infrastructure disturbance area during potential future development

Subsea Infrastructure	Approximate Infrastructure Footprint (km^2)	Approximate Infrastructure Disturbance Area (km^2)
Flowlines, EHUs and associated structures (e.g. UTA, FLET, etc.)	~0.003	~0.200

Subsea Infrastructure	Approximate Infrastructure Footprint (km^2)	Approximate Infrastructure Disturbance Area (km^2)
Wellheads, Xmas trees, and associated connections/equipment (e.g. UCON termination heads, EFLs, HFLs, well jumpers, etc.)	~0.002	~0.002
Total	***~0.005***	***~0.202***

5.3 Drilling and Completions

5.3.1 Overview

A phased drilling program is proposed for the Goodwyn Area Infill Development, with the initial phase anticipated to commence during 2025/2026 (Table 5-2). The proposed production wells are planned to be drilled using a moored, hybrid (DP/moored), or jack-up MODU (Section 5.7.1 describes general MODU operations).

Each production well is anticipated to take ~1–3 months from the start of drilling to completions. Production wells will be drilled to depths of ~3,000–5,000 m beneath sea level to intersect the reservoirs. Wells will be spaced to optimise the layout of subsea infrastructure and bottom-hole targets. Once the reservoir is reached, the well may be drilled horizontally to optimise the length of the well within the reservoir and the recovery of reservoir fluids.

The bottom-hole targets for the Wilcox reservoir may be within the Montebello Marine Park; however, Woodside intend to directionally drill all wells into this reservoir so that top-hole locations are located outside the marine park boundary.

Typically, the drilling process for a production well starts with drilling the largest size hole; a smaller diameter conductor will be cemented inside this hole. Additional smaller diameter hole sections will be drilled, and casings will be run in and cemented. These casings provide structural support for the hole walls, isolate geological formations, and allow pressure management that may be experienced during drilling.

For previously undeveloped reservoirs or reservoirs with a high degree of subsurface uncertainty, the production wells may be a primary wellbore, or drilling a sidetracked well from a previously drilled and suspended exploration/appraisal well[22]. The planned drilling of either a primary wellbore or sidetracked well from a previously drilled and suspended exploration/appraisal well is included within the allowance of up to 8 production wells (Table 5-1) under this OPP.

A blowout preventer (BOP) and riser system will be installed. With the BOP in place, additional hole sections will then be drilled to the top of the reservoir and a liner cemented in place. The final hole section is then drilled through the reservoir as required based on reservoir targets.

Well completion equipment (e.g. tubulars, packers) are then installed into the well. The Xmas tree will be installed either before or after running the upper completion.

Depending on the results of internal risk assessments, the intent for the Goodwyn Area Infill Development is to unload and commission the wells to the GWA platform (unload to host). In the unload to host sequence, suspension fluid will be circulated into the well, the reservoir isolation valve will be opened, and the well will be shut-in at the Xmas tree. If unload to host is not feasible, then the well will be unloaded to the MODU (unload to facility) before suspension. In the unload to facility sequence, the well will be flowed back to a temporary production facility installed on the MODU. Once stable flow is achieved, the produced fluids are sent to tanks for separation on board the host/facility. The water is treated to meet regulatory requirements and then operationally discharged

[22] Exploration and appraisal petroleum activities are not in scope of this OPP (Section 1.4.2).

overboard; and if required any produced hydrocarbons are flared. This first production to host/facility is known as unloading and typically lasts ~12 hours per well.

Key well construction activities are described in detail below.

5.3.2 Geotechnical sampling

Geotechnical sampling (e.g. penetrometer testing, coring) to determine the characteristics and suitability of the seabed may be required before installing MODU mooring systems[23]. Geotechnical sampling is performed using seabed sampling equipment deployed over the side of a vessel. Once the equipment is placed upon the seabed, the test is performed and/or the sample is collected.

5.3.3 Top-hole Section Drilling

Drilling commences with the top-hole section of the well in this sequence:

- the MODU arrives and establishes position over the well site
- a pilot hole or holes may be drilled close to the intended well location
  - pilot holes are used when the geology and shallow hazards need to be confirmed or further understanding of the structural integrity of the rock is required
  - pilot holes are drilled riserless, as described below, and result in additional cuttings, sweeps and potentially deposition to seabed
- top-hole sections are drilled riserless using seawater with pre-hydrated bentonite or guar gum, or similar sweeps or drilling fluids to circulate drill cuttings from the wellbore
  - as a contingency, water-based muds (WBM) may be used (if required) based on shallow hazards
- once each top-hole section is drilled, steel casings are inserted into the wellbore to form the surface casing; these casings are secured in place by pumping cement into the annular above the casing shoe or to the surface (seabed), which may result in excess cement being discharged at the seabed.

Cuttings generated during drilling of the top-hole sections are discharged at the seabed.

5.3.4 Blowout Preventer and Marine Riser Installation

After setting the surface casing, a marine riser and BOP are installed on the wellhead to physically connect the well and MODU. This creates a closed circulation system, where drilling fluids and drill cuttings can be circulated from the wellbore back to the MODU via the riser.

The BOP seals, controls, and monitors the well during drilling activities. The BOP components are operated using open hydraulic systems (using water-based BOP control fluids). Each time the BOP is operated, water-based BOP control fluid is released to the marine environment.

BOP tethering may be required, where multiple spud cans could be installed around a wellhead location to tether and tie down the BOP. These spud cans would be removed at the completion of the drilling activities.

5.3.5 Bottom-hole Section Drilling

Bottom-hole section drilling is done after the marine riser and BOP have been installed. This drilling uses a closed circulation system to the planned wellbore total depth (TD). Bottom-hole sections may be drilled using a combination of WBM and non-water based muds (NWBM).

[23] This is a provision for additional geotechnical sampling (if required), and is separate to the activities within the Goodwyn Area Infill Geophysical and Geotechnical Survey EP (which are subject to a separate EP approval process and are not in scope of this OPP).

Protective steel tubulars (casings and liners) are inserted as required. After installing a string of casings/liners and cementing them into the wellbore, the casing/liner is pressure tested.

Cementing operations are also undertaken to:

- maintain well control (by providing annular isolation between hole sections) and structural support of the casing, as required
- set a plug in an existing well in order to sidetrack
- plug a well so it can be suspended or abandoned.

Support vessels transport cement, barite, and bentonite (as dry bulk) to the MODU. Cement is mixed as required by the cementing unit on the MODU, and is pumped by high-pressure pumps to the surface cementing head then directed down the well. During the cement jobs, some cement bulk could be discharged to the environment during the process of pumping cement downhole.

After well operations are completed, excess cement, barite, and bentonite (dry bulk) are either held on board or may be discharged to the marine environment.

Cuttings circulated back to the MODU are separated from the drilling fluids by the solids control equipment (SCE). The SCE comprises shale shakers to remove coarse cuttings from the drilling fluid. After processing by the shale shakers, the recovered fluids from the cuttings may be directed to centrifuges, which are used to remove the finer solids. The cuttings are usually discharged below the water line, and the fluids are recirculated into the fluid system. If NWBM is needed to drill a well section, the cuttings, which are separated from the NWBM via the shakers, will also pass through a cuttings dryer and associated SCE to reduce the average oil on cuttings.

5.3.6 Drilling Fluids

Drilling fluids (also termed drilling muds) are used to lubricate the drill string, maintain bore stability and hydrostatic pressure, and aid in returning cuttings to surface. They are formulated according to the well design, the expected geological conditions of the reservoir, and the surrounding formations.

Drilling fluids comprise a base fluid, weighting agents, and chemical additives that are used to give the fluid the exact properties required to make drilling as efficient and safe as possible. The selection of fluid types will not be finalised until the detailed design phase when the well design is more confirmed.

All wells will be drilled using WBM for the top-hole sections and either WBMs or NWBMs for the lower sections. The selection of drilling fluid depends on technical aspects of the drilling program that will not be known until completion of detailed design.

WBM is typically used as the first preference when planning to drill a well. WBM mainly comprises water (salt or fresh), although some basic additives (such bentonite or guar gum) may be incorporated. All WBM chemicals selected for use will be assessed under the Woodside Chemical Selection and Assessment Environment Guideline.

NWBM may also be used, subject to a ‘business case deviation’ being developed that considers environment, technical, health and waste management concerns. Typically, the requirement to use NWBM is based on a need for improved management of the technical and safety aspects of drilling technically complex wells. The use of NWBM drilling fluids is subject to a formal written commercial and/or technical justification approved in accordance with the Best Practice – Overburden Drilling Fluids Environmental Requirements. All NWBM chemicals selected for use will be assessed under the Woodside Chemical Selection and Assessment Environment Guideline.

5.3.7 Formation Evaluation

Formation evaluation interprets a combination of measurements taken inside a wellbore to detect and quantify hydrocarbon presence in the rock adjacent to the well once total depth is reached.

Formation Evaluation While Drilling (FEWD) is the process by which the presence and quantity of hydrocarbon in a reservoir is measured according to its response to radioactive and electrical input. FEWD may include extracting small cores, wireline logging, full diameter cores and other downhole technologies, as required. FEWD tools will be incorporated into the drill string during development drilling; these tools may include gamma ray, directional deep resistivity, callipers, density-neutron, sonic and formation pressure measurement tools. Some FEWD tools contain radioactive sources; however, no radioactive material will be released to the environment. Generally, radiation fields are not detectable outside the tool if it is not energised; therefore, radiation does not present an environmental risk.

As a part of formation evaluation (particularly for new reservoirs), Woodside may undertake vertical seismic profiling (VSP) once total depth is reached. VSP is used to generate a high-resolution seismic image of the geology in the well's immediate vicinity. It uses a small airgun array as an acoustic source. During VSP operations, receivers are positioned in a section of the wellbore (station) and the airgun array is discharged. The generated acoustic pulses are reflected through the seabed and are recorded by the receivers to generate a profile along a section of the wellbore. This process is repeated as required for different stations in the wellbore and it may take up to 24 hours to complete, depending on the wellbore's depth and the number of stations profiled.

5.3.8 Well Clean-up

Before undertaking well completion, wells will be displaced from the drilling fluid system to the completions brine system. A chemical cleanout fluids train will be circulated between the two fluids, then seawater or brine will be circulated until operational cleanliness specifications are met, in line with Woodside's Reservoir, Drilling and Completions Fluids Guideline. Brine and seawater will be discharged after this operation. If clean-up brine is contaminated with base oil, it will be unloaded back to host/facility for treatment before it is discharged.

5.3.9 Well Completion

Well completion activities to be undertaken after well clean-up will include:

- installing shallow plugs in the tubing hanger
- pressure testing plugs and Xmas tree valves to verify as suspension barriers
- opening the reservoir isolation value
- shutting in the Xmas tree
- removing the BOP.

Following well completion activities, the wells may be left with subsea equipment (such as Xmas trees[24]) installed, awaiting tie-back to the existing GWF infrastructure. All subsea equipment will contain preservation fluids to prevent corrosion and any other deterioration of the equipment before production flows commence. These preservation fluids will be dewatered to host (as described in Section 5.4.5.4).

5.3.10 Well Unloading

Woodside may conduct well testing or well unloading activities after the production wells are drilled. Well testing and unloading tasks may include:

- reservoir gas flaring
- reservoir gas venting.

[24] Xmas tree installation is described in Section 5.4.3.

The wells will be unloaded to host (i.e. the GWA platform) or unloaded to facility (i.e. the MODU). For wells that are unloaded to host, this will be managed in accordance with the NOPSEMA-accepted GWA Facility Operations EP.

Initial unloading of the well displaces the suspension fluids, and these are discharged overboard—the gas content makes it too dangerous to filter or treat them. After the suspension fluids are unloaded, the gas stream is sent to flare via the production separator.

Once the objectives of the well testing and unloading are achieved, the flow is stopped and the well may be cleaned using a brine that can include several chemicals, such as biocide and surfactant.

5.3.10.1 Produced Water Disposal

For wells flowed back to facility, a temporary production system water filtration treatment package will treat the produced water (PW) before discharge. The fluids are cycled through a filtration system and gauge tank before being discharged. Water filtration is standard practice for well unloading operations.

For wells unloaded to host, any PW will be treated and discharged via the existing systems on the GWA platform and managed in accordance with the GWA Facility Operations EP.

5.3.10.2 Air Emissions

During well unloading to facility it is expected that gas, condensate, base oil, and methanol in the wellbore will be flared and efficiently burned. The flare may be extinguished due to water ingress, lack of pilot (propane), weather impact or equipment failure resulting in cold venting of gas from the flare for several minutes, before the flare can be restarted or venting stopped.

During well unloading to host, typically all fluids will be processed and no flaring is planned. If unload to host is selected for Wilcox flaring may be required. The large volume of fluids in the Wilcox flowline may not be able to be produced by the GWA platform. In this case the flowline will be dewatered to sea using nitrogen. During start-up this nitrogen and some hydrocarbons will be flared at the GWA platform (see Section 5.5.1).

5.3.11 Underwater Acoustic Positioning

An array of long baseline (LBL) transponders that provide accurate positioning information may be installed on the seabed (as required) to support drilling activities.

An LBL array near each production well may be in place for ~1–3 months. Acoustic transmissions are not continuous—they are short ‘chirps’ when active and do not emit any sound when on standby Transponder arrays are removed after drilling activities have been completed.

5.3.12 Contingency Activities

Several contingency activities are associated with any production well drilling program (Table 5-3). Although contingency activities are not planned, consideration of these activities is within the scope of the assessment in this OPP.

Table 5-7: Types of contingency activities for drilling programs

Drilling phase	Type of contingency activity
During drilling	If technical or operational issues are encountered during drilling, contingency activities may include: • well suspension • well abandonment • well re-spud (or re-drill) • sidetrack wells

Drilling phase	Type of contingency activity
	• venting • emergency disconnect.
Maintenance and repair	If maintenance or repair works are required on a production well, contingency activities may include: • well interventions • well workovers. These activities may also occur during operations (Section 5.5.3).

5.4 Subsea Installation and Pre-commissioning

5.4.1 Overview

Construction vessels will be used to install subsea infrastructure. These vessels will typically be equipped with appropriate equipment (e.g. cranes, submersible ROVs, etc.) which will aid in the installation, hook-up, and pre-commissioning processes.

Construction vessels will be used to progressively install flowlines and EHUs within the nominal infrastructure corridor. The flowlines will be laid directly on the seabed (after seabed preparation, if required) and EHUs will be laid alongside the flowlines. The manifolds, well jumpers, and other infield infrastructure will be installed on the seabed.

Once the Goodwyn Area Infill Development subsea infrastructure is installed it will be tied in to existing GWF subsea infrastructure.

5.4.2 Underwater Acoustic Positioning

An array of LBL transponders, or an ultra-short baseline (USBL) transponder, may be installed as required by the installation activities. Transmissions from USBL transponders are similar to LBL transponders (as described in Section 5.3.11). All transponders are removed after installation activities are completed.

5.4.3 Xmas Tree Installation

Xmas trees will be installed from either a construction vessel in simultaneous operations (SIMOPS) with the MODU, or directly from the MODU. Depending on well layout, if a construction vessel was used, the MODU may be required to kedge off or reposition to allow the vessel to install the Xmas trees.

After their installation, Xmas trees will be pressure tested to confirm their integrity before the BOP is reconnected to continue with drilling and completions activities.

The Xmas trees will be installed with a preservation mixture in the production and annulus bores. There will be small discharges of preservation fluid associated with testing and connecting the subsea system.

5.4.4 Flowline Installation

5.4.4.1 Pre-lay Survey

A pre-lay survey to identify debris and hazards (not a full geophysical survey) may be done before starting flowline installation.

The pre-lay survey may use various non-intrusive survey methods and techniques (such as side-scan sonar [SSS], multibeam echo sounder [MBES], or visual [e.g. via an ROV]). Under planned operation, the equipment used will not disturb the seabed.

5.4.4.2 Flexible Flowline Installation

Current design concepts for the Goodwyn Area Infill Development predominantly use flexible flowlines. Table 5-9 summarises the installation activities for flexible flowlines.

Table 5-8: Summary of installation activities for flexible flowlines

Activity	Description
Select flowline route	Optimum flowline and EHU routes will be selected, taking into consideration seabed bathymetry, seabed material, and dropped object risk.
Install flowline supporting structures	If required, supporting structures (e.g. FLET foundations or mudmats) will be installed. FLET foundations provide a solid base on which to land the FLET structure.
Rectify spans	Spans are undulations in the seabed that do not provide sufficient support to the flowline. If required, span rectification using concrete mattresses (or other structures) will be undertaken before the flowline is installed. Post-lay span rectification may also be required after the flowline is installed. Where concrete mattresses and other structures are not suitable, rock may be used for span mitigation before and/or after laying flexible flowlines.
Cross other infrastructure	If the optimum flowline route involves crossing existing infrastructure (e.g. other flowlines or cables), crossing points may need to be created using concrete mattresses (or other structures). Where concrete mattresses and other structures are not suitable for a crossing, rock may be used to construct the crossing before and/or after laying flexible flowlines
Install flowlines	A FLET (if required) is installed on the seabed, and the first end of the flexible flowline is landed on it. The flowline is then continuously lowered from the vessel to the seabed as the vessel moves forward. ROVs will be used to continuously monitor flowline touchdown during start-up, laydown, and installation over any supporting structures. A preinstalled second FLET may also be needed at the second end of the flexible flowline,
Test pressure and leaks	Flexible flowlines will typically be installed filled with chemically treated water/MEG. Pressure and leak testing is described in Section 5.4.5.2.

5.4.4.3 Rigid Flowline Installation

Rigid flowlines are typically only considered for the longer flowlines (e.g. Wilcox). Final selection of flowline type (flexible or rigid) will occur during FEED. Table 5-9 summarises the installation activities for rigid flowlines, if they are selected for use.

Table 5-9: Summary of installation activities for rigid flowlines

Activity	Description
Select flowline route	Optimum flowline and EHU routes will be selected, taking into consideration seabed bathymetry and the associated requirement for span mitigation, seabed materials, dropped object risk, and buckling/walking impact.
Install flowline supporting structures	If required, supporting structures (e.g. buckle initiators, walking anchors, PLET foundations or mudmats, fixed datum points) will be installed. Placing buckle initiators at regular intervals along the flowline route limits the amount of pipe that can feed into each buckle, thus reducing operational buckling loading. The PLET foundations provide a solid base on which to land the PLET structure. Fixed datum structures may be installed (depending on flowline installation method) to provide reference points for future operational inspections of the flowline, to ensure correct buckle initiation, and support flowline management. The supporting structures will be lifted off the construction vessel and lowered to the seabed. The structures will be positioned accurately on the seabed using the installed LBL array or USBL. An ROV from the vessel may be used to orientate the structures during installation. Walking anchors, if required, may need to be connected to the flowline after installation (e.g. using chains).
Rectify spans	Spans are undulations in the seabed that do not provide sufficient support to the flowline. If required, span rectification using concrete mattresses (or other structures) will be undertaken before the flowline is installed.

Activity	Description
	Post-lay span rectification may also be required after the flowline is installed. This typically involves placing grout bags under the span section. The empty bag is moved into position using an ROV, then filled with grout. Where concrete mattresses, grout bags and other structures are not suitable, rock may be used for span mitigation before and/or after laying rigid flowlines.
Cross other infrastructure	If the optimum flowline route involves crossing existing infrastructure (e.g. other flowlines or cables), crossing points may need to be created using concrete mattresses (or other structures). Where concrete mattresses and other structures are not suitable for a crossing, rock may be used to construct the crossing before and/or after laying flexible flowlines.
Use initiation anchors to tension flowlines, if required	When flowline installation starts, an initiation anchor may be required to pull against to provide the required tension to the flowline as it transitions from the vessel to the seabed. Initiation anchors, which will be recovered after use, may comprise a suction pile, drag anchor, or clump weight/dead-man anchor.
Install flowlines	During installation, the flowline is continuously lowered from the vessel to the seabed as the vessel moves forward. Tension is applied to prevent the flowline from buckling as it is lowered to the seabed. PLETs and other infrastructure (e.g. ILTs) are installed onto the flowline at required locations and laid to the seabed with the flowline. ROVs will be used to continuously monitor flowline touchdown during start-up, laydown, and installation over any supporting structures. Other activities included in general flowline installation include: • welding and non-destructive testing on board • field joint coating and attaching anodes • as-laid and as-built surveys for data gathering for free-span rectification, deviations from straightness etc. A wet buckle, which causes the rigid flowline to rupture and flood with seawater, could occur during rigid flowline installation; subsequent recovery, cleaning and repair of the flowline and associated discharges may be required.
Flood, clean, gauge and test flowlines	Typically, rigid flowlines will be laid empty (i.e. filled with air), and then flooded, cleaned, gauged, and tested (FCGT). Some installation methodologies require the rigid flowline to be filled with chemically treated filtered seawater (see description below) which is typically displaced and discharged during FCGT. The flowline may be pigged to clean and preserve its internal surface and to determine if any unacceptable restrictions and/or obstructions exist in the line. Using flooding medium, a pig (mechanised plunger) will be run through the flowline. The flooding medium may be chemically treated filtered seawater, comprising a mixture of chemicals including an oxygen scavenger (to control the potential for corrosion), a biocide (to protect the interior of the flowline from biofouling), and a dye (to visually check for leaks). Such a flooding medium is designed specifically for flowline installation, and is commonly used around the world for this sort of application. Alternatively, the flowline may be flooded with a chemically treated water/MEG mixture. MEG is used to prevent formation of hydrates during start-up. The flowline will be subjected to a hydrostatic pressure test (a hydrotest). A pressure pump will be operated from the construction vessel; the pump has a suitable turbine flowmeter for assessing the pressure-volume relationship. Water used for hydrotesting the flowline will be chemically treated filtered seawater. The hydrotest pressure will be held for 24 hours to test the flowline integrity. Hydrotest fluids may comprise biocide, corrosion inhibitor, oxygen scavenger, scale inhibitor, MEG, and fluorescein dye. For longer flowlines, a ‘dry commissioning’ approach may be used instead of a hydrotest. Dry commissioning relies on data gathered during fabrication and installation to provide assurance of integrity. These flowlines would be preserved with nitrogen at low pressure to avoid air ingress. The nitrogen would be purged to the GWA platform flare system during commissioning and start-up activities. FCGT activities will be undertaken in accordance with Woodside’s Engineering Standard Pipelines Flooding, Cleaning, Gauging and Hydrotesting. All chemicals selected for use in FCGT activities will be assessed under the Woodside Chemical Selection and Assessment Environment Guideline. FCGT fluids will typically be discharged at the GWA platform. However, due to distance to this facility, hydrotest discharge from the Wilcox flowline may need to be discharged in place.

Activity	Description
	For subsea hydrotests (e.g. when subsea infrastructure is connected), small localised discharges will occur around each manifold as that infrastructure is tested.
Install walking mitigation	Before or after FCGT, it may be necessary to install “walking mitigation” to reduce cumulative axial movement of the rigid flowline over time. Walking mitigation would likely use pipe clamping mattresses, which applies a weight load to the pipe where they are clamped, however other solutions may be required such as concrete mattresses, rock installation or suction piles.

5.4.4.4 Post-lay Survey

After the flowline is installed, a post-lay survey of the flowlines and EHUs along the entire route and other subsea infrastructure (e.g. mattresses) will be conducted using an ROV. Rigid flowlines using engineered buckles will have an “as laid” survey, prior to FCGT, and an “as built” survey after FCGT.

5.4.5 Subsea Infrastructure Installation

5.4.5.1 Installation

The final selection and layout of infield infrastructure is not yet known, but may include equipment as described in Section 5.2.1.2

Subsea components will be prefilled with a MEG/water mixture and pressure tested in field. Subsea infrastructures will be placed on the seabed from a vessel. An array of LBL or USBL transponders may be used to assist with positioning (refer to Section 5.3.11).

Wet storage on the seafloor may occur for pieces of equipment that are to be moved to the location before tie-in.

5.4.5.2 Pressure and leak testing

Pressure testing is done to test the integrity of subsea infrastructure, test isolations, and identify any leaks. Pressure will either be applied to the component from the host or via downline from a construction/support vessel. If the testing equipment or integrity of the tested infrastructure fails, a loss of hydrotest fluids to the marine environment may occur. A modest quantity of hydrotest fluid is injected into the system under test in order to pressurise it. The same quantity of fluid will be discharged when the system is subsequently depressurised. The discharged quantity will be reduced if the system is left partially pressurised e.g. to assist with later start-up.

Pressure in the isolated section of the flexible flowline or subsea component is monitored to check for any drop in pressure and/or the location of leaks detected by visual inspection. If a leak is identified, an ROV will be used to locate and observe the leak. Pressure and leak testing of subsea infrastructure may result in small discharges of MEG/water to the marine environment.

Fluid used for testing will be left in place to provide corrosion protection until the reservoir fluids are introduced or, in the case of longer flowlines, may be displaced and dried using nitrogen.

5.4.5.3 Tie-in to Existing GWF Infrastructure

Verification testing of any leakage from the manifold branch isolation valves may be undertaken before the Goodwyn Area Infill Development flowlines are tied-in to the existing GWF manifolds. This testing will verify that suitable isolations for safe tie-in are available, thereby preventing a major hydrocarbon release during tie-in. This verification may result in the release of hydrocarbons to the environment. A minor quantity of hydrocarbons may be released when the flowline tie-ins occur. The hydrocarbons are predominantly gas with a small quantity of condensate.

Water jetting, mechanical brushing/scraping or acid soaking may be used to clean the connections on the infrastructure prior to tie-in.

Small quantities of hydraulic fluid and chemicals may be released when the new system of umbilicals and flying leads is connected to existing and new subsea infrastructures, such as Xmas trees and manifolds.

5.4.5.4 Pre-commissioning

The pre-commissioning associated with subsea infrastructure generally includes leak testing of the flowlines and tie-in jumpers, subsea control systems verification, and function testing of valves to verify that the subsea EHUs, EFLs, and HFLs are ready for entry into the commissioning phase.

The pre-commissioning associated with subsea infrastructure generally includes subsea control systems verification and function testing of valves to verify that the subsea umbilicals, electric and hydraulic flying leads are ready for the commissioning phase.

5.4.5.5 Wet Storage of Equipment

Wet storage of infrastructure may be required intermittently throughout the duration of subsea installation activities. Wet storage may include:

- installation aids (e.g. ROV baskets, clump weights)
- subsea infrastructure (e.g. flowlines, jumpers) prior to connection.

Any installation aids will be removed at the completion of activities (i.e. no wet stored equipment will remain on the seabed).

5.4.6 Site Surveys

Site surveys may be undertaken at various stages during the installation of subsea infrastructure. An initial flowline pre-lay survey will be undertaken (Section 5.4.4.1), with additional surveys carried out with an ROV, as required. These surveys will identify the location of all items placed on the seabed (including wet stored items and installed infrastructure). An as-built survey will be conducted by ROV at the completion of the installation campaign to ensure equipment is installed in the designed location.

5.5 Start-up and Operations

5.5.1 Commissioning (Initial Start-up)

The commissioning (initial start-up) activities of the Goodwyn Area Infill Development wells and associated subsea infrastructure will be conducted from the GWA platform. Commissioning will include testing, adjusting, and monitoring all systems.

Shorter flowlines which are not dewatered during the construction phase will be dewatered during start-up. The intent for the these shorter flowlines is for the flowline preservation fluids to dewater to the GWA platform (host), such that the fluids will be treated and discharged via the existing PW system on the GWA platform, and will be managed in accordance with the NOPSEMA-accepted GWA Facility Operations EP. If dewater to host is not feasible, then the flowline will be dewatered in situ during the construction phase. Discharges are typically treated seawater that can contain chemicals such as a biocide, corrosion inhibitor, MEG, and fluorescein dye. The large volume of fluids in the Wilcox flowline may not be able to be produced by the GWA platform. In this case the flowline will be dewatered to sea and replaced with nitrogen. During start-up this nitrogen and some hydrocarbons will be flared at the GWA platform.

Similarly, if a dry commissioning approach was adopted for any of the flowlines, this nitrogen would be purged to the GWA platform during commissioning and start-up.

Once hydrocarbons have been introduced into the system, preservation fluids are displaced to the GWA platform.

5.5.2 Hydrocarbon Extraction, Processing, and Export

Hydrocarbons from the reservoir will flow via the subsea infrastructure to the GWA platform for processing. The scope of the GWA Facility Operations EP starts once hydrocarbons have been introduced into the system for processing (Section 1.4). Processing of well fluids at the GWA platform, transport via the IFL and export trunkline to the KGP for onshore processing, and export to users is not within scope of this OPP (as described in Section 1.4).

Control of the subsea system is via EHUs, which transport electrical power, control fluids, and chemicals to the required subsea locations. MEG and other chemicals will be injected into the produced fluid at the wellhead to prevent the formation of gas hydrate in the flowlines and risers.

5.5.3 Subsea Inspection, Monitoring, Maintenance and Repair

Subsea infrastructure is designed not to require regular intervention; however, an inspection, maintenance, monitoring, and repair (IMMR) process will be in place for subsea infrastructure associated with the Goodwyn Area Infill Development.

The scope of the IMMR activities for the Goodwyn Area Infill Development will be the same as those for existing GWA subsea infrastructure as described in the NOPSEMA-accepted GWA Facility Operations EP.

Subsea activities are typically undertaken from a support vessel and may use an ROV with transponders to inspect equipment. Maintenance and repair activities may require frames/baskets to be deployed and temporarily placed on the seabed. This temporary equipment is removed from the field via recovery to the support vessels at the completion of IMMR activities.

5.5.3.1 Inspections

Subsea infrastructure inspections physically verify and assess components to detect changes to the as-installed location and condition, using comparisons to the initial state following installation and previous inspections. Subsea infrastructure inspections/surveys may include (but are not limited to) visual inspections, cathodic protection, acoustic surveys, non-destructive testing, seabed sampling, anode inspections and replacements.

5.5.3.2 Monitoring

Subsea infrastructure monitoring surveys the physical and chemical environment that a subsea system or component is exposed to, to determine if and when damage may occur, and (where relevant) predict the rate or extent of that damage. Monitoring activities may include (but are not limited to) process composition testing, corrosion probes, corrosion mitigation checks, metocean and seismic monitoring, and cathodic protection testing. Other monitoring activities include process monitoring (e.g. temperature, pressure), electrical system health testing, cyclone weather monitoring, and hydraulic fluid usage.

5.5.3.3 Maintenance

Subsea infrastructure maintenance activities are required at regular or planned intervals to prevent deterioration or failure of infrastructure. Typical maintenance activities may include (but are not limited to) valve cycling, removing marine growth, flushing hydraulic lines, and leak and pressure testing.

Well maintenance activities, such as interventions and workovers, may also occur during operations. The maintenance of subsea wells would require a suitable vessel or MODU to accommodate and support intervention/workover packages.

5.5.3.4 Repair

Repair activities are required when a subsea system or component is degraded, damaged or has deteriorated to a level outside acceptance limits. Although the damage sustained may not necessarily pose an immediate threat to continued system integrity, it may present an elevated level of risk to environment or production reliability. Due to the design of subsea infrastructure and materials used, repairs are undertaken on an ‘as needed’ basis. The requirements and frequency of these repairs are dictated by the outcomes of inspection, monitoring, and maintenance activities. Typical subsea repair and replacement activities include (but are not limited to):

- subsea choke and/or battery module replacement
- chemical injection metering valve insert replacement
- power and communications router, tree and downhole replacement
- multi-phase flow meter retrievable module replacement
- acoustic sand detector replacement
- hydraulic control router replacement
- HFL, EFL and subsea intensifier replacement
- pipeline or spool support with grout bag, mattress, anchors or rock dumping
- spool disconnection and/or replacement
- umbilical jumper replacement and/or relocation, including subsea communications system repair
- flowline/pipeline replacement
- scour prevention installation
- cathodic protection system replenishment/repair
- replacement, bypass or removal of MEG subsea pressure intensifiers (where fitted).

Typically redundant equipment will be recovered and removed from the field after it has been replaced. The location of any remaining redundant subsea infrastructure items is recorded as part of the ROV as-left survey and included in a database of GWA subsea inventory.

5.6 Decommissioning

Decommissioning is a planned activity. Current best practice is for decommissioning to include:

- designing for decommissioning during the development phase of projects or facilities
- maintaining equipment in the title area used in connection with the operations
- planning for the removal of property (including structures and equipment) that is neither used nor to be used in connection with the operations in which the titleholder is to be engaged and that are authorised by the title (subject to other applicable provisions), or making other satisfactory arrangements in relation to the property
- assessing decommissioning options and opportunities during the operational life of the facility leading up to cessation of production
- selecting, developing, and planning the selected decommissioning option
- executing decommissioning plans
- satisfactorily making good damage to the seabed or subsoil in the surrender area caused by the titleholder or person engaged in the operations authorised by the title.

Subsea equipment, above the mudline, including but not limited to Xmas trees, wellheads, flowlines, umbilicals, manifolds, and installation aids will be designed to be removable when no longer in use, in connection with the operations.

This is consistent with section 572(3) of the OPGGS Act, under which, a titleholder must remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations. Under section 572(7) of the OPGGS Act, the property removal requirements under section 572(3) of the OPGGS Act have effect subject to any other provision of the OPGGS Act, the Environment Regulations, directions given by NOPSEMA or the responsible Commonwealth Minister, and any other law. Under section 270(3) of the OPGGS Act, before title surrender, all property brought into the surrender area must be removed to the satisfaction of NOPSEMA, or arrangements that are satisfactory to NOPSEMA must be made in relation to the property.

Decommissioning planning for the Goodwyn Area Infill Development infrastructure will align with Woodside's process (Figure 5-3). It is not currently possible to fully scope the future decommissioning strategy that will be used as the many variables are not yet known. Woodside will continue to review and identify improvements in technology that may occur between now and then. A broad description of anticipated activities (Sections 5.6.1 and 5.6.2) is provided below for reference.

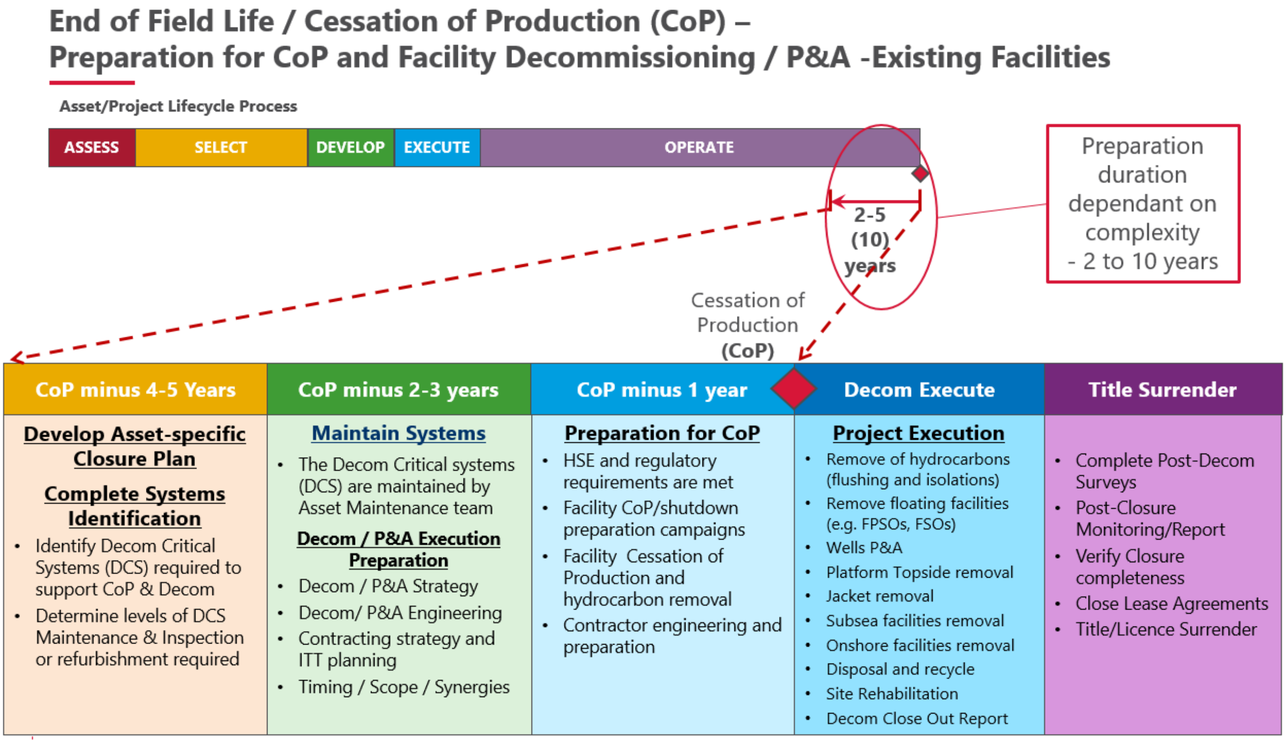


Figure 5-3: Woodside's decommissioning planning process

5.6.1 Plug and Abandonment

Production wells will be abandoned in accordance with the requirements of the OPGGS Act and industry best practice. On abandonment, decommissioning planning is based on the surface casing and wellhead being cut off at or below the mudline and recovered.

Well plug and abandonment include activities such as:

- mobilising MODU and/or vessels to site
- establishing well control

- suspending and recovering any required wellbore equipment
- installing permanent reservoir barriers
- severing and removing surface casing and wellhead.

5.6.2 Removal of Property

Planning for decommissioning is based on subsea infrastructure above the mudline being removed from the title area. Future technical feasibility studies will inform the optimal recovery methods for the Goodwyn Area Infill Development subsea infrastructure.

Removal of property may include activities such as:

- as-found and as-left surveys
- flowline and/or EHU deburial
- subsea flushing of infrastructure
- marine growth removal
- severing at or below mudline
- recovery of infrastructure to surface.

5.7 Field Support Activities

5.7.1 Mobile Offshore Drilling Unit

5.7.1.1 Positioning

A moored, hybrid (moored and DP), or jack-up MODU is planned to be used for the production well drilling.

The type of MODU mooring system used will vary depending on the location and seabed conditions, and may include conventional or pre-lay anchors, or pile moorings. Installation methods for pile-based mooring systems vary, and may include:

- drill and grout piles—drill a hole into the seabed, install a conductor, place the pile in the conductor, and add grout to hold the pile in place
- impact piling—lower the pile to the seabed, and then hammer it into the seabed from the installation vessel
- suction piling—lower the pile to the seabed, where it will then self-penetrate into the seabed.

A jack-up MODU will be positioned using either independent spudcan or mat footings.

Transponders may be used to accurately position the MODU over the proposed well location. Transponders are lowered to the seabed (with a clump weight if required), and then retrieved to the surface following use (including the clump weight, if used). Acoustic positioning equipment is further described in Section 5.3.11.

5.7.1.2 Operations

The MODU, which may operate with up to 200 persons on board (POB), is fitted with various equipment to support drilling activities, including:

- power generation systems
- fuel storage

- cooling water and freshwater systems
- drainage, effluent, and waste systems
- primary and secondary SCE.

Non-drilling activities occurring on the MODU include:

- bunkering or bulk transferring fuel, chemicals, and supplies
- transferring waste to supply vessels
- discharging:
  - sewage, greywater, and food waste
  - cooling water, and reverse osmosis brine
  - deck drainage and bilge.
- helicopter operations.

5.7.2 Vessels

All phases (drilling, installation, operation (IMMR, and decommissioning) of the offshore project will be supported by various vessels. Vessel numbers are expected to be higher during drilling (e.g. typically two support vessels for the MODU during drilling) and installation (e.g. construction vessel plus support vessel/s) phases, compared to the operations phase. Vessel requirements during the decommissioning phase are unknown at this stage, but it can be expected that decommissioning will use similar vessels to those engaged for installation activities.

Activities occurring on the vessels may include:

- bunkering or bulk transferring fuel, chemicals, and supplies
- transferring waste
- anchor handling
- IMMR
- discharging:
  - sewage, greywater, and food waste
  - cooling water, and reverse osmosis brine
  - deck drainage and bilge.
- helicopter operations.

Typically, vessels will use dynamic positioning (DP). Vessel anchoring within the Project Area is not intended for planned activities, but may occur during emergencies. Vessels will not use heavy fuel oil (HFO); instead, they will use a lighter marine fuel such as marine diesel oil (MDO) or marine gas oil (MGO). A support vessel may refuel the MODU and construction vessels, if required. Support vessels are expected to return to port to bunker, although they may occasionally bunker at sea.

Regional ports such as Dampier, Onslow or Exmouth may be used during different phases of the Goodwyn Area Infill Development (including but not limited to mobilisation/resupply/equipment transfer activities). Note: Vessel activities outside the Project Area are not part of the petroleum activity, and are not within scope of this OPP (Section 1.4).

5.7.3 Helicopters

Helicopters are typically the primary means used to transport crew and/or urgent freight to and from the Project Area during the drilling and installation phases, and are also the preferred means of evacuating personnel in an emergency. Helicopter support will likely be sourced from Karratha or Exmouth airports.

Helicopter operations within the Project Area are limited to helicopter take-off and landing on the helideck. Helicopters may be refuelled on the helideck. Note: Helicopter activities outside the Project Area are not part of the petroleum activity, and are not within scope of this OPP (Section 1.4).

5.7.4 Remotely Operated Vehicles

All phases of the offshore project may be supported by ROVs, including drilling, installation, operations (IMMR) and decommissioning.

ROVs may be used for activities such as:

- visual observations or surveys
- anchor hold testing
- positioning of subsea infrastructure
- installing, testing and pre-commissioning subsea infrastructure
- marine growth removal.

An ROV may be fitted with various tools or camera systems as required.

6 ALTERNATIVES ANALYSIS

Regulation 7(2)(f) of the Environment Regulations requires that Woodside describe any feasible alternative to the project or an activity that is part of the project, provide a comparison of the environmental impacts and risks, and an explanation of why the alternative is not preferred.

6.1 Project Alternatives

Woodside identified these project alternatives:

- subsea tieback to the GWA platform (all reservoirs developed via tiebacks to existing GWF infrastructure and well fluids transported to GWA platform)
- subsea tieback to the GWA and Pluto platforms (Wilcox reservoir developed via a tieback directly to Pluto platform, and all other reservoirs developed via tiebacks to existing GWF infrastructure with well fluids transported to GWA platform)
- subsea tieback to the GWA platform and Pluto trunkline (Wilcox reservoir developed via subsea tieback or hot top into the existing Pluto trunkline, and all other reservoirs developed via tiebacks to existing GWF infrastructure with well fluids transported to GWA platform)

  (together, the Feasible Project Alternatives)
- subsea tieback to a greenfield facility (Greenfield Facility Development Alternative)
- no development, including consideration of limiting development of wells near the Montebello Marine Park (No Development Alternative).

A feasible alternative means ‘an alternative that is available and reasonably capable of being carried out after taking into consideration cost, existing technology, and logistics in light of overall project purposes, and having less impact to sensitive areas’ (Law Insider n.d.).

Gas is still considered to have a critical role in energy supply and security during the transition to lower carbon energy sources (AEMO 2022; 2023; IEA 2022). Woodside see an ongoing role for their gas to support customers’ plans to secure their energy needs, while they reduce their emissions (Woodside 2023a). The proposed development is for incremental volumes of gas and condensate and has an EOFL of 2040 (Table 5-1), which fits within the forecasts of gas demand[25] to 2050.

The Greenfield Facility Development Alternative showed there is an insufficient resource base in the target reservoirs to support a standalone development given the capital expenditure requirements to pursue this alternative. The environmental impacts associated with developing an onshore or offshore greenfield facility would also be significantly greater than any tieback alternative to an existing facility. Therefore, this alternative is not considered feasible and is not evaluated further.

The NWSJV has development obligations for commercially viable reservoirs under their production licence and retention lease agreements for the petroleum titles relevant to the offshore project. Although the reservoir targets being pursued by the Goodwyn Area Infill Development are economically challenged, it is expected that commercial viability can be achieved for some, or all, of the targets. The development of these targets supports the overarching goal of improving the efficiency of operations at the GWA platform by utilising ullage which becomes available as existing wells and fields decline. Consideration was also undertaken of not developing the Wilcox reservoir due to the proximity of the Commonwealth Montebello Marine Park. The Wilcox reservoir is the largest of the discovered undeveloped resources in the Project Area and therefore would become stranded and limit the ability of the Goodwyn Area Infill Development to achieve the goal of improving the efficiency of the GWA platform. The No Development Alternative, including not developing the

[25] Note: The most recent stated policies scenario (STEPS) suggest that demand for gas increases slightly to 2030, and then plateaus to 2050 .

reservoir near the Montebello Marine Park, does not satisfy the regulatory obligations or meet the overarching goal; therefore, it is not considered feasible and is not evaluated further.

The three remaining alternatives (i.e. those based on subsea tiebacks to existing facilities) were considered feasible, and Woodside did a comparative assessment of these (Section 6.1.1 and 6.1.2) to identify the benefits, risks, and impacts of each. Woodside considers that the environmental impacts and risks associated with a development can be managed to an acceptable level, as demonstrated in this OPP.

6.1.1 Comparative Assessment Process

A qualitative comparative assessment broadly compares the merit of feasible alternatives.

Woodside developed a set of criteria for key economic, technical, safety, and environmental drivers (Table 6-1), and then considered each as part of the decision-making process to identify the optimal project alternative. The criteria were assessed using the ranking scale shown in Table 6-2.

Table 6-1: Key criteria used to assess alternatives (as relevant)

Driver	Criteria
Economic	
Schedule	• Ability to meet the development timeline
Recoverable volume	• Ability to maximise recovery from the target reservoirs
Cost	• Economic viability
Technical feasibility and safety	
Safety	• In line with industry standards and good practice
Operability	• Technically feasible to meet the field life requirements
Environmental	
Ecological services	• Seabed disturbance • Risk of interaction with marine fauna • Risk of IMS
Emissions and discharges	• Light generation • Sound generation • Atmospheric and GHG emissions • Routine and non-routine discharges • Unplanned hydrocarbon releases
Socioeconomic and cultural	• Interaction with other marine users (including commercial fisheries) • Cultural features and heritage values

Table 6-2: Ranking scale for comparative assessment

Preference	Description	Ranking
Least preferred	Catastrophic impact or risk	6
	Major impact or risk	5
	Moderate impact or risk	4
	Minor impact or risk	3
	Slight impact or risk	2
Most preferred	No or negligible impact or risk	1
	No material difference between alternatives	N/A

6.1.2 Comparative Assessment Outcome

Table 6-3 summarises the qualitative comparative assessment for the Feasible Project Alternatives. Based on considering the drivers listed in Table 6-1, Woodside's preferred project alternative is the subsea tieback to the GWA platform (i.e. all reservoirs developed via tiebacks to existing GWF infrastructure and well fluids transported to GWA platform). This alternative is the subject of this Goodwyn Area Infill Development OPP.

Although there were no material differences in the environmental impacts or risks associated with the Feasible Project Alternatives, Woodside considered the technical feasibility and safety risks associated with the project alternatives involving tiebacks to Pluto were greater. These alternatives would also require two joint venturers, which has subsequent commercial implications. These alternatives also do not fulfil the purpose of the Goodwyn Area Infill Development (i.e. to maintain ullage at the GWA platform) to the same extent as the preferred project alternative.

The subsea tieback to the GWA platform alternative will maximise use of existing infrastructure, maintain ullage at the GWA platform as the existing producing fields decline, and continue to support domestic and export markets until the approved EOFL for the existing GWA Facility operations (which is currently 2040 [Section 1.4.2.1]).

Table 6-3: Woodside assessment against key drivers for alternative concepts for the Goodwyn Area Infill Development

Driver		Criteria	Subsea tieback to the GWA platform[1]		Subsea tieback to the GWA and Pluto platforms[2]		Subsea tieback to the GWA platform and Pluto trunkline[3]	
			Ranking	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***
Economic	Schedule	Ability to meet the development timeline	1	Able to meet development timeline based on greater schedule certainty.	4	Lower certainty of being able to meet development timeline due to host facility (Pluto platform) brownfield modifications required, technical operability risks, and required commercial negotiations with second joint venture.	5	Lowest certainty of being able to meet development timeline due to significant technical and technology risks that need to be addressed. Potential for limited windows for hot tap operation due to shutdown/rate restrictions and weather criteria.
	Recoverable volume	Ability to maximise recovery from the target reservoirs	1	Considered highest recovery alternative.	2	Pluto trunkline minimum turn down may materially impact Wilcox reservoir recovery.	3	Pluto trunkline minimum turn down may materially impact Wilcox reservoir recovery In addition there is likely to be rate limitations on Wilcox production due to subsea equipment capacities and Top Of Line (TOL) corrosion risk.
	Cost	Economic viability	1	Considered to be economically viable and the most cost-efficient alternative.	4	Considered a greater economic risk due to technical operability risks and potential requirement for modifications to the Pluto platform to allow for Wilcox reservoir fluids, and required commercial negotiations with second joint venture	5	Considered the greatest economic risk due to significant additional subsea equipment (high integrity pressure protection systems [HIPPS], meters, coolers, corrosion monitoring spools, hot tap structures) to allow for Wilcox direct tie-in to the trunkline.
Technical	Safety	In line with industry standards and good practice	1	Considered safe due to use of existing technology and existing infrastructure.	3	Considered a safety risk due to technical operability risks (described below). The Pluto platform also operates as a normally unattended platform. Workers will be	2	Significantly reduced workers required on Pluto platform manning due to no process tie-ins being required.

Driver		Criteria	Subsea tieback to the GWA platform[1]		Subsea tieback to the GWA and Pluto platforms[2]		Subsea tieback to the GWA platform and Pluto trunkline[3]	
			Ranking	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***
						required on site during tie-ins and any required topside modifications, and as such introduces an additional safety risk.		However, construction risk of subsea hot tap operation is significant.
	Operability	Technically feasible to meet the field life requirements	1	Considered technically feasible due to use of existing technology and tiebacks to a known existing facility	4	Presents a potential compatibility issue between expected Wilcox reservoir fluids (i.e. higher liquids content, different CO_2 profile) and current process design specifications for the Pluto platform	5	Presents a potential compatibility issue between expected Wilcox reservoir fluids (i.e. higher liquids content, different CO_2 profile). In addition there is likely to be rate limitations on Wilcox production due to subsea equipment capacities and TOL corrosion risk. Increased Pluto trunkline inspection frequency likely.
Environmental	Ecological services	Seabed disturbance	N/A	Potential impacts from seabed disturbance are not expected to be materially different between all project alternatives based on the type of impact (laying of infrastructure), receiving environment (largely bare sediment) and ability to recover. Relatively low level of seabed disturbance from infrastructure (~2 km^2). Disturbance is predominantly within a similar footprint to that of existing infrastructure associated with the GWA Facility. Wilcox tie-in to Lady Nora–Pemberton (LPA) represents	N/A	Potential impacts from seabed disturbance are not expected to be materially different between all project alternatives based on the type of impact (laying of infrastructure), receiving environment (largely bare sediment) and ability to recover. Relatively low level of seabed disturbance from infrastructure (~1.3 km^2). Disturbance is predominantly within a similar footprint to that of existing infrastructure associated with the GWA Facility. Wilcox tie-in to Pluto platform represents a smaller flowline compared to GWA tie-back.	N/A	Potential impacts from seabed disturbance are not expected to be materially different between all project alternatives based on the type of impact (laying of infrastructure), receiving environment (largely bare sediment) and ability to recover. Relatively low level of seabed disturbance from infrastructure (~1.1 km^2). Disturbance is predominantly within similar footprint to that of existing infrastructure associated with the GWA Facility. Wilcox tie-in to Pluto trunkline is the shortest flowline, however significantly more seabed

Driver		Criteria	Subsea tieback to the GWA platform[1]		Subsea tieback to the GWA and Pluto platforms[2]		Subsea tieback to the GWA platform and Pluto trunkline[3]	
			Ranking	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***
				largest flowline required and is in a previously undeveloped area. Recovery of soft sediment habitats from physical disturbance is expected to occur.		However, depending on flowline route this may be in previously disturbed (e.g. alongside the Pluto trunkline) or undisturbed areas. Recovery of soft sediment habitats from physical disturbance is expected to occur.		structures (e.g. HIPPS, meters, coolers, corrosion monitoring spools, hot tap structures) are required. In addition, the umbilical has to go back to the Pluto Platform. Recovery of soft sediment habitats from physical disturbance is expected to occur.
		Risk of interaction with marine fauna	N/A	Risk of interaction with marine fauna is not expected to be materially different between all project alternatives. Low level of vessel movements required—limited to drilling, installation, IMMR during operations, and decommissioning activities. No permanent presence in field.	N/A	Risk of interaction with marine fauna is not expected to be materially different between all project alternatives. Low level of vessel movements required—limited to drilling, installation, IMMR during operations, and decommissioning activities. No permanent presence in field.	N/A	Risk of interaction with marine fauna is not expected to be materially different between all project alternatives. Low level of vessel movements required—limited to drilling, installation, IMMR during operations, and decommissioning activities. No permanent presence in field.
		Risk of IMS	N/A	Risk of IMS is not expected to be materially different between all project alternatives. Note: Distance from shore, water depths, and substrate are typically not favourable for introduction to region.	N/A	Risk of IMS is not expected to be materially different between all project alternatives. Note: Distance from shore, water depths, and substrate are typically not favourable for introduction to region.	N/A	Risk of IMS is not expected to be materially different between all project alternatives. Note: Distance from shore, water depths, and substrate are typically not favourable for introduction to region.
	Emissions and discharges	Light generation	N/A	Potential impacts from artificial light are not expected to be materially different between all project alternatives. Low level of artificial light generation associated with	N/A	Potential impacts from artificial light are not expected to be materially different between all project alternatives. Low level of artificial light generation associated with	N/A	Potential impacts from artificial light are not expected to be materially different between all project alternatives. Low level of artificial light generation associated with

Driver	Criteria	Subsea tieback to the GWA platform[1]		Subsea tieback to the GWA and Pluto platforms[2]		Subsea tieback to the GWA platform and Pluto trunkline[3]	
		Ranking	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***
			MODU and vessels—limited to drilling, installation, IMMR (during operations) and decommissioning activities. No permanent presence in field. Note: All MODUs and vessels must meet minimum requirements for navigation and safety.		MODU and vessels—limited to drilling, installation, IMMR (during operations) and decommissioning activities. No permanent presence in field. Note: All MODUs and vessels must meet minimum requirements for navigation and safety.		MODU and vessels—limited to drilling, installation, IMMR (during operations) and decommissioning activities. No permanent presence in field. Note: All MODUs and vessels must meet minimum requirements for navigation and safety.
	Sound generation	N/A	Potential impacts from underwater sound are not expected to be materially different between all project alternatives. Continuous sound emission typically associated with MODU and vessel operations, which are expected to be highest during drilling and installation activities. Low levels of impulsive sound emissions are associated with acoustic survey techniques. Greatest source of impulsive sound emissions is expected during the drilling phase if a moored MODU with impact driven piles is used.	N/A	Potential impacts from underwater sound are not expected to be materially different between all project alternatives. Continuous sound emission typically associated with MODU and vessel operations, which are expected to be highest during drilling and installation activities. Low levels of impulsive sound emissions are associated with acoustic survey techniques. Greatest source of impulsive sound emissions is expected during the drilling phase if a moored MODU with impact driven piles is used.	N/A	Potential impacts from underwater sound are not expected to be materially different between all project alternatives. Continuous sound emission typically associated with MODU and vessel operations, which are expected to be highest during drilling and installation activities. Low levels of impulsive sound emissions are associated with acoustic survey techniques. Greatest source of impulsive sound emissions is expected during the drilling phase if a moored MODU with impact driven piles is used.
	Atmospheric and GHG emissions	N/A	Potential impacts from atmospheric and GHG emissions are not expected to be materially different between all project alternatives.	N/A	Potential impacts from atmospheric and GHG emissions are not expected to be materially different between all project alternatives.	N/A	Potential impacts from atmospheric and GHG emissions are not expected to be materially different between all project alternatives.

Driver	Criteria	Subsea tieback to the GWA platform[1]		Subsea tieback to the GWA and Pluto platforms[2]		Subsea tieback to the GWA platform and Pluto trunkline[3]	
		Ranking	*Comparative assessment justification*	*Ranking*	*Comparative assessment justification*	*Ranking*	*Comparative assessment justification*
			Low level of direct atmospheric and GHG emissions associated with MODU and vessel operations. Indirect atmospheric and GHG emissions are predominantly based on volume of fluids processed and therefore is expected to be similar for all project alternatives.		Low level of direct atmospheric and GHG emissions associated with MODU and vessel operations. Indirect atmospheric and GHG emissions are predominantly based on volume of fluids processed and therefore is expected to be similar for all project alternatives		Low level of direct atmospheric and GHG emissions associated with MODU and vessel operations. Indirect atmospheric and GHG emissions are predominantly based on volume of fluids processed and therefore is expected to be similar for all project alternatives
	Routine and non-routine discharges	N/A	Potential impacts from routine and non-routine discharges are not expected to be materially different for all project alternatives. Low levels of routine and non-routine discharges typically associated with MODU and vessel operations. Pre-commissioning discharges are typically unloaded to host (i.e. to the GWA platform). However, because of the distance to the GWA platform, hydrotest fluid for the Wilcox flowline would likely be discharged in situ.	N/A	Potential impacts from routine and non-routine discharges are not expected to be materially different for all project alternatives. Low levels of routine and non-routine discharges typically associated with MODU and vessel operations. Pre-commissioning discharges are typically unloaded to host (i.e. to Pluto onshore via the trunkline for Wilcox, and to the GWA platform for all other fields). However given the distance to the Pluto platform, there may be the requirement to discharge hydrotest fluid for the Wilcox flowline in situ.	N/A	Potential impacts from routine and non-routine discharges are not expected to be materially different for all project alternatives. Low levels of routine and non-routine discharges typically associated with MODU and vessel operations. Pre-commissioning discharges are typically unloaded to host (i.e. to Pluto onshore via the trunkline for Wilcox, and to the GWA platform for all other fields).
	Unplanned hydrocarbon releases	N/A	Risk of an unplanned hydrocarbon release is not expected to be materially different between all project alternatives.	N/A	Risk of an unplanned hydrocarbon release is not expected to be materially different between all project alternatives.	N/A	Risk of an unplanned hydrocarbon release is not expected to be materially different between all project alternatives.

Driver		Criteria	Subsea tieback to the GWA platform[1]		Subsea tieback to the GWA and Pluto platforms[2]		Subsea tieback to the GWA platform and Pluto trunkline[3]	
			Ranking	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***	***Ranking***	***Comparative assessment justification***
	Socioeconomic and cultural	Interaction with other marine users (including commercial fisheries)	N/A	Potential impacts from interaction with other marine users are not expected to be materially different between all project alternatives. Low level of MODU and vessel movements required—limited to drilling, installation, IMMR during operations, and decommissioning activities. No permanent presence in field.	N/A	Potential impacts from interaction with other marine users are not expected to be materially different between all project alternatives. Low level of MODU and vessel movements required—limited to drilling, installation, IMMR during operations, and decommissioning activities. No permanent presence in field. Slightly greater area of activities to allow for activities extending to Pluto platform.	N/A	Potential impacts from interaction with other marine users are not expected to be materially different between all project alternatives. Low level of MODU and vessel movements required—limited to drilling, installation, IMMR during operations, and decommissioning activities. No permanent presence in field. Slightly greater area of activities to allow for activities during subsea construction around Pluto trunkline.
		Cultural features and heritage values	N/A	Risk of an unplanned interaction with sites or artefacts of cultural significance is not expected to be materially different between all project alternatives. Relatively low level of seabed disturbance; however, footprint does occur within the Ancient Landscape (i.e. the area between ancient and current coastlines).	N/A	Risk of an unplanned interaction with sites or artefacts of cultural significance is not expected to be materially different between all project alternatives. Relatively low level of seabed disturbance; however, footprint does occur within the Ancient Landscape (i.e. the area between ancient and current coastlines).	N/A	Risk of an unplanned interaction with sites or artefacts of cultural significance is not expected to be materially different between all project alternatives. Relatively low level of seabed disturbance; however footprint does occur within the Ancient Landscape (i.e. the area between ancient and current coastlines).

1. All reservoirs developed via tiebacks to existing GWF infrastructure and well fluids transported to GWA platform.

2. Wilcox reservoir developed via a tieback directly to Pluto platform, and all other reservoirs developed via tiebacks to existing GWF infrastructure with well fluids transported to GWA platform.

3. Wilcox reservoir developed via subsea tieback or hot top into the existing Pluto trunkline, and all other reservoirs developed via tiebacks to existing GWF infrastructure with well fluids transported to GWA platform.

6.2 Activity Alternatives

The Goodwyn Area Infill Development is currently in concept select phase, with FEED scheduled to start during 2024 (Table 5-2).

This section describes the comparative assessment of feasible activity alternatives that are evident at this current design phase. Each feasible activity alternative was assessed against the relevant environmental driver criteria (Table 6-1) that demonstrate a material difference between the activity alternatives under consideration. Where activity alternatives focus predominantly on technical or safety considerations, these are not evaluated further here, as no material difference in environmental impacts or risks is expected.

6.2.1 Type of MODU

These MODU types were considered for the Goodwyn Area Infill Development:

- Option 1: Floating MODU (on DP)
- Option 2: Jack-up MODU
- Option 3: Moored MODU
- Option 4: Hybrid MODU (moored but with DP capability).

A floating MODU (Option 1) is not considered technically feasible for the water depths within the Project Area, and as such is not evaluated further.

Table 6-4 summarises the evaluation of the applicable environment criteria for the options. All options are carried as alternatives within this OPP (see Section 5.7.1.1).

A jack-up MODU (Option 2) has been assessed and deemed not technically feasible for all Goodwyn Area Infill Development sites due to water depths. There are some locations with suitable water depths where the use of a jack-up MODU may be feasible (subject to further seabed evaluations), and as such this option is being carried as an opportunity for future consideration.

The final MODU type decision will be determined during the FEED phase. Note: The MODU type may vary between drill locations, and more than one type may be used.

Table 6-4: MODU type—comparative assessment against key environmental criteria

Criteria	Jack-up MODU		Moored MODU		Hybrid MODU	
	Ranking	*Justification*	*Ranking*	*Justification*	*Ranking*	*Justification*
Seabed disturbance	2	A jack-up MODU will be positioned using either independent spudcan or mat footings. The disturbance footprint associated with jack-up systems is typically smaller than moored semisubmersibles.	3	The seabed disturbance footprint depends on the mooring system, which may include anchors or piles. The disturbance footprint for semisubmersible MODUs is comparatively larger than for jack-up MODUs.	3	The seabed disturbance footprint depends on the mooring system, which may include anchors or piles. The disturbance footprint for semisubmersible MODUs is comparatively larger than for jack-up MODUs.

6.2.2 Pile-based Mooring Systems

These types of pile-based mooring systems for the MODU were considered:

- Option 1: Drill and grout piles

- Option 2: Impact-driven piles
- Option 3: Suction piles.

Table 6-5 summarises the evaluation of the applicable environment criteria for each option.

Although Option 3 is associated with lower environmental impacts, there are potential technical constraints for this option based on geotechnical conditions at the drilling location. Consequently, all options are carried as alternatives within this OPP (see Section 5.7.1.1). The final decision for the type of pile-based mooring system will be determined during the FEED phase. Note: The type of pile-based mooring system may vary between drill locations, and more than one system may be used.

Table 6-5: Pile-based mooring system—comparative assessment against key environmental criteria

Criteria	Drill and grout piles		Impact-driven piles		Suction piles	
	Ranking	*Justification*	*Ranking*	*Justification*	*Ranking*	*Justification*
Sound generation	2	Continuous sound generation during installation of suction piles is associated with the use of vessels and/or MODU. Continuous sound emissions will also be generated from drilling during pile installation.	3	Continuous sound generation during installation of impact piles is associated with the use of vessels. Impact piling will also generate impulsive sound emissions during installation. Installation of each pile is expected to be of a relatively short duration (~1 hour), with only one pile to be installed each day.	1	Continuous sound generation during installation of suction piles is associated with the use of vessels. No additional sources of acoustic sound emissions are associated with this piling option.

6.2.3 Top-hole Locations

Given the proximity of the Commonwealth Montebello Marine Park and the target locations within the Wilcox reservoir, these top-hole locations were considered:

- Option 1: Top-holes within marine park boundary
- Option 2: Top-holes outside the marine park boundary.

Table 6-6 summarises the evaluation of the applicable environment criteria for each option.

Although mining operations (including offshore petroleum activities) are allowed within the Multiple Use Zone of the Montebello Marine Park (Section 3.5.3), Woodside has selected Option 2.

Table 6-6: Top-hole locations—comparative assessment against key environmental criteria

Criteria	Within marine park boundary		Outside marine park boundary	
	Ranking	***Justification***	***Ranking***	***Justification***
Seabed disturbance	3	The seabed disturbance associated with well spudding is relatively small for each top-hole location. However, the seabed disturbance associated with a MODU's mooring system will result in a larger disturbance. Both types of seabed disturbance could occur within the Multiple Use Zone of the Montebello Marine Park.	2	This option reduces the amount of direct seabed disturbance within the Multiple Use Zone of the Montebello Marine Park. No seabed disturbance associated with well spudding will occur within the marine park boundary. However, some of the seabed disturbance footprint associated with a MODU's mooring system may still occur within the marine park boundary. Soft sediment habitats are expected to recover from physical disturbance.
Routine and non-routine discharges	3	Because the top-hole location is within the marine park boundary, the discharge of drill cuttings and drilling fluids will also occur within the Multiple Use Zone of the Montebello Marine Park.	2	Because the top-hole location is outside the marine park boundary, the discharge of drill cuttings and drilling fluids will also occur outside the marine park boundary. Depending on discharge location, discharge volumes, and local hydrodynamics, dispersal of cuttings may extend within the marine park boundary; however, this will be at lower concentrations compared to the alternative option.

6.2.4 Type of Drilling Fluids

These types of drilling fluids were considered:

- Option 1: WBM
- Option 2: NWBM.

Table 6-7 summarises the evaluation of the applicable environment criteria for each option.

Drilling fluid selection depends on technical aspects of the drilling program that will not be known until detailed design is completed. Consequently, both options are carried as alternatives within this OPP (see Section 5.3.6).

Typically, WBM is the first preference when planning to drill a well. NWBM may also be used, subject to a 'business case deviation' being developed that considers environment, technical, health, and waste concerns—the requirement to use NWBM is based on a need for improved management of the technical and safety aspects of drilling technically complex wells.

The final decision for the type of drilling fluids will be determined during the FEED phase. Note: The type of drilling fluid may vary between drill locations and/or within different depths of the wellbore.

Table 6-7: Type of drilling fluid—comparative assessment against key environmental criteria

Criteria	WBM		NWBM	
	Ranking	*Justification*	*Ranking*	*Justification*
Routine and non-routine discharges	1	WBM are predominantly water, with small volumes of chemical or mineral additives. WBM are generally less toxic and less likely to bioaccumulate in the environment (depending on the type and volume of additives).	2	NWBM typically have either an oil- or synthetic-based fluid. NWBM are generally considered more toxic and may bioaccumulate in the environment, depending on the base fluid and the type and volume of additives.

6.2.5 Drilling Discharge Management

These drilling discharge management options were considered:

- Option 1: Transport to shore and onshore disposal
- Option 2: Transport and disposal at an alternative offshore location
- Option 3: Discharge overboard (inclusive of Wilcox)
- Option 4: Discharge overboard (exclusive of Wilcox).

Table 6-8 summarises the evaluation of the applicable environment criteria for each option. The relative level of environment impact associated with the activity's alternatives are not materially differentiated.

Option 1 involves transporting drilling discharges (e.g. cuttings, fluids, cement) to shore using vessels. These transfer operations increase the impacts and risks associated with vessel operations. This option also introduces onshore impacts and risks related to transferring material from vessels to trucks, transporting to waste management facilities, processing, and disposing onshore in landfill. This option does not present material environment benefit over the other options considered, introduces other impacts and risks, and is significantly more expensive; therefore, it is not the preferred option.

Option 2 also increases the impacts and risks associated with vessel operations (similar to Option 1), but potentially not to the same extent because the transfer would be to an alternative offshore location rather than all the way to shore. For Option 2 to be attractive environmentally, an alternative offshore disposal location must be found with environmental sensitivity that is materially lower than that of the drilling locations, and with enough of a difference to offset the impacts and risks associated with increased vessel activity and cost. As such, this is not the preferred option.

Option 3 and Option 4 are expected to present a similar level of environmental impact as the other alternatives, but with lower safety risks (because of comparatively fewer vessel transfers) and lower costs. These options also align with standard industry practice in offshore drilling locations that are not close to sensitive receptors.

The northern extent of the Wilcox reservoir is ~10 km south-west of Wilcox Shoal. Based on drill cuttings dispersion modelling (Section 9.1.10), this shoal is not expected to be exposed to sediment deposition, but may be exposed to very low levels (1 mg/L) of suspended sediment. However, this suspended sediment exposure has a very low probability (1%) of occurring, and will depend on the actual location and distance of the drilling site to Wilcox Shoal (e.g. for drilling locations closer to the Montebello Marine Park, no suspended sediment exposure would be predicted for Wilcox Shoal).

Given the expected minimal environmental benefit of Option 4 over Option 3 (i.e. negligible predicted impact to sensitive benthic habitats and communities within proximity of Wilcox reservoir under either option), Woodside has selected Option 3.

Table 6-8: Drilling discharge management—comparative assessment against key environmental criteria

Criteria	Onshore disposal		Alternate offshore disposal		Overboard discharge (inclusive of Wilcox)		Overboard discharge (exclusive of Wilcox)	
	Ranking	***Justification***	***Ranking***	***Justification***	***Ranking***	***Justification***	***Ranking***	***Justification***
Routine and non-routine discharges	2	Requires additional vessels to transport to shore, then disposal onshore with associated impacts and risks	2	Requires additional vessels to transport to an alternative location. Impacts from discharge similar to overboard discharge	2	Due to location, water depth, and predominantly soft sediment habitat within the Project Area, discharges are expected to have only slight affect. Modelling of drilling discharges in the vicinity of Wilcox reservoir predict negligible exposure to adjacent shoal features.	2	Due to location, water depth, and predominantly soft sediment habitat within the Project Area, discharges are expected to have only slight affect. Modelling of drilling discharges in the vicinity of Wilcox reservoir predict negligible exposure to adjacent shoal features.

6.2.6 Wilcox Flowline Route

Options for flowline routes between Wilcox and LPA are undergoing assessment; the final flowline route will be determined during FEED. The key drivers for the route selection will be to minimise risks associated with geohazards, shallow bathymetry features, or other existing subsea infrastructure.

A nominal Wilcox–LPA flowline corridor has been developed to encompass potential flowline route options (plus an additional contingency buffer) between Wilcox and LPA (Figure 6-1). Any route within this nominal flowline corridor will be of a similar length (~26–30 km), and consequently have a similar infrastructure footprint and infrastructure disturbance area.

The Wilcox–LPA flowline will need to cross two existing fibre optic cables (Figure 6-1). No alternatives exist that could avoid these crossings.

Wilcox Shoal and another smaller shoal feature are both located within this nominal flowline corridor (Figure 6-1). It is intended that final route selection would avoid any direct disturbance to these features (see key control measure CM-08 in Section 9.1.2.4), and minimise potential indirect disturbance to these features.

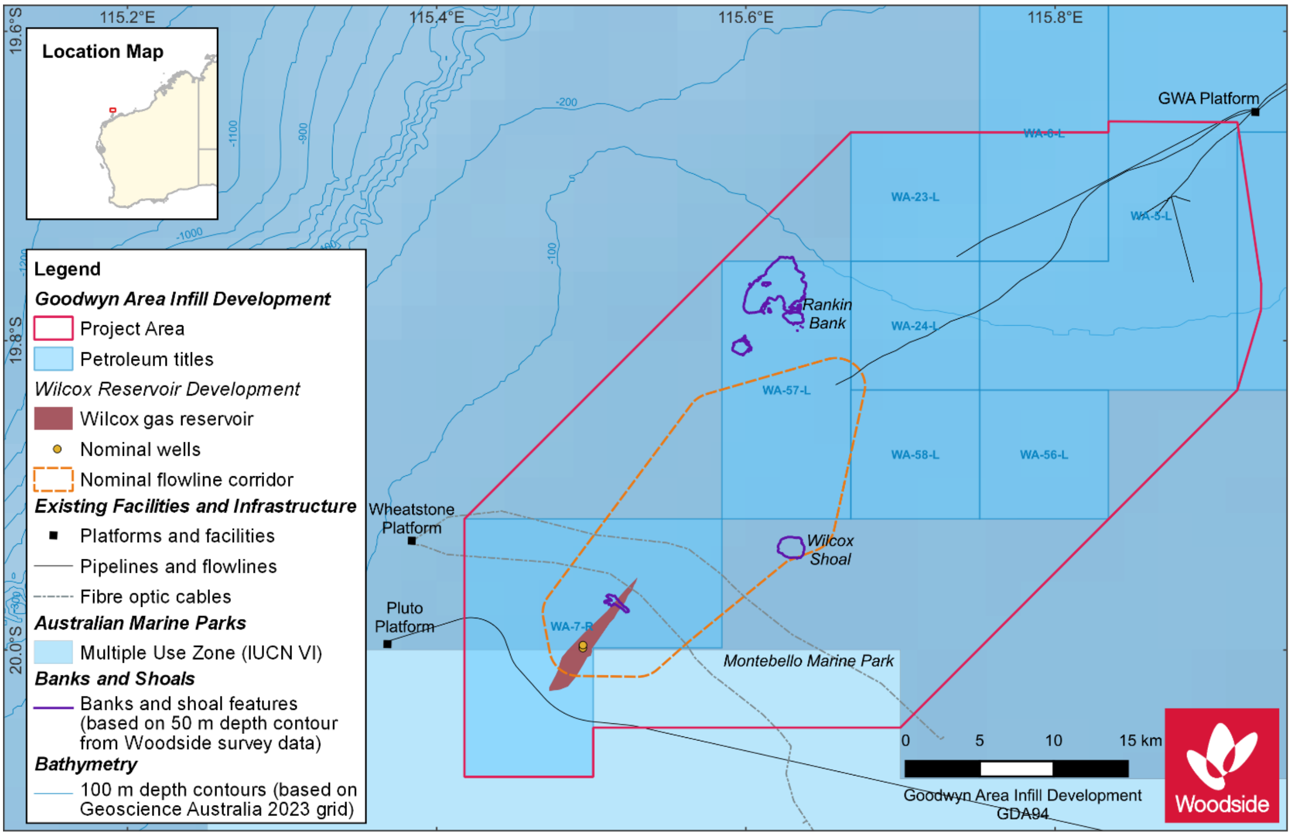


Figure 6-1: Wilcox–LPA flowline corridor

6.2.7 Wilcox Flowline Pre-Commissioning

These flowline pre-commissioning options were considered:

- Option 1: Discharge hydrotesting fluid at Wilcox
- Option 2: Discharge hydrotesting fluid at LPA.

Table 6-9 summarises the evaluation of the applicable environment criteria for each option.

Standard flowline commissioning involves hydrotesting—filling the flowline with water dosed with chemicals to mitigate corrosion, pumping to achieve a desired pressure, and then holding at pressure. Hydrotesting assures there are no leaks in the flowline (a leak would result in pressure loss). The flowline is dewatered after hydrotesting is completed. Due to the distance between Wilcox and the GWA platform, this hydrotest fluid will be discharged in situ.

Based on hydrotest discharge dispersion modelling (Section 9.1.8), the 99th and 95th percentile fields of effect of the plume is predicted to extend up to ~3 km from the discharge location. The overall plume footprint was observed to predominantly drift in a west-north-west and/or east-south-east direction throughout the year.

The relative level of environmental impact associated with the activity's alternatives are not materially differentiated. However, there are some potential safety constraints for Option 2 as it involves discharging over live infrastructure. Consequently, both options are carried as alternatives within this OPP (see Section 5.4.4). The final decision for the hydrotest fluid discharge location will be determined during the FEED phase.

Table 6-9: Wilcox flowline pre-commissioning—comparative assessment against key environmental criteria

Criteria	Discharge at Wilcox		Discharge at LPA	
	Ranking	*Justification*	*Ranking*	*Justification*
Routine and non-routine discharges	2	The field of effect for hydrotest fluid discharge is predicted to extend up to ~3 km from the discharge location. The northern extent of the Wilcox reservoir is ~10 km south-west of Wilcox Shoal. Therefore, Wilcox Shoal is not expected to be exposed to hydrotest fluids discharged from within the Wilcox field. For a discharge location closer to Montebello Marine Park, it would be expected that some of the field of effect may be within the marine park boundary. However, the 95th percentile field of effect is estimated at ~491 m. Therefore, impacts to the values of the marine park are expected to be negligible to slight only.	2	The field of effect for hydrotest fluid discharge is predicted to extend up to ~3 km from the discharge location. Rankin Bank is ~5 km north-west of the proposed tie-in at LPA. Therefore, Rankin Bank is not expected to be exposed to hydrotest fluids discharged from LPA.

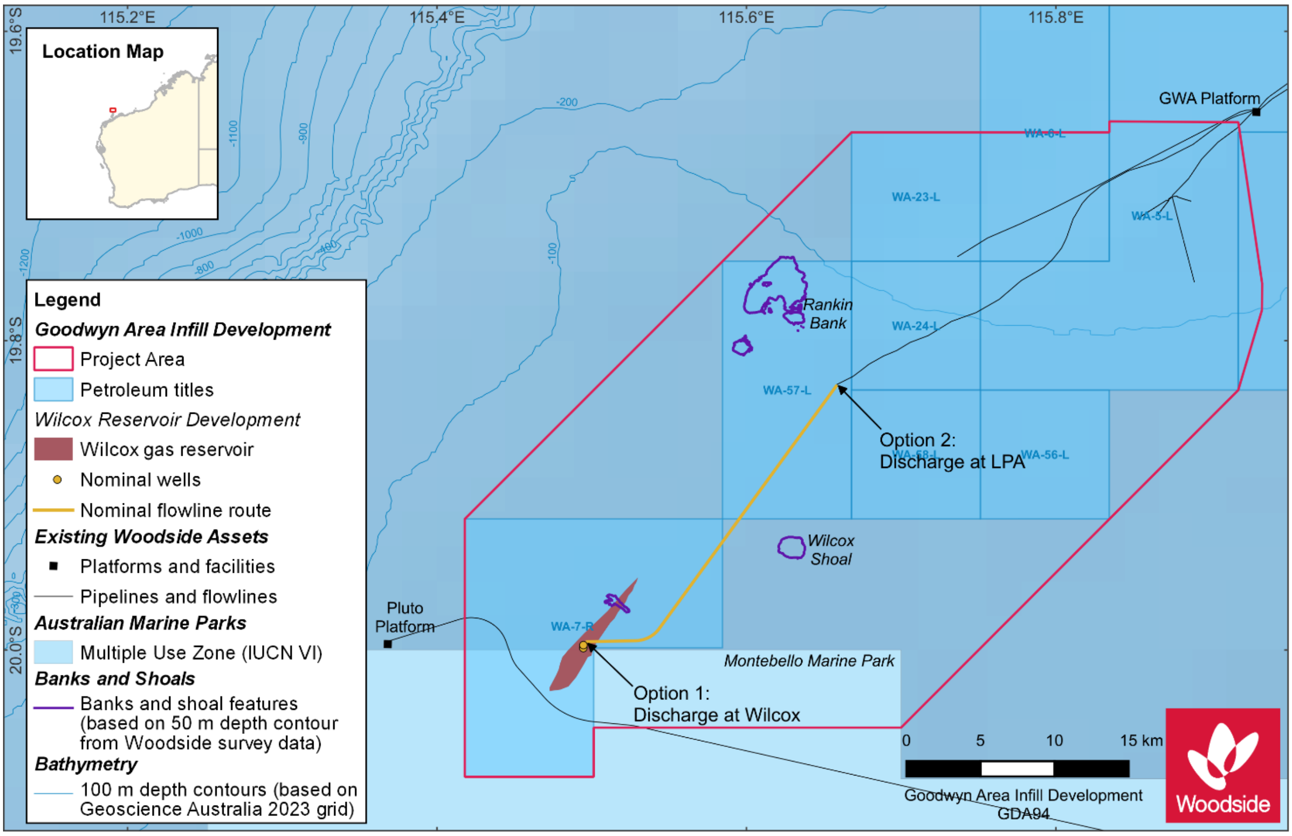


Figure 6-2: Nominal Wilcox–LPA flowline and hydrotest discharge locations

6.2.8 Produced Water Disposal

These produced water disposal options were considered for the Goodwyn Area Infill Development:

- Option 1: Treatment and disposal via the existing system on the GWA platform
- Option 2: Transport from the GWA platform to onshore for treatment and disposal
- Option 3: Reinjection into a reservoir.

Table 6-10 summarises the evaluation of the applicable environment criteria for each option.

For Option 3 to be feasible for the Goodwyn Area Infill Development, a suitable reservoir for produced water storage would need to be identified. The reinjection of produced water would also introduce additional sources of environmental impacts and risks, such as those associated with drilling injection wells (e.g. drill cuttings) or repurposing a production well, and maintaining injection capability (e.g. increased GHG emissions from power generation for pumps, increased chemical usage, etc.). Retrofitting produced water topsides reinjection equipment on the GWA platform introduces significant modifications on an operational facility. The impacts and risks associated with topside retrofitting, and drilling and operation of injection well/s, is considered significantly disproportionate to the potential slight environmental impact improvement from removing the produced water discharge associated with the Goodwyn Area Infill Development.

Option 2, transport to onshore for treatment and disposal is not considered feasible. Getting the produced water to shore would require either a separate pipeline to be constructed, or the produced water to be transported from the GWA platform to shore by a vessel. Both options would require additional infrastructure on the GWA platform (e.g. pumps to supply the pressure needed to pump water to shore or holding tanks to store the produced water in between vessel visits). Additional safety and environmental risks and impacts are also presented by either construction of a separate pipeline or increased number of vessel transits. The discharge of treated produced water into a more sensitive nearshore environment is also considered a worse environmental outcome than an open water offshore environment.

The volume of produced water produced from the Goodwyn Area Infill Development is expected to be incremental in comparison to that already being discharged via the GWA platform for existing operations. Given that the additive total volume (i.e. existing GWA operations plus the Goodwyn Area Infill Development) of produced water is expected to be well within the maximum design capacity of the produced water system on the GWA platform, and that existing modelling for mixing zones, and monitoring for verification of impacts has shown that produced water can be discharged with acceptable environmental impact (see Section 9.1.12) the decision has been made to progress Option 1—the treatment and disposal of produced water via the GWA platform.

Table 6-10: Produced water disposal—comparative assessment against key environmental criteria

Criteria	Treatment and disposal via GWA platform		Transport to onshore for treatment and disposal		Reinjection into a reservoir	
	Ranking	***Justification***	***Ranking***	***Justification***	***Ranking***	***Justification***
Routine and non-routine discharges	2	Low volumes for produced water disposal are estimated; and these volumes are expected to remain well below the maximum design capacity of the existing produced water system on the GWA platform. The approved mixing	3	Would remove the impacts and risks associated with produced water discharge offshore. However, requires either a dedicated pipeline or additional vessel trips, and discharge into more sensitive nearshore environment.	3	Would remove the impacts and risks associated with produced water discharge. However, introduces additional impacts and risks associated with drilling and operating an injection well. These environmental impacts and risks are considered to be

Criteria	Treatment and disposal via GWA platform		Transport to onshore for treatment and disposal		Reinjection into a reservoir	
	Ranking	***Justification***	***Ranking***	***Justification***	***Ranking***	***Justification***
		zone for the GWA platform is based on design capacity; and monitoring data has demonstrated that impacts are localised and do not result in any significant impact.				greater than those posed by produced water discharge to the marine environment.

6.2.9 Carbon Management

Woodside's approach to carbon management includes progressing opportunities such as carbon capture and storage (CCS), carbon capture and utilisation (CCU), and sustainable offsets, in support of our climate goals (see Climate Policy in Appendix A). CCS is the process of capturing carbon and storing it permanently and safely underground in geological structures. CCU refers to a process in which carbon is captured and is then used in a product.

In gas processing, there are two main emission streams that could be considered for carbon capture—CO_2 that exists with hydrocarbon gas in the reservoir which is removed from the product stream during processing (reservoir CO_2) and the exhaust stream from gas turbines. Capturing emissions from flares is not possible because the flare produces widely variable heat and emissions and is required to be unimpeded and physically separate from process equipment.

For the Goodwyn Area Infill Development, emissions of reservoir CO_2 will occur from offshore processing at the GWA platform and from onshore processing at the KGP. As described in Section 1.4.2.1, these facilities both have other approvals associated with their ongoing operations, which include control measures for managing GHG emissions.

Woodside reports and manages emissions from both GWA and KGP as part of the NWS Project under the NGER Safeguard Mechanism reporting requirements. In accordance with section 35A in Division 11, Part 19 of Schedule 1 of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015, the reservoir CO_2 from 'new gas fields'[26] will have a default emissions intensity of 0 t CO_2-e. This has been captured as key control measures for the Goodwyn Area Infill Development within Sections 9.1.6. Note: the reservoirs within scope of the Goodwyn Area Infill Development (Table 5-1) may incorporate both existing (reservoir carbon dioxide commitments described under section 35) and new gas fields (reservoir carbon dioxide commitments described under section 35A).

Capture of CO_2 emitted from gas turbines on the GWA platform would require further processing to strip the CO_2 from the exhaust stream, compress, and reinject. For the GWA platform, which is an existing offshore facility where space is restrictive, this technology is currently complex and cost prohibitive to implement,. The use of CCS or CCU on the GWA platform would also likely require additional pipelines (dedicated for CO_2) or other export/transport mechanism. Given the incremental volume of GHG emissions estimated for the Goodwyn Area Infill Development, the benefit of reduced GHG emissions is disproportionate to the technical and financial costs involved, and potentially new environmental impacts introduced.

However, Woodside is actively pursuing carbon management opportunities, including CCS—it is the operator for a Joint Venture on a greenhouse gas assessment permit (G-10-AP) within the Northern Carnarvon Basin, which contains the depleted Angel gas field. Woodside, on behalf of the Joint

[26] Where a new gas field is defined under subsections3 and 4 of section 35A in Division 11, Part 19 of Schedule 1 of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth).

Venture, is pursuing evaluation and appraisal work to investigate the potential for the geological storage of CO_2 in the permit area.

Woodside is targeting a reduction of net equity Scope 1 and 2 greenhouse gas emissions of 15% by 2025 and 30% by 2030, with an aspiration of net zero by 2050 or sooner.

6.2.10 MEG Injection

The existing GWF subsea MEG injection system cannot inject MEG into several of the potential Goodwyn Area Infill Development wells because the closed in tubing head pressure (CITHP) at some of the Xmas trees will exceed the pressure rating of the current MEG injection system.

MEG injection at each well is needed for several critical operations:

- leak off testing/proving of the isolation valves on each Xmas tree
- surface-controlled subsurface safety vale (SCSSV) testing
- production restart (hydrate prevention).

Therefore, a method of increasing MEG injection at these wells will be needed. Three potential options exist:

- Option 1: subsea MEG booster pump(s)
- Option 2: increase the existing MEG pump pressure rating and use the existing spare umbilical lines
- Option 3: local subsea high-pressure intensifier (HPI) at each Xmas tree

Option 1 is not considered feasible due to extremely high financial costs and has not been evaluated further. Table 6-11 summarises the evaluation of the applicable environment criteria for other two options.

The existing GWF umbilicals have spare lines for hydraulics and for MEG/chemical that are rated sufficiently high for the proposed wells associated with the Dixon, Castor Deep, and Wilcox reservoirs. As such, an upgrade of the existing GWF MEG injection system can be accommodated in these umbilicals (Option 2). This option would, however, mean that spare hydraulic and MEG/chemical lines would be no longer available in case of failure. Future failure of hydraulic or MEG/chemical lines anywhere in GWF system would therefore impact production capacity and/or operating procedures, and require unknown intervention to mitigate the impact which could lead to operational constraints.

Local subsea HPI (Option 3) is a proven technology for control fluid boosting, used by Woodside on previous reservoirs and is also commonly used by other operators. It boosts the inlet pressure using a double-sided piston without the need for external power or controls and can operate on all water-based glycol fluids. As part of the boosting process, MEG is exhausted to sea on every stroke at a ratio of two-parts to every one-part injected (for a 1.5:1 pressure ratio intensifier); i.e. for every 2.5 L of MEG supplied at the low-pressure side, 1 L of MEG is injected at high-pressure and 1.5 L of MEG is vented to sea. Further, if the CITHP of the wells decreases to the point at which the existing MEG injection system can safely operate, the HPI can be disconnected/bypassed, to minimise the MEG usage requirements to operate the wells and reduce the volume of MEG release to the ocean.

The relative level of environmental impact associated with the activity's alternatives are not materially differentiated. However, there are some potential operational constraints for Option 2. Consequently, both options are carried as alternatives within this OPP. The final decision for MEG injection systems will be determined during the FEED phase.

Table 6-11: MEG injection—comparative assessment against key environmental criteria

Criteria	Discharge at Wilcox		Discharge at LPA	
	Ranking	***Justification***	***Ranking***	***Justification***
Routine and non-routine discharges	1	During operations, subsea discharges are intermittent and small volumes, which are expected to rapidly mix and disperse in the open ocean. The aquatic toxicity of MEG is very low; and is on the OSPAR list of substances that are considered to pose little or no risk to the environment once released (PLONOR). MEG is biodegradable and water soluble and dilutes rapidly in the marine environment to low concentrations. Given the relatively small volumes, intermittent discharges, and rapid mixing expected to occur within an open ocean environment, only localised and temporary changes in water quality are predicted.	1	During operations, subsea discharges are intermittent and small volumes, which are expected to rapidly mix and disperse in the open ocean. The aquatic toxicity of MEG is very low; and is on the OSPAR list of substances that are considered to PLONOR. MEG is biodegradable and water soluble and dilutes rapidly in the marine environment to low concentrations. Given the relatively small volumes, intermittent discharges, and rapid mixing expected to occur within an open ocean environment, only localised and temporary changes in water quality are predicted.

7 DESCRIPTION OF THE EXISTING ENVIRONMENT

7.1 Overview

In accordance with regulations 7(2)(c) and 7(2)(d) of the Environment Regulations, this Section describes the existing environment that may be affected by the offshore project (for both planned activities and unplanned events). It includes details of the relevant values and sensitivities of the environment, which were used for the environmental impact and risk assessment (Section 9).

The description of the existing environment relevant to the Goodwyn Area Infill Development is presented for these areas:

- Project Area
- Environment that May Be Affected (EMBA).

The Project Area (as defined in Section 5) is the spatial extent where planned activities associated with the offshore project will occur.

The EMBA is the largest spatial extent where unplanned events could have an environmental consequence on the surrounding environment. The EMBA is the combined potential spatial extent of surface, in-water, and shoreline hydrocarbons at concentrations above ecological impact thresholds (Table 7-1), in the event a worst-case credible unplanned hydrocarbon release scenario occurred (i.e. a loss of well control [Section 9.2.6] or vessel collision [Section 9.2.7]). Woodside recognises that hydrocarbons may be visible at lower concentrations than the ecological impact thresholds (Table 7-1). These visible hydrocarbons are not expected to cause ecological impacts. In respect of this, an additional socio-cultural EMBA is defined as the potential spatial extent within which social-cultural impacts may occur from changes to the visual amenity of the marine environment. Receptors relevant to the socio-cultural EMBA include Commonwealth and State marine protected areas, heritage listed places, areas of tourism and recreation, and commercial and traditional fisheries.

For this OPP, the EMBA has been developed based on the outcome of stochastic spill modelling for the worst-case credible unplanned hydrocarbon release events presented in Sections 9.2.6 and 9.2.7. This area was then further broadened to incorporate a spatial buffer (a minimum of ~50 km), extended inshore along most of the Pilbara and Gascoyne coast, and the shape simplified for ease of use. For this OPP, the socio-cultural EMBA encompasses an area fully within the boundaries of the EMBA.

The EMBA does not represent the predicted coverage of any one hydrocarbon spill or a depiction of a slick or plume at any particular point in time. Rather, this area is a composite of a large number of theoretical spill trajectories, integrated over the full duration of the simulations under various metocean conditions.

The Project Area and EMBA are shown in Figure 7-1.

Table 7-1: Hydrocarbon spill thresholds used to define the EMBA and socio-cultural EMBA

Hydrocarbon	EMBA	Socio-cultural EMBA
Surface	10 g/m^2 This value represents the minimum oil thickness (0.01 mm) at which ecological impacts (e.g. to birds and marine mammals) are expected to occur.	1 g/m^2 This value represents a wider area where a visible sheen may be present on the surface and, therefore, the concentration at which socio-cultural impacts to the visual amenity of the marine environment may occur. However, it is below concentrations at which ecological impacts are expected to occur.

Hydrocarbon	EMBA	Socio-cultural EMBA
In-water (dissolved)	50 ppb This value represents potential toxic effects, particularly sublethal effects to highly sensitive species (NOPSEMA 2019). Because dissolved hydrocarbons are within the water column and not visible, impacts to socio-cultural receptors are associated with ecological impacts. Therefore, dissolved hydrocarbons at this threshold also represent the level at which socio-cultural impacts may occur.	
In-water (entrained)	100 ppb This value represents potential toxic effects, particularly sublethal effects to highly sensitive species (NOPSEMA 2019). Because entrained hydrocarbons are within the water column and not visible, impacts to socio-cultural receptors are associated with ecological impacts. Therefore, entrained hydrocarbons at this threshold also represent the level at which socio-cultural impacts may occur.	
Shoreline	100 g/m^2 This value represents the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat.	10 g/m^2 This value represents the volume where hydrocarbons may be visible on the shoreline but is below concentrations at which ecological impacts are expected to occur.

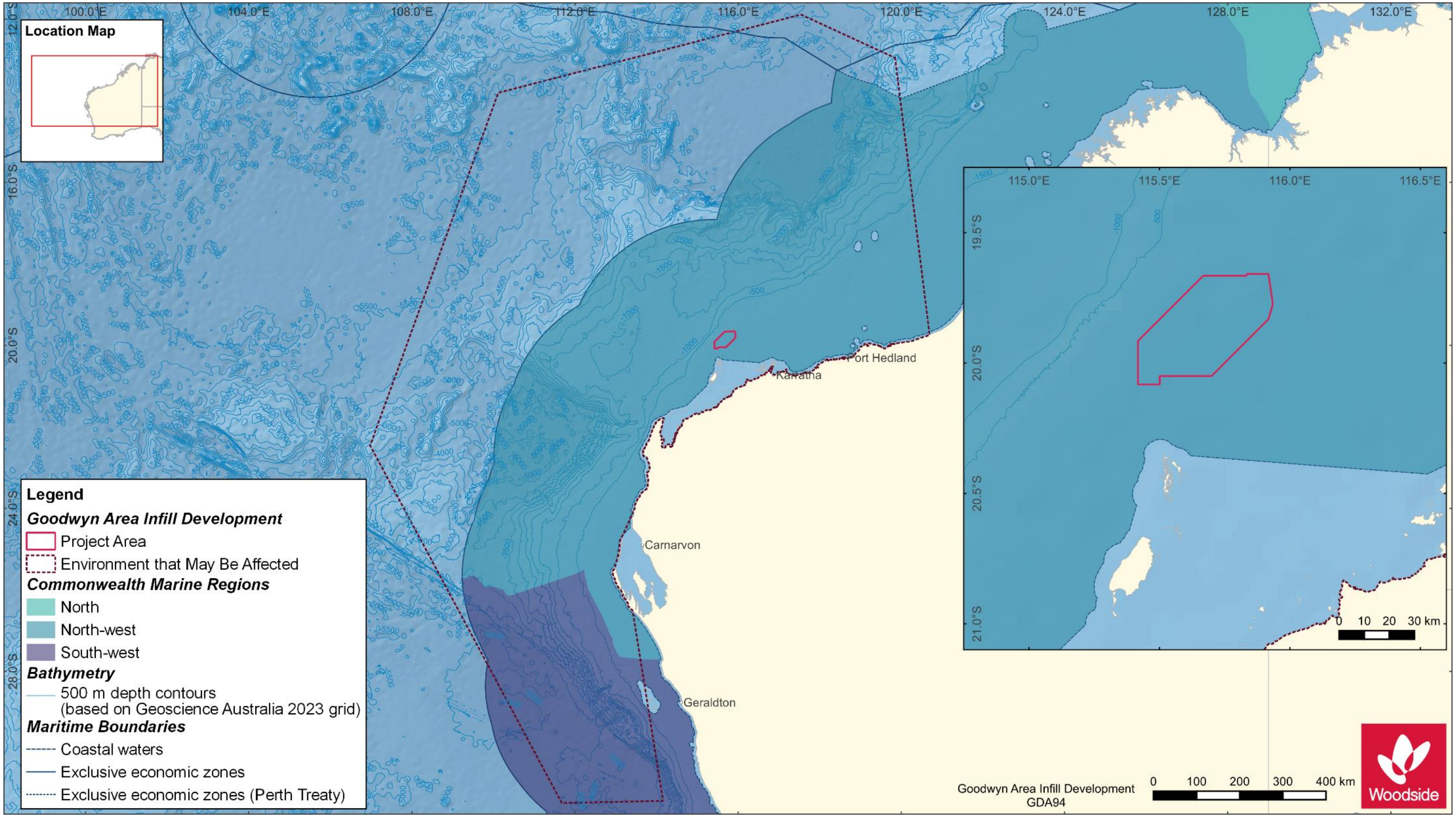


Figure 7-1: Goodwyn Area Infill Development—Project Area and EMBA

7.2 Regional Context

7.2.1 Marine Bioregion

The Project Area is on the Australian continental shelf within Commonwealth waters (~20–180 m depth) and within the North-west Marine Region (NWMR) (Figure 7-1). The NWMR encompasses waters from the WA–NT border south to Kalbarri, WA. The NWMR is a tropical carbonate margin that comprises an extensive area of shelf, slope, and abyssal plain/deep ocean floor, as well as complex areas of bathymetry such as plateau, terraces and major canyons (Harris et al. 2005). The NWMR experiences a tropical monsoonal climate towards the northern extent of the region, transitioning to tropical arid and subtropical arid within the central and southern areas of the region (DSEWPaC 2012b).

The EMBA also extends to the South-west Marine Region (SWMR) (Figure 7-1). The characteristics of both the NWMR and SWMR are summarised in Table 7-2.

Table 7-2: Key characteristics of the NWMR and SWMR

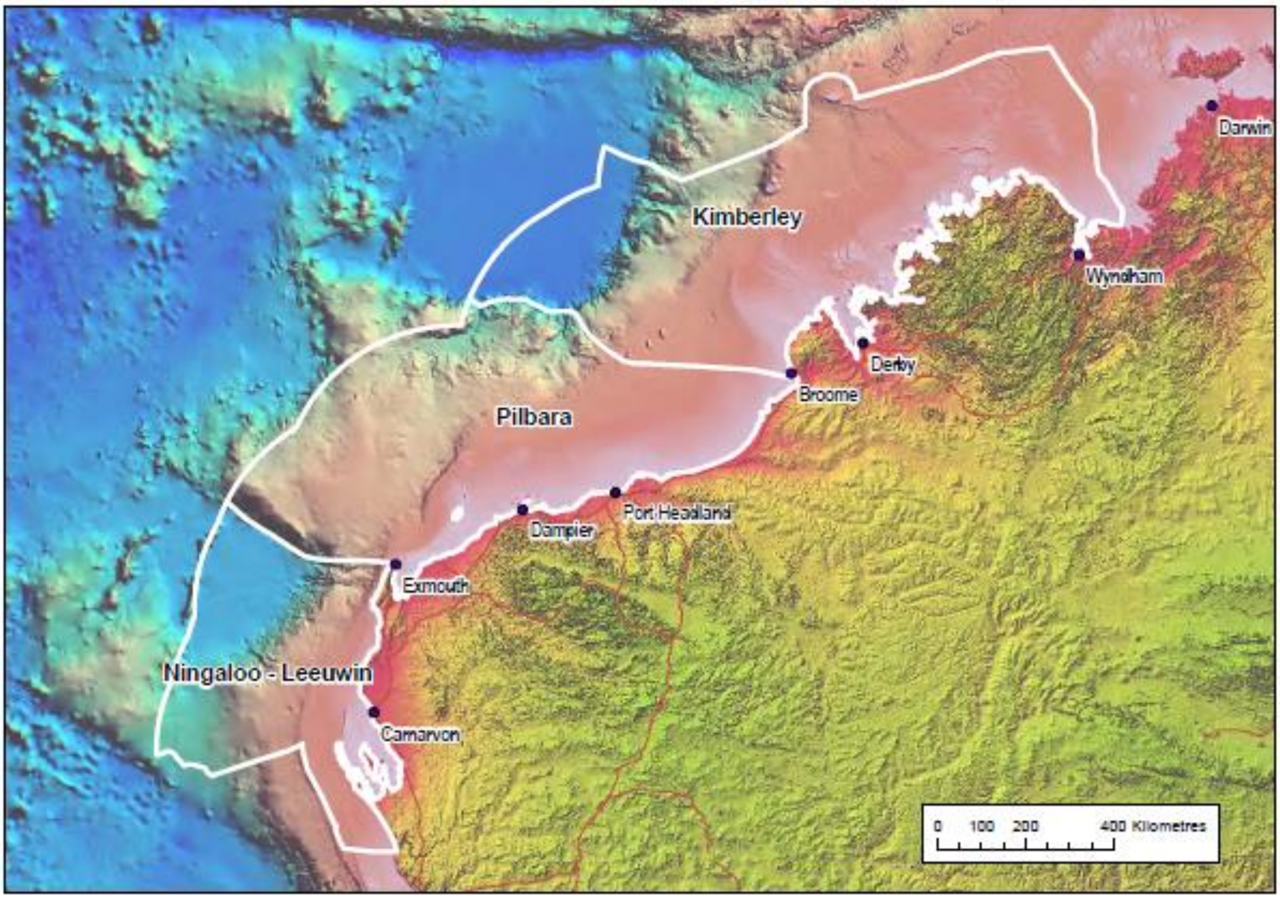
Bioregion	Key characteristics
North-west Marine Region	The NWMR experiences a tropical monsoonal climate towards the northern extent of the region, transitioning to tropical arid and subtropical arid within the central and southern areas of the region (DSEWPaC 2012b).
	The NWMR is part of the Indo–Australian Basin, the ocean region between the north-west coast of Australia and the Indonesian islands of Java and Sumatra. Dominant currents in the NWMR include the South Equatorial Current, the Indonesian Throughflow, the Eastern Gyral Current, and the Leeuwin Current (DEWHA 2007).
	The seafloor of the NWMR comprises four general feature types: continental shelf, continental slope, continental rise, and abyssal plain and is distinguished by a range of topographic features including canyons, plateaus, terraces, ridges, reefs, and banks and shoals.
South-west Marine Region	The SWMR contains both subtropical and temperate climates.
	The SWMR experiences complex and unusual oceanographic patterns, driven largely by the Leeuwin Current and its associated currents, which have a significant influence on biodiversity distribution and abundance.
	The major seafloor features of the SWMR include a narrow continental shelf on the west coast to the waters off south-west WA, and a wide continental shelf dominated by sandy carbonate sediments of marine origin in the Great Australian Bight. The SWMR also contains a steep, muddy continental slope, many canyons and large tracts of abyssal plains (DSEWPaC 2012c).

7.2.2 Marine Systems of the NWMR

The NWMR can be divided into three large-scale ecological marine systems, which are based on the influence of major ocean currents, seafloor features and eco-physical processes (Figure 7-2).

The Project Area is located within the Pilbara marine system (DEWHA 2007), a transitionary oceanographic region between the surface waters to the north (strongly influenced by the Indonesian Throughflow [ITF]) and those to the south (influenced by the Leeuwin Current).

Six subsystems (differentiated by depth) were identified in the Pilbara system. The Mid Shelf (60–100 m deep) and Outer Shelf (100–200 m deep) subsystems are relevant to the Project Area; Table 7-3 describes their distinctive features and key characteristics.



Source: (DEWHA 2007)

Figure 7-2: Marine systems of the NWMR

Table 7-3: Distinctive features and characteristics of Pilbara marine subsystems intersecting with the Project Area

Pilbara subsystem	Extent and distinctive features[1]	Description of subsystem characteristics[1]
Mid Shelf 60–100 m	Incorporates the mid shelf and waters between the 60 m and 100 m isobaths. Important features or species include: • Glomar Shoal • humpback whale southern migration (thought to be mostly inshore of the 100 m depth contour).	The edge of this subsystem marks a differentiation in sediments between the landward side of the 100 m isobath in comparison to deeper waters. Sediments in this subsystem comprise sands and gravels on cemented hard grounds. It is a reasonably barren substrate with 50% comprising relict reworked material (e.g. ooid old shoal) and hence there is little recent organic material. These substrates support a generally low biota. Rhodolith beds are known in this subsystem to depths of 90 m. Glomar Shoal's drowned reef is also located here and is believed to be a site of higher productivity, as evident in high catches of commercial fisheries in this area. The processes facilitating increased productivity at this location are not known. The waters are clear and the thermocline (and therefore chlorophyll maxima) intersects with the seafloor. Primary productivity is pelagic driven, but in the past would have included a significant benthic component, which has been removed/damaged by fishing trawling activities. Some recovery in benthic environments, particularly sponge communities, has resulted in their sparse distribution throughout the area.

Pilbara subsystem	Extent and distinctive features[1]	Description of subsystem characteristics[1]
		Internal waves are thought to provide some inflow of nutrients into the subsystem, as would the barotropic tide to a limited extent. The subsystem was described as comprising productivity fronts that form ‘lines’ of nutrients, which act as feeding routes for migratory species. Pelagic species feeding in the area include turtles, cetaceans, sharks and rays as well as fish species such as red emperor, rock cod, sweetlip, goatfish, trigger fish and threadfin bream. Benthic species would include foraminifera, bryozoans, molluscs and holothurians. Humpback whales on their southern migration would frequently traverse this subsystem. Trap and trawl fisheries are active in this subsystem.
Outer Shelf 100–200 m	Incorporates the outer shelf and waters between the 100 m and 200 m isobaths. Important features or species include: • ancient coastline at ~120 m isobath as a possible migratory pathway for cetaceans (e.g. humpback whales) and other pelagic species such as the whale shark.	The outer shelf is characterised as a seaward sloping surface. There is a change in gradient at the 120 m isobath, which marks the location of the ancient coastline and forms a prominent scarp through much of this subsystem. An absence of canyons on the outer shelf in the Pilbara system is also notable. The sediments of the outer slope comprise sands and gravels, transitioning to muds with increasing distance offshore. Planktonic material (planktic forams) and relict substrates, including calcified tubeworms, are also present. This subsystem is influenced by internal tides, which are thought to contribute to nutrient mixing in the water column and the movement of nutrients further offshore into deeper waters. Primary productivity is believed to be seasonal (associated with seasonality in internal tides) and is thought to be primarily pelagic. Detrital rain would transport some organic material to the seafloor; however, very few benthic living organisms are believed to exist in this subsystem. Characteristic pelagic fish species include deep goatfish, deep lizardfish, ponyfish, deep threadfin bream, adult trevally, billfish and tuna. Leatherback, olive ridley and loggerhead turtles, sharks and whale sharks would also occur in this subsystem. None of the turtle species are currently abundant in this subsystem, but these species occur and may be found further out as well. It was suggested by the workshop attendees (DEWHA 2007)that the ancient coastline is used by cetaceans, including migrating humpback whales, and perhaps other pelagic species (i.e. whale shark) and may be an area of enhanced productivity as well as a structural feature.

1. Source: (DEWHA 2007)

7.3 Matters of National Environmental Significance (EPBC Act)

Table 7-4 summarises the MNES overlapping the Project Area and EMBA. Note: The EPBC Act protected matters search tool (PMST) is a general database that conservatively identifies areas in which protected species or habitats have the potential to occur.

Additional information on these MNES are provided in the subsections referenced in Table 7-4.

Table 7-4: Summary of MNES identified as potentially occurring within the Project Area and EMBA

MNES	Number present		Relevant section
	Project Area	EMBA	
World Heritage Properties	0	2	Section 7.8.1
National Heritage Places	0	6	Section 7.8.2
Commonwealth Marine Area	1	2	Section 7.2, Figure 7-1

MNES	Number present		Relevant section
	Project Area	EMBA	
Wetlands of International Importance (Ramsar)	0	1	Section 7.8.4
Listed threatened ecological communities	0	0	Section 7.5.5
Listed threatened species		82	Section 7.6
Listed migratory species	38	97	Section 7.6

7.4 Physical Environment

7.4.1 Marine and Coastal Regionalisation

Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) (CoA 2006), the Project Area occurs within the Northwest Shelf Province provincial bioregion[27] (Figure 7-3). This bioregion is a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells, and internal tides (DEWHA 2008b). Its waters derive from the ITF, are warm and oligotrophic, and circulate throughout the bioregion via branches of the South Equatorial and Eastern Gyral Currents (DEWHA 2008b). Fish communities are diverse, and both benthic and pelagic fish communities appear to be closely associated with different depth ranges. Several seabird breeding sites are located in the bioregion (adjacent to Commonwealth waters), including Montebello and Barrow islands. The bioregion is important for the petroleum industry and commercial fishing operations (DEWHA 2008b).

[27] Provincial bioregions were developed based on geophysical characteristics and demersal fish diversity. Each 'province' represents regions of biotic endemism; 'transitions' occur between the provinces and are less well-defined mixing areas that capture the overlap of demersal fish species ranges between the provinces .

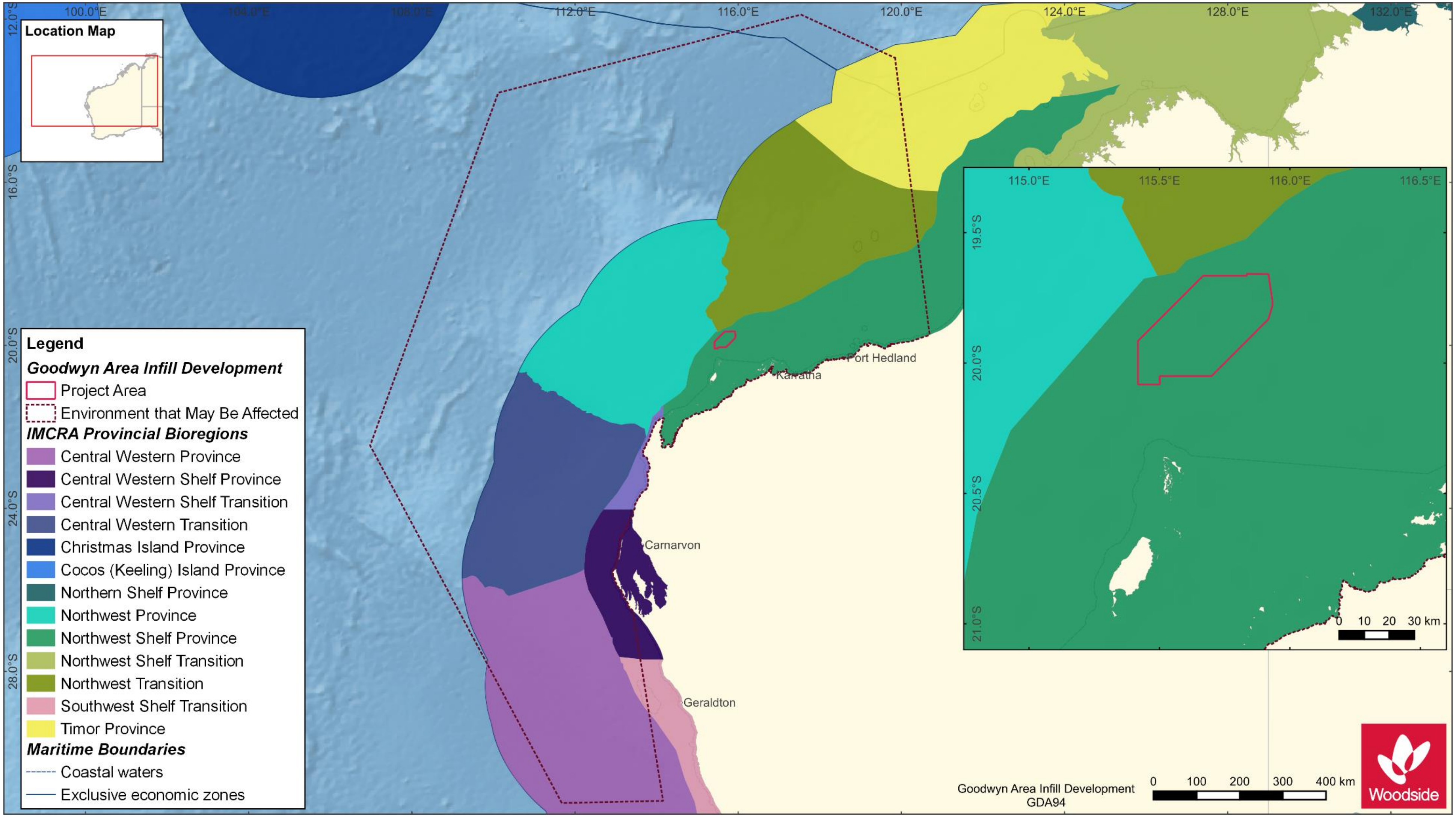


Figure 7-3: IMCRA provincial bioregions within the Project Area and EMBA

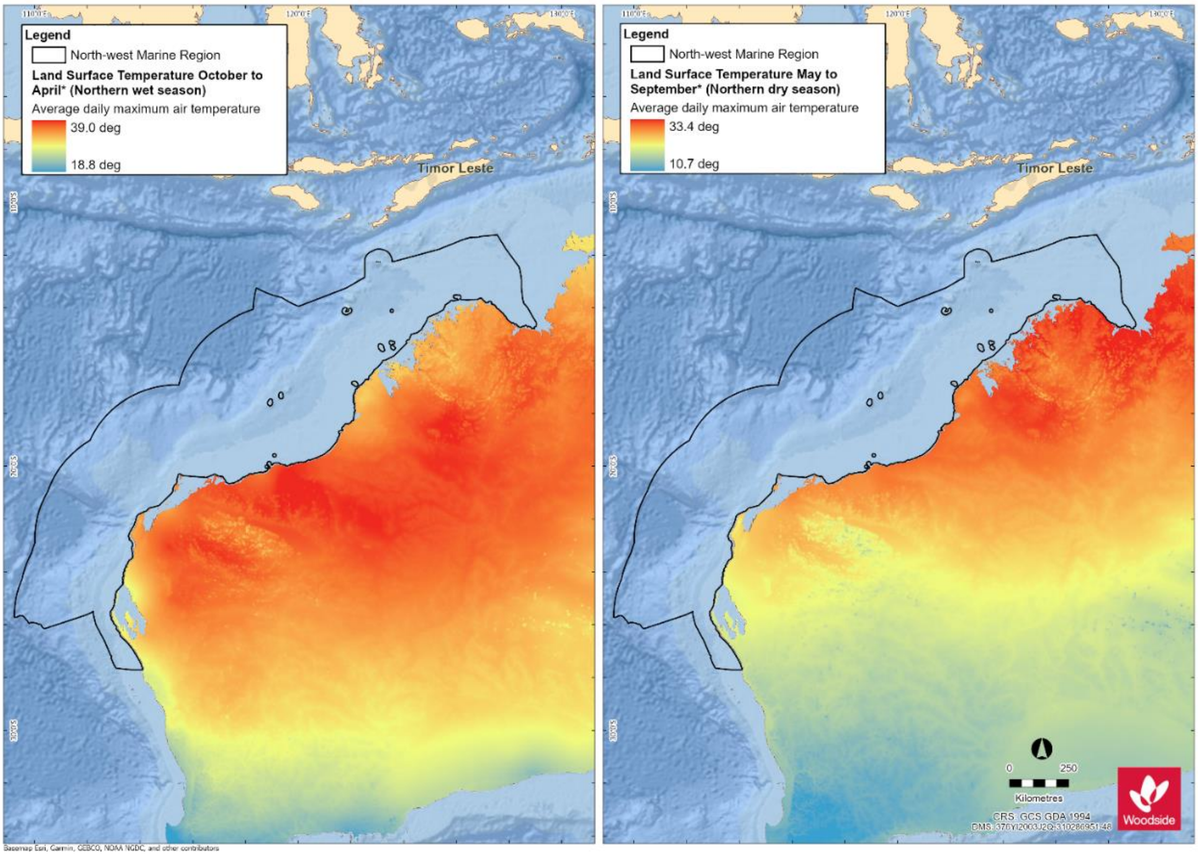
7.4.2 Meteorology and Oceanography

The NWMR is influenced by a complex system of ocean currents that change between seasons and between years, which generally result in its surface waters being warm, nutrient-poor, and of low salinity (DEWHA 2007). Table 7-5 summarises the NWMR's meteorology and oceanography.

Table 7-5: NWMR: Meteorology and oceanography summary

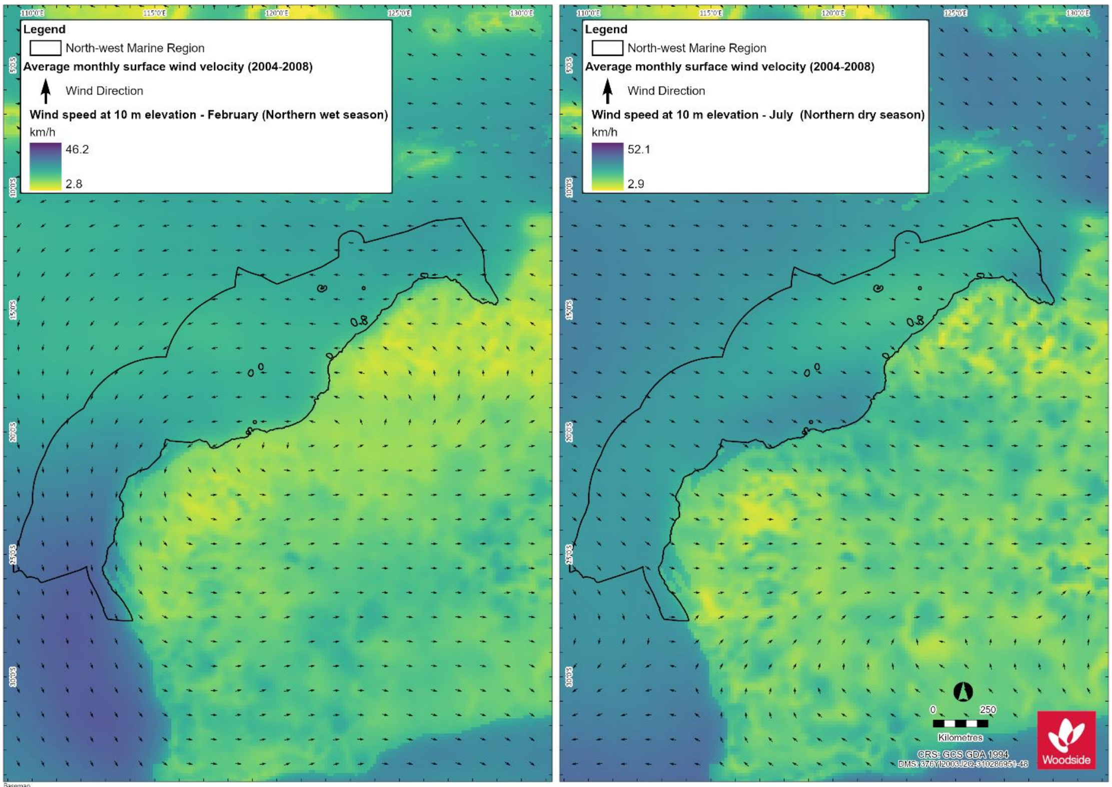
Feature	Description
Meteorology	
Seasonal patterns	The land mass of the Australian continent associated with the NWMR is characterised as a hot and humid summer climate zone. The broader NWMR experiences variations of a tropical or monsoon climate. In the far north-west (Kimberley), there is a hot summer season from December to March and a milder winter season between April and November. The Pilbara area has a tropical arid climate with high cyclone activity (DEWHA 2007). The Pilbara and North West Cape has a hot summer season from October to April and a milder winter season between May and September with transition periods between the summer and winter regimes. The NWS areas experience the monsoonal climate of the wider NWMR with a distinct wet and dry seasonal regime and transition periods between seasons.
Air temperature and rainfall	In summer (September to March), maximum mean temperatures at Barrow Island range from 27.2 ºC to 33.7 ºC, and during winter (May to July), minimum mean temperatures range from 17.5 ºC to 21.3 ºC (BoM 2023). Air temperatures, as measured at the North Rankin A platform, range from a maximum average of 39.5 ºC in summer to a minimum average temperature of 15.6 ºC in winter (Woodside 2012). Figure 7-4 shows seasonal air temperature for land adjacent to the NWMR. Rainfall in the NWMR typically occurs during the summer, with highest falls observed late in the season. Rainfall is often associated with the passage of tropical low-pressure systems and cyclones.
Wind	Wind patterns in north-west WA are dictated by the seasonal movement of atmospheric pressure systems. During summer, high-pressure cells produce prevailing winds from the north-west and south-west, which vary between 10 m/s and 13 m/s. During winter, high-pressure cells over central Australia produce north-easterly to south-easterly winds with average speeds of between 6 m/s and 8 m/s (Figure 7-5).
Tropical cyclones	The Pilbara (within the NWMR) experiences more cyclonic activity than any other region of the Australian mainland coast (Sudmeyer 2016). Tropical cyclone activity in the region typically occurs between November and April and is most frequent between December and March (i.e. considered the peak period), with an average of about one cyclone per month (Figure 7-6).
Oceanography	
Ocean temperature	Waters in NWMR are tropical year-round, with sea surface temperature in open shelf waters reaching ~26 °C in summer and dropping to ~22 °C in winter. Annually, nearshore temperatures (as recorded for the NWS area) fluctuate more widely, from ~17 °C in winter to ~31 °C in summer (CAPL 2010).
Currents	The major surface currents influencing north-west WA flow towards the poles and include the ITF, Leeuwin Current, South Equatorial Current, and the Eastern Gyral Current. The Ningaloo Current, Holloway Current, Shark Bay Outflow, and the Capes Current are seasonal surface currents in the region. Below these surface currents are several subsurface currents, the most important of which are the Leeuwin Undercurrent and the West Australian Current. These subsurface currents flow towards the equator in the opposite direction to surface currents (DEWHA 2007). Typically, there is a warm and well-mixed oligotrophic surface layer and a cooler and more nutrient-rich, deeper water layer (Menezes et al. 2013). The large-scale ocean currents of the NWMR, primarily the ITF, Leeuwin Current, and Holloway Current, are the primary influence on the NWS area. The ITF and Leeuwin Current are strongest during the late summer and winter. Flow reversals to the north-east (which are typically short-lived and weak) can occur when there are strong south-westerly winds and can generate localised upwelling on the shelf edge (Holloway and Nye 1985; James et al. 2004; Condie et al. 2006). The offshore waters of the NWMR are characterised by surface and subsurface boundary currents that flow along the continental shelf/slope, are enhanced by inflows from the ocean basins, and are an important conduit for the poleward heat and mass transport along the west coast (Wijeratne, Pattiaratchi, and Proctor 2018).

Feature	Description
Waves	Sea surface waves within the NWMR generally reflect the direction of the synoptic winds and flow predominantly from the south-west in the summer and from the east in winter (Pearce et al. 2003). The NWS within the NWMR is a known area of internal wave generation. Both internal tides and internal waves are thought to be more prevalent during summer months due to the increased stratification of the water column (DEWHA 2007). Along the continental slope of the NWMR, strong internal waves and interaction between semidiurnal tidal currents and seabed topographic features facilitates upwelling events and localised productivity events (Holloway 2001).
Tides	Tides on the NWS (NWMR) increase as the water moves from deep towards the shallower coast. The highest offshore tides are experienced at the border of the Browse and Canning basins. The smallest tides are experienced at the Exmouth Plateau, near the coast. NWS (NWMR) tides are predominantly semidiurnal (two highs and two lows each day), but with increasing importance of the diurnal (once per day) inequality at the southern and northern extremities of the NWS. The tidal range—represented by the Mean Spring Range (MSR)—increases northwards along the coast from 1.4 m at North West Cape (Point Murat) to 7.7 m at Broome, before decreasing again (apart from local amplification in King Sound and Collier Bay) to about 5 m off Cape Londonderry. The MSR then increases again through Joseph Bonaparte Gulf and on up to 5.5 m at Darwin (RPS MetOcean 2016).



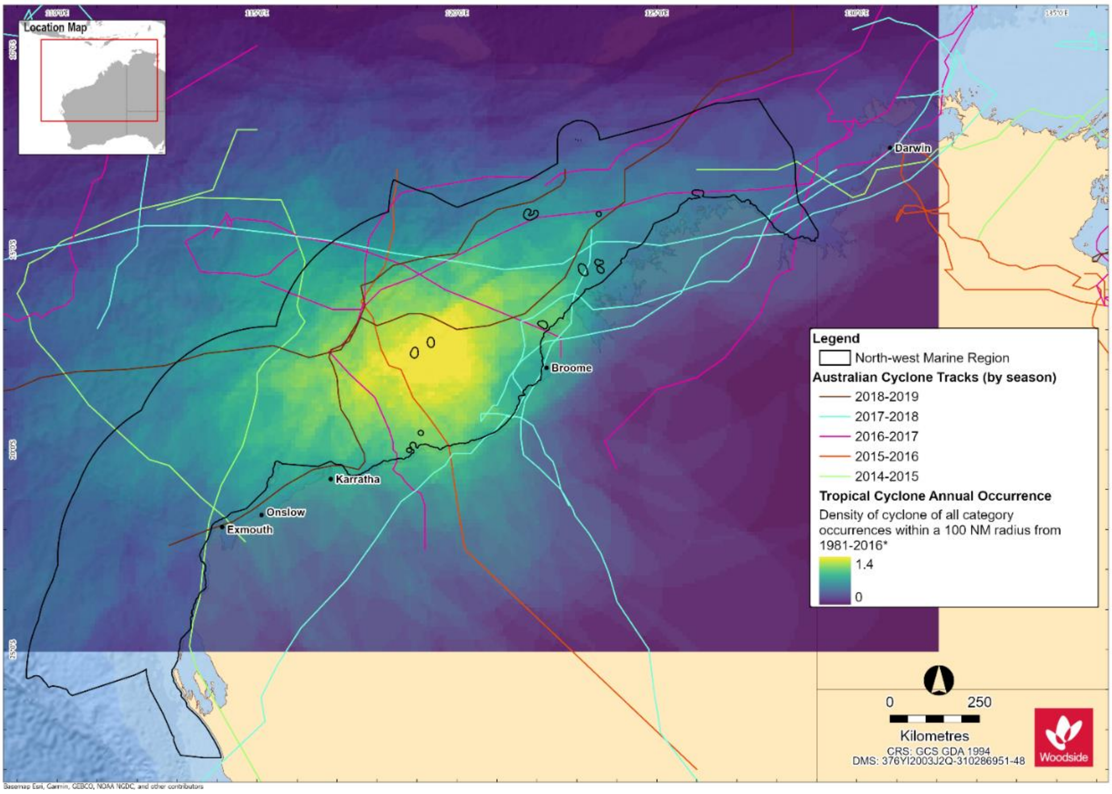
Source: (Woodside 2023b)

Figure 7-4: Average daily maximum air temperature for land surface adjacent to NWMR: (left) Oct–Apr (northern wet season) and (right) May–Sep (northern dry season)



Source: (Woodside 2023b)

Figure 7-5: Average monthly surface wind direction and velocity for NWMR: (left) February (northern wet season) and (right) July (northern dry season)



Source: (Woodside 2023b)

Figure 7-6: Tropical cyclone annual occurrence and cyclone tracks for NWMR

7.4.3 Geology and Geomorphology

The NWS seabed has a gentle (0.05°) seaward gradient extending to a steep distal slope occurring between 200 and 300 km offshore in water depths of around 200 m (Dix et al. 2005). The continental slope then descends more rapidly from the shelf edge to depths greater than 1,000 m to the north-west (James et al. 2004).

The Project Area lies on the outer continental shelf in waters ~20–180 m deep. The bathymetry within the Project Area is generally flat, which is consistent with the broader Northwest Shelf Province shelf region (Baker et al. 2008). Note: The Project Area does contain some shallow submerged features (Figure 7-7). The two shallowest features (<30 m water depth) correspond with Rankin Bank and Wilcox Shoal, which are described further in Section 7.5.3.6.

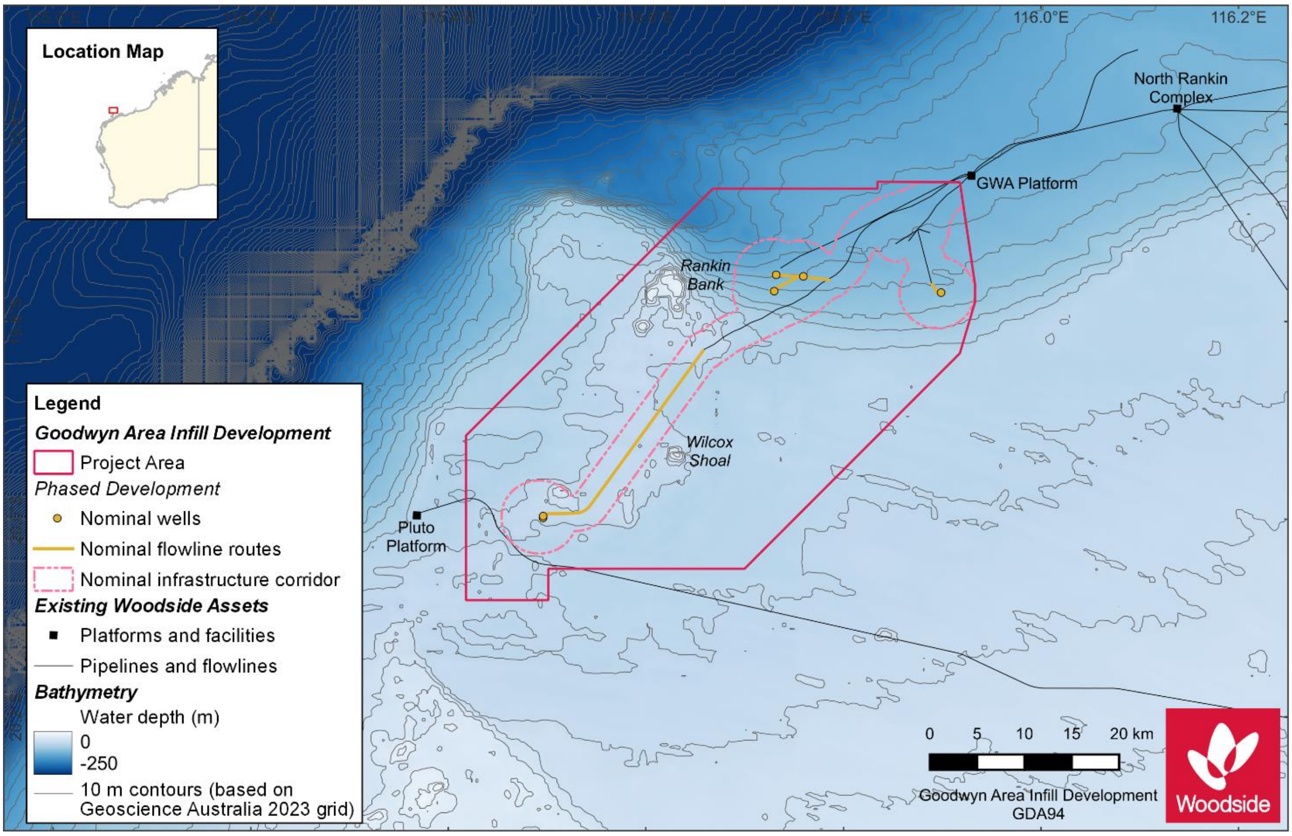


Figure 7-7: Seabed bathymetry within the vicinity of the Project Area

7.4.4 Water Quality

Marine water quality considers chemical, physical, and biological characteristics with respect to the water's suitability to support marine life, or for purposes such as swimming or fishing. Marine water quality can be measured by several factors, such as the concentration of dissolved oxygen, salinity, amount of material suspended in the water (turbidity or total suspended solids), as well as the concentration of contaminants such as hydrocarbons and heavy metals.

In the NWMR, water quality is regulated by the ITF, which plays a key role in initiating the Leeuwin Current and brings warm, low-nutrient, low-salinity water to the NWMR. It is the primary driver of the oceanographic and ecological processes in WA. Much of the surface water in this area is nutrient-poor and has low primary productivity.

Coastal waters of the Pilbara are turbid due to a combination of high tidal ranges and terrestrial run-off from rainwater, peaking during summer months (Human and McDonald 2009). Cyclones are a prevalent meteorological feature during summer that add to the turbidity (DEWHA 2008b).

Water quality in the Project Area is expected to reflect the offshore oceanic conditions of the wider WA coastal region, which has high water quality (except in ports and harbours, which can be locally influenced by industry effluent).

7.4.5 Marine Sediments and Sediment Quality

Marine sediments are the deposits of insoluble material found on the seafloor. These deposits can include rock and soil particles originating from adjacent land masses (terrigenous) or the remains of marine organisms (pelagic). They can also originate from volcanic sources beneath the surface of the ocean or from chemical precipitation processes that occur in the water column. The composition, distribution, and movement of marine sediments is an important component of a marine ecosystem. These sediments can influence the primary biological production in the water column as well as the evolution and distribution of marine habitats.

The NWMR comprises bio-clastic, calcareous, and organogenic sediments deposited from relatively slow and uniform sedimentation rates (Baker et al. 2008). Sediments in the region generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the continental slope and abyssal plain (Brewer et al. 2007).

Sediments in the Project Area are broadly consistent with those in the Northwest Shelf Province, with typically low levels of potential contaminants of geogenic origin (often below laboratory limits of detection), with the exception of localised areas of elevated barium (AIMS 2014b; 2019). The localised areas of elevated barium have been attributed to historical drilling activities (AIMS 2014b; 2019), as barite (barium sulfate) is commonly used in drilling fluids. Sediments in the outer Northwest Shelf Province are relatively homogenous and typically are dominated by sands and a small portion of gravel (Baker et al. 2008). Fine sediment size classes (e.g. muds) increase closer to the shoreline and the shelf break but are less prominent on the continental shelf (Baker et al. 2008). Carbonate sediments typically account for the bulk of sediment composition, with both biogenic and precipitated sediments present on the outer shelf (Dix et al. 2005). Beyond the shelf break, the proportion of fine sediments increases along the continental slope towards the Exmouth Plateau and the abyssal plain (Baker et al. 2008).

Based on a national seafloor sediment database for the Australian region (CSIRO 2015), the predominant seabed type at the Project Area is calcareous ooze (Figure 7-8).

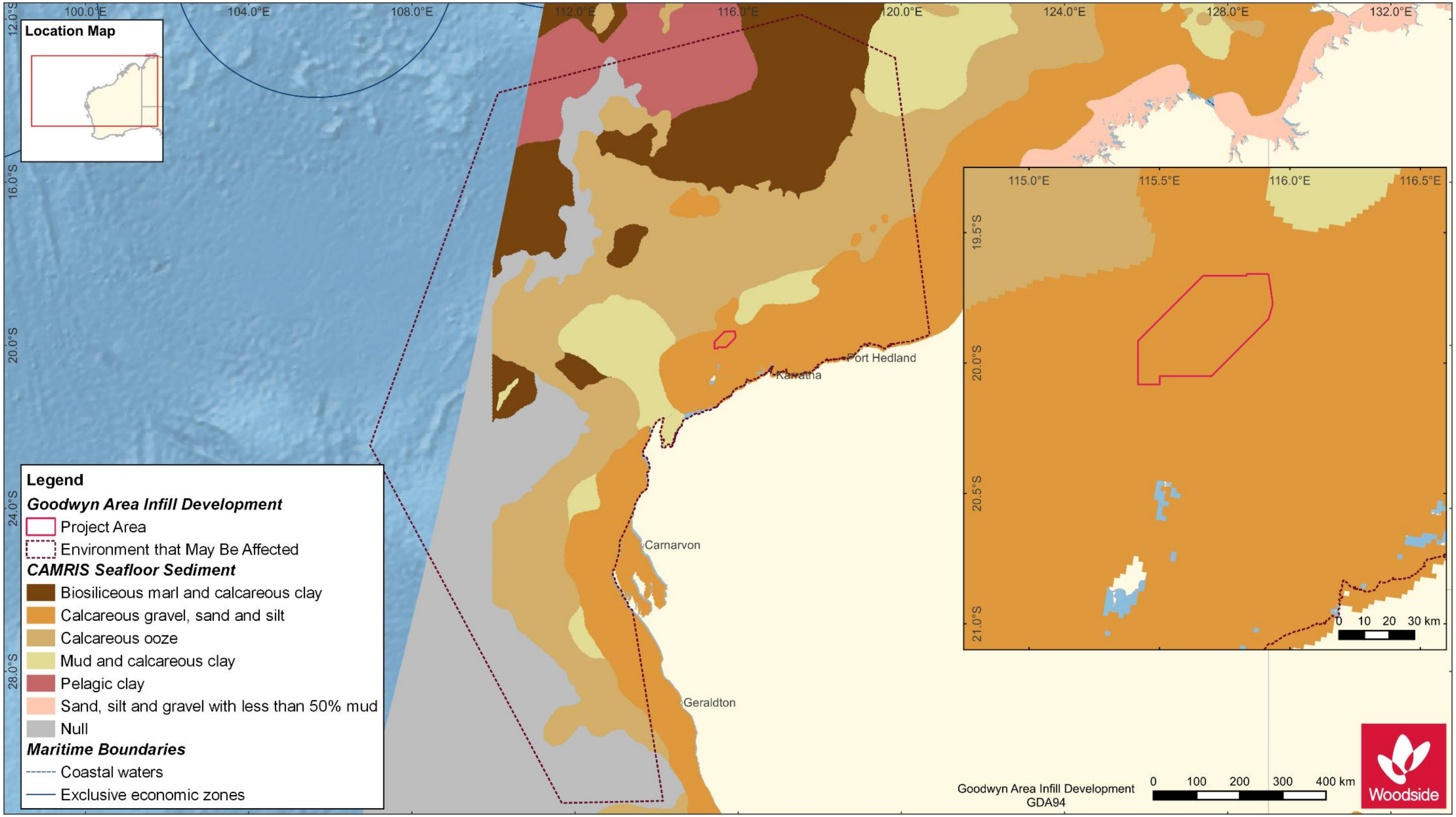


Figure 7-8: Benthic substrate within the Project Area and EMBA

7.4.6 Air Quality

There is a lack of air quality data for the greater offshore NWMR airshed. However, the area is very remote relative to other areas of Australia and globally and therefore air quality in nearshore and offshore waters of the Pilbara area is considered high.

Due to the extent of the open ocean area and the activities that are currently undertaken within the NWS, it is considered the ambient air quality in the Project Area, EMBA, and wider offshore NWMR will be high.

7.5 Habitat and Biological Communities

The NWMR habitats range from nearshore benthic primary producer habitats (e.g. seagrass beds, coral communities, and mangrove forests) to offshore soft sediment seabed habitats and submerged and emergent reef systems. These habitats support biological communities that range from low-density sessile and mobile benthos, such as sponges, molluscs, and echinoids (with noted areas of sponge hotspot diversity) in offshore soft sediment habitat (DSEWPaC 2012b) to complex, diverse, remote coral reef systems.

7.5.1 Biological Productivity

Primary productivity of the NWMR is generally low and appears to be largely driven by offshore influences (Brewer et al. 2007), with periodic upwelling events and cyclonic influences driving coastal productivity with nutrient recycling and advection. Seasonal weather patterns also influence the delivery of nutrients from deep water to shallow water. Cyclones and north-westerly winds during the north-west monsoon (approximately November–March) and the strong offshore winds of the south-east monsoon (approximately April–September) facilitate the upwelling and mixing of nutrients from deepwater to shallow-water environments (Brewer et al. 2007).

The ITF has an important effect on productivity in the northern areas of the NWMR. Generally, its deep, warm, and low-nutrient waters suppress upwelling of deeper comparatively nutrient-rich waters, thereby forcing the highest rates of primary productivity to occur at depths associated with the thermocline. When the ITF is weaker, the thermocline lifts, bringing deeper, more nutrient-rich waters into the photic zone, resulting in conditions favourable to increased productivity (DEWHA 2007). Similarly, the Leeuwin Current has a significant role in determining primary productivity in the southern areas of the NWMR. As with the ITF, the overlying warm oligotrophic waters of the Leeuwin Current suppress upwelling. Therefore, a subsurface chlorophyll maximum is formed at a depth in the water column where nutrients and light are sufficient for photosynthesis to proceed. Seasonal changes in the strength of the Leeuwin Current influence primary productivity levels and seasonal interactions between the Leeuwin and Ningaloo currents in the south of the NWMR are believed to be particularly important (DEWHA 2007).

Water depth also has a significant overriding influence over productivity in the marine environment, due to its influence on light availability. This is reflected by distinct onshore and offshore assemblages of major pelagic groups of phytoplankton, microzooplankton, mesoplankton, and ichthyoplankton. Productivity blooms are thought to be triggered by seasonal changes to physical drivers or episodic events, which result in rapid increases in primary production over short periods, followed by extended periods of lower primary production. The trophic systems in the NWMR are able to take advantage of blooms in primary production, enabling nutrients generated to be used by different groups of consumers over long periods (DEWHA 2007).

Little detailed information is available about the trophic systems in the NWMR. The usage of available nutrients is thought to differ between pelagic and benthic environments, influenced by water depth and vertical migration of some species groups in the water column. In the pelagic system, it is thought that approximately half the available nutrients are used by microzooplankton (e.g. protozoa) with the remainder going to macro/meso-zooplankton (e.g. copepods). As primary and secondary consumers, gelatinous zooplankton (e.g. salps, coelenterates) and jellyfish are thought to play an important role in the food web, contributing a significant proportion of biomass in the marine system during and after blooms in primary productivity. Salps are semi-transparent, barrel-shaped marine animals that can reproduce quickly in response to bursts in primary productivity; they provide a food source for many pelagic fish species (DEWHA 2007).

7.5.2 Planktonic Communities

The NWMR has two distinct phytoplankton assemblages—a tropical oceanic community in offshore waters, and a tropical shelf community confined to the NWS (Hallegraeff 1995). Moderate Resolution Imaging Spectrometer (MODIS) satellite datasets from the NWMR indicates that chlorophyll (and thus phytoplankton) levels are low in summer months (December–March) and higher in the winter months (Schroeder et al. 2009). Low chlorophyll levels during summer may be a result of lower plankton productivity or lower nutrient inputs from warm surface waters dominant during those months. However, it is likely that much of the primary production takes place below the surface, where the MODIS imagery does not penetrate (Schroeder et al. 2009). The winter months are relatively cloud free and surface chlorophyll is high throughout most of the region.

Zooplankton may include organisms that complete their lifecycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals, and molluscs. Peaks in zooplankton such as during primary and secondary mass coral spawning events (typically March–April and September–November) (Rosser and Gilmour 2008) and fish larvae abundance (Harris et al. 2005) can occur throughout the year. Spatial and temporal patterns in the distribution and abundance of macrozooplankton on the NWS are influenced by sporadic climatic and oceanographic events, with large interannual (year on year) changes in assemblages (Wilson, Carleton, and Meekan 2003). Amphipods, euphausiids, copepods, mysids and cumaceans are among the most common components of the zooplankton in the region (Wilson, Carleton, and Meekan 2003).

Plankton communities within the NWS are expected to reflect conditions of the NWMR. Internal tides along the NWS and Exmouth Plateau result in the drawing of deeper cooler waters into the photic zone, stirring up nutrients and triggering primary productivity. Broadly, the greatest productivity within this subsystem is found around the 200 m isobath associated with the shelf break.

7.5.3 Offshore Habitats and Biological Communities

The key offshore habitats and biological communities representative of the broader NWMR are summarised in the subsections below.

7.5.3.1 Soft sediment with infauna

The predominant habitat within the Project Area is expected to be soft sediment with infauna communities.

The offshore environment of the NWMR is mainly seabed habitats dominated by soft sediments (sandy and muddy substrata with occasional patches of coarser sediments) and sparse benthic biota. The benthic communities inhabiting the predominantly soft, fine sediments of the offshore habitats are characterised by infauna such as polychaetes, and sessile and mobile epifauna such as crustacea (shrimp, crabs and squat lobsters) and echinoderms (starfish, sea cucumbers). Typically, the density of benthic fauna is lower in deep-sea sediment habitats (greater than 200 m) than in shallower coastal sediment habitats, but the diversity of communities may be similar.

7.5.3.2 Soft sediment with hard substrate outcropping

This seafloor habitat combines both soft sediment and hard substrates, including outcrops, terraces, continental slope, and escarpments. This habitat is found in offshore areas of the NWMR.

Hard substrates are often associated with key ecological features (KEFs; e.g. the ancient coastline at 125 m depth contour [Section 7.7], which intersects with the north-east Project Area).

7.5.3.3 Coral Reef

Coral reef habitats within the NWMR have a high species diversity that includes corals and associated reef species such as fishes, crustaceans, invertebrates, and algae. Coral reef habitats of the offshore environment of the NWMR include remote oceanic reef systems, large platform reefs, submerged banks and shoals.

Hard (zooxanthellate) corals are typically found in shallow waters and are unlikely to be found in the Project Area (except at shallow banks and shoals as described in Section 7.5.3.6).

Soft (azooxanthellate) corals are found at most depths, but they need to attach to hard substrate. Hard substrate outcropping, if it does occur within the Project Area, is not expected to be a dominant substrate.

Examples of the presence of offshore coral reef habitat in the EMBA include Rowley Shoals (including Mermaid Reef, Clerke Reef, and Imperieuse Reef).

7.5.3.4 Seagrass and Macroalgae Communities

Seagrass beds and benthic macroalgae reefs are a main food source for many marine species and also provide key habitats and nursery grounds (Heck, Hays, and Orth 2003; Wilson et al. 2010).

In the northern half of WA these habitats are restricted to sheltered and shallow waters, including around offshore reef systems, due to large tidal movement, high turbidity, large seasonal freshwater run-off and cyclones. Seagrasses are generally found in coastal waters at depths of <10 m, although they have been recorded at ~50 m in some Australian waters. It is highly unlikely that seagrasses will be present in the Project Area, mainly due to light attenuation.

Macroalgae require a hard substrate, sufficient light, and water clarity to survive, and are generally limited to shallow water. It is unlikely that macroalgae will be present in the Project Area, due to light attenuation and lack of suitable substrate.

Examples of the presence of offshore seagrass and macroalgae habitat in the EMBA include Rowley Shoals (including Mermaid Reef, Clerke Reef, and Imperieuse Reef).

7.5.3.5 Filter Feeders

Filter-feeding epifauna (e.g. sponges, ascidians, soft corals and gorgonians) are animals that feed by actively filtering suspended matter and food particles from water by passing the water over specialised filtration structures (DEWHA 2008b). Filter feeders generally live in areas that have strong currents and hard substrates. Hard substrate outcropping, if it does occur within the Project Area, is not expected to be a dominant substrate. Hard substrates are often associated with KEFs (e.g. the ancient coastline at 125 m depth contour [Section 7.7], which intersects with the north-east Project Area) or shallow banks and shoals (as described in Section 7.5.3.6).

7.5.3.6 Shoals, Banks, and Reefs

Shallow submerged bathymetry features within the Project Area have been identified; those that occur at ≤50 m depth are shown in Figure 7-9.

Rankin Bank and Wilcox Shoal are located within the Project Area (Figure 7-9), and features within the EMBA include Glomar Shoal; these three features are described in the following subsections

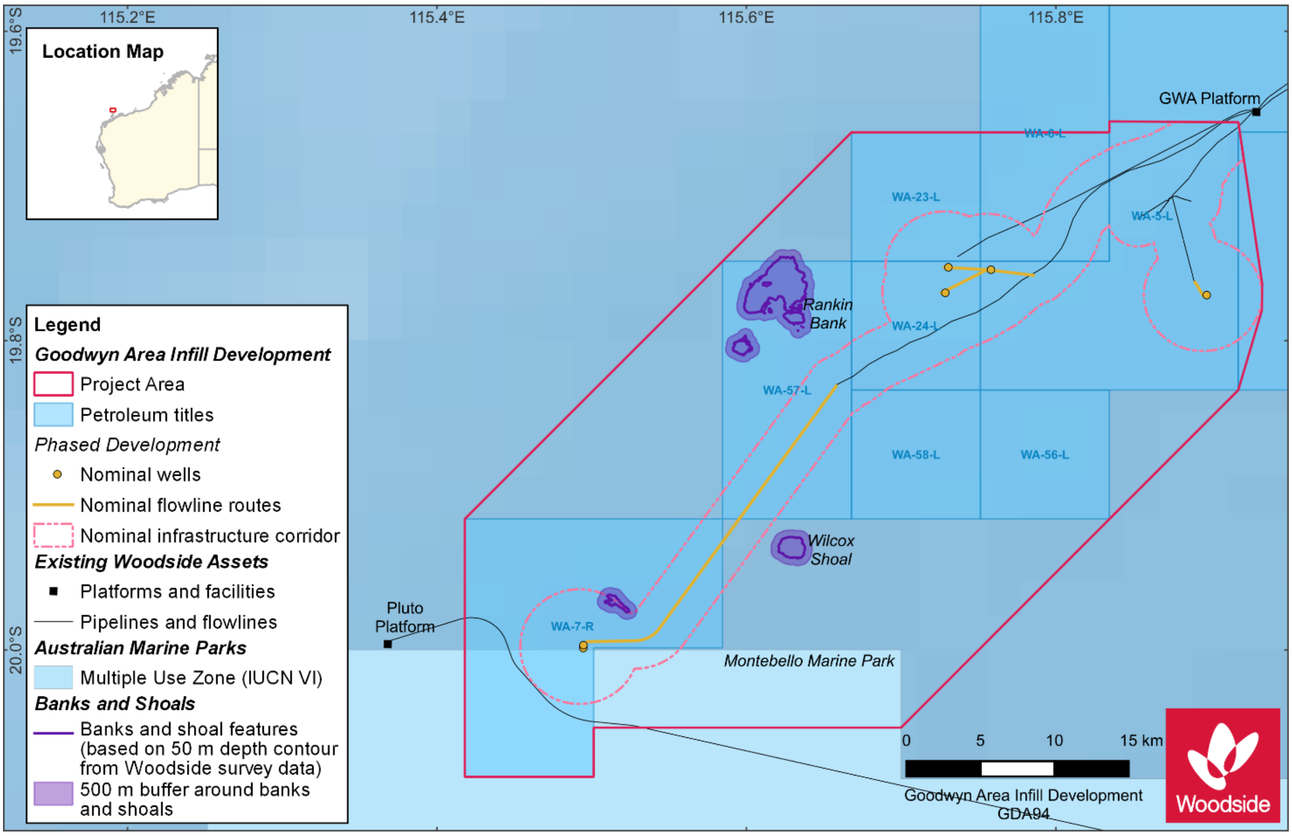


Figure 7-9: Banks and shoals within the Project Area

7.5.3.6.1 Rankin Bank

Rankin Bank is on the continental shelf, ~5 km north-west of the proposed tie-in to LPA (Figure 7-9). Although it is not a KEF, Rankin Bank, along with Glomar Shoal, are large and complex bathymetric features on the outer western shelf of the Pilbara and represents habitats that are likely to play an important role in the productivity of the Pilbara region (AIMS 2014a). Rankin Bank comprises three submerged shoals delineated by the 50 m depth contour, with water depths of ~18–30.5 m (AIMS 2014a).

Rankin Bank has a diverse marine environment, predominantly comprising consolidated reef and algae habitat (~55% cover at depths of <40 m), followed by hard corals (~25% cover at depths of <40 m), unconsolidated sand/silt habitat (~16% cover with increasing prevalence at depth), and benthic communities comprising macroalgae, soft corals, sponges and other invertebrates (~3% cover) (AIMS 2014a). Hydrocarbon and trace metal concentrations in sediments indicate the bank has not been affected by anthropogenic pollution (AIMS 2014a). Hard corals are a significant component of the benthic community of some parts of the bank, with abundance in the upper end of the range observed elsewhere on the submerged shoals and banks of north-west Australia (Heyward et al. 2012).

Rankin Bank supports a diverse fish assemblage (AIMS 2014a), consistent with studies showing a strong correlation between habitat diversity and fish assemblage species richness (Gratwicke and Speight 2005; Last et al. 2005). Fish abundance and diversity at Rankin Bank are comparable within other reefs in north-west Australia, and notably twice as abundant and 1.5 times more diverse than that identified in a comparable survey at Glomar Shoal (Abdul Wahab et al. 2018). A total of 205 fish species were recorded at Rankin Bank, 100 of which were common to both Glomar Shoal and Rankin Bank. Depth, location, sand, sponges, and hard coral were all found to contribute to the fish communities present. Specifically, fish communities were primarily associated with hard coral and shallow depths at Rankin Bank (Abdul Wahab et al. 2018) indicating diverse and abundant site-attached fish assemblages (AIMS 2019).

The habitat surrounding Rankin Bank (<50 m) was mapped by AIMS on behalf of Woodside (AIMS 2014b) and hosts filter-feeding communities in areas of consolidated substrate interspersed by sand.

7.5.3.6.2 Glomar Shoal

Glomar Shoal is a large (~215 km^2) and complex bathymetric feature situated on the outer continental shelf off the Pilbara coast. Glomar Shoal is ~8.5 times wider than Rankin Bank at the 60 m contour. Glomar Shoal is a shallow sedimentary bank comprising coarser biogenic material than the surrounding seabed. The shoal is ~26–70 m below the sea surface (Falkner et al. 2009b) and is ~60 km east of the Project Area. Glomar Shoal has been identified as a KEF for its high productivity and aggregations of marine life (Falkner et al. 2009b). This KEF encompasses a wider area than the shoal feature itself. Together with Rankin Bank, these remote shallow-water areas represent regionally significant habitats and are considered likely to play an important role in the productivity of the Pilbara region (AIMS 2014a; Abdul Wahab et al. 2018).

Glomar Shoal has a high percentage of marine-derived sediments with high carbonate content and gravels of weathered coralline algae and shells (McLoughlin and Young 1985) The area’s higher concentrations of coarse material compared to surrounding areas are indicative of a high-energy environment subject to strong seafloor currents (Falkner et al. 2009b). Cyclones are also frequent in this area and stimulate periodic bursts of productivity because of increased vertical mixing (Abdul Wahab et al. 2018). Studies by Abdul Wahab et al. (2018) found several hard coral and sponge species in water depths <40 m. A total of 170 different species of fish were detected, with greatest species richness and abundance in shallow hard coral habitats (Abdul Wahab et al. 2018). Fish species present include various commercial and recreational targeted species such as Rankin cod, brownstripe snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish (Falkner et al. 2009a; Fletcher and Santoro 2009). These species have recorded high catch rates, indicating that the shoals are likely to be an area of high productivity.

In general, the fish abundance and diversity of Glomar Shoal are considered comparable with other reefs and the submerged shoals and banks in the region, although less diverse and abundant than fish assemblages at Rankin Bank (Abdul Wahab et al. 2018).

7.5.3.6.3 Wilcox Shoal

Wilcox Shoal is ~1 km south-east of the phased development nominal infrastructure corridor (Figure 7-9). Coarse-scale bathymetry indicates the top of the shoal is ~39 m deep, and the shoal has an area of ~2.84 km^2 bounded by the 60 m contour (AIMS 2023). The north and north-eastern side has a steep slope dropping from 40 m down to 75 m, while the southern side of the shoal has a gentler slope and a long plateau out to the 70 m contour (AIMS 2023).

Based on other shoal features on the NWS, it is known that diverse benthic communities can occur across the equivalent depth range of Wilcox Shoal (AIMS 2023). While Wilcox Shoal is currently unsurveyed[28], based on the bathymetry it is considered that the upper reaches of the shoal may support a high cover of benthic organisms comprising mixed hard and soft corals, transitioning to a deeper water benthic community comprising soft corals and mixed biota (sponges, other sessile invertebrate biota).

The biodiversity value of the coral-dominated mesophotic coral ecosystems and associated abundance and diversity of the fish communities have been documented for Rankin Bank and Glomar Shoal (Abdul Wahab et al. 2018) and, given its proximity to Rankin Bank, it is considered possible that Wilcox Shoal has similar biodiversity values. However it is noted that shoal fish communities vary with many factors including substratum type, seabed complexity and depth, and

[28] Environmental monitoring of Wilcox Shoal is proposed to be undertaken in the future—refer to Appendix C for preliminary scope and objectives.

considerable variation in communities among shoals, even those in close relatively proximity has been observed on the NWS (AIMS 2023).

7.5.3.7 Montebello Marine Park

The Project Area extends ~5–9 km into the northern extent of the Montebello Marine Park (Section 7.8.6).

An ROV survey within the northern extent of the Montebello Marine Park was undertaken in 2019 to characterise the benthic habitats and communities (Advisian 2019). Video imagery was collected from transects, and the habitat was classified in accordance with the Collaborative and Automated Tools for the Analysis of Marine Imagery (CATAMI) classification system. Five areas within the Montebello Marine Park were surveyed, of which three (Area 2, Area 3, Area 4) are within or near the Project Area (Figure 7-10). Water depths in the three areas were very similar, with the midpoints depth of transects ranging from ~70–78 m. The survey findings are summarised in Table 7-6.

Table 7-6: Summary of benthic habitat and communities in the northern Montebello Marine Park

Area	Summary description[1]	Example ROV footage
2	• The seafloor was relatively flat and sandy with a light to high cover of unconsolidated biologenic gravel and/or organic material. Small undulations of the seabed were seen but no other regular bedforms such as sand ripples or sand waves were apparent. • No significant high relief habitat features, or areas of consolidated hard substrate, were observed in any transect. • Some areas of seafloor were relatively bare while others included a low (~5%) to high (~80%) density cover of benthic organisms. This benthic cover changed continually and often (within metres) over each transect. Benthic fauna comprised a diverse array of sponges and corals with varying forms, sizes and colours. Hydroids and cnidarians were also apparent on occasion. • Bioturbation of the seafloor in the form of small cones, craters, burrows, small and large trails was also apparent. Mobile organisms including fish, echinoderms and jellyfish, were also noted on the videos.	 
3	• The seafloor in Area 3 was relatively flat and sandy with a light to high cover of biologenic gravel and/or organic material over its entire length (continually changing). Small undulations of the seabed and some small sand waves were present on occasion, but no other regular bedforms such as sand ripples or sand waves were apparent. • No significant moderate or high relief habitat features were observed on the video or can be seen on the transect maps with detailed bathymetry. Any features seen are ~1 m high and occur over relatively large scales. • The seabed was a mosaic of bare substrate and low (~5%) to high (~75%) density cover of benthic organisms (e.g. sponges, corals). Benthic fauna comprised a diverse array of sponges and corals with varying forms, sizes and colours. Hydroids	

Area	Summary description[1]	Example ROV footage
	and cnidarians were also apparent on occasion along the transect length. • Bioturbation of the seafloor in the form of small cones, craters, burrows and small and large trails was apparent. Mobile organisms including fish, echinoderms and jellyfish were also noted on the videos. Fish fauna diversity was quite high, and varying sizes of fish were seen amongst the aggregations of corals and sponges and also over bare sandy seafloor.	
4	• The seafloor within Area 4 was typically flat sand with a high level of biologenic gravel of unknown origin. Small mounds, waves and undulations all <50 cm high were seen on occasion, mainly around aggregations of benthic epifauna (i.e. sponges and corals). • No significant moderate or high relief features or significant areas of consolidated hard substrate were present in Area 4 that could be seen on the video or transect maps. • The seafloor was scattered with sponges and corals of varying forms and sizes; these occurred as individuals with a low-density cover (~5%) up to more dense clusters (~50%). Other benthic epifauna included echinoderms and cnidaria. Mobile fauna (mainly small bony fishes) were most common around the larger clusters of sponges and corals. • Areas of bare sand occurred amongst the patches of epifauna. The switch between bare sand and benthic cover changed constantly and over short distances. • Bioturbation of the seafloor in the form of small mounds and craters was evident along the entire transect length.	 

1. Source: (Advisian 2019)

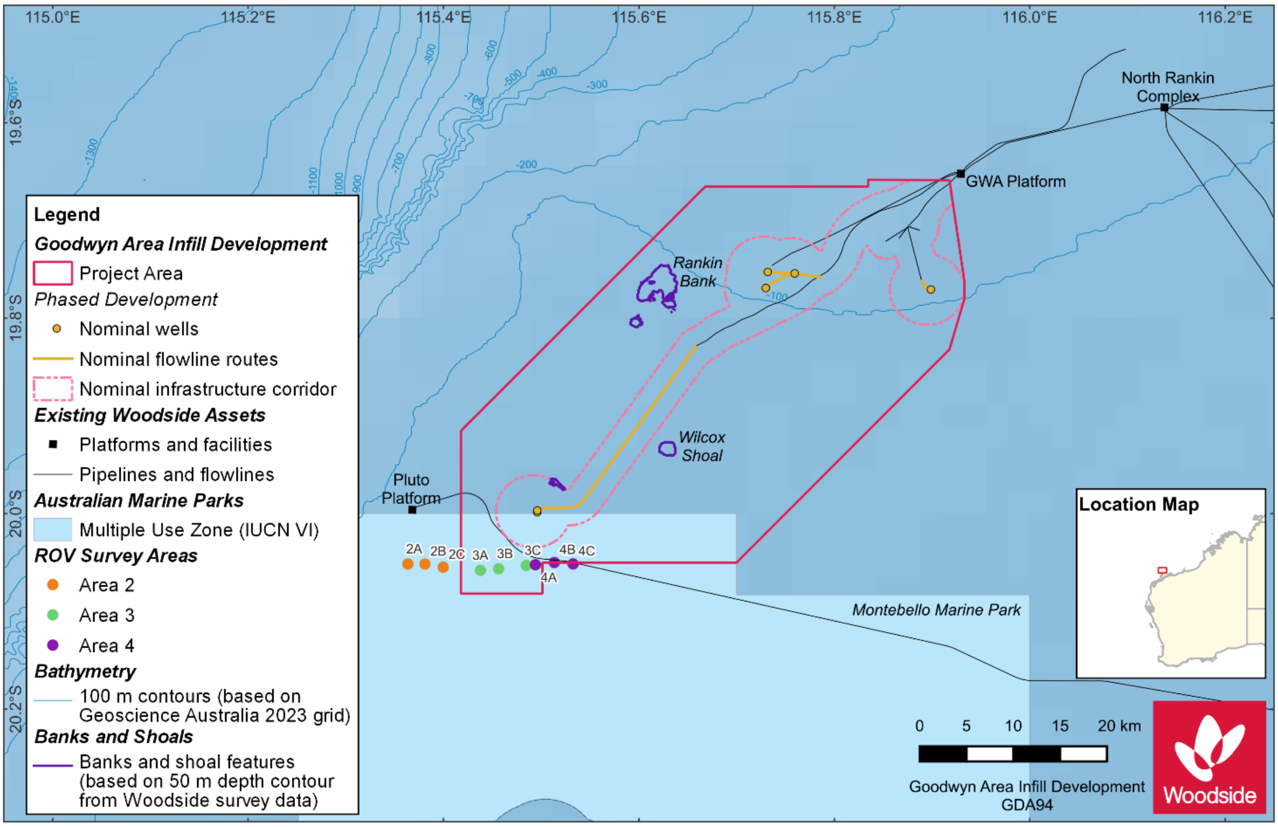


Figure 7-10: Benthic habitat transect locations

7.5.4 Nearshore and Coastal Habitats and Biological Communities

The EMBA encompasses offshore and coastal waters, islands and mainland shoreline habitats typified by mangroves, tidal flats, saltmarshes, sandy beaches, and smaller areas of rocky shores. Each shoreline type has the potential to support different flora and fauna assemblages due to the different physical factors (e.g. waves, tides, light) influencing the habitat.

Table 7-7 summarises the key shoreline habitats representative of the broader EMBA.

Table 7-7: Nearshore and coastal habitats and biological communities within the NWMR

Habitat or community	Description	Example(s) of presence within the EMBA
Coral reef	Coral reef habitats typically found in nearshore regions of the NWMR include the fringing reefs around coastal islands and the mainland shore.	Dampier Archipelago Montebello, Lowendal, and Barrow islands Ningaloo Reef Houtman Abrolhos Islands
Seagrass and macroalgae communities	Seagrass beds and benthic macroalgae reefs are a main food source for many marine species and provide key habitats and nursery grounds (Heck, Hays, and Orth 2003; Wilson et al. 2010). In the nearshore areas of the NWMR, these habitats—which include bays, sounds and around reef and island groups—are restricted to sheltered and shallow waters due to large tidal movement, high turbidity, large seasonal freshwater run-off and cyclones.	Dampier Archipelago Montebello, Lowendal, and Barrow islands Ningaloo Reef Houtman Abrolhos Islands
Filter feeders	Filter-feeding epifauna (e.g. sponges, ascidians, soft corals and gorgonians) are animals that feed by actively filtering suspended matter and food particles from water by passing the water over specialised filtration structures (DEWHA 2007). Filter feeders generally live in areas that have strong currents and hard substratum. Conversely, higher diversity infauna are mainly associated with soft unconsolidated sediment. Infauna communities are considered widespread and well represented along the continental shelf and upper slopes of the NWMR. In nearshore areas of the NWMR, these species are generally found around reef systems.	Deeper habitats of Ningaloo Reef Houtman Abrolhos Islands
Mangroves	Mangroves grow in intertidal mud and sand. They have specially adapted aerial roots (pneumatophores) that provide for gas exchange during low tide (McClatchie et al. 2006). Mangrove forests can help stabilise coastal sediments, provide a nursery ground for many species of fish and crustaceans, and provide shelter or nesting areas for seabirds (McClatchie et al. 2006). Mangroves are confined to shoreline habitats, in nearshore areas of the NWMR.	Pilbara coast (including Ashburton River Delta, Coolgra Point, Robe River Delta, Yardie Landing, Yammadery Island and the Mangrove Islands) Montebello, Lowendal, and Barrow islands Mangrove Bay, North West Cape peninsula
Saltmarshes	Saltmarsh communities, which are confined to shoreline habitats, are typically dominated by dense stands of halophytic plants such as herbs, grasses, and low shrubs. The diversity of saltmarsh plant species increases with increasing latitude. The vegetation in these environments is essential to the stability of the saltmarsh, because it traps and binds sediments. The sediments are generally sandy silts and clays and can often have high organic material content.	Eighty Mile Beach
Sandy beaches	Sandy beaches are dynamic environments, naturally fluctuating in response to external factors (e.g. waves, currents). Sandy beaches vary in length, width and gradient, and in sediment type, composition, and grain size. Sandy beaches are important for both resident and migratory seabirds and shorebirds, and can also provide important habitat for turtle nesting and breeding.	Eighty Mile Beach Dampier Archipelago Montebello, Lowendal, and Barrow islands, inshore Pilbara islands

7.5.5 Threatened Ecological Communities

The Project Area and EMBA do not intersect with any threatened ecological communities (TECs) as designated under section 181 of the EPBC Act.

No TECs occur within the Project Area or EMBA. The closest TECs to the Project Area are subtropical and temperate coastal saltmarsh (~560 km south-west near Carnarvon; listed as vulnerable under the EPBC Act) and the monsoon vine thickets on the coastal sand dunes of the Dampier Peninsula (~685 km east-north-east; listed as endangered).

7.5.6 Critical Habitats

No critical habitats as identified and listed on the Register of Critical Habitat (in accordance with section 207A(1) of the EPBC Act) (DCCEEW 2023m) are present within the Project Area or EMBA.

7.5.7 Habitat Critical to the Survival of a Species or Ecological Community

Habitat critical to the survival of a species or ecological community refers to areas that are necessary:

- for activities such as foraging, breeding, roosting, or dispersal
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- to maintain genetic diversity and long-term evolutionary development
- for the reintroduction of populations or recovery of the species or ecological community.

Such habitat may be identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community (in accordance with section 270(2)(d) of the EPBC Act), and/or habitat listed on the Register of Critical Habitat (Section 7.5.6).

Habitat critical to the survival of marine turtles has been identified and described in Section 7.6.1.

7.5.8 Wetlands

Wetlands are areas of land where water covers the soil, and can include swamps, lagoons, saltmarshes, mudflats, or mangroves. Wetlands provide a variety of important environmental, social and economic services such as providing nursey habitat for fauna, and protecting shorelines.

Australia currently has 67 Ramsar wetlands listed as Wetlands of International Importance under the Ramsar Convention on Wetlands. Ramsar wetlands are also considered an MNES under the EPBC Act.

The Project Area does not intersect with any Ramsar wetland. The EMBA does interface with one Ramsar wetland (Eighty-mile Beach), which is further described in Section 7.8.4.

7.6 Protected Species

A total of 113 EPBC Act listed species considered to be MNES were identified as potentially occurring within the EMBA, of which a subset of 44 species were identified as potentially occurring within the Project Area. Appendix B contains the full list of marine species identified from the PMST reports, including MNES that are not considered to be credibly impacted (e.g. terrestrial species).

Relevant EPBC Act threatened and migratory species identified as potentially occurring within the Project Area and EMBA, and biologically important areas (BIAs) or habitat critical to the survival or a species that overlap the Project Area and EMBA are described in the following subsections.

7.6.1 Fish, Sharks, and Rays

The EPBC Act Protected Matters search (Appendix B) identified 12 species of fish, shark and rays listed as threatened and/or migratory with the potential to occur within the Project Area, and an additional four that may occur in the EMBA (Table 7-8). Further information regarding the threatened and/or migratory species with the potential to occur within the Project Area or EMBA are provided in the subsections that come after Table 7-9.

A review of the BIAs of regionally significant marine species database (DCCEEW 2016) identified a BIA for one species within the Project Area, and four species within the EMBA (Table 7-9).

Opportunistic cetacean sighting reports from Woodside's facilities on the NWS from 2018–2022 indicate:

- whale sharks are the most commonly observed shark species—they are typically observed in higher numbers between July and September, but are also present throughout the rest of year at lower and intermittent frequency
- identification of other fish, sharks, or rays at species level was infrequent; for example:
  - a group of hammerhead sharks were observed in February 2018
  - manta rays (single or pair) were observed in May 2018, January and March 2019, and July 2021.

Table 7-8: Threatened, migratory and listed fish, shark and ray species that may occur within the Project Area and EMBA

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Acentronura australe	Southern pygmy pipehorse	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Acentronura larsonae	Helen's pygmy pipehorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Anoxypristis cuspidate	Narrow sawfish	N/A	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat known to occur within area
Bhanotia fasciolata	Corrugated pipefish, barbed pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Bulbonaricus brauni	Braun's pughead pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Campichthys galei	Gale's pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Campichthys tricarinatus	Three-keel pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Carcharhinus longimanus	Oceanic whitetip shark	N/A	Migratory	Marine	Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Carcharias taurus (west coast population)	Grey nurse shark (west coast population)	Vulnerable	N/A	Marine	Species or species habitat likely to occur within area	Species or species habitat known to occur within area
Carcharodon carcharias	White shark	Vulnerable	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat known to occur within area
Centrophorus zeehaani	Southern dogfish	Conservation dependent	N/A	Marine	N/A	Species or species habitat likely to occur within area
Choeroichthys brachysoma	Pacific short-bodied pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Choeroichthys latispinosus	Muiron Island pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Choeroichthys suillus	Pig-snouted pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Corythoichthys amplexus	Fijian banded pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Corythoichthys flavofasciatus	Reticulate pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Corythoichthys intestinalis	Australian messmate pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Corythoichthys schultzi	Schultz's pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Cosmocampus banneri	Roughridge pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Doryrhamphus dactyliophorus	Banded pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Doryrhamphus excisus	Bluestripe pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Doryrhamphus janssi	Cleaner pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Doryrhamphus multiannulatus	Many-banded pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Doryrhamphus negrosensis	Flagtail pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Festucalex scalaris	Ladder pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Filicampus tigris	Tiger pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Halicampus brocki	Brock's pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Halicampus dunckeri	Red-hair pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Halicampus grayi	Mud pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Halicampus nitidus	Glittering pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Halicampus spinirostris	Spiny-snout pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Haliichthys taeniophorus	Ribboned pipehorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippichthys penicillus	Beady pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippocampus angustus	Western spiny seahorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippocampus breviceps	Short-head seahorse	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Hippocampus histrix	Spiny seahorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippocampus kuda	Spotted seahorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippocampus planifrons	Flat-face seahorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippocampus spinosissimus	Hedgehog seahorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Hippocampus subelongatus	West Australian seahorse	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Hippocampus trimaculatus	Three-spot seahorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Isurus oxyrinchus	Shortfin mako	N/A	Migratory	Marine	Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Isurus paucus	Longfin mako	N/A	Migratory	Marine	Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Lamna nasus	Porbeagle	N/A	Migratory	Marine	N/A	Species or species habitat may occur within area
Lissocampus fatiloquus	Prophet's pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Maroubra perserrata	Sawtooth pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Micrognathus micronotopterus	Tidepool pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Mitotichthys meraculus	Western crested pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Mobula alfredi	Reef manta ray	N/A	Migratory	Marine	N/A	Species or species habitat known to occur within area
Mobula birostris	Giant manta ray	N/A	Migratory	Marine	N/A	Species or species habitat known to occur within area
Nannocampus subosseus	Bonyhead pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Phoxocampus belcheri	Black rock pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Phycodurus eques	Leafy seadragon	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Phyllopteryx taeniolatus	Common seadragon	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Pristis clavata	Dwarf sawfish	Vulnerable	Migratory	Marine	Species or species habitat known to occur within area	Species or species habitat known to occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Pristis pristis	Freshwater sawfish	Vulnerable	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat likely to occur within area
Pristis zijsron	Green sawfish	Vulnerable	Migratory	Marine	Species or species habitat known to occur within area	Species or species habitat known to occur within area
Pugnaso curtirostris	Pugnose pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Rhincodon typus	Whale shark	Vulnerable	Migratory	Marine	Foraging, feeding or related behaviour known to occur within area	Foraging, feeding or related behaviour known to occur within area
Solegnathus hardwickii	Pallid pipehorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Solegnathus lettiensis	Gunther's pipehorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Solenostomus cyanopterus	Robust ghostpipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Sphyrna lewini	Scalloped hammerhead	Conservation Dependent	N/A	Marine	Species or species habitat known to occur within area	Species or species habitat known to occur within area
Stigmatopora argus	Spotted pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Stigmatopora nigra	Widebody pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Syngnathoides biaculeatus	Double-end Pipehorse	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Thunnus maccoyii	Southern bluefin tuna	Conservation Dependent	N/A	Marine	Breeding known to occur within area	Breeding known to occur within area
Trachyrhamphus bicoarctatus	Bentstick pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Trachyrhamphus longirostris	Straightstick pipefish	N/A	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Urocampus carinirostris	Hairy pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area
Vanacampus margaritifer	Mother-of-pearl pipefish	N/A	N/A	Marine	N/A	Species or species habitat may occur within area

Table 7-9: Fish, shark, and ray BIAs within the Project Area and EMBA

Species name	Common name	BIA type	Approx. distance and direction	
			Project Area	EMBA
Carcharodon carcharias	White shark	Foraging	~940 km south	Overlap
Rhincodon typus	Whale shark	Foraging (northward from Ningaloo along 200 m isobath)	Overlap	Overlap
		Foraging (high-density prey)	~240 km south-west	Overlap
Pristis clavata	Dwarf sawfish	Foraging	~400 km east	Overlap
		Nursing	~400 km east	Overlap
		Pupping	~400 km east	Overlap
Pristis pristis	Freshwater sawfish	Foraging	~400 km east	Overlap
		Pupping	~400 km east	Overlap
Pristis zijsron	Green sawfish	Foraging	~390 km east	Overlap
		Nursing	~390 km east	Overlap
		Pupping	~390 km east	Overlap

7.6.1.1 Narrow sawfish (*Anoxypristis cuspidate*)

The narrow sawfish is listed as migratory under the EPBC Act. It occurs from the northern Arabian Gulf to Australia and north to Japan. The species inhabits inshore and estuarine waters and offshore waters up to depths of 100 m (IUCN 2022) and is most commonly found in sheltered bays with sandy bottoms. It is not currently listed as Threatened but is commonly caught as bycatch and comprised more than half of sawfish bycatch in the Northern Prawn Fishery in 2013 (Morgan, Whitty, and Phillips 2010; DCCEEW n.d.).

This species is unlikely to occur in the Project Area but may be present in the shallower waters of the EMBA. No BIAs for this species occur in the Project Area or EMBA.

7.6.1.2 Oceanic whitetip shark (*Carcharhinus longimanus*)

The oceanic whitetip shark is listed as migratory under the EPBC Act. It is globally distributed in areas of warm temperate and tropical oceans (Andrzejaczek et al. 2018), and may occur in tropical and subtropical offshore and coastal waters around Australia. It primarily lives in pelagic waters in the upper 200 m of the water column; however, members of this species have been observed diving to depths of around 1,000 m, potentially associated with foraging behaviour (Howey-Jordan et al. 2013; D'Alberto et al. 2017). The species is highly migratory, travelling large distances between shallow reef habitats in coastal waters and oceanic waters (Howey-Jordan et al. 2013), and exhibits a strong preference for warm and shallow waters above 120 m.

Given its migratory nature, this species is expected to be broadly distributed within the NWMR, and may be present within the Project Area and EMBA. No BIAs for this species occur in the Project Area or EMBA.

7.6.1.3 Grey nurse shark (*Carcharias taurus*)

The grey nurse shark (west coast population) is listed as vulnerable under the EPBC Act. It is broadly distributed in inner continental shelf waters, primarily in subtropical to cool temperate waters (DotE 2014b). The species primarily occurs in coastal waters (20–140 m deep) off south-west WA (Chidlow, Gaughan, and McAuley 2006). Grey nurse sharks have been documented as aggregating in specific areas (typically reefs); however, no clear aggregation sites off WA have been identified

(Chidlow, Gaughan, and McAuley 2006). Details of movement patterns of the western subpopulation are unclear (McAuley 2004) and key aggregation sites have not been formally identified within the NWMR (Chidlow, Gaughan, and McAuley 2006). The NWMR represents the northern limit of the west coast population.

Given the species' preference for relatively shallow temperate waters, grey nurse sharks are not expected to occur in the Project Area, but may be present in the shallower waters of the EMBA. No BIAs have been identified within the Project Area or EMBA.

7.6.1.4 White shark (*Carcharodon carcharias*)

The white shark is listed as vulnerable and migratory under the EPBC Act. It typically occurs in temperate coastal waters between the shore and the 100 m depth contour; however, adults and juveniles have been recorded diving to depths of 1000 m (Bruce, Stevens, and Malcolm 2006; Bruce 2008).

There are no known aggregation sites for white sharks in the NWMR, and this species is most often found in low densities south of North West Cape (DSEWPaC 2012b).

Given its migratory nature, this species is expected to have a broad distribution within the NWMR. The Project Area is unlikely to represent an important habitat for this species. No BIAs have been identified within the Project Area, but they have been identified in the EMBA (Figure 7-11).

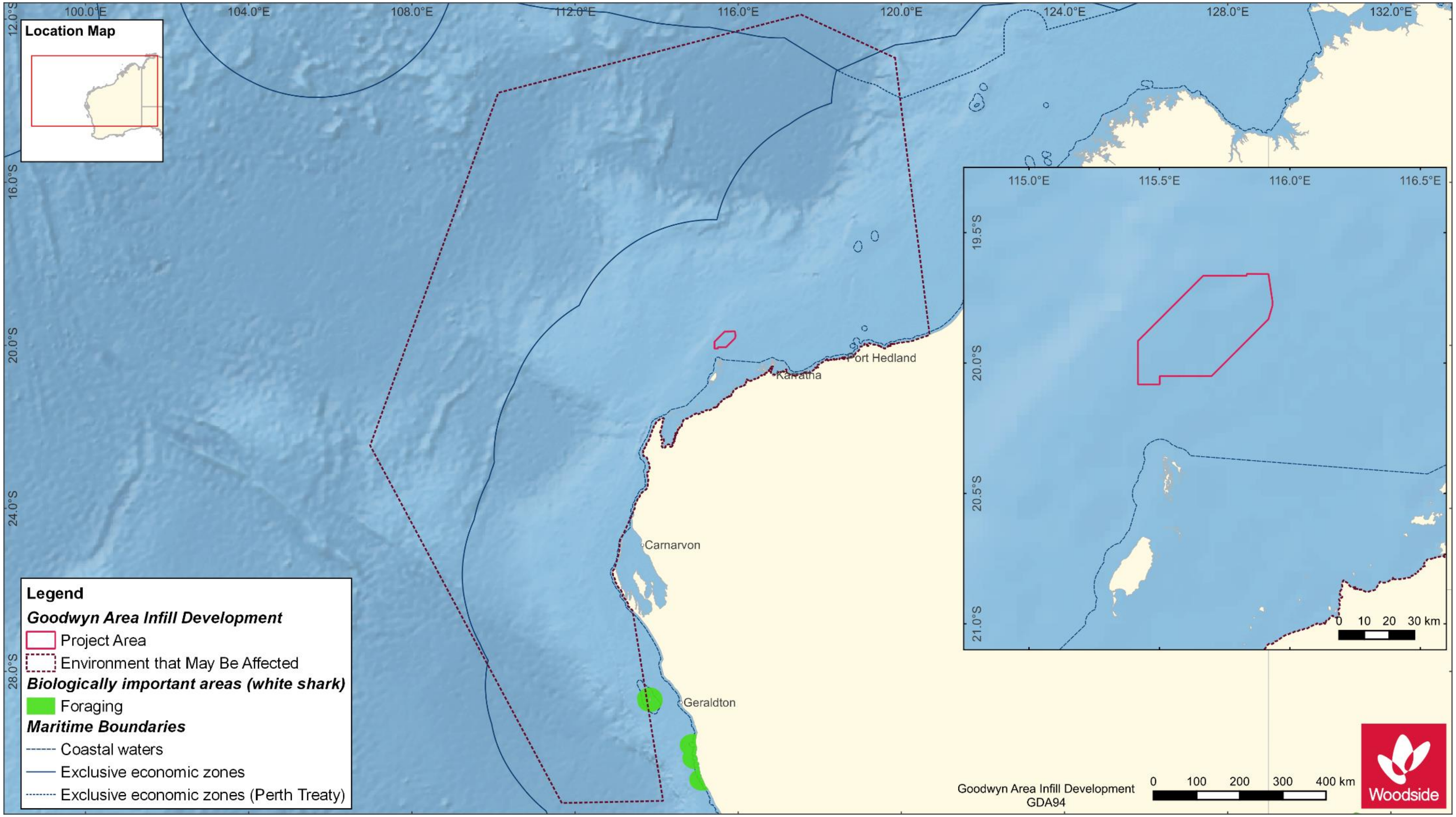


Figure 7-11: White shark—BIAs within the EMBA

7.6.1.5 Southern dogfish (*Centrophorus zeehaani*)

The southern dogfish is listed as conservation dependant under the EPBC Act. It is a demersal species of 'gulper sharks' (family centrophoridae) with a depth range of 180–900 m (Williams et al. 2012). This species is distributed along the upper and southern continental shelf and is endemic to Australian waters (TSSC 2013) where it primarily feeds on fish and invertebrates.

No BIAs have been identified within the Project Area or EMBA.

7.6.1.6 Shortfin mako (*Isurus oxyrinchus)*

The shortfin mako is listed as migratory under the EPBC Act. It is a pelagic species with a circum-global, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al. 2000). Tagging studies indicate shortfin makos spend most of their time in water less than 50 m deep but with occasional dives up to 880 m (Abascal et al. 2011; Stevens, Bradford, and West 2010).

Although tagging has indicated a preference for shallower waters, this species' migratory nature and oceanic distribution suggests it could occur in low numbers in the Project Area. No BIAs have been identified within the Project Area or EMBA.

7.6.1.7 Longfin mako (*Isurus paucus*)

The longfin mako is listed as migratory under the EPBC Act. It is a pelagic species with a wide-ranging, patchy, oceanic distribution in tropical and temperate seas (Mollet et al. 2000).

Records on longfin mako sharks are sporadic and their complete geographic range is not well known (IUCN 2018).

Given its broad oceanic distribution, this species may occur in low numbers in the Project Area. No BIAs have been identified within the Project Area or EMBA.

7.6.1.8 Porbeagle shark (*Lamna nasus*)

The porbeagle shark (also known as the mackerel shark) is listed as migratory under the EPBC Act. It is a geographically wide-ranging species that inhabits oceanic waters around the continental shelf (DCCEEW n.d.) and is known to dive to depths of over 1300 m (Campana, Joyce, and Fowler 2010; Saunders, Royer, and Clarke 2011).

Records of the porbeagle movement patterns are not well understood but there is some evidence showing a seasonal migration, with tracked individuals moving distances of 1500–1800 km (Francis, Natanson, and Campana 2002).

Given its broad distribution, this species may occur in the Project Area and EMBA. No BIAs have been identified within the Project Area or EMBA.

7.6.1.9 Reef manta ray (*Mobula alfredi*)

The reef manta ray is listed as migratory under the EPBC Act. The reef manta ray are large pelagic, planktivorous rays with geographical distribution throughout the Indo–Pacific region within tropical and subtropical waters (Armstrong et al. 2020). Sightings of this species primarily occur within productive nearshore environments (e.g. island groups, atolls or continental coastlines) and it can dive to depths of 0–432 m (Kyne et al. 2021). The species has also been recorded at offshore coral reefs and rocky reefs (Marshall, Compagno, and Bennett 2009), and a resident population of reef manta rays has been recorded at Ningaloo Reef.

No BIAs have been identified within the Project Area or EMBA.

7.6.1.10 Giant manta ray (*Mobula birostris*)

The giant manta ray or oceanic manta ray is listed as migratory under the EPBC Act. It primarily inhabits nearshore environments along productive coastlines with regular upwelling, but seems to be a seasonal visitor to coastal or offshore sites (e.g. offshore islands groups, offshore pinnacles and seamounts) (IUCN 2019). It can dive to depths of 0–1000 m, and is a planktivorous ray that feeds on planktonic organisms (including krill and crab larvae).

The Ningaloo coast is an important area for this species (March–August) (Preen et al. 1997). No BIAs have been identified within the Project Area or EMBA.

7.6.1.11 Dwarf sawfish (*Pristis clavata*)

The dwarf sawfish is listed as vulnerable and migratory under the EPBC Act. It is found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland, across the NT and the Kimberley, and south to the Pilbara coast (DCCEEW n.d.). Dwarf sawfish typically inhabit shallow (up to 20 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al. 2008). Juvenile dwarf sawfish use estuarine habitats in north-western WA as nursery areas (Thorburn et al. 2008; DEWHA 2009) and migrate to deeper waters as adults. Most capture locations for the species in WA waters have occurred within King Sound (>800 km from the Project Area) and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan, Whitty, and Phillips 2010). Individuals have been recorded at Eighty Mile Beach, and occasional individuals have also been taken by trawl fisheries from considerably deeper water (Morgan, Whitty, and Phillips 2010). Coastal waters around Eighty Mile Beach are a possible pupping area for this species, with a BIA designated accordingly.

This species is not expected to occur in the Project Area, which has a deep, offshore environment. No BIAs for this species occur in the Project Area, but have been identified within the EMBA (around Eighty Mile Beach; Figure 7-12).

7.6.1.12 Freshwater sawfish (*Pristis pristis*)

The freshwater sawfish is listed as vulnerable and migratory under the EPBC Act. It is found in sandy or muddy bottoms of shallow coastal waters, estuaries, river mouths, freshwater rivers, and isolated water holes. This species is widely distributed in northern Australia (DCCEEW n.d.).

This species is not expected to occur in the Project Area, which has a deep, offshore environment. No BIAs for this species occur in the Project Area, but have been identified within the EMBA (around Eighty Mile Beach; Figure 7-13).

7.6.1.13 Green sawfish (*Pristis zijsron*)

The green sawfish is listed as vulnerable and migratory under the EPBC Act. It is found in inshore coastal environments including estuaries, river mouths, embayments, and along sandy and muddy beaches, as well as offshore marine habitat (Stevens, Pillans, and Salini 2005). Within Australia, green sawfish are currently distributed from the Whitsundays in Queensland across northern Australian waters to Shark Bay in WA. Individuals have been recorded in inshore coastal environments and estuaries but the species does not penetrate into fresh water (DCCEEW n.d.). Despite records of the species in deeper offshore waters, green sawfish typically occur in the inshore fringe, and have a strong association with mangroves and adjacent mudflat habitats (CoA 2015b; Stevens, Pillans, and Salini 2005). Movements within these preferred habitats correlates with tidal movements (Stevens et al. 2008).

This species is known to occur in offshore waters of the NWS, with known pupping areas in coastal waters north of Port Hedland to Roebuck Bay; pupping is likely to occur south of Port Hedland, Exmouth Gulf and North West Cape (CoA 2015b). However, BIAs for pupping, nursing and foraging have only been designated for the coastal waters of Eighty Mile Beach.

This species is not expected to occur in the Project Area, which has a deep, offshore environment. No BIAs for this species occur in the Project Area, but have been identified within the EMBA (around Eighty Mile Beach; Figure 7-14).

7.6.1.14 Whale shark (*Rhincodon typus*)

The whale shark is listed as vulnerable and migratory under the EPBC Act. It is widely distributed in Australian waters, most commonly aggregating at Ningaloo in WA (March–July), and to a lesser extent at Christmas Island (December–January), and in the Coral Sea (November–December). The seasonal aggregation of whale sharks at Ningaloo Reef is estimated at 300–500 individuals, although the status of the population is unknown (DSEWPaC 2012f). The species is generally encountered close to or at the surface (although they sharks are known to dive to depths of at least 980 m (Wilson et al. 2006)), and as single individuals or occasionally in schools or aggregations of up to hundreds of sharks. Aggregations around Ningaloo Reef are generally greatest during La Niña years rather than El Niño years due to an intensification of the Leeuwin current (DEWHA 2008b).

The NWMR is considered important to whale sharks for foraging. Key foraging areas include the Ningaloo Marine Park and adjacent Commonwealth waters (depths of 60–100 m; March–July), and northward from Ningaloo Marine Park along the 200 m isobath (July–November) (DSEWPaC 2012f). Satellite tracking of whale sharks from the Ningaloo Reef area have shown movement in a northerly, north-easterly and north-westerly direction towards or into Indonesian waters (Wilson et al. 2006). Anecdotal evidence from sightings data collected from the Woodside offshore facilities on the NWS indicate whale sharks are present on the NWS in April and July–October, corresponding with the species' seasonal migration to and from Ningaloo Reef.

The Project Area overlaps with a foraging BIA for whale sharks (Figure 7-15). Whale sharks are likely to be present in the Project Area, particularly July–November, as they migrate northward within the BIA.

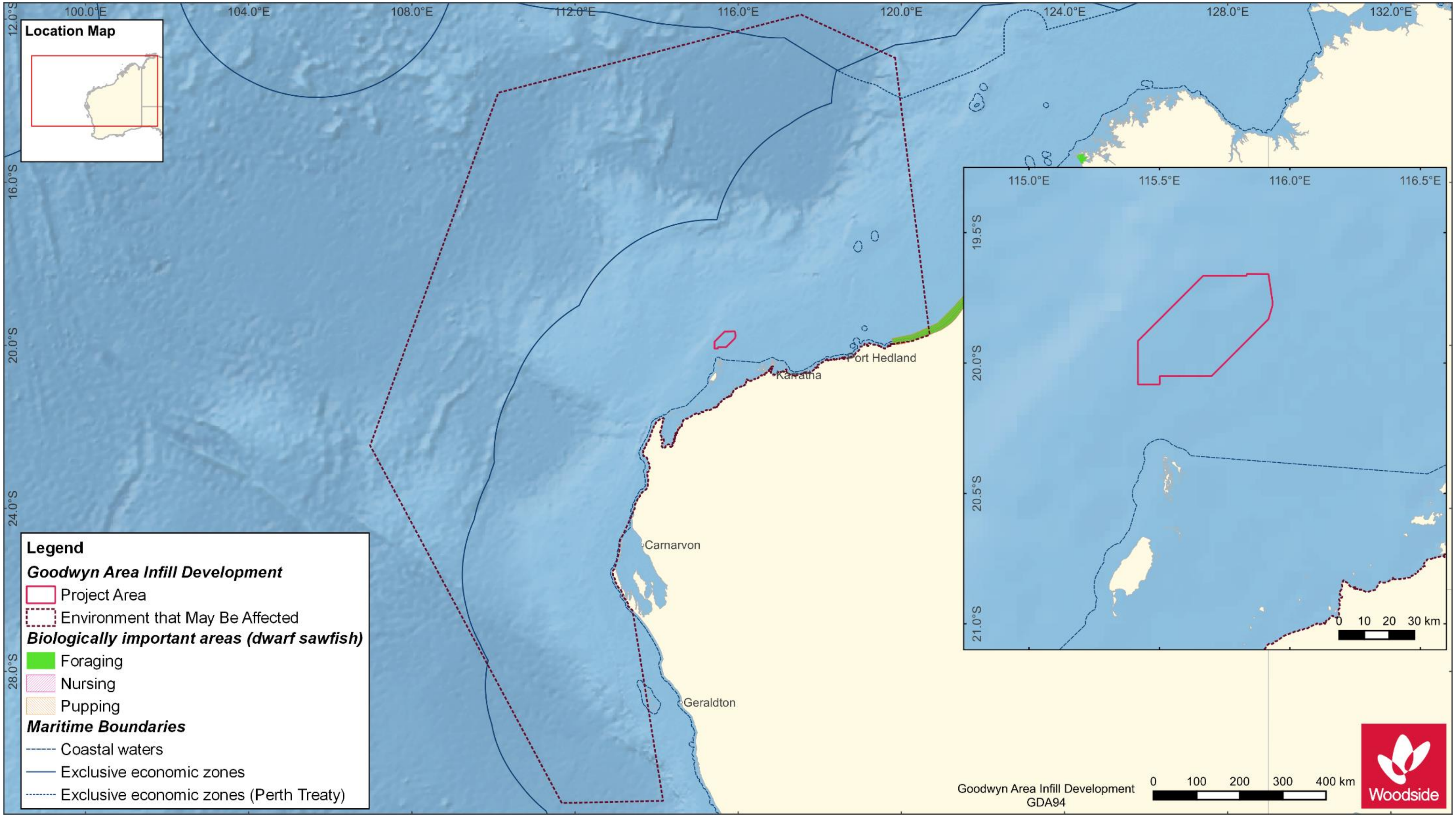


Figure 7-12: Dwarf sawfish—BIAs within the EMBA

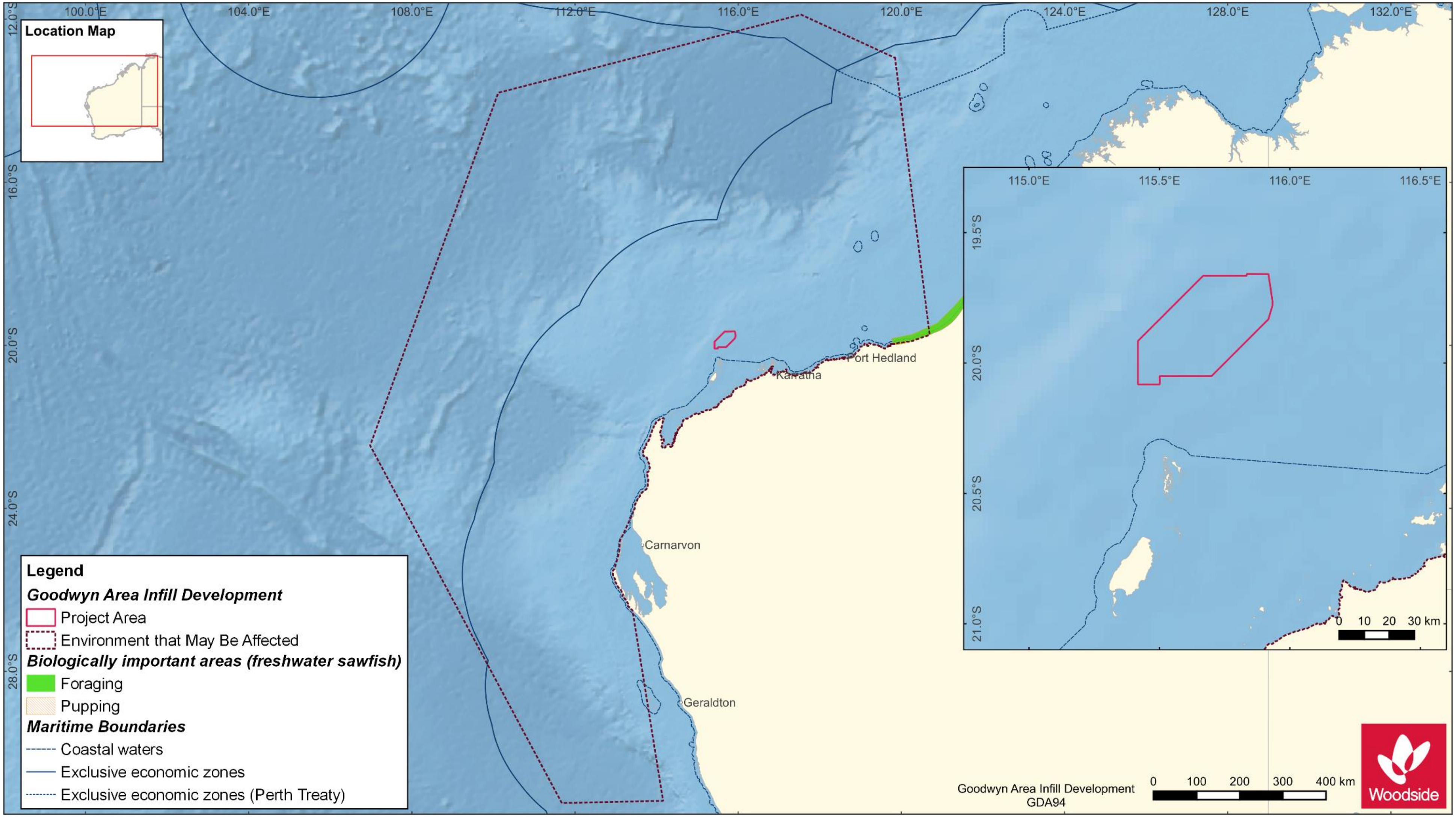


Figure 7-13: Freshwater sawfish—BIAs within the EMBA

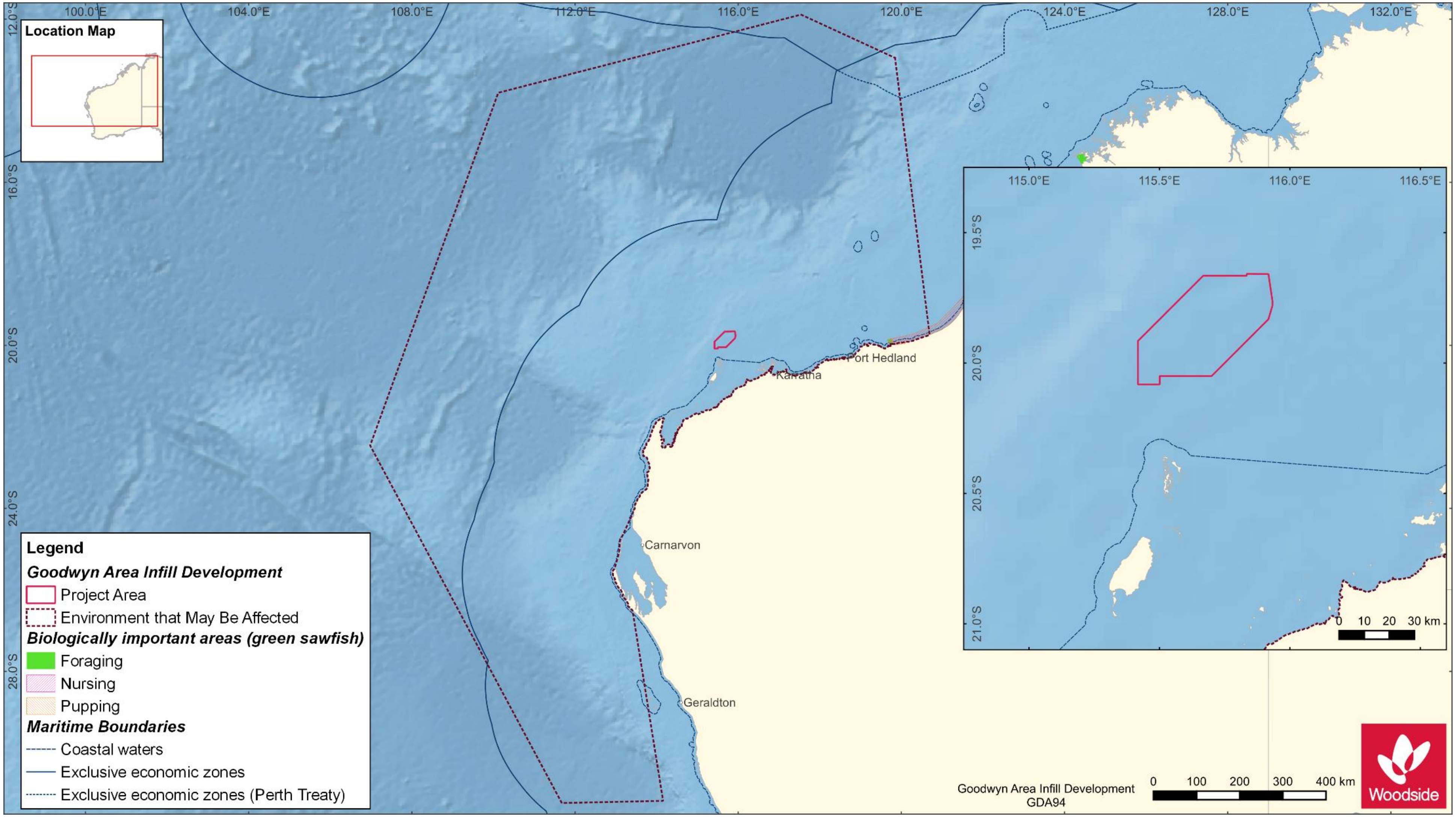


Figure 7-14: Green sawfish—BIAs within the EMBA

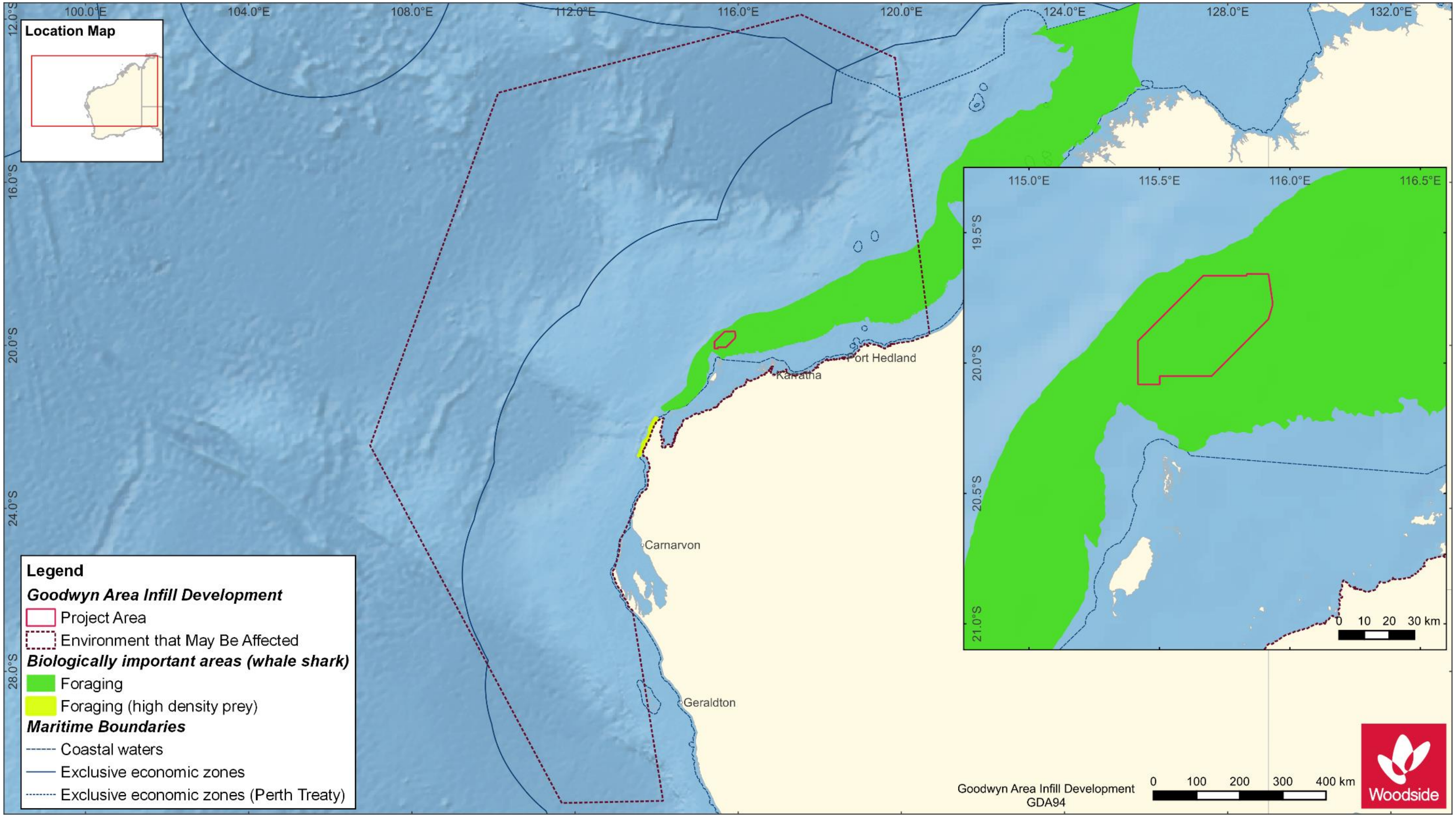


Figure 7-15: Whale shark—BIAs within the Project Area and EMBA

7.6.1.15 Scalloped hammerhead (*Sphyrna lewini*)

The scalloped hammerhead is listed as conservation dependent under the EPBC Act. It has a circum-global distribution in tropical and subtropical waters, and is a mobile species that ranges widely over shallow coastal shelf waters, but rarely ventures into or across deep ocean waters. Within Australian waters, this species extends from NSW (approximately from Wollongong, where it is less abundant), around the north of the continent and then south into WA to approximately Geographe Bay, although it is rarely recorded south of the Houtman Abrolhos Islands (TSSC 2018).

This species is not expected to occur in the Project Area, which has a deep, offshore environment. No BIAs for this species occur in the Project Area or EMBA.

7.6.1.16 Southern bluefin tuna (*Thunnus maccoyii*)

The southern bluefin tuna is listed as conservation dependent under the EPBC Act. It is a highly migratory species, occurring globally in waters between 30–50 °S; it is mainly found in the eastern Indian Ocean and the south-west Pacific Ocean. Adult southern bluefin tuna are widely distributed in Australian waters, ranging from northern WA to the southern region of the continent, including Tasmania, and to northern NSW (Honda et al. 2010). Juveniles (1–2 years of age) inhabit inshore waters in WA and South Australia (SA) (Honda et al. 2010).

This species has a single known spawning ground between Java and northern WA (TSSC 2010). The northern extent of the Project Area intersects with the indicative spawning area[29] (Figure 7-16). Spawning occurs between September and April, with peaks in October and February (Hobday et al. 2015), with individual fish probably staying in the spawning area for one month or so (Farley et al. 2015). Spawning adults frequently dive to 150 m depth to thermoregulate (Hobday et al. 2015).

This species is a high-level apex predator and an opportunistic feeder, preying on a wide variety of fishes, crustaceans, cephalopods, salps, and other marine animals. As larvae, the species mainly consumes microcrustacea and macrozooplanktonic crustacea; some cannibalism occurs (Caton 1991). As juveniles, a large proportion of their diet is sardines (Ward et al. 2006). Smaller adults feed mainly on crustaceans, and larger adults feed on fish in deeper, colder waters (Caton 1991; Davis and Farley 2001).

This species is targeted by fisheries globally; specifically within Australia, it is targeted by the Southern Bluefin Tuna Fishery (SBTF). No recent fishing effort for the SBTF has been recorded within the Project Area (discussed further in Section 7.10.1.1). The current mean estimate for total reproductive output of this species is 20% of unfished levels. Therefore, the stock is classified as not overfished (Patterson and Dylewski 2022).

No BIAs for this species occur in the Project Area or EMBA.

[29] Indicative spawning area for southern bluefin tuna provided by Australian Bureau of Agricultural and Resource Economics and Sciences.

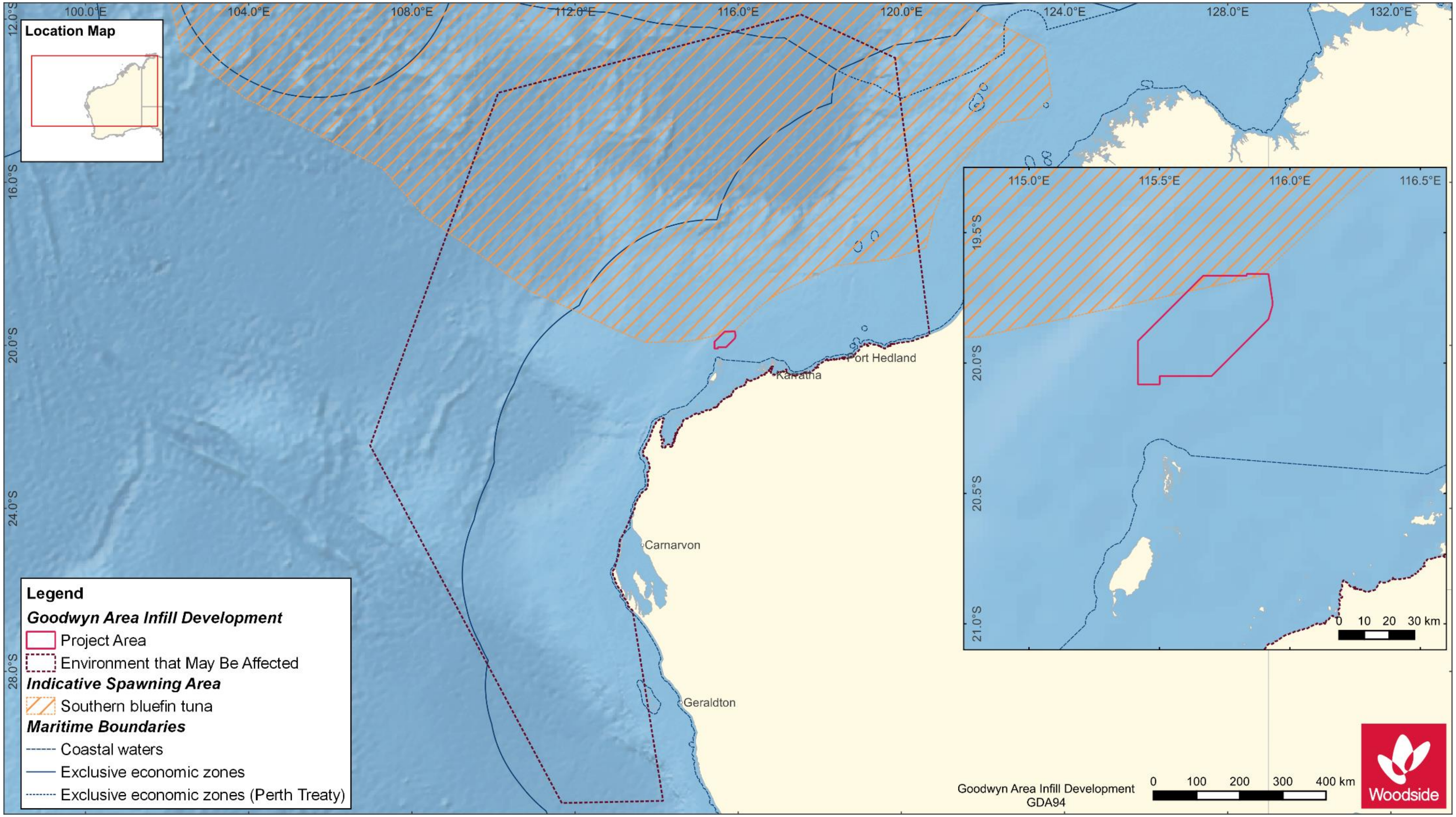


Figure 7-16: Southern bluefin tuna spawning area

7.6.2 Marine Reptiles

The EPBC Act protected matters search (Appendix B) identified seven marine reptile species listed as threatened and/or migratory with the potential to occur within the Project Area, and an additional one that may occur in the EMBA (Table 7-10). Further information regarding the threatened and/or migratory species with the potential to occur within the Project Area or EMBA is provided in the following subsections.

A review of the BIAs of regionally significant marine species database (DCCEEW 2016) identified a BIA for one species within the Project Area, and four species within the EMBA; these are described in Table 7-11.

The Recovery Plan for Marine Turtles of Australia (CoA 2017b) identifies habitat critical to the survival of a species for marine turtle stocks under the EPBC Act. Habitat critical to survival is defined as areas necessary:

- for activities such as foraging, breeding or dispersal
- for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)
- to maintain genetic diversity and long-term evolutionary development
- for the reintroduction of populations or recovery of the species.

The Recovery Plan for Marine Turtles of Australia (CoA 2017b) has identified nesting locations and associated internesting areas as habitat critical to survival for four marine turtle species within the EMBA; these are identified and described in Table 7-12 and shown in Figure 7-17 to Figure 7-20.

Table 7-10: Threatened, migratory and listed marine reptile species that may occur within the Project Area and EMBA

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Acalyptophis peronii	Horned seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Aipysurus apraefrontalis	Short-nosed seasnake	Critically endangered	N/A	Listed	Species or species habitat likely to occur within area	Species or species habitat known to occur within area
Aipysurus duboisii	Dubois' seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Aipysurus eydouxii	Spine-tailed seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Aipysurus foliosquama	Leaf-scaled seasnake	Critically endangered	N/A	Listed	Species or species habitat likely to occur within area	Species or species habitat known to occur within area
Aipysurus laevis	Olive seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Aipysurus pooleorum	Shark bay seasnake	N/A	N/A	Listed	N/A	Species or species habitat may occur within area
Aipysurus tenuis	Brown-lined seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Astrotia stokesii	Stokes' seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Caretta caretta	Loggerhead turtle	Endangered	Migratory	Listed	Species or species habitat known to occur within area	Breeding known to occur within area
Chelonia mydas	Green turtle	Vulnerable	Migratory	Listed	Species or species habitat known to occur within area	Breeding known to occur within area
Chitulia ornata	Spotted seasnake	N/A	N/A	Listed (as *Hydrophiid ornatus*)	Species or species habitat may occur within area	Species or species habitat may occur within area
Dermochelys coriacea	Leatherback turtle	Endangered	Migratory	Listed	Species or species habitat likely to occur within area	Foraging, feeding or related behaviour known to occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Disteira kingii	Spectacled seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Disteira major	Olive-headed seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Emydocephalus annulatus	Turtle-headed seasnake	N/A	N/A	Listed	N/A	Species or species habitat may occur within area
Ephalophis greyi	North-western mangrove seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	Listed	Species or species habitat known to occur within area	Breeding known to occur within area
Hydrelaps darwiniensis	Black-ringed seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Hydrophis elegans	Elegant seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area
Hydrophis macdowelli	Small-headed seasnake	N/A	N/A	Listed (as *Hydrophis mcdowelli*)	Species or species habitat may occur within area	Species or species habitat may occur within area
Leioselasma czeblukovi	Fine-spined seasnake, geometrical seasnake	N/A	N/A	Listed (as *Hydrophis czeblukovi*)	Species or species habitat may occur within area	Species or species habitat may occur within area
Lepidochelys olivacea	Olive Ridley turtle	Endangered	Migratory	Listed	N/A	Species or species habitat likely to occur within area
Natator depressus	Flatback turtle	Vulnerable	Migratory	Listed	Congregation or aggregation known to occur within area	Breeding known to occur within area
Pelamis platurus	Yellow-bellied seasnake	N/A	N/A	Listed	Species or species habitat may occur within area	Species or species habitat may occur within area

Table 7-11: Marine reptile BIAs within the Project Area and EMBA

Species name	Common name	BIA type	Approx. distance and direction	
			Project Area	EMBA
Caretta caretta	Loggerhead turtle	Foraging	~280 km east	Overlap
		Internesting	~645 km south-west	Overlap
		Internesting buffer	~15 km south	Overlap
		Nesting	~35 km south	Overlap
Chelonia mydas	Green turtle	Aggregation	~35 km south	Overlap
		Basking	~62 km south	Overlap
		Foraging	~62 km south	Overlap
		Internesting	~25 km south	Overlap
		Internesting buffer	~5 km south	Overlap
		Mating	~25 km south	Overlap
		Migration corridor	~105 km south-east	Overlap
		Nesting	~25 km south	Overlap
Eretmochelys imbricata	Hawksbill turtle	Foraging	~25 km south	Overlap
		Internesting	~55 km south	Overlap
		Internesting buffer	~8 km south	Overlap
		Mating	~55 km south	Overlap
		Migration corridor	~105 km south-east	Overlap
		Nesting	~25 km south	Overlap
Natator depressus	Flatback turtle	Aggregation	~35 km south	Overlap
		Foraging	~35 km south	Overlap
		Internesting	~35 km south	Overlap
		Internesting buffer	Overlap	Overlap
		Mating	~35 km south	Overlap
		Migration corridor	~105 km south-east	Overlap
		Nesting	~25 km south	Overlap

Table 7-12: Habitat critical to the survival of marine turtles occurring within the Project Area and EMBA

Common name	Genetic stock	Nesting locations	Internesting buffer	Nesting period	Hatching period	Approx. distance and direction	
						Project Area	EMBA
Flatback turtle	Pilbara	Barrow Island, Montebello Islands, coastal islands from Cape Preston to Locker Island	60 km	Oct–Mar (peak: Nov–Jan)	Feb–Mar	Overlap	Overlap
Green turtle	North-west	Barrow Island, Montebello Islands, Serrurier Island and Thevenard Island	20 km	Nov–Mar	Dec–May (peak: Feb–Mar)	~5 km south	Overlap

Common name	Genetic stock	Nesting locations	Internesting buffer	Nesting period	Hatching period	Approx. distance and direction	
						Project Area	EMBA
Hawksbill turtle	North-west	Cape Preston to mouth of Exmouth Gulf including Montebello Islands and Lowendal Islands	20 km	Oct–Feb	All year (peak: Dec–Feb)	~8 km south	Overlap
Loggerhead turtle	North-west	Exmouth Gulf and Ningaloo coast	20 km	Nov–May	Jan–May	~15 km south	Overlap

7.6.2.1 Short-nosed seasnake (*Aipysurus apraefrontalis*)

The short-nosed seasnake is listed as critically endangered under the EPBC Act. Within the NWMR, it has been recorded at Ashmore and Hibernia reefs. Guinea and Whiting (2005) reported that very few short-nosed seasnakes moved as far as 50 m from the reef flat.

Given the coral reef habitat preferences for this species, presence within the Project Area is limited. No BIAs have been identified for this species in the Project Area or EMBA.

7.6.2.2 Leaf-scaled seasnake (*Aipysurus foliosquama*)

The leaf-scaled seasnake is listed as critically endangered under the EPBC Act. Within the NWMR, it has been recorded at Ashmore and Hibernia reefs. The leaf-scaled seasnake occurs primarily on the reef flats or in shallow waters of the outer reef edges to depths of 10 m (Minton and Heatwole 1975).

Given the coral reef habitat preferences for this species, its presence within the Project Area is limited. No BIAs have been identified for this species in the Project Area or EMBA.

7.6.2.3 Loggerhead turtle (*Caretta caretta*)

Loggerhead turtles are listed as endangered and migratory under the EPBC Act. Within Australia two breeding stocks exist—the western breeding stock is the larger. This species occurs throughout the NWMR and forages across a wide range of habitats, including rocky and coral reefs, seagrass pastures, estuaries, muddy bays and open ocean environments (DCCEEW n.d.).

In the NWMR, this species breeds from November to March and it requires sandy beaches to nest. Nesting occurs principally from Shark Bay to the North West Cape, with Dirk Hartog Island a major nesting site (typically 800–1500 breeding females annually). Other key breeding locations include Gnaraloo Bay, the Muiron Islands and beaches along the North West Cape; with occasional records from Varanus and Rosemary islands, Barrow Island, Lowendal Islands (DBCA 2020b) and Ashmore Reef (Guinea 2016).

Although the then WA Department of Conservation and Land Management (CALM) (1990) reported loggerhead turtle nesting activity on Cohen Island, Pendoley et al. (2016) did not find any evidence of loggerhead nesting activity there when they analysed more than 20 years of track data. The northernmost key loggerhead nesting areas include the North West Cape and Muiron Islands and any nesting activity by loggerhead turtles in the Dampier Archipelago does not represent significant rookeries for this species (Pendoley Environmental 2020a).

During internesting periods, female loggerhead turtles generally remain within 10 km of nesting beaches (DCCEEW n.d.). Movement patterns during internesting are generally short forays of 4–8 km, with distance increasing towards the end of the internesting period. Larger movements

(~10 km) were mainly longshore, rather than directly offshore, and confined to water <15 m deep (Tucker, Janzen, and Paukstis 1995).

No BIAs for this species were identified in the Project Area. However, there are multiple BIAs associated with the Montebello Islands and the Dampier Archipelago, including nesting and internesting buffer BIAs (Figure 7-17).

Although individuals may transit through the Project Area, large numbers are not expected given the lack of habitat that would promote aggregating behaviours, such as breeding or foraging.

7.6.2.4 Green turtle (*Chelonia mydas*)

Green turtles are listed as vulnerable and migratory under the EPBC Act. They are the most common marine turtle breeding in the NWMR (DSEWPaC 2012d). Three distinct breeding stocks of green turtles occur in the region: the North West Shelf (G-NWS) stock, the Scott Reef–Browse Island (G-ScBr) stock and the Ashmore Reef (G-AR) stock. The trend for the G-NWS stock is reported as stable (CoA 2017b). Locations of key nesting beaches for the G-NWS stock include the Montebello Islands, west coast of Barrow Island, Muiron Islands and North West Cape, and Dampier Archipelago.

Habitat distribution of the species varies depending on their life stage, with general distribution from the ages of five to ten within offshore pelagic environments, followed by a retreat to shallow nearshore tropical–subtropical benthic habitats including seagrass pastures, rocky reef and coral reef systems. The nesting period for the NWS stock is expected to begin in November, peak in January–February, and end in April (CoA 2017b). Seasonality of nesting for green turtles in the Dampier Archipelago is not well defined from the available data (Whiting 2018). Given the discrete duration of surveys at Legendre Island (Biota 2009), insufficient data are available to refine seasonality for this location.

During the non-breeding season, green turtles typically occupy nearshore, coastal bays, feeding on seagrasses and macroalgae (Bjorndal 1997; Bolten 2003). They are herbivorous for most of their life; however, post-hatching green turtles are omnivorous in their pelagic stage, and recent findings point to an oceanic diet (including jellyfish) for some populations (Arthur, Boyle, and Limpus 2008; Bolten 2003).

Although information on internesting turtle movement in WA is limited, tracking data has shown that during nesting periods, female green turtles typically internest in shallow, nearshore waters 0–10 m deep (Pendoley 2005) and remain <5 km from nesting beaches on Barrow Island, Varanus Island, and Rosemary Island (Pendoley 2005) and within 10 km of nesting beaches on the Lacepede Islands (Waayers, Smith, and Malseed 2011). These conclusions for green turtle internesting are also supported by other international scientific studies that suggest internesting grounds are located close to nesting beaches, in 10–18 m of water (Stoneburner 1982; Mortimer and Portier 1989; Meylen 1982; Tucker, Janzen, and Paukstis 1995; Starbird et al. 1999).

No BIAs or habitat critical for survival for green turtles have been identified within the Project Area (Figure 7-18). However, there are multiple BIAs associated with Barrow Island, the Montebello Islands and the Dampier Archipelago within >6 km (at closest) of Project Area, including migration corridor, foraging, internesting, internesting buffer, mating and nesting BIAs.

Although individuals may transit through the Project Area, large numbers are not expected given the distance offshore, water depths, and lack of primary producers and nesting beaches.

7.6.2.5 Leatherback turtle (*Dermochelys coriacea*)

Leatherback turtles are listed as endangered and migratory under the EPBC Act. Although this species has a broad distribution worldwide, it is not common within its Australian range, particularly within the NWMR (DCCEEW n.d.). Leatherback turtles are rarely recorded breeding within Australia with no large rookeries recorded. However, they are known to regularly forage within tropical and temperate continental shelf waters. The leatherback turtle is an oceanic, pelagic species that feeds primarily on jellyfish, sea squirts and other soft-bodied invertebrates (DSEWPaC 2012d).

Given their broad distribution the leatherback turtle could occur in the Project Area in low numbers. No BIAs for this species have been identified in the Project Area or EMBA.

7.6.2.6 Hawksbill turtle (*Eretmochelys imbricata*)

Hawksbill turtles are listed as vulnerable and migratory under the EPBC Act. They typically occupy tidal and subtidal tropical to warm temperate waters around the northern coast of Australia from NSW to Shark Bay in WA. Hawksbill turtles are the most tropical of all sea turtle species and are found within rock and reef habitats, coastal areas and lagoons (DCCEEW n.d.). The species is omnivorous and is known to forage amongst vertical underwater cliffs, on coral reefs and on gorgonian (soft coral) flats, as well as seagrass or algae meadows (Bjorndal 1997). Hawksbills feed primarily on sponges, but will also consume shrimp, squid, anemones, algae, seagrass, sea cucumbers and soft corals (Bjorndal 1997). In Fog Bay, Joseph Bonaparte Gulf, hawksbills feed primarily on algae and sponges (Whiting 2000) and on the reefs of the Cocos Islands in the Indian Ocean, they feed on algae, seagrass and sponges (Whiting 2004).

Juvenile hawksbill turtles appear to dive to relatively shallow depths when foraging. Blumenthal et al. (2009) reported mean diurnal dive depths of 8 ± 5 m, and a range of 2–20 m for juveniles on a Caribbean coral reef. Similarly, von Brandis et al. (2010) recorded average foraging dives in water depths <15 m for juvenile hawksbills on a coral reef at D'Arros Island, Seychelles. Data on foraging dive depths for adult hawksbill turtles in Australian waters is limited. Hoenner et al. (2015) recorded a maximum dive depth of 45 m in a study of seven adult females nesting on Groote Eylandt, western Gulf of Carpentaria.

The Western Australian (H-WA) stock, which is centred in the Dampier Archipelago, is the only breeding stock in the region and is one of the largest stocks in the world. The trend for the H-WA stock viability is unknown (CoA 2017b). The most significant breeding areas of the species within the NWMR include Rosemary Island in the Dampier Archipelago, Varanus Island in the Lowendal group, Barrow Island and some islands in the Montebello group (DSEWPaC 2012d). Nesting in the region can occur year-round, but peaks between October and January (DCCEEW n.d.). Whiting (2018) provided season-specific nesting data for Rosemary Island, which showed that hawksbill turtles have a much earlier peak (October–November) than flatback turtles (December–January peak).

Rosemary Island, which is recognised as an internationally significant rookery for hawksbill turtles (Limpus 2009), has the most significant nesting beaches for the H-WA stock, determined as mean number of turtle tracks per day (Pendoley et al. 2016). On Rosemary Island, most hawksbill nesting occurs on the north-western (NW) beaches (Pendoley Environmental 2020a), with lower density flatback and green nesting occurring at beaches on the east of the island. An analysis of 1990–2017 turtle track data from these Rosemary Island beaches concluded that nest counts were dominated by hawksbill turtles (9860 nesting events, or 92.1%), with lower flatback and green nests counts at 366 (3.4%) and 478 (4.5%), respectively (Whiting 2018). These results corroborate other conclusions that the nesting population of hawksbill turtles at Rosemary Island is one of the largest populations in Australia and globally (Limpus 2009).

Information on hawksbill turtles nesting on Varanus and Rosemary Islands suggests females remain within <10 km of their nesting beaches on Varanus Island and within 1 km of nesting beaches on Rosemary Island (Pendoley 2005).

No BIAs or habitat critical for survival for hawksbill turtles have been identified within the Project Area (Figure 7-19). However, there are multiple BIAs associated with Barrow Island, the Montebello Islands and the Dampier Archipelago within >8 km (at closest) of Project Area, including migration corridor, foraging, internesting, internesting buffer, mating and nesting BIAs.

Although individuals may transit through the Project Area, large numbers are not expected given the distance offshore and lack of coral reef or rocky shore and nesting beaches.

7.6.2.7 Olive Ridley turtle (*Lepidochelys olivacea*)

Olive Ridley turtles are listed as endangered and migratory under the EPBC Act. This species has a widespread global distribution within tropical waters. Two Olive Ridley turtle stocks have been identified in Australia; the NT stock and the north-western Cape York stock (CoA 2017b). Satellite tracking data indicates that they appear to remain on the Australian continental shelf into waters off Indonesia (Whiting, Long, and Coyne 2007). Low density nesting occurs along the northern coasts of WA and the NT (CoA 2017b). Olive Ridley turtles have been recorded foraging in both benthic and pelagic foraging habitats (Musick and Limpus 1997), and have a primarily carnivorous diet of soft-bodied invertebrates and jellyfish (CoA 2017b).

No BIAs for this species have been identified in the Project Area or EMBA. Olive Ridley turtles are not expected to be present within the Project Area, and may be present within the EMBA (Table 7-10).

7.6.2.8 Flatback turtle (*Natator depressus*)

Flatback turtles are listed as vulnerable and migratory under the EPBC Act. They are endemic to the northern Australia/southern New Guinea continental shelf. Flatback turtles differ from other marine turtles in that they do not have a pelagic phase to their lifecycle; instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches. They also prefer soft-bottom habitats away from rock and reef systems. Flatback turtle foraging areas have been found to occur in waters shallower than 130 m and within 315 km of the shore, with many areas located in 50 m water depth and 66 km from shore (Whittock, Pendoley, and Hamann 2016b). Their main diet comprises algae and a variety of invertebrates (e.g. molluscs, soft corals, sea cucumbers and jellyfish).

There are two breeding stocks within the NWMR, one of which (the Pilbara stock [F-Pil]) has significant rookeries on Thevenard Island, Barrow Island, the Montebello Islands, Varanus Island, the Lowendal Islands, islands of the Dampier Archipelago (particularly Delambre Island), and coastal areas around Port Hedland (DCCEEW n.d.). The trend of the F-Pil stock viability is currently unknown (CoA 2017b). Nesting begins in late November–December, peaks in January, and finishes by February–March.

Both an internesting BIA and habitat critical for flatback turtles have been identified within the Project Area around the Montebello, Lowendal and Barrow islands and the Dampier Archipelago (Table 7-11, Table 7-12, and Figure 7-20). Although internesting distances of up to 70 km have been recorded, these were either in a longshore direction or from islands to mainland, rather than out in open water. A number of individuals, from four different rookeries, remained within 10 km of the nesting site (Whittock, Pendoley, and Hamann 2014). These distances are less than previous studies, which showed flatback turtles travelled at least 26 km and up to 48 km in all directions from nesting beaches on the Lacepede Islands during internesting (Waayers, Smith, and Malseed 2011), although water depths are not reported.

Although individuals may transit through the Project Area, the distance offshore, water depths, and lack of primary producers and nesting beaches, prevents the Project Area from providing habitat that encourages aggregation of this species.

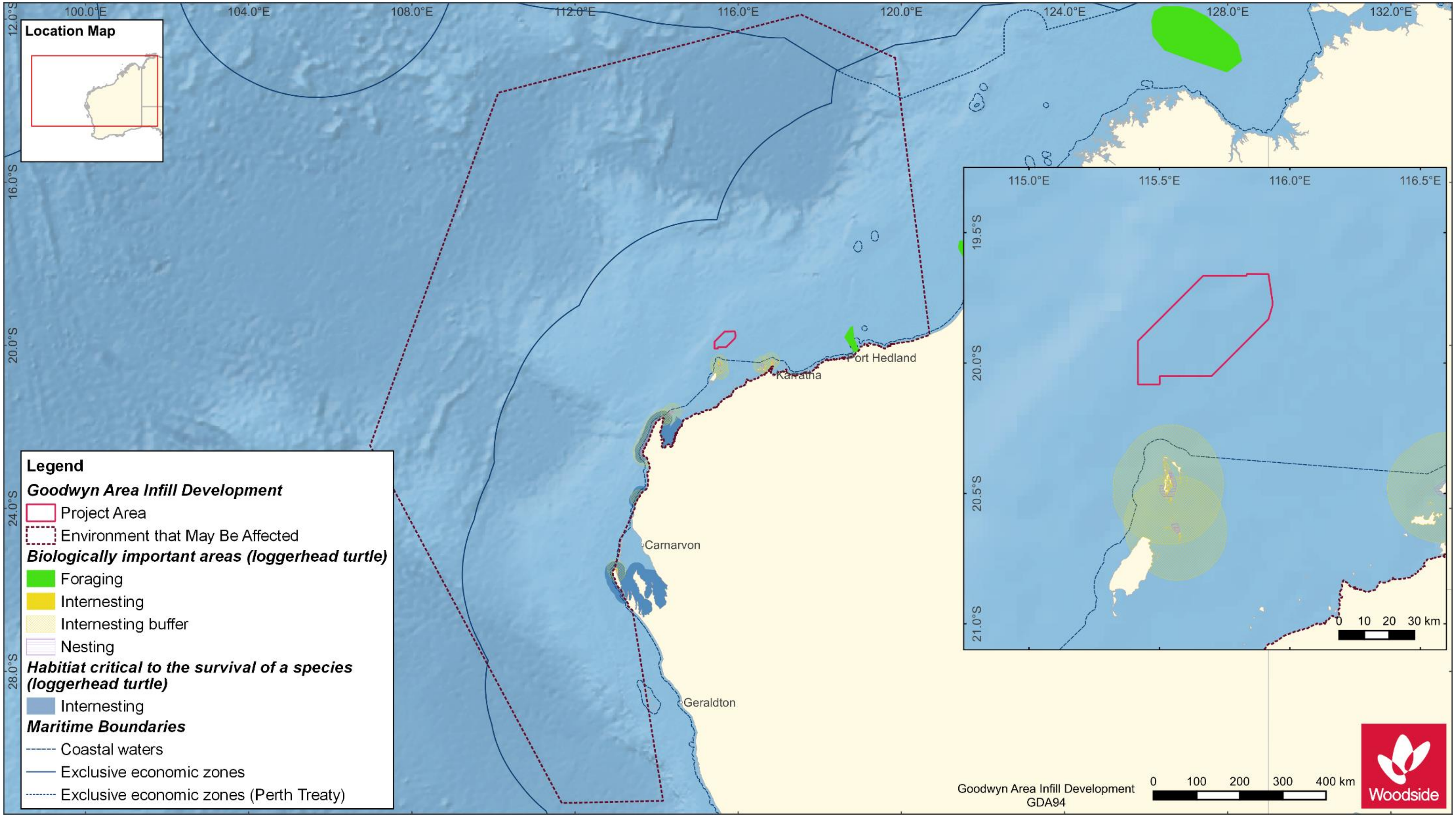


Figure 7-17: Loggerhead turtle—BIAs and habitat critical for the survival of the species within the EMBA

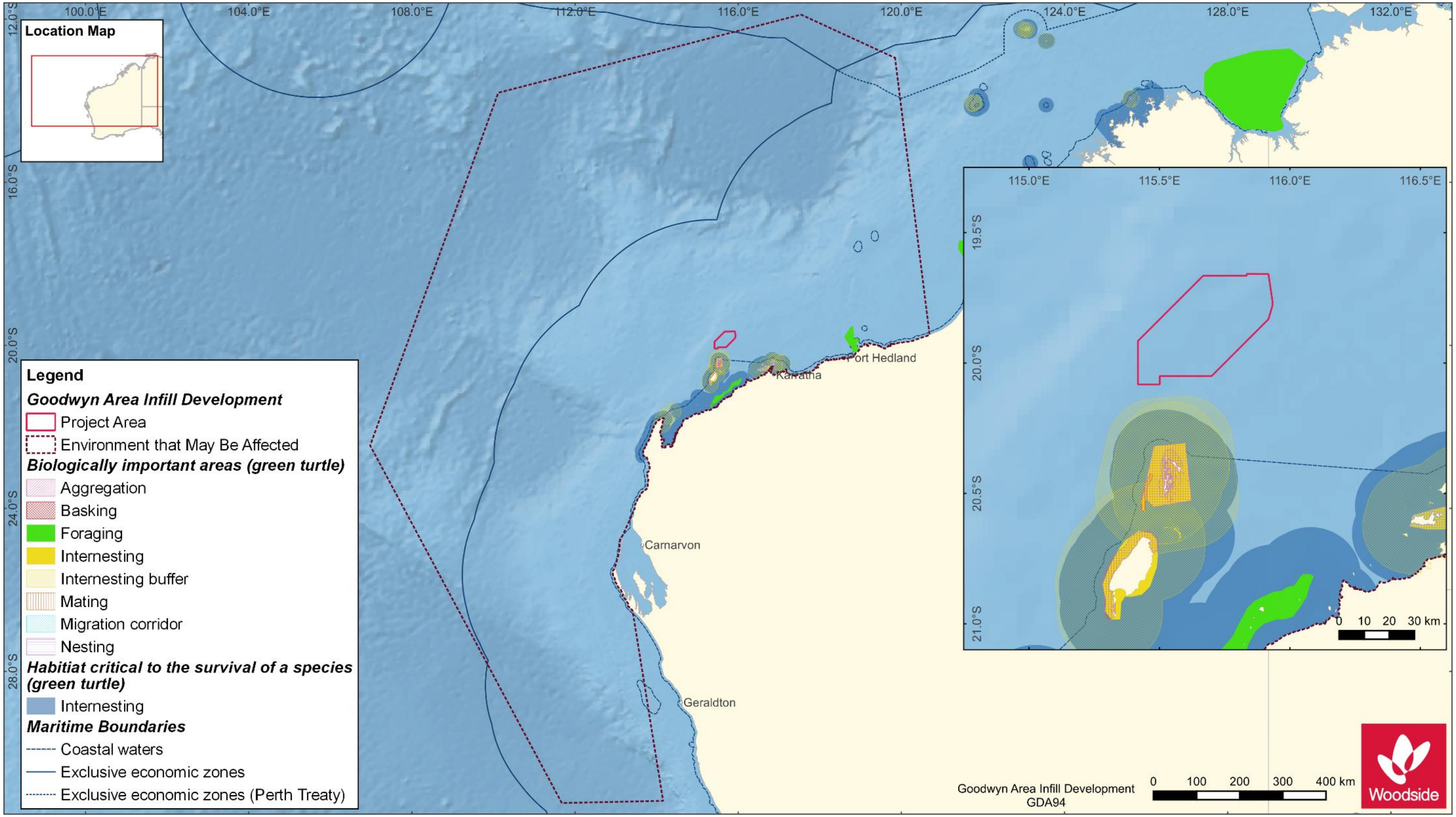


Figure 7-18: Green turtle—BIAs and habitat critical for the survival of the species within the EMBA

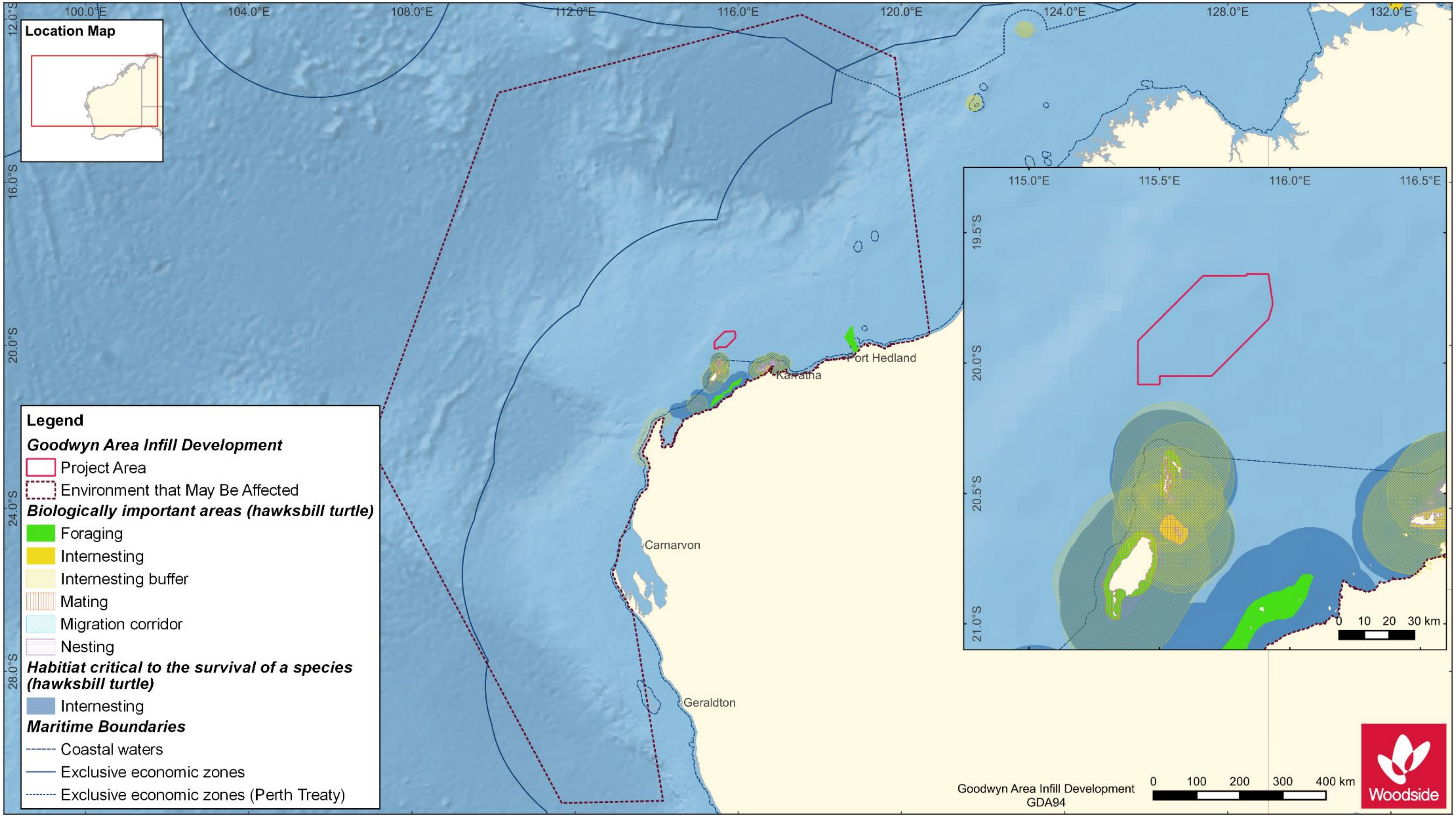


Figure 7-19: Hawksbill turtle—BIAs and habitat critical for the survival of the species within the EMBA

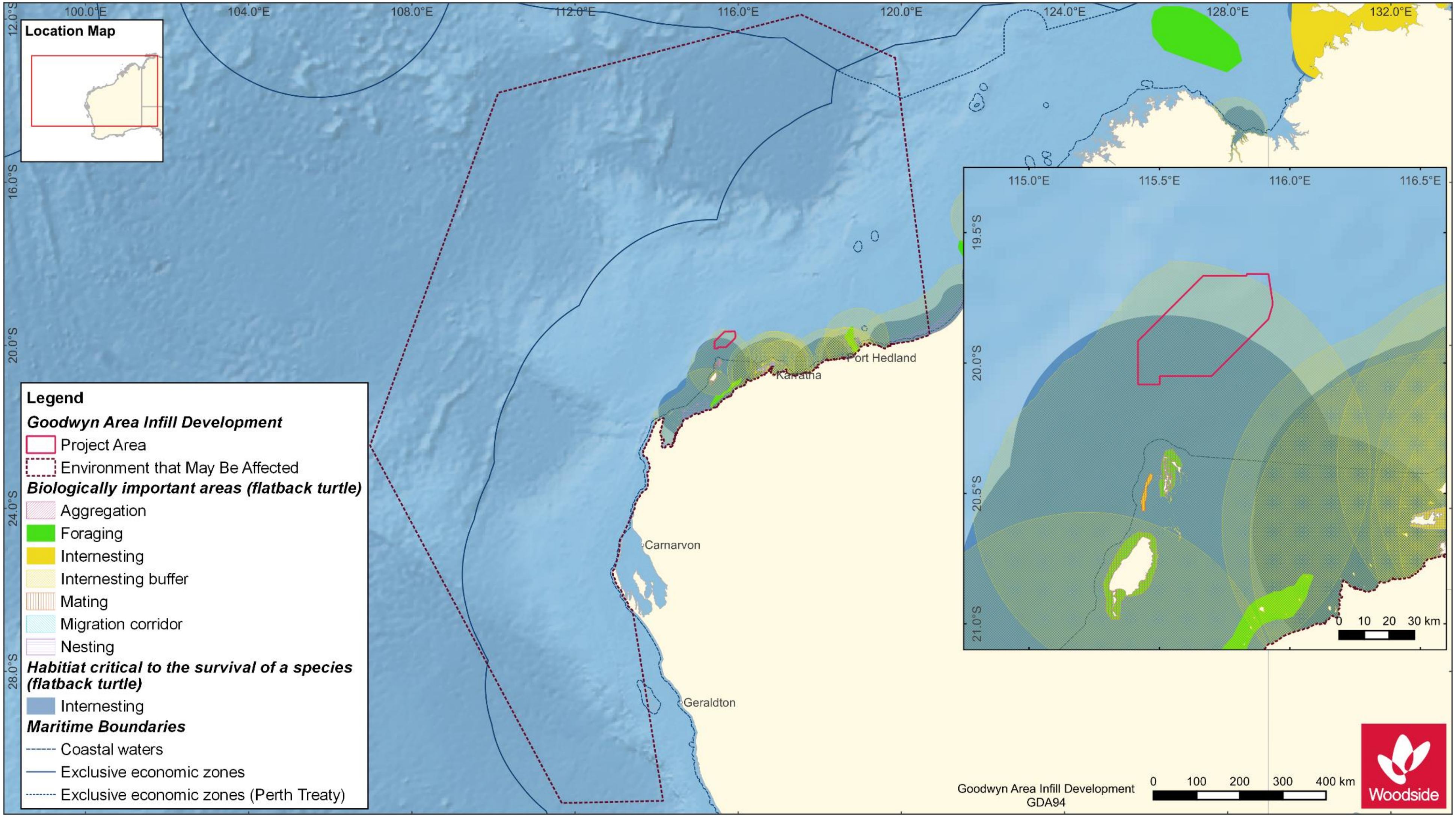


Figure 7-20: Flatback turtle—BIAs and habitat critical for the survival of the species within the EMBA

7.6.3 Marine Mammals

The EPBC Act Protected Matters search (Appendix B) identified 10 species of marine mammals listed as threatened and/or migratory with the potential to occur within the Project Area, and an additional five that may occur in the EMBA (Table 7-13). Further information regarding the threatened and/or migratory species with the potential to occur within the Project Area or EMBA is provided in the following subsections.

The threatened and/or migratory cetaceans that may be present within the Project Area and EMBA are predominantly low-frequency cetaceans[30] (e.g. blue, Bryde's, fin, humpback, and sei whales) and high-frequency cetaceans[31] (e.g. sperm whale, Australian humpback dolphin, Australian snubfin dolphin). Very high-frequency cetaceans[32] (e.g. dwarf sperm, and pygmy sperm whales) were also identified within the PMST (Appendix B) as species or species habitat that may occur within the Project Area and EMBA, these species are not listed as threatened and/or migratory under the EPBC Act.

A review of the BIAs of regionally significant marine species database (DCCEEW 2016) did not identify any BIAs within the Project Area; BIAs associated with three species were identified within the EMBA (Table 7-14).

Opportunistic cetacean sighting reports from Woodside's facilities on the NWS from 2018–2022 indicate:

- humpback whales are the most commonly observed whale species, typically between June and September
- identification of other baleen whales at species level was infrequent; for example
  - minke whales (single or in small groups) in August 2018 and August 2021
  - a pair of fin whales in April 2020
  - a pair of blue whales in November 2021
- unidentified baleen whale species have been recorded between June and September
- dolphins (typically common or bottlenose dolphins) are observed throughout the year.

[30] Low-frequency cetaceans are the functional cetacean hearing group that are specialised for hearing low frequencies (e.g. baleen whales).

[31] High-frequency cetaceans are the functional cetacean hearing group that are specialised for hearing mid frequencies (e.g. toothed whales, beaked whales, dolphins).

[32] Very high-frequency cetaceans are the functional cetacean hearing group that are specialised for hearing high frequencies (e.g. *Kogia* spp).

Table 7-13: Threatened, migratory and listed marine mammal species that may occur within the Project Area and EMBA

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Arctocephalus forsteri	Long-nosed fur-seal	N/A	N/A	Listed	N/A	Breeding known to occur within area
Balaenoptera acutorostrata	Minke whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Balaenoptera bonaerensis	Antarctic minke whale	N/A	Migratory	Cetacean	N/A	Species or species habitat likely to occur within area
Balaenoptera borealis	Sei whale	Vulnerable	Migratory	Cetacean	Species or species habitat likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni	Bryde's whale	N/A	Migratory	Cetacean	Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Balaenoptera musculus	Blue whale	Endangered	Migratory	Cetacean	Migration route known to occur within area	Migration route known to occur within area
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	Cetacean	Species or species habitat likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata	Pygmy right whale	N/A	Migratory	Cetacean	N/A	Species or species habitat may occur within area
Delphinus delphis	Common dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Dugong dugon	Dugong	N/A	Migratory	Cetacean	N/A	Breeding known to occur within area
Eubalaena australis	Southern right whale	Endangered	Migratory (as *Balaena glacialis australis*)	Cetacean	N/A	Species or species habitat likely to occur within area
Feresa attenuata	Pygmy killer whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Globicephala macrorhynchus	Short-finned pilot whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Globicephala melas	Long-finned pilot whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Grampus griseus	Risso's dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Hyperoodon planifrons	Southern bottlenose whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Indopacetus pacificus	Longman’s beaked whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Kogia breviceps	Pygmy sperm whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Kogia sima	Dwarf sperm whale	N/A	N/A	Cetacean (as *Kogia simus*)	Species or species habitat may occur within area	Species or species habitat may occur within area
Lagenodelphis hosei	Fraser’s dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Lissodelphis peronii	Southern right whale dolphin	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Megaptera novaeangliae	Humpback whale	N/A	Migratory	Cetacean	Breeding known to occur within area	Breeding known to occur within area
Mesoplodon bowdoini	Andrew’s beaked whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Mesoplodon densirostris	Blainville’s beaked whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Mesoplodon ginkgodens	Gingko-toothed beaked whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Mesoplodon grayi	Gray's beaked whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Mesoplodon layardii	Strap-toothed beaked whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Mesoplodon mirus	True's beaked whale	N/A	N/A	Cetacean	N/A	Species or species habitat may occur within area
Neophoca cinerea	Australian sea lion	Endangered	N/A	Listed	N/A	Breeding known to occur within area
Orcaella heinsohni	Australian snubfin dolphin	N/A	Migratory	Cetacean (as *Orcaella brevirostris*)	Species or species habitat may occur within area	Species or species habitat known to occur within area
Orcinus orca	Killer whale	N/A	Migratory	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Peponocephala electra	Melon-headed whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Physeter macrocephalus	Sperm whale	N/A	Migratory	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Pseudorca crassidens	False killer whale	N/A	N/A	Cetacean	Species or species habitat likely to occur within area	Species or species habitat may occur within area
Sousa sahulensis	Australian humpback dolphin	N/A	Migratory	Cetacean (as *Sousa chinensis*)	Species or species habitat may occur within area	Species or species habitat known to occur within area
Stenella attenuata	Spotted dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Stenella coeruleoalba	Striped dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Stenella longirostris	Long-snouted spinner dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Steno bredanensis	Rough-toothed dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Tursiops aduncus	Indian ocean bottlenose dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat likely to occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Tursiops aduncus (Arafura / Timor Sea populations)	Spotted bottlenose dolphin (Arafura / Timor sea populations)	N/A	Migratory	Cetacean	Species or species habitat likely to occur within area	Species or species habitat known to occur within area
Tursiops truncatus s. str.	Bottlenose dolphin	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area
Ziphius cavirostris	Cuvier's beaked whale	N/A	N/A	Cetacean	Species or species habitat may occur within area	Species or species habitat may occur within area

Table 7-14: Marine mammals BIAs within the Project Area and EMBA

Species name	Common name	BIA type	Approx. distance and direction	
			Project Area	EMBA
Balaenoptera musculus brevicauda	Blue pygmy whale	Foraging	~250 km south-west	Overlap
		Migration	~15 km north	Overlap
Dugong dugon	Dugong	Breeding	~205 km south-west	Overlap
		Calving	~205 km south-west	Overlap
		Foraging	~715 km south-west	Overlap
		Foraging (high density seagrass beds)	~205 km south-west	Overlap
		Nursing	~205 km south-west	Overlap
Eubalaena australis	Southern right whale	Migration	~225 km south-west	Overlap
		Reproduction	~210 km south-west	Overlap
Megaptera novaeangliae	Humpback whale	Calving	~715 km north-east	Overlap
		Migration	~715 km north-east	Overlap
		Migration (north and south)	~2 km south	Overlap
		Nursing	~715 km north-east	Overlap
		Resting	~210 km south-west	Overlap
Neophoca cinerea	Australian sea lion	Foraging (male)	~960 km south-west	Overlap
		Foraging (male and female)	~960 km south-west	Overlap

7.6.3.1 Antarctic minke whale (*Balaenoptera bonaerensis*)

The Antarctic minke whale is listed as migratory under the EPBC Act. It is distributed worldwide and has been recorded off all Australian states (except the NT). It feeds in cold waters and migrates to warmer waters to breed. In WA, it is thought that this species migrates from Antarctic waters up the WA coast to about 20°S to feed and possibly breed (Bannister, Kemper, and Warneke 1996); however, detailed information about timing and location of migrations and breeding grounds within the NWMR is not well known. In the high latitudinal winter breeding grounds in other regions, the species appears to be distributed off the continental shelf edge. No population estimates are available for this species in Australian waters.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.3.2 Sei whale (*Balaenoptera borealis*)

The sei whale is listed as vulnerable and migratory under the EPBC Act. Like many baleen whale species, the population of sei whales was significantly reduced by commercial whaling operations, most of which ceased in the mid-1980s. The species has a worldwide oceanic distribution and is expected to undertake seasonal migrations between low latitude wintering areas and high latitude summer feeding grounds (Bannister, Kemper, and Warneke 1996; Prieto et al. 2012). Sei whales have been infrequently recorded in Australian waters (Bannister, Kemper, and Warneke 1996); however, these low numbers could be due to the similarity in appearance of sei whales and Bryde's whales leading to incorrect recordings. This species prefers deep waters, and typically occurs in oceanic basins and continental slopes (Prieto et al. 2012); records of the species occurring in the waters on the Australian continental shelf (<200 m water depth) are uncommon (Bannister, Kemper, and Warneke 1996).

Given the large, oceanic distribution of the sei whale, and the absence of defined migration pathways or foraging areas, the Project Area is unlikely to represent an important habitat for this species.

Occurrence within the Project Area is possible given their preference for deepwater habitats, however, they are unlikely to occur in large numbers. There are no identified BIAs for sei whales in the Project Area or EMBA.

7.6.3.3 Bryde's whale (*Balaenoptera edeni*)

The Bryde’s whale is listed as migratory under the EPBC Act. It has a wide distribution throughout tropical, subtropical and temperate waters from the equator to about 40°S (Bannister, Kemper, and Warneke 1996). Bryde’s whales can occur in oceanic and inshore waters; the only key localities recognised in WA are the Abrolhos Islands and Shark Bay (Bannister, Kemper, and Warneke 1996). Data suggests offshore whales may migrate seasonally through a broad area of the continental shelf, heading towards warmer tropical waters during the winter; however, information on migration is not well known (McCauley and Duncan 2011; RPS 2012a). This species has been detected on the North West Shelf from mid-December to mid-June, peaking in late February to mid-April (RPS 2012a).

Due to the large oceanic distribution of Bryde’s whale, the Project Area is unlikely to represent an important habitat for this species. Foraging areas have been identified in Shark Bay, >600 km from the Project Area. Because they have been observed in offshore and nearshore waters (Bannister, Kemper, and Warneke 1996), individuals may occur in the Project Area; however, they are unlikely to occur in large numbers. There are no known BIAs for Bryde’s whales in the Project Area or EMBA.

7.6.3.4 Blue whale (*Balaenoptera musculus)*

Blue whales are listed as endangered and migratory under the EPBC Act. There are two subspecies of blue whales found in the southern hemisphere and known to occur in Australian waters: the Antarctic blue whale (or ‘true’ blue whale, *Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). Blue whales are generally associated with deep water beyond continental shelves, although they can be found in shallow-water regions with narrow continental shelves (Branch et al. 2007). Antarctic blue whales are uncommon north of 60°S (DCCEEW n.d.). Whereas pygmy blue whales occur in waters north of 55°S (i.e. not in the Antarctic); and have been recorded along the western and southern coasts of Australia (Gill et al. 2011; McCauley 2011; Double et al. 2014; Möller et al. 2015). On this basis, nearly all blue whales sighted in the NWMR are likely to be pygmy blue whales.

The East Indian Ocean (EIO) pygmy blue whale population is seasonally distributed, migrating biannually (northwards and southwards) along the WA coast, from the Banda Sea in Indonesia to south-west of Australia and east across the Great Australian Bight and Bonney Upwelling to beyond the Bass Strait (BPM 2020).

McCauley et al. (2018) describe three migratory stages around Australia for the EIO pygmy blue whale population:

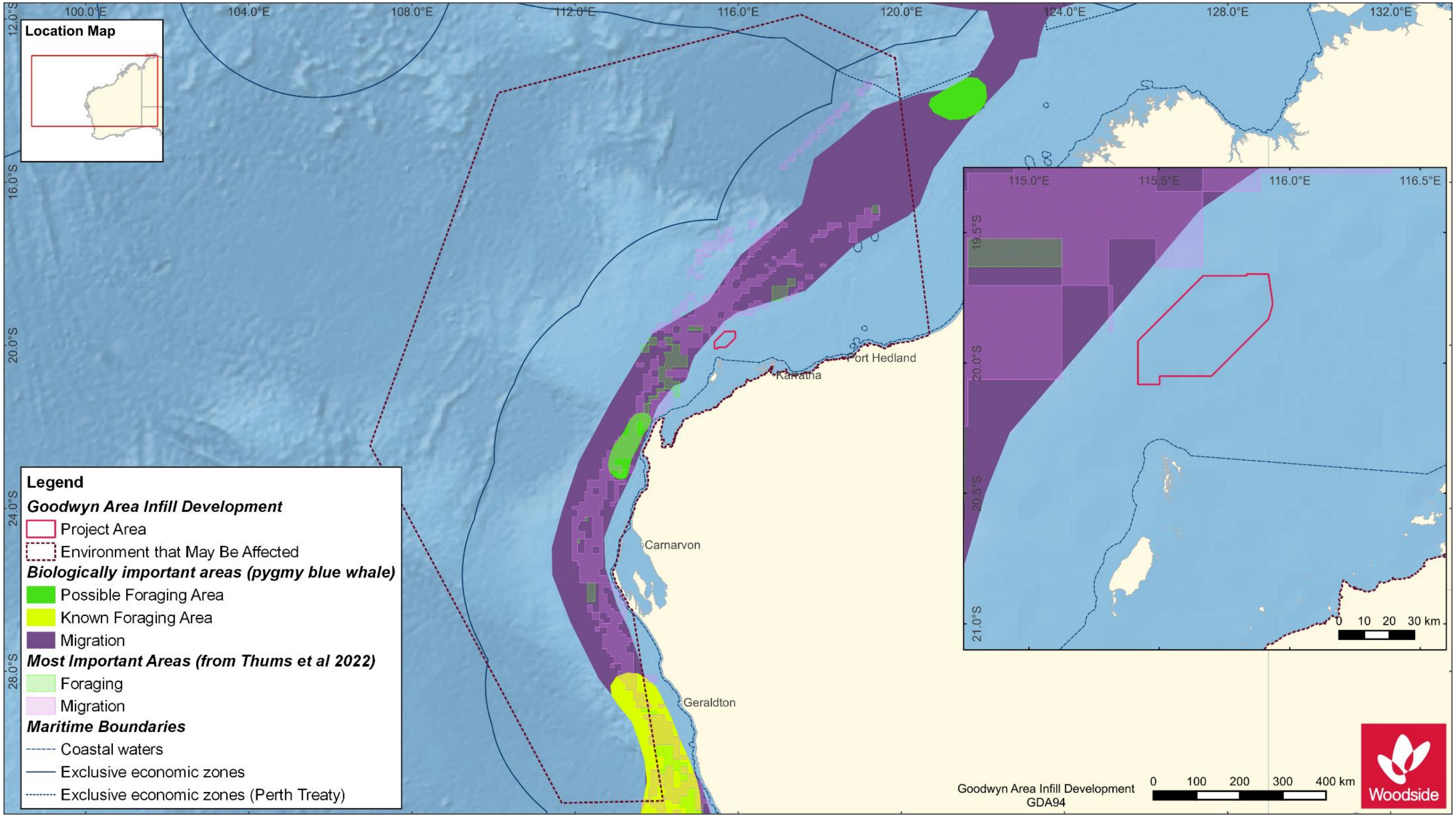
- a ‘southbound migratory stage’ where whales, including males, females and calf pairs, travel southwards from Indonesian waters offshore from the WA coast, mostly from October to December but possibly into January of the following year
- a protracted ‘southern Australian stage’ (January–June) where animals spread across southern waters of the Indian Ocean and south of Australia
- a ‘northbound migratory stage’ (April–August) where whales, males and females, travel north back to Indonesia again.

Pygmy blue whales are ‘income breeders’ (IMMA n.d.) and as such may opportunistically feed along their migratory path if food sources are available. Thums et.al. (2022) used passive acoustic monitoring and satellite telemetry data to assess the spatial extent of the distribution, migration, and foraging areas for pygmy blue whales in the south-east Indian Ocean. They highlighted extensive use of slope habitat off WA and minimal use of shelf habitat, with pygmy blue whales off WA mostly engaged in migration, with short periods of foraging. Whale density was highest in the southern part of the north-west Australian coast and whales were there from April–June and November–December. Modelling predictions based on passive acoustic data indicated higher densities of pygmy blue whales around the Montebello Island region during May and June (northern migration) and November and December (southern migration) (Thums et al. 2022).

This study also compared foraging and migration areas to described BIAs—some aligned while others only had <10% overlap (Thums et al. 2022). Thums et. al. (2022) identified the most important foraging (and/or resting/breeding) areas from south to north as the Perth Canyon and vicinity, the shelf edge off Geraldton, the shelf edge from Ningaloo Reef to the Rowley Shoals (not continuous) and including a few small areas near the shelf edge off ~25°S, and the Banda Sea. The Known Foraging Area BIA off the south-west of WA encompassed 83% of the most important areas in that region (Thums et al. 2022). The Project Area does not intersect with any of the areas identified as 'most important' for migration or foraging for pygmy blue whales (Figure 7-21).

Based on acoustic data, pygmy blue whales are likely to travel alone or in small groups. For example, acoustic loggers deployed during June and July 2009 in the vicinity of Wheatstone platform indicated that there were up to six pygmy blue whales calling at any point in time, and noted that these vocalisations occurred in pulses with quiet periods (average of 4.2±2.6 days) occurring between calls (McCauley and Salgado Kent 2009).

There are currently insufficient data to accurately estimate population numbers of the pygmy blue whale in Australian waters (BPM 2020; CoA 2015a). However there are two estimates of the EIO pygmy blue whale population size for WA: McCauley and Jenner (2010) estimated the population to be 662–1,559 individuals in 2004 based on passive acoustics (whale vocalisations), and Jenner et al. (2008) estimated the population as 712–1,754 individuals based on photographic mark and recapture analysis. However, both estimates did not account for animals travelling further west into the Indian Ocean (McCauley et al. 2018). Given the species migration patterns it is possible that individuals will occur in the Project Area, with a higher occurrence during the migration seasons (predicted peak periods of May–June for northbound, and November–December for southbound).



Spatial definition of BIAs sourced from DCCEEW (2016) database; naming convention for foraging areas aligned with the Conservation Management Plan for the Blue Whale (CoA 2015a).

Figure 7-21: Pygmy blue whale—BIAs and most important areas for foraging and migration within the EMBA

7.6.3.5 Fin whale (*Balaenoptera physalus*)

The fin whale, a large baleen whale, is listed as vulnerable and migratory under the EPBC Act. This species is distributed worldwide, migrates annually between high latitude summer feeding grounds and lower latitude overwintering areas (Bannister, Kemper, and Warneke 1996) . This species is not commonly encountered in coastal or continental shelf waters. Australian Antarctic waters are important feeding grounds for fin whales but there are no known mating or calving areas in Australia's continental waters (Morrice et al. 2004). The species has been observed in groups of six to 10 individuals, as well as in pairs and alone (TSSC 2015b). Accurate distribution patterns are not known within Australian waters and most data are from stranding events.

Because of the large oceanic distribution of the fin whale, the Project Area is unlikely to represent an important habitat for this species. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.3.6 Pygmy right whale (*Caperea marginata*)

The pygmy right whale is listed as migratory under the EPBC Act. This species is found within temperate and sub-Antarctic waters of the Southern Hemisphere, and have been recorded primarily in areas associated with upwellings and with high zooplankton abundance (Kemper 2002b). Within Australia, pygmy right whales have been recorded along the west and east coasts, by the warm, south-flowing Leeuwin and East Australian currents (Kemper 2002a).

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.3.7 Dugong (*Dugong dugon)*

The dugong is listed as migratory under the EPBC Act. Dugongs inhabit seagrass meadows in coastal waters, estuarine creeks and streams, and reef systems (DSEWPaC 2012b).

Dugongs are distributed along the WA coast throughout the Gascoyne, Pilbara, and Kimberley. Specific areas supporting dugong populations include Shark Bay; Ningaloo and Exmouth Gulf; the Pilbara coast; Eighty Mile Beach; and the Kimberley coast, including Roebuck Bay (Brown et al. 2014). Dugong distribution correlates with the seagrass habitats upon which it feeds; water temperature has also been correlated with dugong movements (Preen et al. 1997; Preen 2004).

Dugongs are known to migrate hundreds of kilometres between seagrass habitats (Sheppard et al. 2006), and in Shark Bay they exhibit seasonal movements as a behavioural thermoregulatory response to winter water temperatures (Holley, Lawler, and Gales 2006; Marsh, O'Shea, and Reynolds 2011). Aerial surveys since the mid-1980s indicate that dugong populations are now stable at a regional scale in Shark Bay and in the Exmouth/Ningaloo Reef area.

There are no BIAs for dugongs within the Project Area, but they are present within nearshore mainland areas within the EMBA (Figure 7-22).

7.6.3.8 Southern right whale (*Eubalaena australis*)

The southern right whale occurs primarily in waters between about 20°S and 60°S and moves from high latitude feeding grounds in summer to warmer low latitude coastal locations in winter (Bannister, Kemper, and Warneke 1996). Southern right whales aggregate in calving areas along the south coast of WA, which is outside the NWMR. However, there have been sightings of this species in waters of the NWMR as far north as Ningaloo (Bannister and Hedley 2001), and a stranding record exists for the far north Kimberley coast (ALA 2020). Southern right whale calving grounds are found at mid to lower latitudes and are occupied during winter and early–mid spring. This species is are regularly present near the southern Australian coast from about mid-May to mid-November, and the peak mating period is mid-July–August. Mating occurs within these breeding grounds as evidenced by many observations of intromission and mating behaviours. Southern right whales in south-western Australia appear to be increasing at the maximum biological rate but there is limited evidence of an increase in south-eastern Australian waters (DSEWPaC 2012a).

There are no BIAs for southern right whales within the Project Area, but they are present along the coasts and gulf areas within the EMBA (Figure 7-23).

7.6.3.9 Humpback whale (*Megaptera novaeangliae*)

The humpback whale is listed as migratory under the EPBC Act. In Australian waters two genetically distinct populations migrate annually along the west (Group IV) and east coasts (Group V) between May and November. In WA, the migration pathway for the Group IV population (also known as Breeding Stock D) extends from Albany to the Kimberley coastline, passing through the NWMR (TSSC 2015d). Since the 1982 moratorium on commercial whaling, population numbers have recovered significantly—from ~2000–3000 individuals in 1991, to between 19,200–33,850 individuals in 2008 (Bannister and Hedley 2001; Bejder et al. 2019; Hedley, Bannister, and Dunlop 2011). Aerial surveys off the WA coast undertaken between 2000 and 2008 produced a population estimate for the Group IV population of 26,100 individuals (Confidence Interval: 20,152–33,272) in 2008 (Salgado Kent et al. 2012). Current population growth for the Group IV population is estimated at 9.7–13% per annum (TSSC 2015d). Using the Salgado Kent et al. (2012) estimate of 26,100 individuals and an annual population growth rate of ~10%, current population size could be in excess of 75,000 individuals (Woodside 2019a).

The humpback whale was previously listed as vulnerable under the EPBC Act (originally under Schedule 1 of the *Endangered Species Protection Act 1992*). In February 2022, the humpback whale was removed from the threatened species list as it was deemed no longer eligible for inclusion (TSSC 2022).

The Group IV population migrates northward from their Antarctic feeding grounds around May each year, reaching the NWMR around early June. The southward migration subsequently starts in mid-September, around the time of breeding and calving (typically August–September) (TSSC 2015d). Within the NWMR there are key calving areas between Broome and the northern end of Camden Sound, and resting areas in the southern Kimberley region, Exmouth Gulf and Shark Bay. High numbers of humpback whales are observed in Camden Sound and Pender Bay from June to September each year (TSSC 2015d), but there are reports of neonates further south, suggesting that the calving areas may be poorly defined. Aerial photogrammetric surveys in 2013 and 2015 recorded large numbers of humpback whale calves along North West Cape, with estimated minimum relative calf abundance of 463–603 in 2013 and 557–725 in 2015 (Irvine et al. 2018). Most of the calves sighted in both years (85% in 2013; 94% in 2015) were neonates, and these observations indicate that a minimum of ~20% of the expected number of calves of this population are born near, or south of, North West Cape. Thus, the calving grounds for the Group IV population extend south from Camden Sound to at least North West Cape, 1000 km south-west of the currently recognized calving area (Irvine et al. 2018).

There are no BIAs for the humpback whale within the Project Area, but there is a migration (north and south) BIA within the EMBA (at its closest ~2 km south of the Project Area; Figure 7-24).

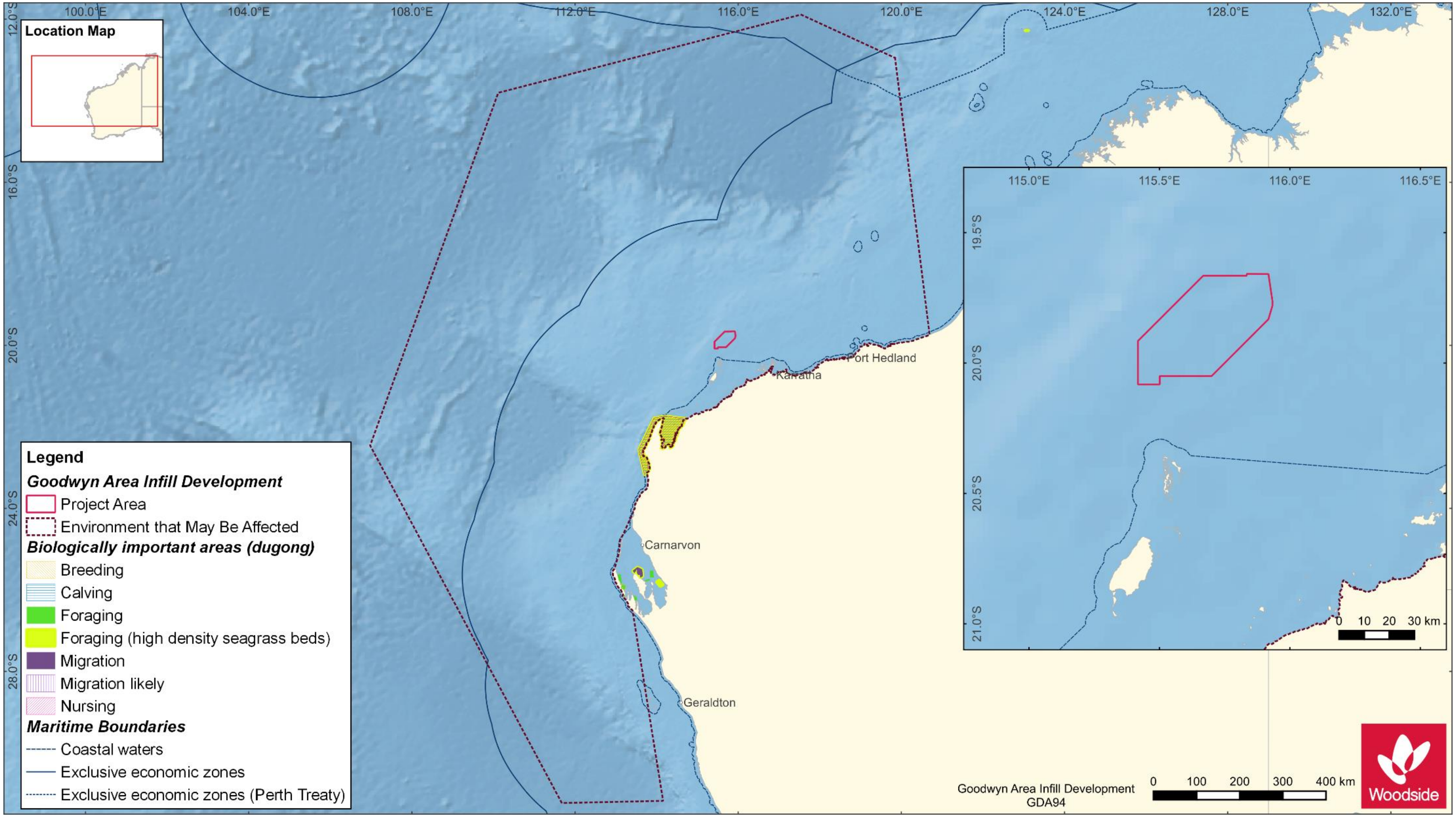


Figure 7-22: Dugong—BIAs within the EMBA

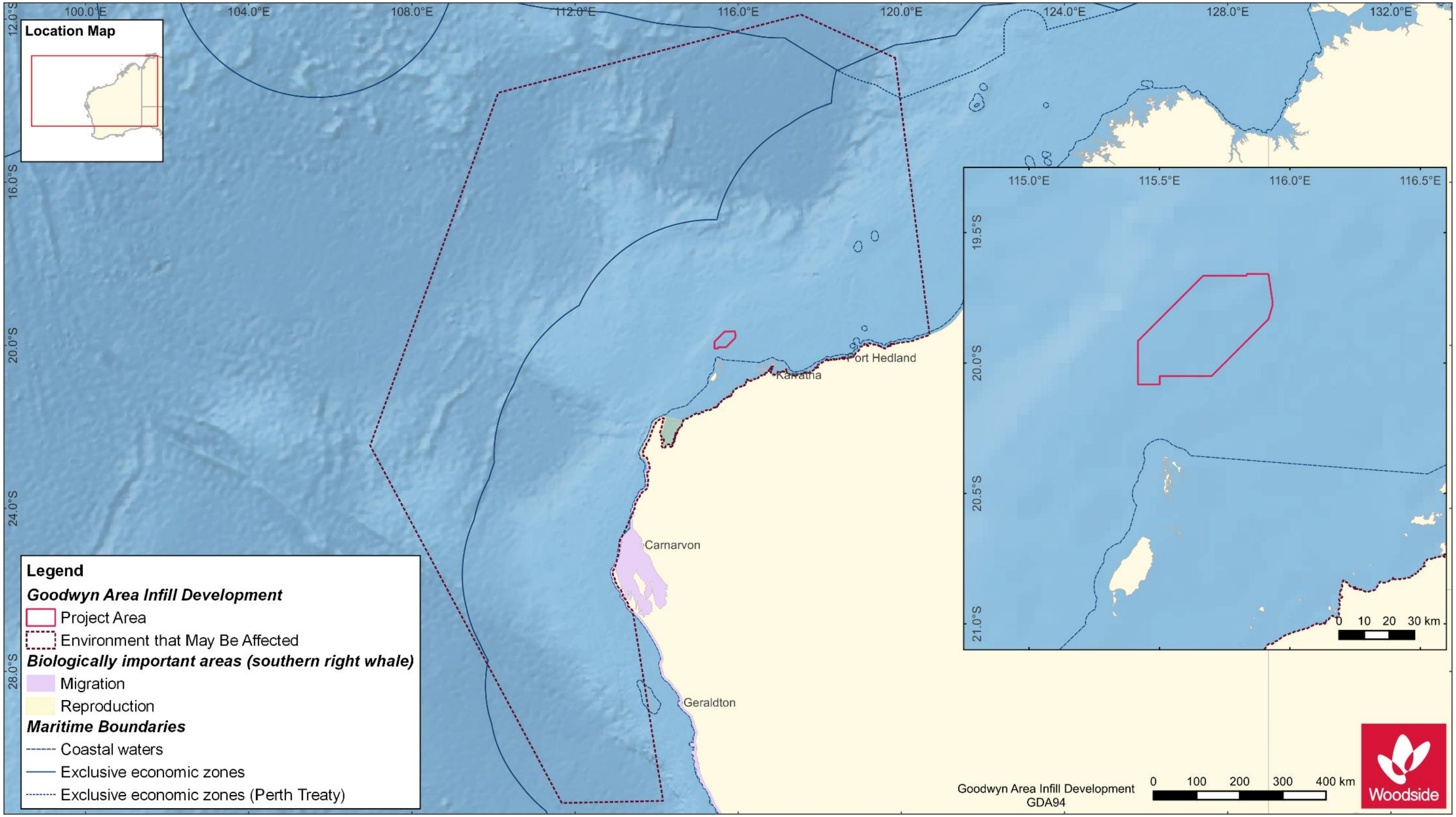


Figure 7-23: Southern right whale—BIAs within the EMBA

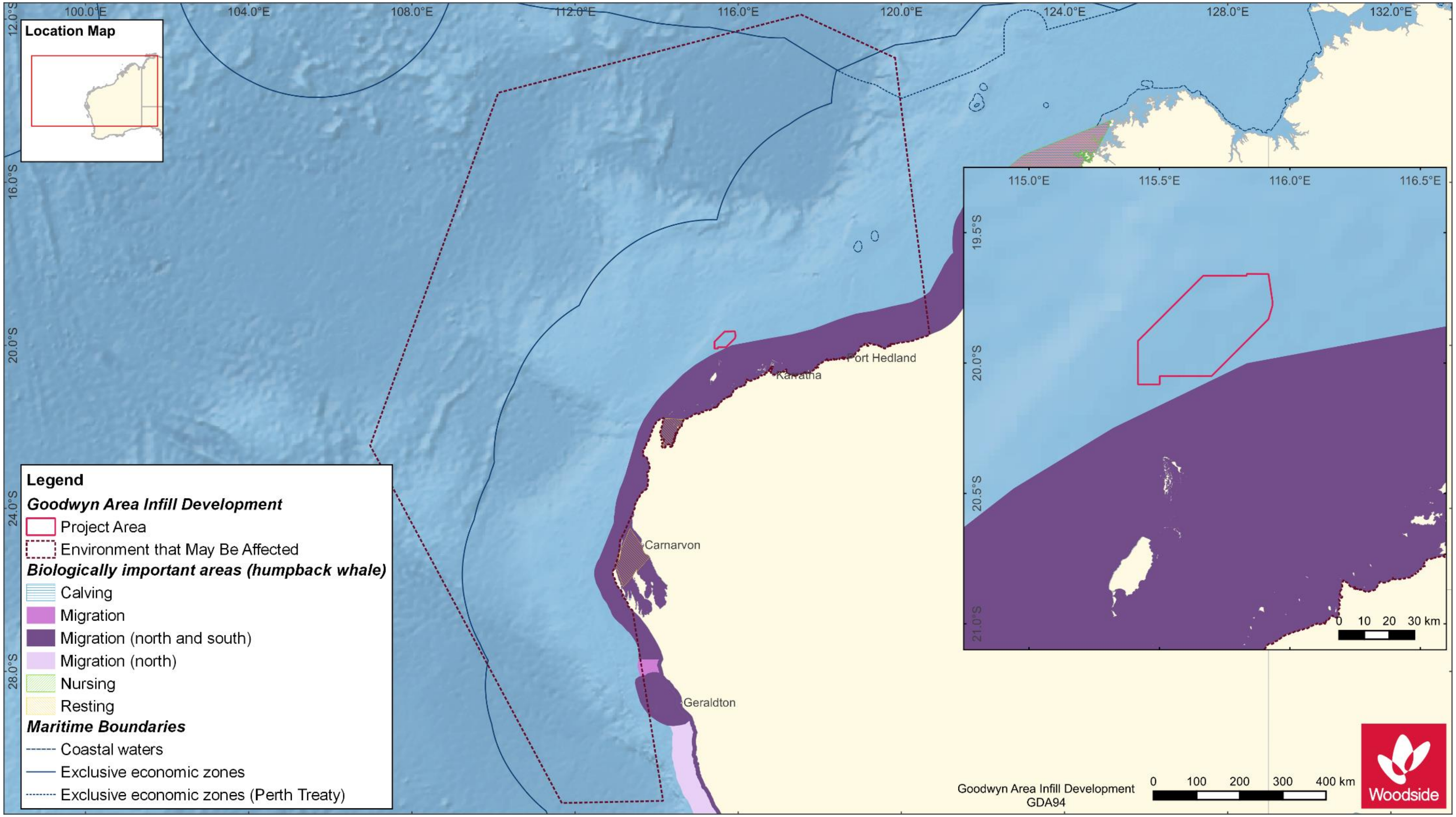


Figure 7-24: Humpback whale—BIAs within the EMBA

7.6.3.10 Australian sea lion (*Neophoca cinerea*)

The Australian sea lion is listed as endangered under the EPBC Act. The Australian sea lion is the only pinniped endemic to Australia (Strahan 1983) and has been recorded within the southern extent of the NWMR at Shark Bay, WA (Kirkwood, Pemberton, and Copson 1992).

The most northern known breeding colony is at the Houtman Abrolhos Islands in the SWMR. The Australian sea lion's breeding range extends from the Houtman Abrolhos Islands, WA to The Pages Island, east of Kangaroo Island, SA.

The Australian sea lion is considered to be a specialised benthic forager—that is, it feeds primarily on the sea floor. Studies have shown that the species will eat a range of prey, including fish, cephalopods (squid, cuttlefish and octopus), sharks, rays, rock lobsters and penguins (DSEWPaC 2013b; TSSC 2020a). The Australian sea lion feeds on the continental shelf, most commonly in depths of 20–100 m, and they typically travel up to about 60 km from their colony on each foraging trip, with a maximum distance of around 190 km when over shelf waters.

There are no BIAs for the Australian sea lion in the Project Area, however there are foraging BIAs within the EMBA associated with Houtman Abrolhos Islands (Figure 7-25).

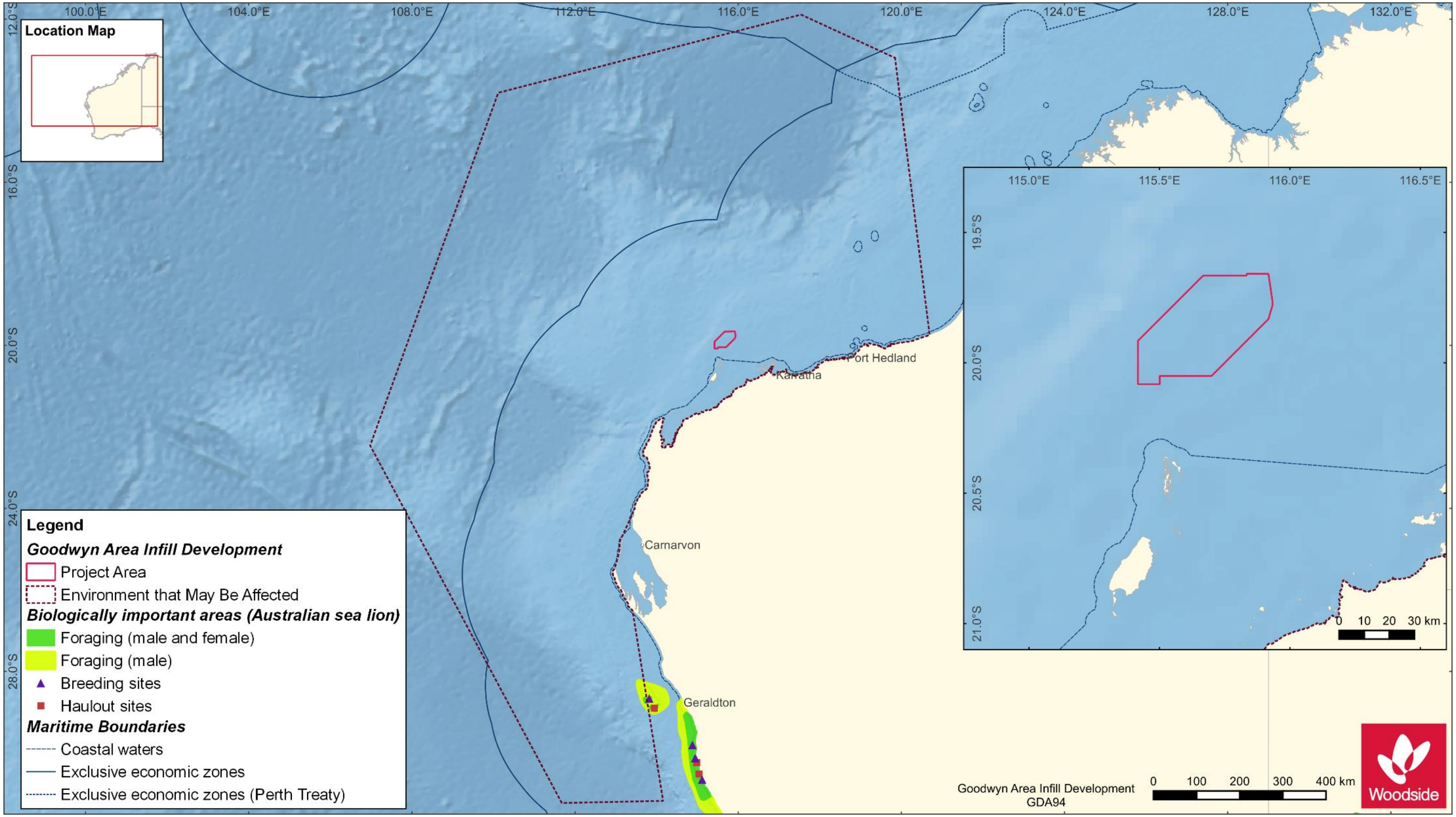


Figure 7-25: Australian sea lion—BIAs within the EMBA

7.6.3.11 Australian snubfin dolphin (*Orcaella heinsohni*)

The Australian snubfin dolphin is listed as migratory under the EPBC Act and the BC Act. This species has been recorded almost exclusively in Australia's coastal and estuarine waters. Stranding and museum specimen records indicate that this species occurs only in waters off northern Australia, from approximately Broome on the west coast to the Brisbane River on the east coast (Parra, Corkeron, and Marsh 2002). Aerial and boat-based surveys indicate that it occurs mostly in protected shallow waters close to the coast, and close to river and creek mouths (Parra 2006; Parra, Corkeron, and Marsh 2006; 2002).

Within the NWMR, this species has been found in the shallow coastal waters and estuaries along the Kimberley coast. Important areas for this species include Beagle and Pender bays on the Dampier Peninsula, and tidal creeks around Yampi Sound and between Kuri Bay and Cape Londonderry (DEWHA 2008b). Roebuck Bay, which supports one of the largest known populations of this species (D'Cruz et al. 2022), has generally been considered the south-western limit of this species' distribution across northern Australia, but it has also been recorded in Port Hedland harbour, the Dampier Archipelago, Montebello Islands, Exmouth Gulf and off North West Cape (Allen et al. 2012).

This species feeds in a variety of habitats (mangroves, sandy bottom estuaries and embayments, rock and/or coral reefs), primarily in shallow waters (<20 m) close to river mouths and creeks (DCCEEW n.d.).

Given the nearshore shallow distribution of the Australian snubfin dolphins, the Project Area is unlikely to represent an important habitat for this species There are no BIAs for this species within the Project Area or EMBA.

7.6.3.12 Killer whale (*Orcinus orca*)

The killer whale is listed as migratory under the EPBC Act and the BC Act. It is a cosmopolitan species, occurring throughout all oceans and contiguous seas. Its preferred habitat includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters. Killer whales appear to be more common in cold, deep waters; however, they have been observed along the continental slope and shelf, particularly near seal colonies, as well as in shallow coastal areas of WA (Bannister, Kemper, and Warneke 1996; Thiele and Gill 1999).

Killer whales are known to make seasonal movements, and probably follow regular migratory routes, but no information is available for the species in Australian waters (DCCEEW n.d.). They are known to target humpback whales, particularly calves, off Ningaloo Reef during the humpback southern migration season (Pitman et al. 2015). Overall, observations suggest that humpback calves are a predictable, plentiful, and readily taken prey source for killer whales off Ningaloo Reef for at least five months per year. There are also records of killer whales attacking dugongs in Shark Bay (Anderson and Prince 1985). However, there are no recognised key localities or important habitats for killer whales within the NWMR (DSEWPaC 2012b).

Due to the large oceanic distribution of killer whales, the Project Area is unlikely to represent an important habitat for this species. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.3.13 Sperm whale (*Physeter macrocephalus*)

The sperm whale is listed as migratory under the EPBC Act and vulnerable under the BC Act. Sperm whales are the largest of the toothed whales and are distributed worldwide in deep waters (>200 m) off continental shelves and sometimes near shelf edges (Bannister, Kemper, and Warneke 1996). The species tends to inhabit offshore areas at depths of 600 m or more and is uncommon in waters <300 m deep (Ceccareli et al. 2011). There is limited information about sperm whale distribution in Australian waters; however, they are usually found in deep offshore waters, with more dense populations close to continental shelves and canyons. In the open ocean, there is a generalised movement of sperm whales southwards in summer, and corresponding movement northwards in winter, particularly for males. Detailed information about the distribution and migration patterns of sperm whales off the WA coast is not available. Females with young may reside within the NWMR all year round, males may migrate through the region, and the species may be associated with canyon habitats (Ceccareli et al. 2011).

Given the large oceanic distribution of the sperm whale, and the absence of defined migration pathways or foraging areas, the Project Area is unlikely to represent an important habitat for this species. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.3.14 Australian humpback dolphin (*Sousa sahulensis)*

Previously included with *Sousa chinensis*, the Australian humpback dolphin (*S. sahulensis*) was elevated to a species in 2014. *S. chinensis* is now applied to humpback dolphins in the eastern Indian and western Pacific oceans, while *S. sahulensis* applies to humpback dolphins in the waters of the Sahul Shelf from northern Australia to southern New Guinea (Jefferson and Rosenbaum 2014). The Australian humpback dolphin is listed as *S. chinensis* under the EPBC Act.

The Australian humpback dolphin (referred to as ‘humpback dolphin’ hereafter) is listed as migratory under the EPBC Act and the BC Act. It does not appear to undergo large-scale seasonal migrations, although seasonal shifts in abundance have been observed (Parra and Cagnazzi 2016).

Allen et al. (2012) suggested that humpback dolphins use a range of inshore habitats, including both clear and turbid coastal waters across northern WA. Boat-based surveys up to 5 km out from the coast (Brown et al. 2012) recorded humpback dolphins 0.3–4.5 km away from shore and in depths of 1.2–20 m (mean: ~8 m). Other studies around North West Cape, which surveyed waters up to 5 km from the coast, recorded humpback dolphins in water depths of up to 40 m (Hanf, Hunt, and Parra 2016).

Aerial surveys targeting dugongs over the western Pilbara have recorded humpback dolphins more than 60 km from the mainland in shallow shelf waters (i.e. <30 m deep) near Barrow Island and the western Lowendal Islands (Hanf 2015). This species has also been recorded in fringing coral reefs and shallow sheltered sandy lagoons at the Montebello Islands (Raudino, Hunt, and Waples 2018). Several studies have focused on populations of humpback dolphins along the Kimberley coast, including Roebuck Bay, the Dampier Peninsula, Cone Bay, Yampi Sound, Prince Regent River and the Cambridge Gulf (Brown et al. 2016)).

Given the nearshore shallow distribution of the humpback dolphins, the Project Area is unlikely to represent an important habitat for this species There are no BIAs for this species within the Project Area or EMBA.

7.6.3.15 Spotted bottlenose dolphin (*Tursiops aduncus*)

Spotted bottlenose dolphins are listed as migratory under the EPBC Act. There are four known subpopulations of this species, of which the Arafura/Timor Sea populations were identified as potentially occurring within the NWMR. The species is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters including coastal areas around oceanic islands, from Shark Bay to the western edge of the Gulf of Carpentaria. It forages in a range of habitats but is generally restricted to water depths <200 m (DSEWPaC 2012b). Important foraging/breeding areas include the shallow coastal waters and estuaries along the Kimberley coast and Roebuck Bay.

Given the nearshore shallow distribution of the spotted bottlenose dolphins, the Project Area is unlikely to represent an important habitat for this species There are no BIAs for this species within the Project Area or EMBA.

7.6.4 Seabirds and Migratory Shorebirds

The EPBC Act protected matters search (Appendix B) identified 15 species of seabirds and shorebirds listed as threatened and/or migratory with the potential to occur within the Project Area, and an additional 59 species that may occur in the EMBA (Table 7-15). Further information regarding the threatened and/or migratory species with the potential to occur within the Project Area or EMBA are provided in the following subsections.

A review of the BIAs of regionally significant marine species database (DCCEEW 2016) identified a BIA for one species within the Project Area, and BIAs associated with 19 species within the EMBA (Table 7-16).

The NWMR is situated within the East Asian–Australian Flyway (EAAF), a geographic region supporting populations of migratory shorebirds throughout their annual cycle. The EAAF extends from breeding grounds in the Russian tundra, Mongolia and Alaska southwards through east and south-east Asia, to non-breeding areas of Indonesia, Papua New Guinea, Australia and New Zealand (Weller and Lee 2017). All shorebird species identified undertake annual migrations from breeding sites in the northern hemisphere to more southern non-breeding sites within the EAAF (Bamford et al. 2008).

The EAAF encompasses a large proportion of the NWMR. Migratory shorebirds may migrate through the offshore areas of the NWMR between overwintering grounds in Australia and breeding sites in the northern hemisphere (Bamford et al. 2008). Peak migration occurs between March and May (northern migration) and August and November (southern migration) (Bamford et al. 2008). Migration routes of some migratory shorebird species have been characterised using bird identification band recoveries (Minton et al. 2006); however, the migration pathways taken by these species between sightings are poorly understood.

Migratory shorebird species are present in Australia during the non-breeding period (December–February) in coastal and inland habitats where adult birds build up the energy reserves necessary to support northward migration and subsequent breeding (CoA 2015c). During this time, individuals must maintain an energy intake greater than their energy expenditure to recover from the southward migration, to allow moulting, and to build fat reserves in preparation for the northward migration (CoA 2015c). The high-energy demands of migration means that both foraging and resting during the non-breeding period are vital for individual fitness and survival.

Due to differences in coastal or wetland habitat requirements between roosting and foraging behaviours, areas used most by migratory shorebirds usually comprise networks of foraging and roosting habitats. Shorebirds move between areas of this network depending on the time of day, availability of resources, levels of disturbance and environmental conditions (CoA 2015c). Displacement from one habitat or the other may result in them using sub-optimal habitat and/or increase their energy demands because of the increased distance between habitats.

Within the EAAF, sites of international importance are identified as ‘a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird’ (Ramsar Convention Bureau 2000). All shorebirds identified as high occurrence key species occur in shoreline habitats within the NWMR for at least part of their non-breeding season in Australia.

Sites of international importance for the identified migratory species within the NWMR are included in the following subsections.

Table 7-15: Threatened, migratory and listed seabirds and shorebirds species that may occur within the Project Area and EMBA

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Actitis hypoleucos	Common sandpiper	N/A	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat known to occur within area
Anous stolidus	Common noddy	N/A	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat likely to occur within area
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	N/A	Marine	N/A	Foraging, feeding or related behaviour likely to occur within area
Apus pacificus	Fork-tailed swift	N/A	Migratory	Marine	N/A	Species or species habitat likely to occur within area
Ardenna carneipes	Flesh-footed shearwater	N/A	Migratory	Marine	N/A	Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica	Wedge-tailed shearwater	N/A	Migratory	Marine	N/A	Breeding known to occur within area
Arenaria interpres	Ruddy turnstone	Vulnerable	Migratory	Marine	N/A	Species or species habitat known to occur within area
Bubulcus ibis	Cattle egret	N/A	N/A	Overfly marine area	N/A	Species or species habitat may occur within area
Calidris acuminata	Sharp-tailed sandpiper	Vulnerable	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat known to occur within area
Calidris alba	Sanderling	N/A	Migratory	Marine	N/A	Species or species habitat known to occur within area
Calidris canutus	Red knot	Vulnerable	Migratory	Overfly marine area	Species or species habitat may occur within area	Species or species habitat known to occur within area
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	Overfly marine area	Species or species habitat may occur within area	Species or species habitat known to occur within area
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	Overfly marine area	Species or species habitat may occur within area	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Calidris ruficollis	Red-necked stint	N/A	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Calidris subminuta	Long-toed stint	N/A	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Calidris tenuirostris	Great knot	Vulnerable	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	Marine	Species or species habitat likely to occur within area	Species or species habitat known to occur within area
Chalcites osculans	Black-eared cuckoo	N/A	N/A	Overfly marine area	N/A	Species or species habitat known to occur within area
Charadrius leschenaultii	Greater sand plover	Vulnerable	Migratory	Marine	N/A	Species or species habitat known to occur within area
Charadrius mongolus	Lesser sand plover	Endangered	Migratory	Marine	N/A	Roosting known to occur within area
Charadrius ruficapillus	Red-capped plover	N/A	N/A	Overfly marine area	N/A	Species or species habitat known to occur within area
Charadrius veredus	Oriental plover	N/A	Migratory	Overfly marine area	N/A	Species or species habitat may occur within area
Chroicocephalus novaehollandiae	Silver gull	N/A	N/A	Marine (as *Larus novaehollandiae*)	N/A	Breeding known to occur within area
Diomedea amsterdamensis	Amsterdam albatross	Endangered	Migratory	Marine	N/A	Species or species habitat likely to occur within area
Diomedea epomophora	Southern royal albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Diomedea exulans	Wandering albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Erythrotriorchis radiatus	Red goshawk	Vulnerable	N/A	N/A	N/A	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Fregata ariel	Lesser frigatebird	N/A	Migratory	Marine	Species or species habitat likely to occur within area	Species or species habitat known to occur within area
Fregata minor	Great frigatebird	N/A	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat likely to occur within area
Gallinago megala	Swinhoe's snipe	N/A	Migratory	Overfly marine area	N/A	Roosting likely to occur within area
Gallinago stenura	Pin-tailed snipe	N/A	Migratory	Overfly marine area	N/A	Roosting likely to occur within area
Glareola maldivarum	Oriental pratincole	N/A	Migratory	Overfly marine area	N/A	Species or species habitat may occur within area
Haliaeetus leucogaster	White-bellied sea-eagle	N/A	N/A	Marine	N/A	Species or species habitat known to occur within area
Halobaena caerulea	Blue petrel	Vulnerable	N/A	Marine	N/A	Species or species habitat may occur within area
Himantopus himantopus	Pied stilt	N/A	N/A	Overfly marine area	N/A	Species or species habitat known to occur within area
Hirundo rustica	Barn swallow	N/A	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Hydroprogne caspia	Caspian tern	N/A	Migratory	Marine	N/A	Breeding known to occur within area
Larus pacificus	Pacific gull	N/A	N/A	Marine	N/A	Foraging, feeding or related behaviour known to occur within area
Limicola falcinellus	Broad-billed sandpiper	N/A	Migratory	Overfly marine area	N/A	Roosting known to occur within area
Limnodromus semipalmatus	Asian dowitcher	Vulnerable	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Limosa lapponica	Bar-tailed godwit	N/A	Migratory	Marine	N/A	Species or species habitat known to occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit	Endangered	N/A	N/A	N/A	Species or species habitat known to occur within area
Limosa limosa	Black-tailed godwit	Endangered	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Macronectes giganteus	Southern giant-petrel	Endangered	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Macronectes halli	Northern giant petrel	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Merops ornatus	Rainbow bee-eater	N/A	N/A	Overfly marine area	N/A	Species or species habitat may occur within area
Motacilla cinerea	Grey wagtail	N/A	Migratory	Overfly marine area	N/A	Species or species habitat may occur within area
Motacilla flava	Yellow wagtail	N/A	Migratory	Overfly marine area	N/A	Species or species habitat may occur within area
Numenius madagascariensis	Eastern curlew	Critically endangered	Migratory	Marine	Species or species habitat may occur within area	Species or species habitat known to occur within area
Numenius minutus	Little curlew	N/A	Migratory	Overfly marine area	N/A	Roosting known to occur within area
Numenius phaeopus	Whimbrel	N/A	Migratory	Marine	N/A	Species or species habitat known to occur within area
Onychoprion anaethetus	Bridled tern	N/A	Migratory	Marine (as *Sterna anaethetus*)	N/A	Breeding known to occur within area
Onychoprion fuscatus	Sooty tern	N/A	N/A	Marine (as *Sterna fuscata*)	N/A	Breeding known to occur within area
Pandion haliaetus	Osprey	N/A	Migratory	Marine	N/A	Breeding known to occur within area
Papasula abbotti	Abbott's booby	Endangered	N/A	Marine	N/A	Species or species habitat may occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Pelagodroma marina	White-faced storm-petrel	N/A	N/A	Marine	N/A	Breeding known to occur within area
Phaethon lepturus	White-tailed tropicbird	N/A	Migratory	Marine	Species or species habitat may occur within area	Breeding known to occur within area
Phaethon lepturus fulvus	Christmas Island white-tailed tropicbird	Endangered	N/A	Marine	Species or species habitat may occur within area	Species or species habitat may occur within area
Phaethon rubricauda	Red-tailed tropicbird	N/A	Migratory	Marine	N/A	Breeding known to occur within area
Phaethon rubricauda westralis	Red-tailed Tropicbird (Indian Ocean)	Endangered	N/A	N/A	Species or species habitat known to occur within area	Breeding known to occur within area
Phalacrocorax fuscescens	Black-faced cormorant	N/A	N/A	Marine	N/A	Breeding likely to occur within area
Phalaropus lobatus	Red-necked phalarope	N/A	Migratory	Marine	N/A	Species or species habitat known to occur within area
Philomachus pugnax	Ruff (reeve)	N/A	Migratory	Overfly marine area	N/A	Roosting known to occur within area
Phoebetria fusca	Sooty albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Pluvialis fulva	Pacific golden plover	N/A	Migratory	Marine	N/A	Roosting known to occur within area
Pluvialis squatarola	Grey plover	Vulnerable	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Pterodroma macroptera	Great-winged petrel	N/A	N/A	Marine	N/A	Foraging, feeding or related behaviour known to occur within area
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	N/A	Marine	N/A	Foraging, feeding or related behaviour likely to occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Puffinus assimilis	Little shearwater	N/A	N/A	Marine	N/A	Foraging, feeding or related behaviour known to occur within area
Puffinus huttoni	Hutton's shearwater	N/A	N/A	Marine	N/A	Foraging, feeding or related behaviour known to occur within area
Recurvirostra novaehollandiae	Red-necked avocet	N/A	N/A	Overfly marine area	N/A	Species or species habitat known to occur within area
Rostratula australis	Australian painted snipe	Endangered	N/A	Overfly marine area	N/A	Species or species habitat likely to occur within area
Stercorarius antarcticus	Brown skua	N/A	N/A	Marine (as *Catharacta skua*)	N/A	Species or species habitat may occur within area
Stercorarius skua	Great skua	N/A	N/A	Marine (as *Catharacta skua*)	N/A	Species or species habitat may occur within area
Sterna dougallii	Roseate tern	N/A	Migratory	Marine	N/A	Breeding known to occur within area
Sternula albifrons	Little tern	N/A	Migratory	Marine (as *Sterna albifrons*)	N/A	Congregation or aggregation known to occur within area
Sternula nereis	Fairy tern	N/A	N/A	Marine (as *Sterna nereis*)	N/A	Breeding known to occur within area
Sternula nereis nereis	Australian fairy tern	Vulnerable	N/A	N/A	Foraging, feeding or related behaviour likely to occur within area	Breeding known to occur within area
Stiltia isabella	Australian pratincole	N/A	N/A	Overfly marine area	N/A	Roosting known to occur within area
Sula dactylatra	Masked booby	N/A	N/A	Marine	N/A	Breeding known to occur within area
Sula leucogaster	Brown booby	N/A	Migratory	Marine	N/A	Breeding known to occur within area

Species name	Common name	Threatened status	Migratory status	Listed status	Potential for interaction	
					Project Area	EMBA
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Thalassarche cauta	Shy albatross	Endangered	Migratory	Marine	N/A	Species or species habitat may occur within area
Thalassarche impavida	Campbell albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Thalassarche melanophris	Black-browed albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Thalassarche steadi	White-capped albatross	Vulnerable	Migratory	Marine	N/A	Species or species habitat may occur within area
Thalasseus bengalensis	Lesser crested tern	N/A	N/A	Marine (as *Sterna bengalensis*)	N/A	Breeding known to occur within area
Thalasseus bergii	Greater crested tern	N/A	Migratory	Marine (as *Sterna bergii*)	N/A	Breeding known to occur within area
Tringa brevipes	Grey-tailed tattler	N/A	Migratory	Marine (as *Heteroscelus brevipes*)	N/A	Species or species habitat known to occur within area
Tringa glareola	Wood sandpiper	N/A	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area
Tringa nebularia	Common greenshank	Endangered	Migratory	Overfly marine area	N/A	Species or species habitat likely to occur within area
Tringa stagnatilis	Marsh sandpiper	N/A	Migratory	Overfly marine area	N/A	Roosting known to occur within area
Tringa totanus	Common redshank	N/A	Migratory	Overfly marine area	N/A	Roosting known to occur within area
Turnix varius scintillans	Painted button-quail (Houtman Abrolhos)	Endangered	N/A	N/A	N/A	Species or species habitat known to occur within area
Xenus cinereus	Terek sandpiper	Vulnerable	Migratory	Overfly marine area	N/A	Species or species habitat known to occur within area

Table 7-16: Seabirds and migratory shorebirds BIAs within the Project Area and EMBA

Species name	Common name	BIA type	Approx. distance and direction	
			Project Area	EMBA
Anous stolidus	Common noddy	Foraging (provisioning young)	~905 km south-west	Overlap
Anous tenuirostris melanops	Australian lesser noddy	Foraging (provisioning young)	~925 km south-west	Overlap
Ardenna pacifica	Wedge-tailed shearwater	Breeding	Overlap	Overlap
		Foraging (in high numbers)	~690 km south-west	Overlap
Fregata ariel	Lesser frigatebird	Breeding	~230 km north-east	Overlap
Hydroprogne caspia	Caspian tern	Foraging (provisioning young)	~870 km south-west	Overlap
Larus pacificus	Pacific gull	Foraging (in high numbers)	~850 km south	Overlap
Onychoprion anaethetus	Bridled tern	Foraging (in high numbers)	~685 km south-west	Overlap
Onychoprion fuscata	Sooty tern	Foraging	~700 km south-west	Overlap
Pelagodroma marina	White-faced storm petrel	Foraging (in high numbers)	~825 km south-west	Overlap
Phaethon lepturus	White-tailed tropicbird	Breeding	~270 km north-east	Overlap
Pterodroma mollis	Soft-plumaged petrel	Foraging (in high numbers)	~1025 km south	Overlap
Puffinus assimilis tunneyi	Little shearwater	Foraging (in high numbers)	~830 km south-west	Overlap
Sterna dougallii	Roseate tern	Breeding	~30 km south	Overlap
		Foraging (provisioning young)	~900 km south-west	Overlap
Sternula albifrons sinensis	Little tern	Resting	~370 km north-east	Overlap
		Breeding	~425 km east	Overlap
Sternula nereis	Fairy tern	Breeding	~25 km south	Overlap
		Foraging (in high numbers)	~905 km south-west	Overlap
Sula leucogaster	Brown booby	Breeding	~700 km north-east	Overlap
Thalasseus bengalensis	Lesser crested tern	Breeding	~30 km south	Overlap

7.6.4.1 Common sandpiper (*Actitis hypoleucos*)

The common sandpiper is listed migratory under the EPBC Act. This species is widespread within Australia and is found along all coastlines and many inland areas. It breeds in Eurasia and moves south for the boreal winter, with most of the western breeding populations wintering in Africa, and eastern breeding populations wintering in south Asia to Melanesia and Australia (Cramp and Simmons 1983). Some stay in south-east Asia during the breeding months (Higgins and Davies 1996). Post-breeding, the southward migration usually begins July–November, with individuals arriving from July onwards in SA, WA and the NT, and from August onwards in NSW and Queensland. The non-breeding movements of the species within Australia are poorly known (Higgins and Davies 1996).

This species uses a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats. Generally it forages in shallow water and on bare soft mud at the edges of wetlands; often where obstacles project from substrate (e.g. rocks, mangrove roots). Birds sometimes venture into grassy areas adjoining wetlands. Roost sites are typically on rocks or in roots or branches of vegetation, especially mangroves. The species is known to perch on posts, jetties, moored boats and other artificial structures, and sometimes rests on mud or 'loafs' on rocks (Higgins and Davies 1996).

Given the primarily coastal and inland distribution of this species, its presence within the Project Area is expected to be limited. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.2 Common noddy (*Anous stolidus*)

The common (or brown) noddy is listed as migratory under the EPBC Act. This species is widespread in tropical and subtropical areas within and beyond Australia. It is gregarious and normally occurs in flocks, up to hundreds of individuals, when feeding or roosting.

The Houtman Abrolhos is the primary breeding habitat for the common noddy in the eastern Indian Ocean. Breeding (but in fewer numbers) also occurs across offshore islands of the NWMR, including Bedout Island, Montebello Islands and Frazer Island (Johnstone, Burbidge, and Darnell 2013), and at Ashmore Reef (April–November) (Clarke and Herrod 2016).

During breeding, individuals nesting on Lancelin Island in the SWMR were found to forage diurnally (Shephard, Dunlop, and Bouten 2018). Tracked individuals travelled an average of 97 km from the colony with an average trip distance of 141 km, with significantly longer trips during chick rearing compared to incubation (Shephard, Dunlop, and Bouten 2018).

The species is highly pelagic outside breeding periods (March–August), with breeding individuals of the Houtman Abrolhos Islands travelling ~950 km north to the NWMR (Surman, Nicholson, and Ayling 2017).

Although widespread across the NWMR during breeding and non-breeding seasons, no BIAs for this species are located in the Project Area. The EMBA overlaps with one foraging BIA for this species (Figure 7-26).

7.6.4.3 Australian lesser noddy (*Anous tenuirostris melanops*)

The Australian lesser noddy, which is endemic to Australia, is listed as vulnerable under the EPBC Act. The largest breeding colonies are found on the Houtman Abrolhos Islands, with fewer records of breeding on Ashmore Reef (Clarke et al. 2011; Cannell and Surman 2021). This species is a frequent key pelagic seabird species within the NWMR (Advisian 2022).

At the Houtman Abrolhos Islands, the breeding population has been estimated at ~50,000 breeding pairs (Surman, Burbidge, and Fitzhardinge 2016). At this location, studies indicate that breeding is not highly synchronised; the single egg clutches were laid over a 102-day period from late August to early December, peaking in September (Surman and Wooller 1995). The incubation period averaged 34 days and the fledging period 40 days. (Surman and Wooller 1995).

The foraging behaviour of breeding Australia lesser noddies at the Houtman Abrolhos Islands is largely diurnal—they forage between 0400 and 2040 hours and return to their colony at night (Surman, Nicholson, and Ayling 2017). GPS tracking of 17 adults during incubation or chick provisioning revealed that most foraging trips were 2–4 hours, with a total trip distance of <40 km. However, some trips lasted up to 16 hours covering distances of up to 112 km (Surman, Nicholson, and Ayling 2017). During non-breeding, birds appear to remain near the breeding islands year-round (Higgins and Davies 1996)

No BIAs for this species overlap the NWMR and tracking data suggests that individuals breeding at the Houtman Abrolhos Islands predominantly forage in a south-westerly direction, remaining within waters of the SWMR (Surman, Nicholson, and Ayling 2017). Therefore, it is unlikely that waters of the NWMR provide significant habitat for individuals breeding at the Houtman Abrolhos Islands. However, if this subspecies breeds on Ashmore Reef, those individuals may show similar foraging behaviour during breeding and remain near islands of the reef, but use habitats of the NWMR. Due to differences in climate and seasons at the Houtman Abrolhos Islands and Ashmore Reef, timing of breeding may differ.

Both Houtman Abrolhos Islands and Ashmore Reef are >900 km from the Project Area, and as such presence of the Australian lesser noddy within the Project Area is not expected to occur. No BIAs for this species are located in the Project Area, however the EMBA overlaps with one foraging BIA (Figure 7-27).

7.6.4.4 Fork-tailed swift (*Apus pacificus*)

The fork-tailed swift, which is considered endemic to Australia, is listed as migratory under the EPBC Act. It has a widespread distribution and inhabits coastal waters as far north as Carnarvon, including nearshore and offshore islands (DotE 2015b). It is considered a moderate occurring key species within the NWMR (Advisian 2022), and has been recorded scattered along the Pilbara coast to the east Kimberley region (DCCEEW n.d.). This insectivorous species is almost exclusively an aerial forager that flies 1–300 m above ground and typically feeds in flocks of 10–1,000 birds (DotE 2015b; DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.5 Flesh-footed shearwater (*Ardenna carneipes*)

The flesh-footed shearwater is listed as migratory under the EPBC Act. This species is a local visitor to waters of the continental shelf and is widely distributed across the southern Indian and south-western Pacific oceans (DCCEEW n.d.). It is considered a moderate occurring key species within the NWMR (Advisian 2022). This species is a trans-equatorial migrant and breeds from late August to mid-May across ~60 islands in its distribution area (TSSC 2014).

This species predominantly forages at sea, with its diet comprising small fish, cephalopod molluscs, crustaceans and other soft-bodied invertebrates (CoA 2022c; DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.6 Wedge-tailed shearwater (*Ardenna pacifica*)

The wedge-tailed shearwater is listed as migratory under the EPBC Act. It is a pelagic marine seabird known from tropical and subtropical waters, with a widespread distribution across the Indian and Pacific oceans. It has an estimated global population of 2.6 million pairs, of which ~1 million pairs breed in Australia, mostly on WA islands between Rottnest Island in the south and Ashmore Reef in the north. The largest breeding populations are at the Houtman Abrolhos (600,000 pairs (Surman and Nicholson 2009)), and throughout the NWS region of the NWMR, where large populations on Muiron Islands (300,000 pairs) and Serrurier Island (60,000 pairs) exist (Surman and Nicholson 2009; 2015).

Adults are absent from their breeding colonies during the interbreeding period; they return from their tropical Indian Ocean overwintering grounds from late June onwards to re-excavate their burrows. This species is highly synchronous in timing of breeding—all eggs within a colony are laid within a 10-day period. They lay their single egg during early November, which is then incubated until the chick hatches (after 53 days) in early January. Once hatched, adults leave the burrows to forage locally during the day, returning at night to feed chicks until they are ready to fledge (Nicholson 2002). Due to the high synchronicity in egg laying, fledging is occurs in the first two weeks of April (Nicholson 2002).

This species has nocturnal breeding behaviours—adults return to and depart the colony at night and fledglings depart the colony at night. In the lead up to fledging, chicks also leave their burrows to exercise their wings outside burrows.

Adults may not return to feed chicks each night; wedge-tailed shearwaters breeding on the Muiron Island (north) undertook extensive foraging trips during the incubation period (1,200–1,400 km) and shorter trips during chick rearing (<300 km; (Cannell, Hamilton, and Driessen 2019)). Longer foraging trips took individuals in a north-west direction offshore towards oceanic seamounts. Conversely, the shorter trips tended to include waters to the west and north-west of the Muiron Islands (Cannell, Hamilton, and Driessen 2019). In addition to the Muiron Islands, this dual foraging strategy, whereby parents alternate or mix short and long trips, have been recorded in wedge-tailed shearwaters breeding at Heron Island, Lord Howe Island (Peck and Congdon 2005), and New Caledonia (Weimerskirch et al. 2020). However, divergent foraging strategies have been detected between colonies, which is linked to the distance between colonies and high productivity waters (Weimerskirch et al. 2020).

The presence of squid and lanternfish in their diet (Surman and Nicholson 2009) suggests nocturnal foraging occurs in this species; however, GPS tracking found that foraging activities at sea were more frequent during the day than at night (Weimerskirch et al. 2020). During the day, resting periods on the sea surface were short whereas at night individuals spent large proportion of their time resting at the surface (Weimerskirch et al. 2020). Other prey species include schooling bait fishes and cephalopods, often feeding in association with other pelagic seabird species such as sooty terns and common noddies, and pelagic fishes such as tunas and mackerels. Diet composition is likely to vary between colonies, depending upon the prey available, and thus determining both the foraging strategy, as described above, and also the division of nocturnal and diurnal foraging. Wedge-tailed shearwaters dive between 3 and 66 m, actively pursuing prey by feeding at the surface or by actively swimming below bait schools.

Post-breeding, wedge-tailed shearwaters that bred on the Houtman Abrolhos Islands and Varanus Island migrated 4,500 km north-west to equatorial waters of the Indian Ocean around 90°E (Surman, Nicholson, and Phillips 2018), traversing the NWMR, and those from Great Barrier Reef migrated to the northern hemisphere, ~6,000 km northwards to Micronesia (McDuie and Congdon 2016).

During breeding, wedge-tailed shearwaters are observed across all shelf waters and are the most frequently encountered seabird at sea. Foraging and breeding BIAs for this species are located across the NWMR. The Project Area partially overlaps with a breeding BIA for this species, associated with Kimberley, Pilbara and Gascoyne coasts and islands. including Ashmore Reef (Table 7-16, Figure 7-28).

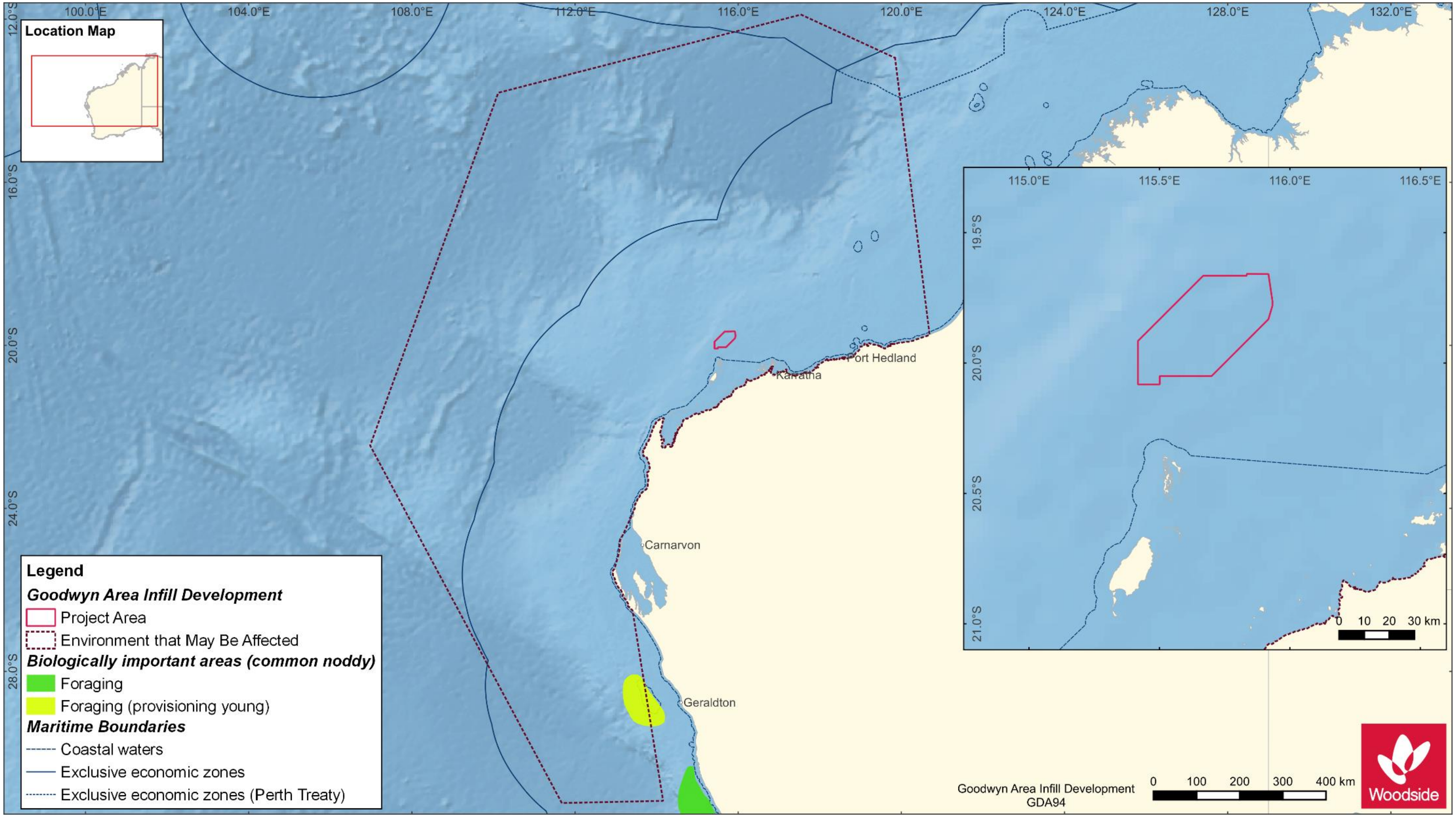


Figure 7-26: Common noddy—BIAs within the EMBA

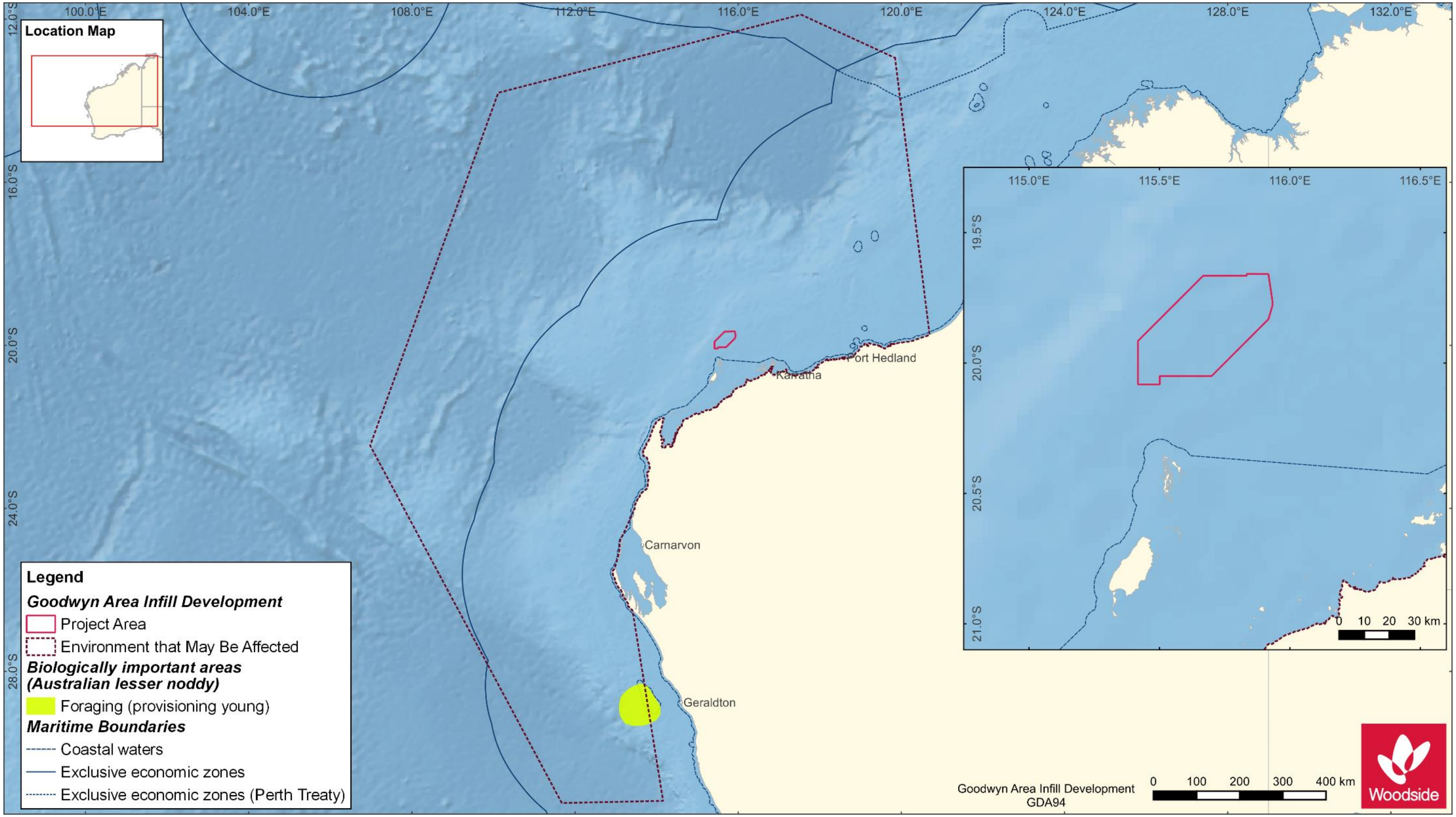


Figure 7-27: Australian lesser noddy—BIAs within the EMBA

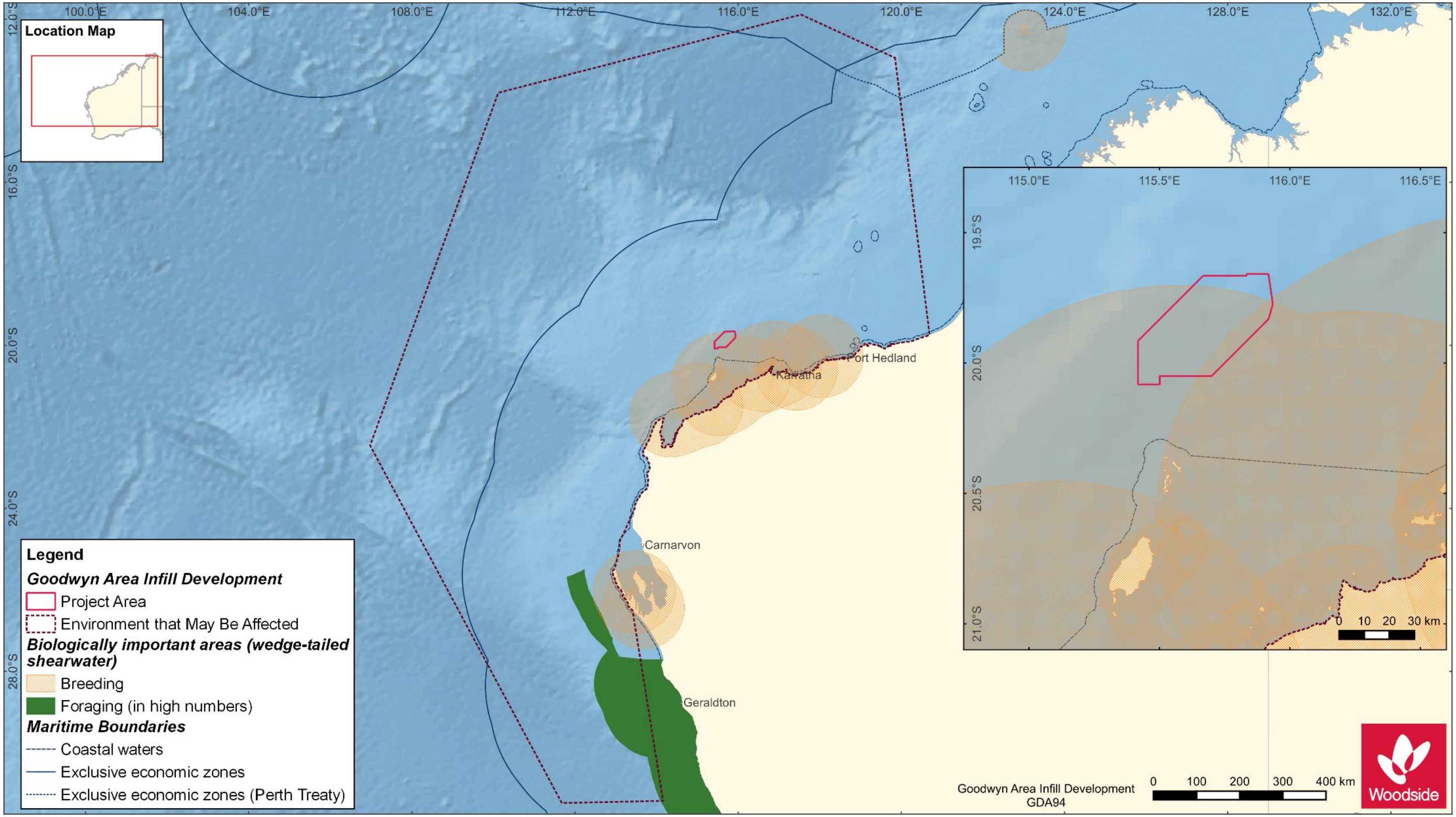


Figure 7-28: Wedge-tailed shearwater—BIAs within the Project Area and EMBA

7.6.4.7 Ruddy turnstone (*Arenaria interpres*)

The ruddy turnstone is listed as vulnerable and migratory under the EPBC Act. It is widespread within Australia, and is found in most coastal regions with occasional records of inland populations (Higgins and Davies 1996). This species mainly forages between lower supralittoral and lower littoral zones of foreshores, from strand-line to wave-zone. It roosts on beaches above the tideline among rocks, shells, wrack, or other debris (Higgins and Davies 1996). It does not breed in Australia (DCCEEW n.d.).

There may be two routes of migration to Australia, with birds occurring in east Australia and New Zealand arriving from a migration south across the Pacific from east Asia and returning north via the east coast of Asia. The birds in the western areas of Australia are thought to come from populations migrating south from east Asia that then return north via east Asia (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Ashmore Reef
- Roebuck Bay
- Barrow Island
- Lacepede Islands.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.8 Sharp-tailed sandpiper (*Calidris acuminata*)

The sharp-tailed sandpiper is listed as vulnerable and migratory under the EPBC Act. It spends the non-breeding season in Australia; small numbers occur regularly in New Zealand. Most of the population migrates to Australia, mostly to the south-east, and it is widespread in both inland and coastal locations and in both freshwater and saline habitats (Higgins and Davies 1996). It is a high occurring shorebird key species (Advisian 2022). In WA, it occurs from Cape Arid (on the south coast) to Carnarvon and in the coastal and subcoastal plains from the Pilbara to the Kimberley (Advisian 2022; DCCEEW n.d.).

This species forages at the edge of the water—on bare wet mud/sand or in the shallow water of wetlands or intertidal mudflats (Higgins and Davies 1996). It also forages in inundated saltmarsh vegetation, grass or sedges and feeds predominantly on seeds, worms, molluscs, crustaceans and insects (Advisian 2022; DCCEEW n.d.). Roosting occurs at the edges of wetlands, on wet open mud or sand, in shallow water, or in short sparse vegetation, such as grass or saltmarsh; occasionally, they roost on sandy beaches, stony shores or on rocks in water (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Port Hedland Saltworks
- Eighty Mile Beach.

Given the broad distribution of this species, and that foraging and roosting primarily occurs in coastal and inland areas, presence within the Project Area is expected to be limited. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.9 Sanderling (*Calidris alba*)

The sanderling is listed as migratory under the EPBC Act. It occurs in coastal areas around Australia. In WA, it occurs on most of the coast from Eyre to Derby and around Wyndham, but mostly in north-western Australia (DCCEEW n.d.).

This species is a widespread non-breeding visitor to coastal Australia (Higgins and Davies 1996), arriving during September. It moves through Roebuck Bay, Darwin and Eyre from September–November and then crosses the continent to the SA coast. Small numbers regularly arrive at Rottnest Island, WA, during late August and early September, while others arrive in the Sydney area, NSW, from August (Higgins and Davies 1996).

The sanderling depart the non-breeding range in south-east Australia from March–May. They are thought to move west along the south coast of Australia and then back across the continent before moving north, with at least some birds stopping on the north coast. A few birds, particular young birds, remain in Australia during winter, and in other non-breeding areas during the breeding season; bird numbers may vary at a site over several days indicating birds are nomadic during this time (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay
- Ashmore Reef.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.10 Red knot (*Calidris canutus*)

The red knot is listed as vulnerable and migratory under the EPBC Act. It has a worldwide distribution; within Australia, it is common in coastal regions, with large numbers recorded in north-west Australia (DCCEEW 2024a). This species breeds in the northern hemisphere and migrates along the EAAF to spend the boreal winter in Australasia. Most of the population is considered to spend the non-breeding period in Australia (Bamford et al. 2008).

In Australia, this species mainly inhabits intertidal mudflats, sandflats and sandy beaches of sheltered coasts; estuaries, bays, inlets, lagoons and harbours; sometimes sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs. It usually forages in soft substrate near the water's edge on intertidal mudflats or sandflats exposed by low tide. At high tide they may feed at nearby lakes, sewage ponds and floodwaters (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

Given the widespread and primarily coastal distribution of this species, its presence within the Project Area is expected to be limited. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.11 Curlew sandpiper (*Calidris ferruginea*)

The curlew sandpiper is listed as migratory and critically endangered under the EPBC Act. In Australia, this species occurs around the coast and is also recorded inland, though in smaller numbers. In WA, it is typically found around coastal and subcoastal plains from Cape Arid to south-west Kimberley, and more sparsely distributed between Carnarvon and Dampier Archipelago (DCCEEW 2023b). Curlew sandpipers forage on mudflats and nearby shallow water, and generally roost on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands; they occasionally roost in dunes during very high tides and sometimes in saltmarsh (Higgins and Davies 1996). This species does not breed in Australia.

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Dampier Saltworks
- Port Hedland Saltworks
- Eighty Mile Beach
- Roebuck Bay.

Given the primarily coastal and inland distribution of this species, its presence within the Project Area is expected to be limited. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.12 Pectoral sandpiper (*Calidris melanotos*)

The pectoral sandpiper is listed as migratory under the EPBC Act. It breeds in northern Russia and North America, and is transient through Central America and the Caribbean while on route to its non-breeding areas in South America. The species is rarely recorded within WA. There are scattered records in the tropical Pacific, including Australasia (DCCEEW n.d.).

In Australasia, this species prefers shallow fresh to saline wetlands. It is usually found in coastal or near-coastal habitat but occasionally it is found further inland. It prefers wetlands that have open fringing mudflats and low, emergent or fringing vegetation, such as grass or samphire. It forages in shallow water or soft mud at the edge of wetlands and is omnivorous, consuming algae, seeds, crustaceans, arachnids and insects (Higgins and Davies 1996).

Given the primarily coastal distribution of this species, and that it is rarely recorded within WA, its presence within the Project Area is expected to be limited. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.13 Red-necked stint (*Calidris ruficollis*)

The red-necked stint is listed as migratory under the EPBC Act. In Australasia, this species is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. It mostly forages on bare wet mud on intertidal mudflats or sandflats, or in very shallow water; mostly in areas with a film of surface water and mostly close to the edge of the water. During high tides it sometimes forages in non-tidal wetlands. It roosts on sheltered beaches, spits, banks or islets, of sand, mud, coral or shingle, sometimes in saltmarsh or other vegetation, and occasionally on exposed reefs or shoals (Higgins and Davies 1996).

This species mainly breeds in Siberia and sporadically in north and west Alaska. It migrates through Japan, the Korean Peninsula, China, Taiwan, Hong Kong, Vietnam, Malaysia, the Philippines and west Micronesia. It spends winter in Australasia (mostly in Australia, with smaller numbers in New Guinea and New Zealand), with some arriving in Australia from August (and possibly July) and most arriving from early September; it leaves Australia from late February or March to April (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Port Hedland Saltworks
- Roebuck Bay.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.14 Long-toed stint (*Calidris subminuta*)

The long-toed stint is listed as migratory under the EPBC Act. In Western Australia the species is found mainly along the coast, with a few scattered inland records. They are found in terrestrial wetlands, and show a preference for shallow freshwater or brackish wetlands, though are also found tidal estuaries, saline lakes, salt ponds and bore swamps. The long-toed stint forages on wet mud or in shallow water, and occasionally in open water. They roost or loaf in sparse vegetation at the edges of wetlands and on damp mud near shallow water (Higgins and Davies 1996).

This species mainly breeds in Siberia. It migrates to Australia in the summer months, arriving on the north coast, west of Darwin, and occupying freshwater wetlands in the west Kimberley and Pilbara. During summer they disperse across the continent, mainly between Pilbara and the coast of South Australia, with only a few moving farther east (Higgins and Davies 1996).

There are no identified internationally important sites or BIAs for this species in the Project Area or EMBA.

7.6.4.15 Great knot (*Calidris tenuirostris*)

The great knot is listed as vulnerable and migratory under the EPBC Act. It has been recorded around the entirety of the Australian coast, with a few scattered records inland; most are found in northern WA and the NT (DCCEEW 2024b). This species prefers sheltered coastal habitats with large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons (Higgins and Davies 1996).

Typically, this species roosts in large groups in open areas, often at the water's edge or in shallow water close to feeding grounds. It feeds on invertebrates that it finds by pecking at or just below the surface of moist mud or sand (Higgins and Davies 1996).

The great knot breeds in the northern hemisphere and undertakes twice-yearly migrations along the EAAF (DCCEEW 2024b). Large numbers arrive in north-west Australia in late August–early September, although juveniles and many males may not arrive till October–November(DCCEEW n.d.). Most birds leave Australia directly from the north coast in March–April (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.16 Streaked shearwater (*Calonectris leucomelas)*

The streaked shearwater (previously known as *Puffinus leucomelas*) is listed as migratory under the EPBC Act. It breeds in the northern hemisphere, in the north-west Pacific Ocean (DEWHA 2008b). The NWMR is within known range of this species; it is expected to migrate through during non-breeding season. It is regularly recorded offshore from Broome (WA) to the Timor Sea, and from Barrow Island to the Houtman Abrolhos Islands (WA) (DEWHA 2008b).

No important areas have been identified within or adjacent to the NWMR (DEWHA 2008b). There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.17 Greater sand plover (*Charadrius leschenaultii*)

The greater sand plover is listed as vulnerable and migratory under the EPBC Act. Its distribution is widespread between North West Cape and Roebuck Bay (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

This species inhabits coastal, littoral, and estuarine habitats around Australia in sheltered, sandy or muddy beaches with large intertidal flats, feeding on molluscs, worms, crustaceans and insects. It does not breed in Australia (DCCEEW 2023c).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.18 Lesser sand plover (*Charadrius mongolus*)

The lesser sand plover is listed as endangered and migratory under the EPBC Act, and endangered under the BC Act. The lesser sand plover is known to breed in the Northern Hemisphere during the boreal summer and annually migrate to the non-breeding grounds of Australia along the EAAF for the austral summer. There are five different sub-species and it is most likely the non-breeding ranges of the sub-species *Charadrius m. mongolus* overlaps with the NWMR. This species is widespread in coastal regions, preferring sandy beaches, mudflats of coastal bays and estuaries (TSSC 2016).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.19 Oriental plover (*Charadrius veredus*)

The oriental plover is listed as migratory under the EPBC Act. Most records of this species in Australia occur along north-western coastal and inland regions, between Exmouth Gulf and Derby. It is a non-breeding visitor to Australia (DCCEEW n.d.). This species forages among short grass and stony bare ground, mudflats and wrack, feeding on insects, including termites, beetles, grasshoppers, crickets (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay
- Dampier Saltworks.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.20 Amsterdam albatross (*Diomedea amsterdamensis*)

The Amsterdam albatross is listed as endangered and migratory under the EPBC Act. It is a marine pelagic seabird that is often misidentified at sea as the wandering albatross. The Amsterdam albatross is not a resident of Australia. It mainly forages in the open waters surrounding Amsterdam Island (France) in the southern Indian Ocean, feeing on squid, fish and crustaceans (CoA 2021; 2022c; DCCEEW n.d.). It breeds on Amsterdam Island where it nests in open patchy vegetation near exposed cliffsides; it rests on ocean waters when not breeding (DCCEEW n.d.). It is a non-key pelagic seabird species within the NWMR (Advisian 2022).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.21 Southern royal albatross (*Diomedea epomophora*)

The southern royal albatross, which is endemic to New Zealand (ACAP 2009), is listed as vulnerable and migratory under the EPBC Act. This species has a circumpolar distribution, predominantly around New Zealand, south-eastern Australia and southern South America (ACAP 2009).

This species only breeds on Campbell Island and in the Auckland Islands, with birds returning to colonies in October. Eggs are laid from late November–late December. Incubation takes 74–85 days with chicks hatching early February–early March, and fledging in early October–early December (ACAP 2009). Tracking studies indicate that during the breeding season the birds mostly forage in New Zealand waters, but their dispersal is circumpolar during non-breeding periods, including in southern and sub-Antarctic Australia (Richard 2005).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.22 Wandering albatross (*Diomedea exulans*)

The wandering albatross is listed as vulnerable and migratory under the EPBC Act. It is a non-key species of seabird with low occurrence within the NWMR (Advisian 2022).

The wandering albatross breeds on Macquarie Island, a habitat that is critical to the survival of the species (DCCEEW n.d.), and feeds within the boundaries of the Australia's Southern Ocean. It is a marine, pelagic and aerial seabird that mainly feeds on squid and fish, with the occasional addition of crustaceans and carrion (Marchant and Higgins 1990). It has the longest wingspan of any seabird (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.23 Red goshawk (*Erythrotriorchis radiatus*)

The red goshawk is listed as vulnerable under the EPBC Act. It is a non-key species to the NWMR with low occurrences (Advisian 2022). It is endemic to Australia and has a widespread distribution across coastal and sub-coastal regions (DCCEEW n.d.). Its diet is predominantly (95%) birds (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.24 Lesser frigatebird (*Fregata ariel*) and great frigatebird (*Fregata minor*)

The lesser and great frigatebirds are both listed as migratory under the EPBC Act. They are the most widely distributed of the frigatebirds, with a pan-tropical distribution.

In the NWMR, the greater frigatebird nests at Ashmore Reef, where it breeds year-round, and Adele Island (Clarke and Herrod 2016). The lesser frigatebird also nests at Ashmore Reef and Adele island, as well as Cartier Island, the Lacepede Islands and Bedout Island, which is thought to support >1% of the world’s breeding population (BirdLife International 2023). On Ashmore Reef, the lesser frigatebird breeds in the austral (southern hemisphere) winter (Clarke and Herrod 2016).

Great frigatebirds in the South China Sea foraged 75 km (average; maximum is 150 km) from their breeding colony during breeding, while lesser frigatebirds forage 123 km (average; maximum 300 km) from their breeding colony (Mott, Herrod, and Clark 2017).

Frigatebirds may disperse significant distances from their breeding colonies outside the breeding season (Mott, Herrod, and Clark 2017). Great frigatebirds are wide ranging—some have been recorded 900–1,400 km from their natal colonies (Dunlop, Surman, and Wooller 2001). Tracking studies of non-breeding lesser and great frigatebirds roosting on Ashmore Reef and Adele Island demonstrated that individuals have large distributions, including Australian coastal waters, the South China, Java and Sulu Seas, and the Gulf of Thailand (Mott, Herrod, and Clark 2021). Australian waters provide optimal habitat for non-breeding individuals of both species during the northern Australian wet season (Mott, Herrod, and Clark 2021).

Both frigatebird species forage by snatching prey from the surface waters, or when prey break the surface. They also rely heavily upon kleptoparasitism, harrying other seabirds returning to their colonies with food until it is regurgitated. Frigatebirds are susceptible to waterlogging, so they do not plunge or splash dive for prey nor do they roost on the sea's surface. Across the NWMR they forage on flying fish, cephalopods, anchovies, northern pilchards and other medium-sized prey.

No BIAs for this species were identified within the Project Area, however a breeding BIA for the lesser frigatebird is present within the EMBA (Figure 7-29). Breeding/foraging BIAs for the lesser frigatebird, breeding/foraging BIAs are associated with breeding colonies on Ashmore Reef, Adele Island, White Island, Lacepede Islands, Bedout Island, and the Kimberley Coast (>200 km from the Project Area at closest). Individuals may transit through the Project Area, but large numbers are not expected given the lack of habitat that would promote aggregating behaviours, such as foraging.

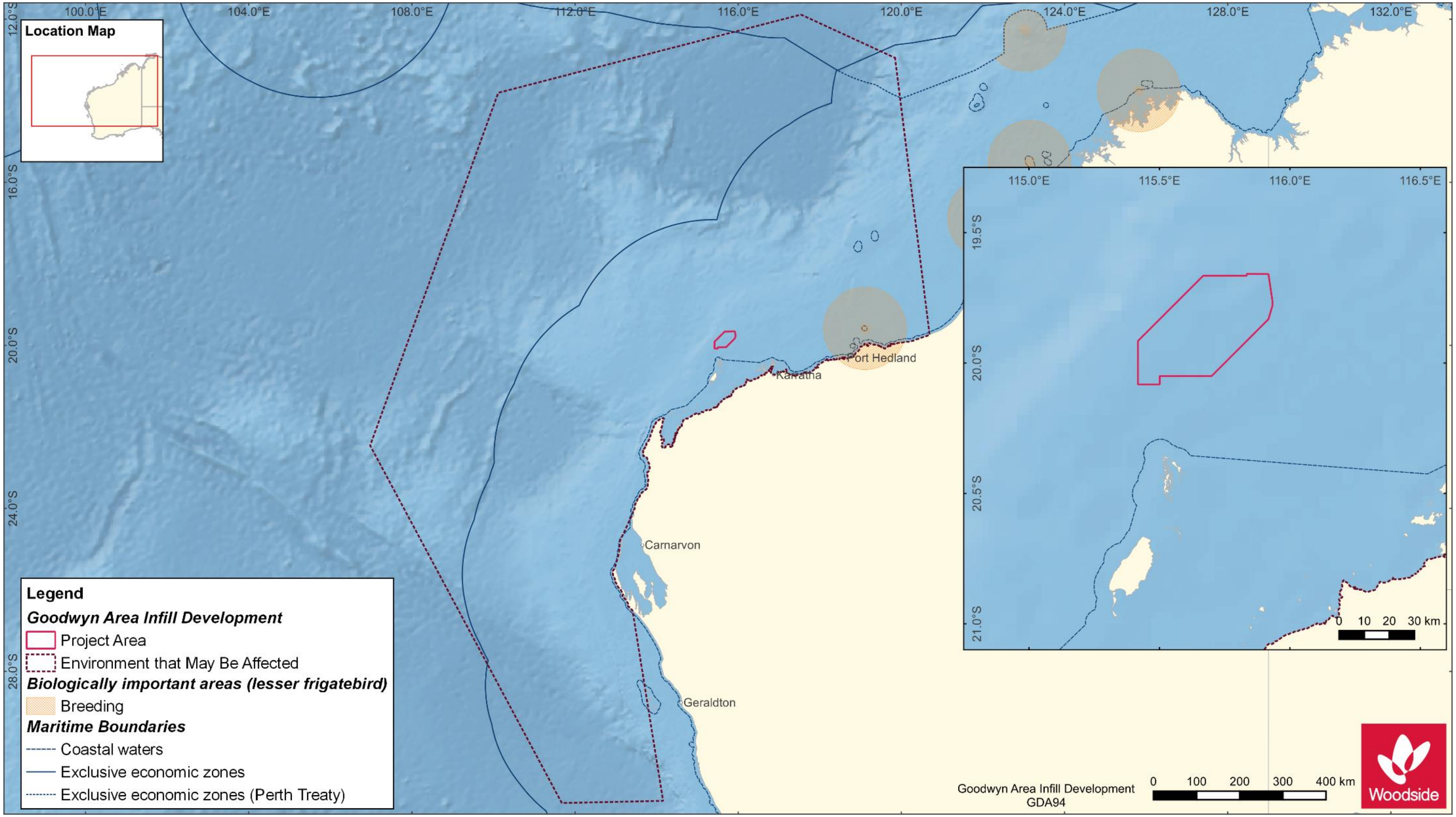


Figure 7-29: Lesser frigatebird—BIAs within the EMBA

7.6.4.25 Swinhoe's snipe (*Gallinago megala*)

The swinhoe’s snipe is listed as migratory under the EPBC Act. This species breeds in central and southern Siberia, and migrates south for the boreal winter. Swinhoe's snipe is recorded in north Australia, particularly the Kimberley region, from October–April (Higgins and Davies 1996). Within Australia, they are known to occur at the edges of wetlands, such as wet paddy fields, swamps and freshwater streams.

There are no identified internationally important sites or BIAs for this species in the Project Area or EMBA.

7.6.4.26 Pin-tailed snipe (*Gallinago stenura*)

The pin-tailed snipe is listed as migratory under the EPBC Act. This species breeds in Russia, and arrives in Australia during the non-breeding season from late September to March (Higgins and Davies 1996). During non-breeding period the pin-tailed snipe occurs most often in or at the edges of shallow freshwater water bodies, such as swamps and wetlands (Higgins and Davies 1996).

There are no identified internationally important sites or BIAs for this species in the Project Area or EMBA.

7.6.4.27 Oriental pratincole (*Glareola maldivarum*)

The oriental pratincole is listed as migratory under the EPBC Act. It is widely distributed along the Pilbara and Kimberley coasts (DCCEEW n.d.).

On their non-breeding grounds, this species usually inhabits open plains, floodplains, wetlands and coastal habitats such as beaches, mudflats and islands and coastal lagoons. This species does not breed in Australia but roosting occurs in bare areas such as claypans or areas with low vegetation (saltmarsh or airfield) (DCCEEW n.d.).

It usually feeds aerially, at heights varying from just above the ground up to 300 m, and its diet includes insects, such as dragonflies, cicadas, beetles, moths, ants, termites, locusts, grasshoppers, flies, bees and wasps (DCCEEW n.d.) .

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Plains.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.28 Blue petrel (*Halobaena caerulea*)

The blue petrel is listed as vulnerable under the EPBC Act. It is marine bird that occurs in Antarctic to subtropical waters. The blue petrel forages in Antarctic and subantarctic waters for pelagic crustaceans, fish, cephalopods and insects (Marchant and Higgins 1990). The species breeds in offshore stacks near Macquarie Island and other subantarctic islands in the Indian and Atlantic Oceans (Marchant and Higgins 1990).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.29 Barn swallow (*Hirundo rustica*)

The barn swallow is listed as migratory under the EPBC Act. This is a cosmopolitan species that has been recorded at scattered sites along coastal and subcoastal areas in the Pilbara and Kimberley, from Exmouth to Kununurra (DotE 2015c).They inhabit the air above open vegetated areas including farmland, endemic grasslands and airstrips, and forage singularly or in groups (DotE 2015b). This species is an aerial insectivore, pursuing and consuming flying insects (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.30 Caspian tern (*Hydroprogne caspia*)

The Caspian tern is listed as migratory under the EPBC Act. It is moderately common across coastlines of the NWMR and offshore islands (Johnstone, Burbidge, and Darnell 2013), and is a frequent key nearshore seabird species within the NWMR (Advisian 2022).

Breeding (late March–early November) is either in solitary nests or in colonies of up to 52 breeding pairs. Breeding mainly occurs on islands (including North Turtle Island, Dampier Archipelago including Enderby Island, and Frazer Island), and occasionally on mainland coasts (e.g. Cape Preston, North West Cape) (Johnstone, Burbidge, and Darnell 2013).

During breeding, adults can forage up to 60 km from the colony to catch fish and meet their elevated energy requirements (Burger, Gochfeld, and Bonan 1996). This species is a diurnal forager. The length and frequency of its foraging trips, as well the time spent foraging or attending chicks, changes with food resource availability (Dunlop and McNeill 2017).

This species usually forages in shallow sheltered waters by plunge diving for various prey species (Serventy, Serventy, and Warham 1971).

No BIAs for this species have been identified within the Project Area, however a foraging (provisioning young) BIA is present within the EMBA (Figure 7-30).

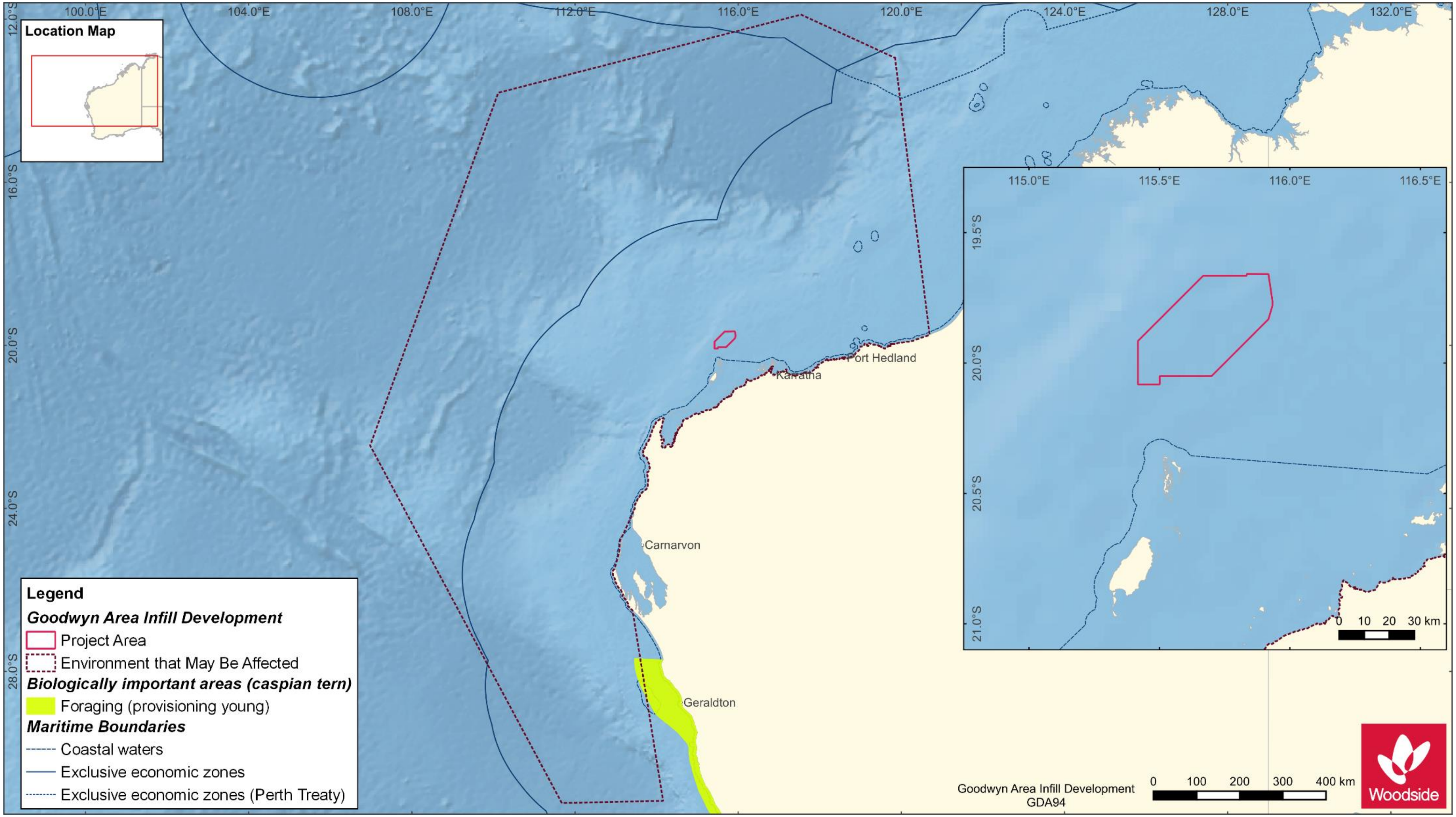


Figure 7-30: Caspian tern—BIAs within the EMBA

7.6.4.31 Broad-billed sandpiper (*Limicola falcinellus*)

The broad-billed sandpiper is listed as migratory under the EPBC Act. This species breeds in northern Europe, and moves south for the non-breeding season. They migrate through eastern China, Korea, Japan, Taiwan and Philippines, to the non-breeding range in Indonesia and northern Australia (Higgins and Davies 1996). They may arrive in Australia as early as August, and usually depart by May.

The broad-billed sandpiper occurs in sheltered parts of the coast, foraging on wet mud or in shallow water. They roost on the banks of sheltered sandy, shelly or shingly beaches (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Port Hedland Saltworks.

There are no BIAs for this species in the Project Area or EMBA.

7.6.4.32 Asian dowitcher (*Limnodromus semipalmatus*)

The Asian dowitcher is listed as vulnerable and migratory under the EPBC Act. This species visits the north-west of Australia between Port Hedland and Broome, inhabits sheltered coastal environments such as coastal lagoons, estuaries, tidal creeks, and is known to frequent tidal mudflats for foraging (DCCEEW n.d.). Its diet is mostly polychaete worms and larvae, as well as insect larvae and molluscs. It is a frequent key shorebird species within the NWMR (Advisian 2022).

No BIAs for this species are identified within the Project Area or EMBA.

7.6.4.33 Bar-tailed godwit (*Limosa lapponica*) and northern Siberian bar-tailed godwit (*Limosa lapponica menzbieri*)

The bar-tailed godwit is listed as migratory under the EPBC Act. It is widely distributed across the coastal areas of Australia (DCCEEW n.d.) and inhabits intertidal sandflats, banks, mudflats, estuaries, near-coastal saltmarshes, coastal lagoons and bays. It is a frequent key shorebird species within the NWMR (Advisian 2022). Its diet comprises worms, molluscs, crustaceans, insects and some plant material (DCCEEW n.d.) .

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

The northern Siberian godwit is listed as endangered under the EPBC Act. It is a non-key shorebird species to the NWMR with low occurrences (Advisian 2022). During the non-breeding period it is found in the north and north-west of WA (DCCEEW 2024f), mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays where it forages close to the edge of shallow waters (DCCEEW 2024f).

No BIAs for the bar-tailed godwit or northern Siberian godwit were identified within the Project Area or EMBA.

7.6.4.34 Black-tailed godwit (*Limosa limosa*)

The black-tailed godwit is listed as endangered and migratory under the EPBC Act. It is found in all states and territories of Australia, with the largest populations of this species found on the northern Australian coast between Darwin and Weipa. It prefers coastal regions and is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; it has occasionally been recorded on rocky coasts or coral islets (DCCEEW n.d.).

This species forages on wide intertidal mudflats or sandflats, in soft mud or shallow water and occasionally in shallow estuaries (DCCEEW n.d.). It breeds in the northern hemisphere and moves south, in broad fronts and often overland, for the boreal winter (Higgins and Davies 1996), arriving in north-west Australia from late August (Lane 1987) and returning to breeding grounds in April and May (Higgins and Davies 1996).

Within the NWMR, this internationally important site was identified for this species (Bamford et al. 2008):

- Roebuck Bay.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.35 Southern giant petrel (*Macronectes giganteus)*

The southern giant petrel is listed as endangered and migratory under the EPBC Act. It is marine bird that occurs in Antarctic to subtropical waters. In summer, it mainly occurs over Antarctic waters, and it is widespread south as far as the pack-ice and onto the Antarctic continent (Marchant and Higgins 1990).

Within Australia, this species is limited to breeding colonies on Heard and Macquarie Island and in the Australian Antarctic Territory. Beyond Australia, it breeds on islands in the southern Pacific, Indian and Atlantic oceans, at Cape Horn and on the Antarctic Peninsula (TSSC 2001).

At sea, this species mainly feeds on the surface but occasionally dives to shallow depths. It is an opportunistic scavenger and predator (DCCEEW n.d.).

Individuals may transit through the Project Area, but large numbers are not expected given the lack of habitat that would promote aggregating behaviours, such as foraging. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.36 Northern giant petrel (*Macronectes halli*)

The northern giant petrel is listed as endangered and migratory under the EPBC Act. It breeds in the sub-Antarctic and is a marine and oceanic species considered to be a moderate occurring key species within the NWMR (Advisian 2022; DCCEEW n.d.). It is mainly found in the sub-Antarctic but has been recorded within the NWMR during winter and spring. It is a surface-seizing scavenger, feeding on fish, cephalopods, seals, whales, chicks, seabirds and carrion (DCCEEW n.d.).

Individuals may transit through the Project Area, but large numbers are not expected given the lack of habitat that would promote aggregating behaviours, such as foraging. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.37 Grey wagtail (*Motacilla cinerea*) and yellow wagtail (*Motacilla flava*)

The grey wagtail is listed as migratory under the EPBC Act. It is a common visitor to northern Australia from the end of October to March, and uses islands as stopovers during its migration (DotE 2015c). It has a strong affiliation with water and is found across wetlands, watercourses, and marshes (DotE 2015b). It feed on insects and small prey items such as molluscs, crustaceans, fish and tadpoles (DotE 2015c).

The yellow wagtail is listed as migratory under the EPBC Act. It is a wet season visitor to northern Australia (Pilbara and Kimberley in WA) and is considered a vagrant species (DotE 2015c). It has a highly variable habitat of open areas with low vegetation near water (airstrips, pastures, fields, wetlands, rivers) (DotE 2015b).

No BIAs for these species were identified within the Project Area or EMBA.

7.6.4.38 Eastern curlew (*Numenius madagascariensis*)

The eastern curlew is listed as migratory and critically endangered under the EPBC Act, and as critically endangered under the BC Act. The bulk of the global population spend non-breeding periods (September–November) in Australia; it does not breed in Australia (Bamford et al. 2008). Within Australia, it has a primarily coastal distribution, with a continuous distribution from Barrow Island and the Dampier Archipelago in the Pilbara to the Kimberley. During the non-breeding season it forages on soft sheltered intertidal sandflats or mudflats, on salt flats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DCCEEW 2023e).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Roebuck Bay
- Port Hedland Saltworks.

Given the primarily coastal distribution of this species, its presence within the Project Area is expected to be limited. There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.39 Little curlew (*Numenius minutus*)

The little curlew is listed as migratory under the EPBC Act. This species breeds in Siberia, and spends the non-breeding season in northern Australia from Port Hedland WA to the Queensland coast. The little curlew is most often found feeing in short, dry grassland and sedgeland, thought it also forages in saltmarshes, coastal swamps, mudflats or sandflats of estuaries or beaches on sheltered coasts (Higgins and Davies 1996).

Within the NWMR, this internationally important sites was identified for this species (Bamford et al. 2008):

- Roebuck Plains.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.40 Whimbrel (*Numenius phaeopus*)

The whimbrel is listed as migratory under the EPBC Act. It is a regular migrant to Australia and New Zealand, with a primarily coastal distribution, and is often found on the intertidal mudflats of sheltered coasts. It is found in all states but is more common in the north (DCCEEW n.d.).

This species generally forages on intertidal mudflats, along the muddy banks of estuaries, and in coastal lagoons, either in open unvegetated areas or among mangroves. It often roosts in the branches of mangroves around mudflats and in estuaries, and occasionally in tall coastal trees (Higgins and Davies 1996).

Within the NWMR, this internationally important sites was identified for this species (Bamford et al. 2008):

- Roebuck Bay.

There are no identified BIAs for this species in the Project Area or EMBA.

7.6.4.41 Bridled tern (*Onychoprion anaethetus*)

The bridled tern is listed as migratory under the EPBC Act. It is a common summer breeding visitor to the NWMR (September–April), especially around the Dampier Archipelago and the Montebello Islands (Johnstone, Burbidge, and Darnell 2013), and is a frequent key nearshore seabird species within the NWMR (Advisian 2022). Breeding has been reported on the Dampier Archipelago, Montebello Islands, Lowendal Islands, Passage Islands and islands off Onslow in December–February (Johnstone, Burbidge, and Darnell 2013).

The migration and local movements of breeding birds within the NWMR are poorly defined. For example, two individuals were tracked departing the Houtman Abrolhos islands in April/May, transiting along the continental shelf waters before departing Australian waters and migrating towards the western Celebes Sea, east of Borneo (Surman, Nicholson, and Phillips 2018). They departed the western Celebes Sea in August/September and returned to the Houtman Abrolhos islands about 14 days later (Surman, Nicholson, and Phillips 2018).

This species feeds diurnally on fish, crustaceans, cephalopods and insects. In Australia, their diet is almost entirely fish, although they also take crustaceans and aquatic insects occasionally. They often feed on schools of fish that have been forced to the surface by other predators (Dunlop 1997). They forage mainly by contact dipping—they hover or glide close to the sea surface and then swoop down and immerse only their head and breast when attacking prey, which are usually taken from within the top 20 cm of the sea surface (Dunlop 1997).

No BIAs for this species have been identified within the Project Area, but it does occur within the southern extent of the EMBA (Figure 7-31).

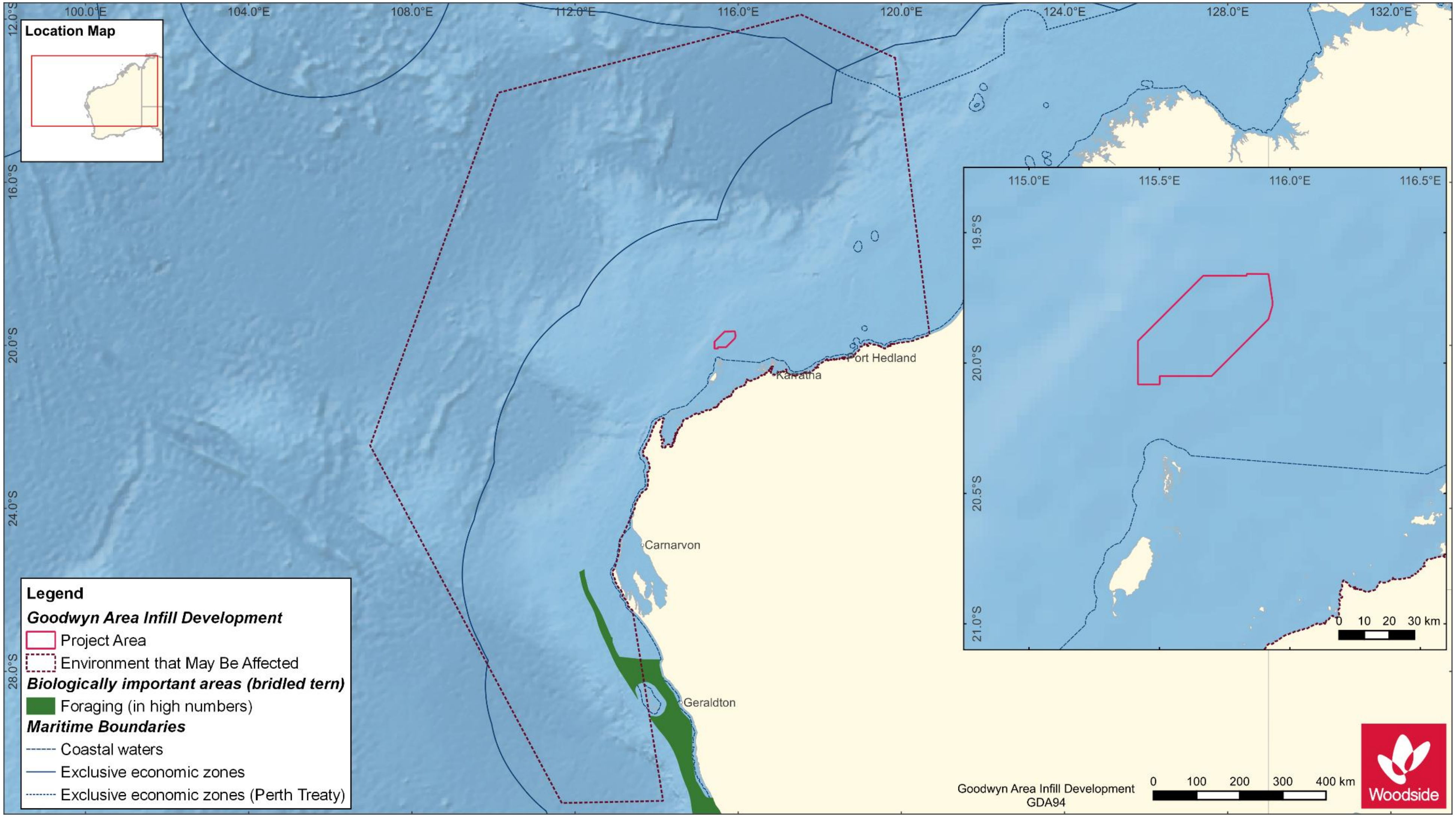


Figure 7-31: Bridled tern—BIAs within the EMBA

7.6.4.42 Osprey (*Pandion haliaetus*)

The osprey is listed as migratory under the EPBC Act. The distribution of the species around the northern coast (south-western WA to south-eastern NSW) appears continuous except for a possible gap at Eighty Mile Beach, WA (DCCEEW n.d.), and is a frequently occurring key marine species within the NWMR (Advisian 2022). This species inhabits coastal habitats and wetlands across temperate and tropical Australia and offshore islands. Osprey breed in monogamous pairs and their breeding cycle depends on latitude; in the NWMR, individuals breed early in the season (April–February) (DCCEEW n.d.).

Osprey hunt by hovering momentarily and then diving (sometimes in stages) into the water. They use their feet to snatch prey from the near the surface or plunge into the water feet first (Advisian 2022). Their main diet is fish, especially mullet where it is available (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.43 Abbot's booby (*Papasula abbotti*)

The Abbott's booby is listed as endangered under the EPBC Act. It is a large, long-lived seabird, which only nests at Christmas Island in the Indian Ocean (DCCEEW n.d.). It spends much of its time at sea and forages over large offshore distances when nesting. Its range may possibly extend into the north-western extent of the NWMR. It is considered a non-key pelagic seabird species within the NWMR (Advisian 2022).

No BIAs are identified within the Project Area or EMBA.

7.6.4.44 White-tailed tropicbird (*Phaethon lepturus*) and Christmas Island white-tailed tropicbird (*Phaethon lepturus fulvus*)

The white-tailed tropicbird is listed as migratory under the EPBC Act. It breeds across many sites, but in low numbers (CoA 2022c). In Australia, 6,000–12,000 pairs nest on Christmas Island, with smaller fragmented populations at North Keeling Island (40 pairs). These breeding pairs on Christmas Island are expected to be members of the Christmas Island white-tailed tropicbird subspecies. Although individuals of this subspecies can forage at great distances from colonies (see below), the numbers occurring in the NWMR are expected to be low.

The white-tailed tropicbird ranges widely over the ocean surrounding its breeding locations (Marchant and Higgins 1990). At the species level, the white-tailed tropicbird appears to be a moderately common visitor to the seas off northern WA, west of the continental shelf. It is occasionally sighted close to the WA mainland (Dunlop, Surman, and Wooller 2001; Marchant and Higgins 1990). Dunlop et al. (2001) observed birds from Christmas Island foraging singly some 1,400–1,600 km south-east of Christmas Island.

In between bouts of foraging, this species regularly roosts on the sea's surface. It is a solitary forager, rarely feeding in association with other seabird species and always in waters favourable for its principal prey—flying fish (Santos, Campos, and Efe 2019). It is a surface forager that occasionally undertakes shallow dives (Marchant and Higgins 1990).

No BIAs for this species were identified within the Project Area, but are present within the EMBA (Figure 7-32).

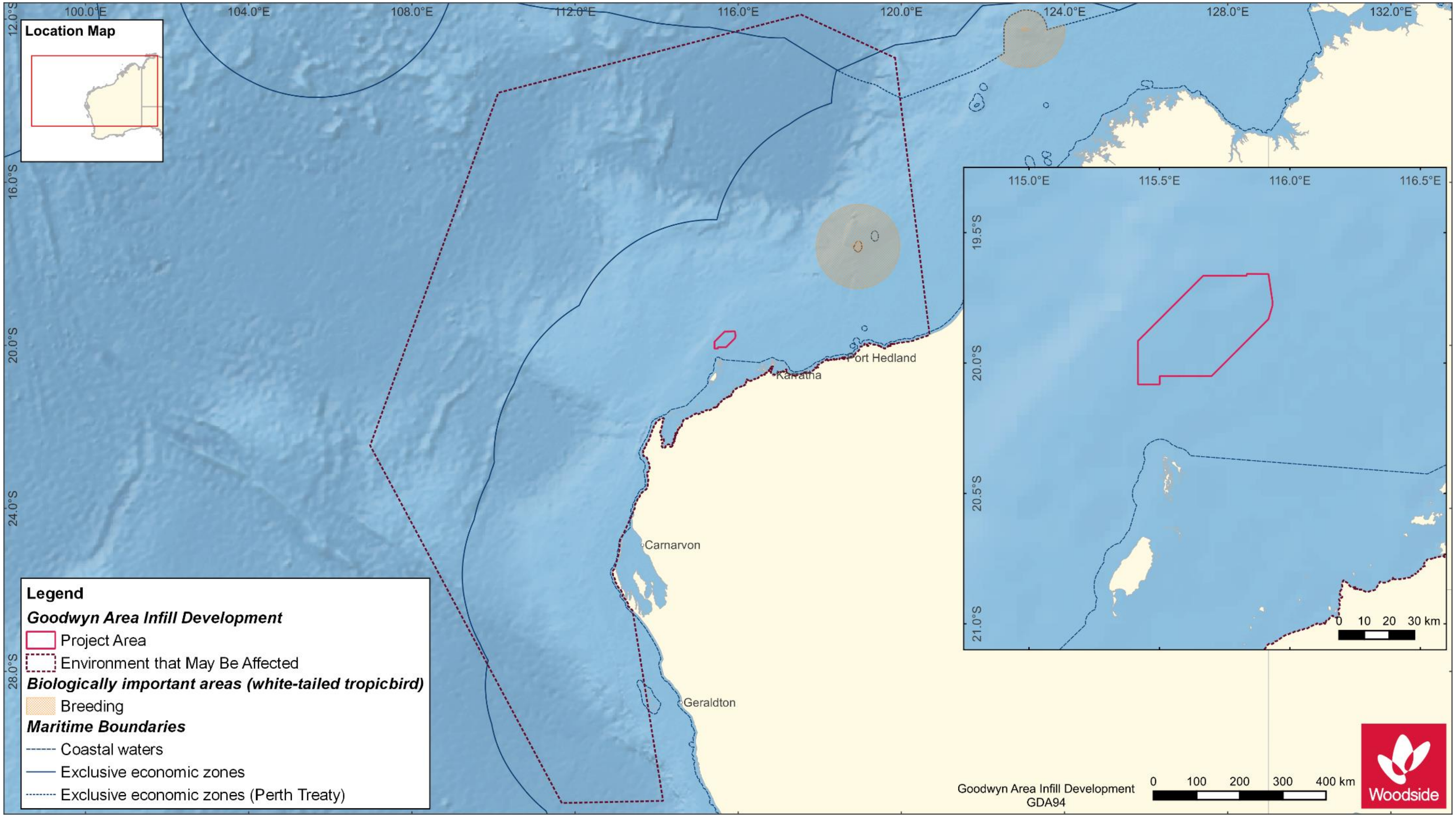


Figure 7-32: White-tailed tropicbird—BIAs within the EMBA

7.6.4.45 Red-tailed tropicbird (*Phaethon rubricauda*) and red-tailed tropicbird (Indian Ocean) (*Phaethon rubricauda westralis*)

The red-trailed tropicbird is listed as migratory under the EPBC Act. This oceanic Indo–Pacific seabird (CoA 2022c) is present year-round in the NWMR and is a moderate occurrence key species of seabird in the NWMR. It has small breeding colonies near Ashmore Reef (Advisian 2022). It hunts by plunge diving, and feeds on fish and cephalopods (Advisian 2022).

The red-tailed tropicbird (Indian Ocean) is a subspecies that is listed as endangered under the EPBC Act. The subspecies is only known to breed on islands offshore of WA, including Christmas Island, Cocos (Keeling) Islands, Bedwell Island, Rowley Shoals, Ashmore Reef (West, Middle, and East Island), and Rottnest Island (DCCEEW 2023o). All known and potential breeding habitat and islands should be considered habitat critical to the survival of the subspecies (DCCEEW 2023o). The preferred nest sites are rock crevices or under vegetation; they may nest alone or in loose colonies (DCCEEW 2023o). The subspecies has a wide range across the eastern Indian Ocean when not breeding (DCCEEW 2023o).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.46 Red-necked phalarope (*Phalaropus lobatus*)

The red-necked phalarope is listed as migratory under the EPBC Act. This species breeds in the Arctic and subarctic North America, Europe and Russia. They spend winter at sea around the tropics, but are occasionally seen on coastal and inland wetlands. In Australia, they are recorded at both inland and coastal lakes/swamps, including highly saline waters and artificial wetlands notably saltfields (Higgins and Davies 1996).

The species is known to take invertebrates in the open water, and very rarely on mudflats. They have been observed feeding at the Port Hedland Saltworks, WA (Higgins and Davies 1996).

There are no identified internationally important sites or BIAs for this species in the Project Area or EMBA.

7.6.4.47 Ruff (*Philomachus pugnax*)

The ruff is listed as migratory under the EPBC Act. The ruff breeds in Europe from north Russia to north-west Kazakhstan, and spends the non-breeding season mostly in Africa and India. The ruff is a rare visitor to Australia, though they are known to be in Australia from September to April (Higgins and Davies 1996)

Within Australia, the ruff has been found in generally fresh, brackish of saline wetlands with exposed mudflats at the edges. It has also been observed in terrestrial wetlands and occasionally sheltered coasts and saltworks (Higgins and Davies 1996).

There are no identified internationally important sites or BIAs for this species in the Project Area or EMBA.

7.6.4.48 Sooty albatross (*Phoebetria fusca*)

The sooty albatross is listed as vulnerable and migratory under the EPBC Act. It is a rare, but probably regular migrant to Australia, mostly in the autumn–winter months, occurring in Queensland, NSW, Victoria, Tasmania and SA (DCCEEW n.d.). It breeds on islands in the southern Indian and Atlantic oceans, and forages south of 30°S, between southern NSW and Argentina (Marchant and Higgins 1990). The species flies within 10–15 m of the sea surface, using updrafts from wave fronts for lift, and forages at the sea surface (Marchant and Higgins 1990).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.49 Pacific golden plover (*Pluvialis fulva*)

The pacific golden plover is listed as migratory under the EPBC Act. The pacific golden plover breeds mostly in northern Siberia, and spends the non-breeding season in coastal areas of Asia, Australasia, Melanesia and Polynesia (DCCEEW n.d.).

In non-breeding grounds in Australia this species usually inhabits coastal habitats, though it occasionally occurs around inland wetlands. Pacific golden plovers usually occur on beaches, mudflats and sandflats, in sheltered areas including harbours, estuaries and lagoons, and also in evaporation ponds in saltworks. This species usually forages on sandy or muddy shores or margins of sheltered areas such as estuaries and lagoons, though it also feeds on rocky shores, islands or reefs. They usually roost near foraging areas (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.50 Grey plover (*Pluvialis squatarola*)

The grey plover is listed as vulnerable and migratory under the EPBC Act. It breeds in the northern hemisphere (north of 65°N, near the Arctic Circle). During the non-breeding season, it is widespread on the coasts of North and South America, western and southern Europe, Africa, western, southern, south-eastern and eastern Asia, and Australia (DCCEEW n.d.). When it migrates to Australia during the non-breeding season, this species occurs almost entirely in coastal areas, where it usually inhabits and forages within sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.51 Soft-plumaged petrel (*Pterodroma mollis*)

The soft-plumaged petrel is listed as vulnerable under the EPBC Act. This species breeds only at two locations in Australian waters, both within the Southern Ocean (off Tasmania and Macquarie Island) (TSSC 2015e). It is a frequently occurring key seabird species within the NWMR (Advisian 2022). As a mainly sub-Antarctic species it is usually distributed in cooler seas but its distribution extends into subtropical waters and its known distribution includes the southern extent of the NWMR (DCCEEW n.d.). It hunts by surface-seizing, mainly feeding on cephalopods, some fish and crustaceans (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area, but have been identified within the EMBA (Figure 7-33).

7.6.4.52 Australian painted snipe (*Rostratula australis*)

The Australian painted snipe is listed as endangered under the EPBC Act. It is a non-key species of shorebird within the NWMR with low occurrences (Advisian 2022). This species occurs in shallow freshwater and varied wetlands across Australia (DSEWPaC 2013a), and uses areas with tree coverage. Its diet includes vegetation, insects, molluscs crustaceans and other invertebrates (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.53 Roseate tern (*Sterna dougallii*)

The roseate tern is listed as migratory under the EPBC Act. It is generally subtropical in distribution and there are many breeding populations in the NWMR, including Ashmore Reef, Bonaparte Archipelago, Lacepede Islands, Dampier Archipelago, and the Lowendal Islands.

The largest breeding colony for this species in WA is in the Houtman Abrolhos Islands (Surman and Nicholson 2009). Large colonies also breed within the Lowendal Island and Montebello Island region (Higgins and Davies 1996), with another recorded on Goodwyn Island on the Dampier Archipelago (Higgins and Davies 1996). Peak breeding times across the NWMR is May–August.

Birds of this species typically move away from breeding colonies after breeding, but their non-breeding range is not well defined (Higgins and Davies 1996). Many non-breeding roseate terns have been observed at several remote locations in the Kimberley and high numbers have also been recorded at the Eighty Mile Beach Ramsar site (Surman pers comms; cited in Woodside 2023b).

This species forages diurnally, up to 60 km from their colonies and always over deeper shelf waters, rather than shallow coastal areas (Surman and Wooller 2003). They will readily raft (roost in flocks on the sea's surface) after foraging episodes (CoA 2022c).

Their main diet comprises small pelagic fish taken by plunge diving (to 20 cm deep) or surface dipping, typically foraging in dense flocks overflying predatory fish that push their prey to the surface.

Breeding BIAs across the NWMR are associated with known breeding colonies on islands, while a resting BIA has been identified at Eighty Mile Beach. No BIAs for this species are within the Project Area; however, they do overlap the EMBA (Figure 7-34).

7.6.4.54 Little tern (*Sternula albifrons*)

The little tern is listed as migratory under the EPBC Act. Three subpopulations of this species occur in Australia, with two in the NWMR—the northern Australian breeding subpopulation (around Broome and across the NWMR to Cape York); and an east Asian breeding subpopulation (Shark Bay to south-eastern Queensland during the austral summer). The little tern is a frequent key species within the NWMR (Advisian 2022).

Recent surveys have found that little terns breed across the NWMR in small colonies (Surman pers comm; cited in Woodside 2023b). But it is difficult to identify the subpopulations, and thus population estimates have high error because of the overlapping range of the subpopulations and the difficulty in accessing the remote breeding sites of the northern populations.

Little terns usually forage close (within 5 km) to their breeding colonies (Bertolero et al. 2007), mainly on small fish (<10 cm long), but they also eat crustaceans, insects, annelids and molluscs.

Little is known about the breeding and foraging ecology of little terns; however, BIAs for foraging and resting have been identified across the NWMR, with a peak in breeding activity from June–October. BIAs were identified within the EMBA but these do not overlap the Project Area (Figure 7-35).

7.6.4.55 Australian fairy tern (*Sternula nereis nereis*)

The Australian fairy tern is listed as vulnerable under the EPBC Act and the BC Act. The WA breeding population (~5,000–6,000 mature individuals) is dispersed over ~2,500 km of coastline (Greenwell 2021). Within WA, the subspecies comprises a sedentary Pilbara population and a partially migratory population that extends from Exmouth to Point Malcolm.

The partially migratory population is widely distributed and winters primarily around the northern Houtman Abrolhos Islands (Greenwell 2021). These birds migrate to breeding areas as far south as Point Malcolm on the eastern south coast and as far north as the Ningaloo coast, while others remain within the Houtman Abrolhos Islands (Greenwell 2021).

Within the NWMR, breeding occurs in small colonies from June–September on offshore islands, including Simpson Island, Barrow Island, the Montebello Islands, the Lowendal Islands, Thevenard Island, Serrurier Island, the islands in the Dampier Archipelago, Maryanne Shoals and Egret Island (Dunlop 2018; Johnstone, Burbidge, and Darnell 2013). Colonies tend to occupy areas rather than fixed sites, and nest sites can be abandoned after one or more years, even if they have been successful (Saunders and De Rebeira 1985).

Although information regarding the foraging ecology of this species within the NWMR is lacking, this species has been studied in SA, where it typically forages in inshore waters and has been reported to rarely travel beyond 2 km during the breeding season (Paton and Rogers 2009).

Australian fairy terns are diurnal plunge-diving feeders that predate exclusively on small (<60 mm) surface schooling bait fish throughout their range. Prey include species of sprats, hardy heads and larval prey of some demersal fish species. Unlike many other terns, fairy terns do not depend on large pelagic fishes to drive their prey to the surface.

No BIAs for this species have been identified within the Project Area. However, there are multiple breeding BIAs associated with Barrow Island, the Montebello Islands, and the Dampier Archipelago (Figure 7-36).

7.6.4.56 Brown booby (*Sula leucogaster*)

The brown booby is listed as migratory under the EPBC Act. It is a cosmopolitan species with a pan-tropical distribution. Within the NWMR, large colonies occur at offshore islands including the Lacepede Islands (10,000 pairs), Ashmore Reef (4,000 pairs), Bedout Island (1,000 pairs) and Adele Island (2,900 pairs). The total breeding population in the Australian region in 1996–1997 was estimated at 59,940–73,900 pairs (WBM Oceanics Australia and Claridge 1997). It is a frequent key pelagic seabird species within the NWMR (Advisian 2022).

This species does not migrate far from its breeding islands, rarely dispersing more than 240 km from their natal colony (Dunlop, Surman, and Wooller 2001). It forages within 50 km of its colony, plunge diving up to 15 m deep and pursuing its prey when ascending after the dive (Austin et al. 2021). Its diet is mainly medium to large surface schooling prey (northern pilchard, Indian anchovy, flying fish and cephalopods), often associated with feeding tuna and mackerel (Austin et al. 2021).

Brown boobies are not prone to waterlogging, will roost on the sea's surface, and are known to form large aggregations on oil and gas platforms throughout the NWMR (Surman pers comms; cited in Woodside 2023b).

Breeding/foraging BIAs for this species in the NWMR are associated with breeding colonies on Ashmore Reef, Adele Island, White Island, Lacepede Islands and Bedout Island. Breeding is reported as occurring between February and March.

No BIAs for this species are identified within the Project Area; however, they are present within the EMBA (Figure 7-37).

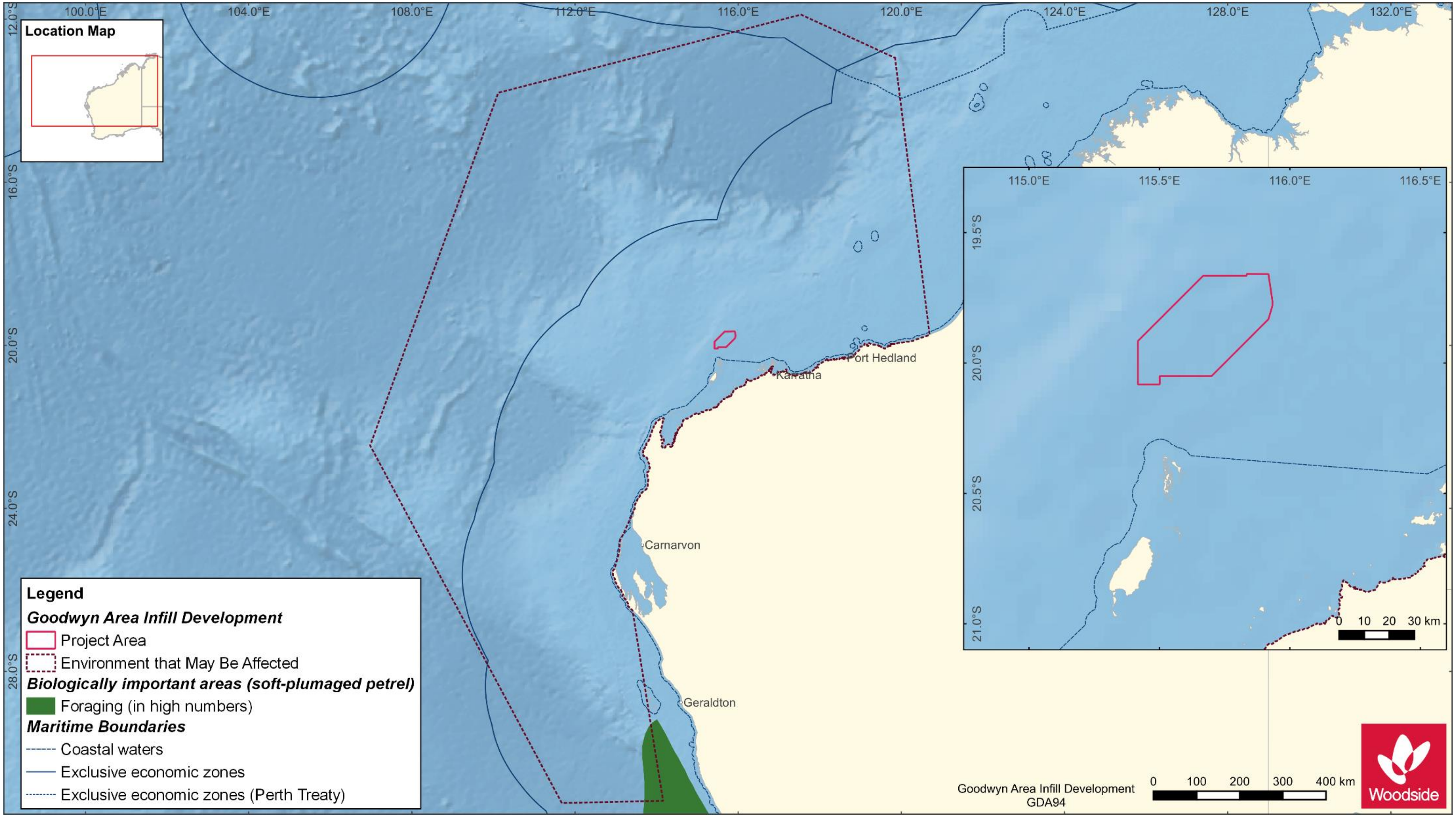


Figure 7-33: Soft-plumaged petrel—BIAs within the EMBA

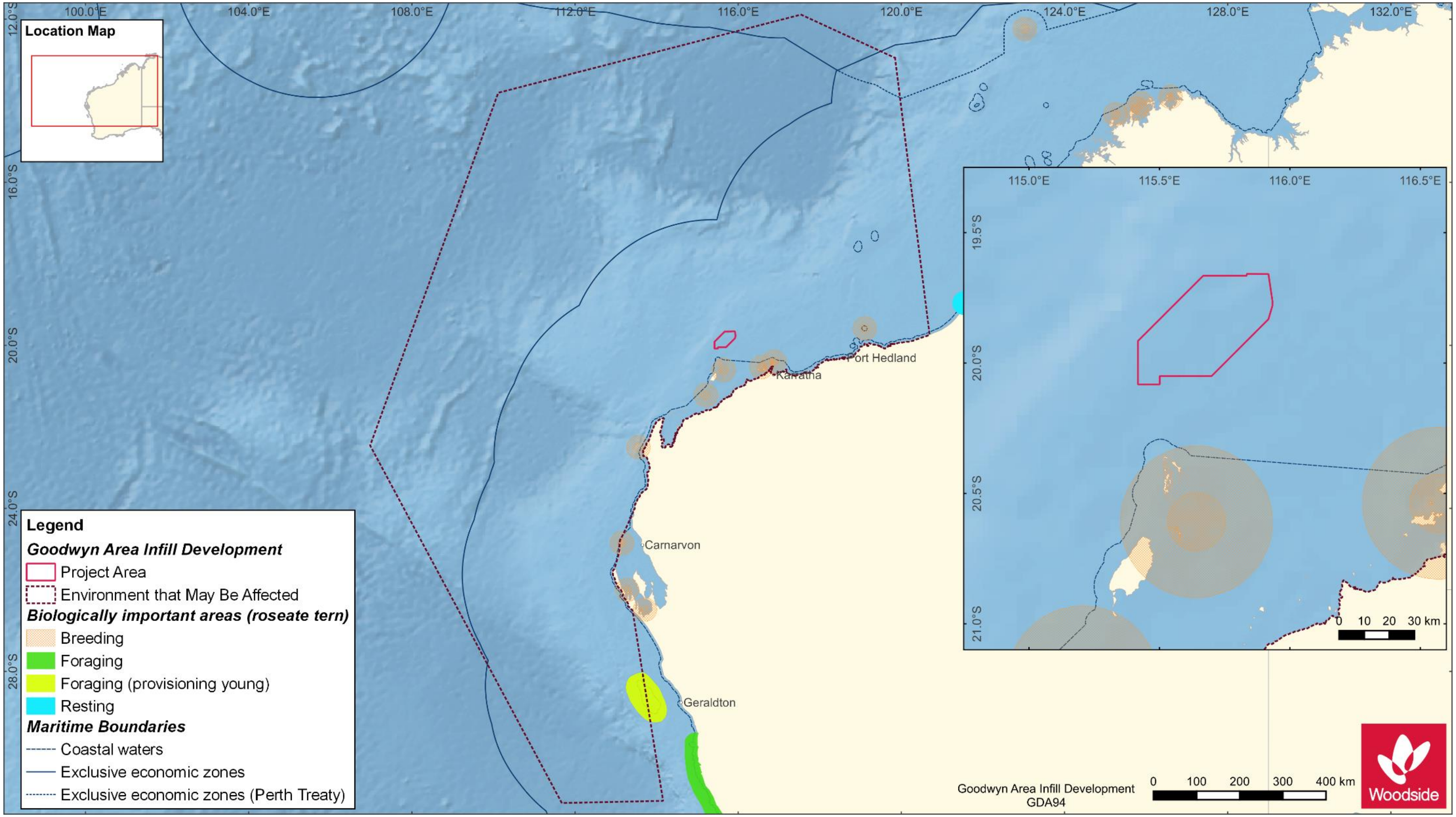


Figure 7-34: Roseate tern—BIAs within the EMBA

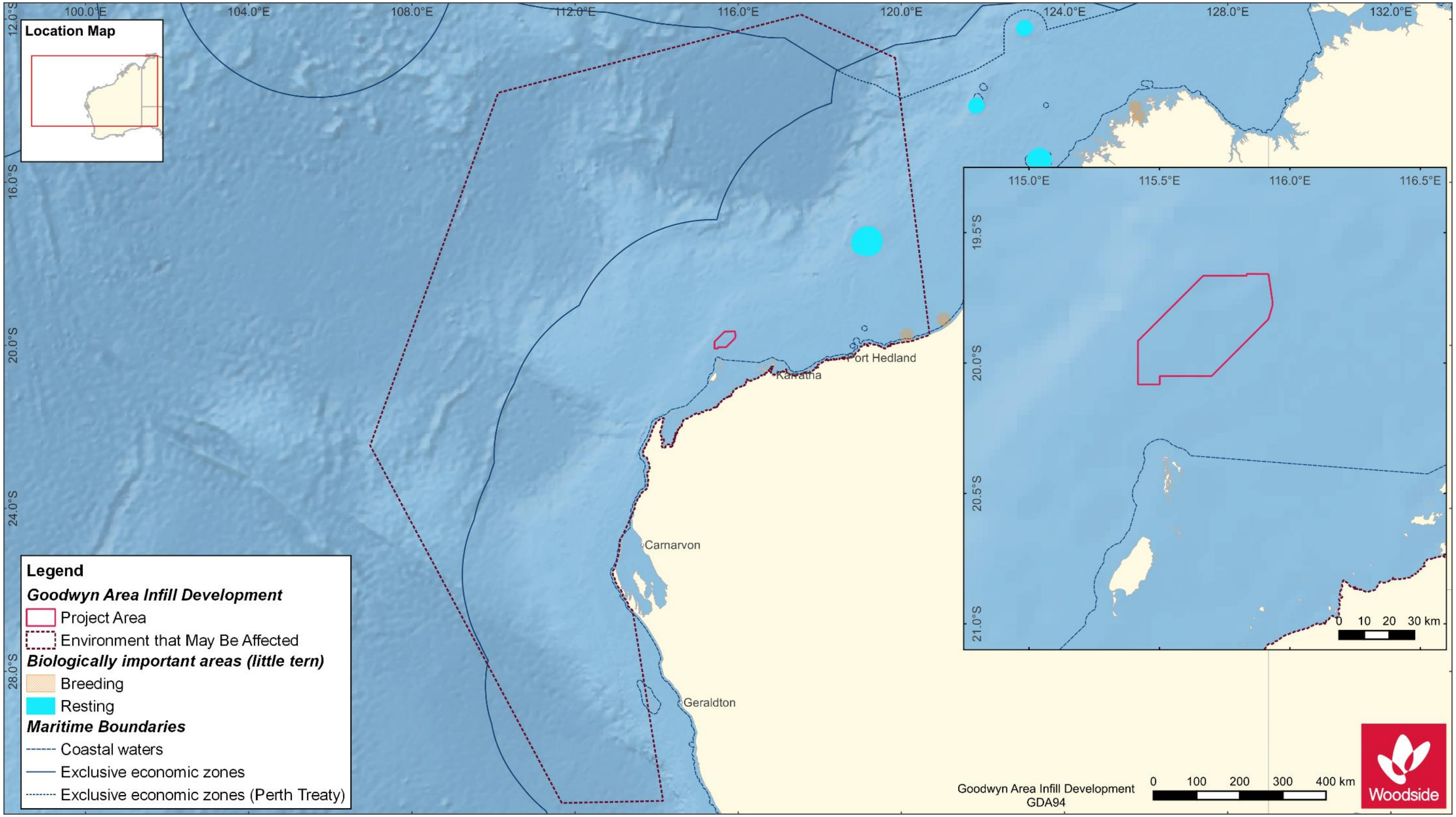


Figure 7-35: Little tern—BIAs within the EMBA

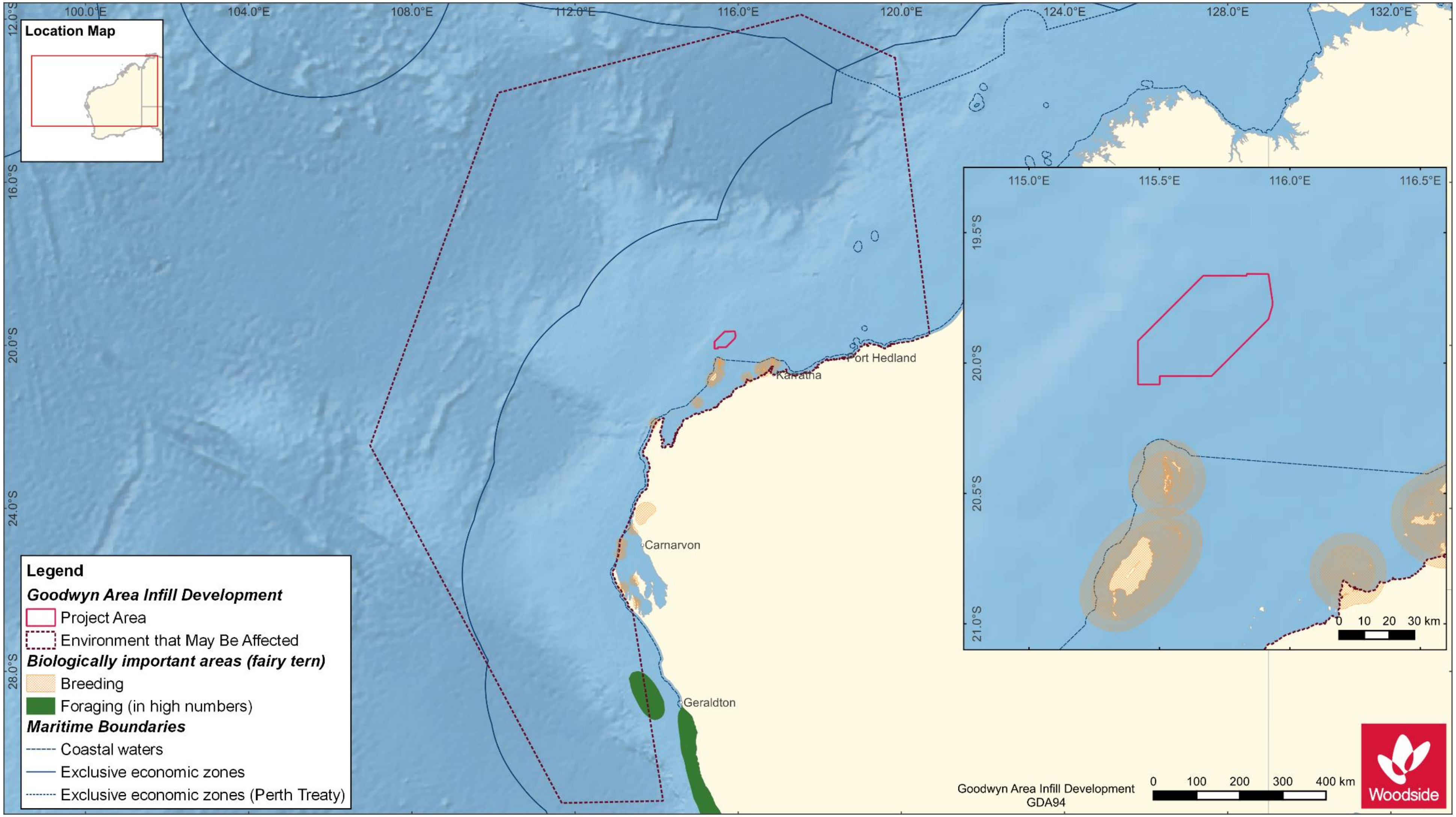


Figure 7-36: Fairy tern—BIAs within the EMBA

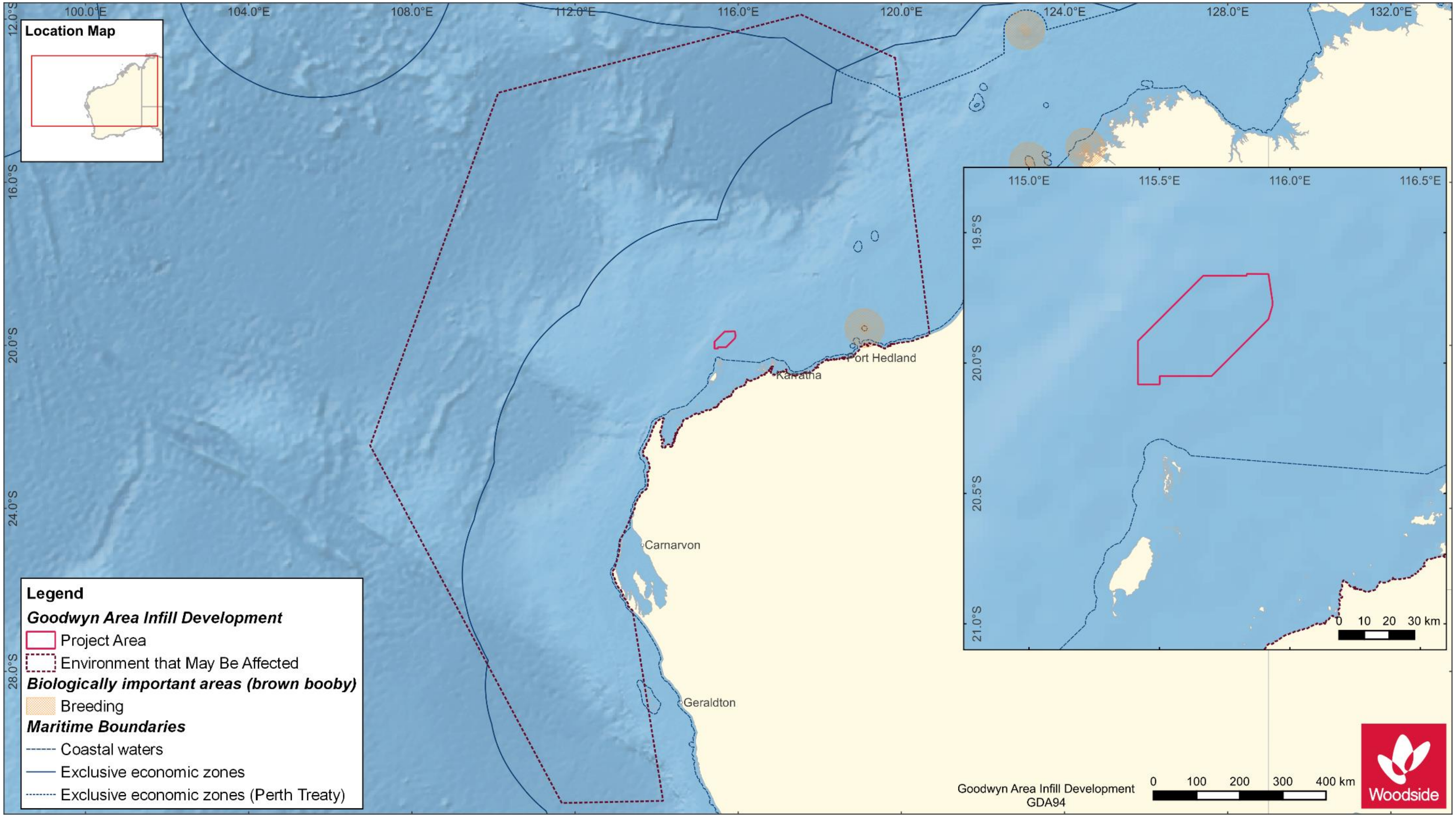


Figure 7-37: Brown booby—BIAs within the EMBA

7.6.4.57 Indian yellow-nosed albatross (*Thalassarche carteri*)

The Indian yellow-nosed albatross is listed as vulnerable and migratory under the EPBC Act. This species is considered a small albatross (up to ~75 cm long). It is abundant off WA foraging mostly in the southern Indian Ocean, and is considered a low occurring, non-key species to the NWMR (Advisian 2022). It is a migratory species with six island breeding sites external to Australia, where it nests on coastal cliffs and slopes (CoA 2021; DCCEEW n.d.). Its diet is mainly cephalopods (squid) and fish (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.58 Shy albatross (*Thalassarche cauta*)

The shy albatross, which is endemic to Australia (TSSC 2020b), is listed as endangered and migratory under the EPBC Act. It breeds annually and is less oceanic than other albatross species (CoA 2021); it is a non-key species of pelagic seabird with low occurrence within the NWMR (Advisian 2022).

This species is generally found along coastlines and continental shelves. It hunts singly or in flocks from the sea surface, but can dive to 3 m deep and swim to 7 m deep (TSSC 2020b). Its diet includes fish, cephalopods and some crustaceans; a significant portion of their diet is met by following fishing vessels and foraging on the fish processing discharges (TSSC 2020b).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.59 Campbell albatross (*Thalassarche impavida*)

The Campbell albatross is listed as vulnerable and migratory under the EPBC Act. In Australia, it generally forages in the higher latitudes of western Pacific and eastern Indian oceans (CoA 2021). It is a non-breeding visitor (DCCEEW n.d.), and is a non-key species of pelagic seabird with low occurrence within the NWMR (Advisian 2022).

This species is a pelagic seabird that inhabits sub-Antarctic and subtropical waters. It is an opportunistic scavenger, often found following fishing vessels for easy prey, and is also a plunging hunters that takes food from the sea surface from heights of up to 9 m (DCCEEW n.d.). Its diet is mainly krill and fish with some cephalopods, salps and jellyfish, and this species is known to feed with other albatrosses and petrels (DCCEEW n.d.).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.60 Black-browed albatross (*Thalassarche melanophris*)

The black-browed albatross is listed as vulnerable and migratory under the EPBC Act. It is known to nest on Heard Island, McDonald Islands and Macquarie Island in the summer (CoA 2021) and migrate northwards to forage around the continental shelf, coastal waters, harbours, bays and channels off Australia, New Zealand, South Africa and South America (TSSC 2005). This species is a non-key species of pelagic seabird with low occurrence within the NWMR (Advisian 2022).

It is a surface-seizing, plunging and pursuit diving hunter, often found following fishing vessels for easy prey (CoA 2021). Its diet is mainly cephalopods, fish, molluscs, crustaceans (DCCEEW n.d.), and this species mixes with other seabirds (including petrels and other albatrosses) when foraging (Marchant and Higgins 1990).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.61 White-capped albatross (*Thalassarche steadi)*

The white-capped albatross is listed as vulnerable and migratory under the EPBC Act. It is endemic to New Zealand and forages in Australia's higher southern hemisphere latitudes (CoA 2021). It is a marine species that occurs in inshore and offshore environments, and is a moderately occurring species of pelagic seabird within the NWMR (Advisian 2022).

This species is a known scavenger and gathers at commercial fishing grounds for opportunistic feeding (DCCEEW n.d.). It feeds on cephalopods and fish but this has not been well studied; it has been seen diving to depths for food (Marchant and Higgins 1990).

No BIAs for this species have identified within the Project Area or EMBA.

7.6.4.62 Greater crested tern (*Thalasseus bergii*)

The great crested tern is listed as migratory under the EPBC Act. It is widespread along coastlines of the NWMR and offshore islands (Johnstone, Burbidge, and Darnell 2013).

Many populations remain sedentary in their breeding areas or disperse locally (Burger, Gochfeld, and Bonan 1996), although some are more migratory. This species breeds in large, dense colonies, or in small groups of <10 pairs amidst colonies of other species, such as silver gull (Burger, Gochfeld, and Bonan 1996). Colonies are located on islands, including those as far offshore as Bedout, Legendre and the Montebello and Lowendal islands (Johnstone, Burbidge, and Darnell 2013). Adult breeders have shown both high site fidelity and also flexibility in their breeding locations, depending on the spatial and temporal reliability of food resources (Crawford et al. 2002).

Breeding occurs late March–May (Johnstone, Burbidge, and Darnell 2013). During breeding, this species conducts short, diurnal foraging trips close (<40 km) to the colony (Surman and Wooller 2003; Rock, Leonard, and Boyne 2007; McLeay et al. 2010), with most foraging behaviour displayed by individuals at distances >5 km (McLeay et al. 2010).

Adults may forage more widely on inshore reef fish (Surman and Wooller 2003), crustaceans and cephalopods using a plunge-diving method (CoA 2022c).

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.63 Grey-tailed tattler (*Tringa brevipes)*

The grey-tailed tattler is listed as migratory under the EPBC Act. It has a wide global distribution. Within Australia, it has a primarily northern coastal distribution and is found in most coastal regions (Higgins and Davies 1996).

This species is often found on sheltered coasts with reefs and rock platforms or intertidal mudflats. It usually forages in shallow water, on hard intertidal substrates, such as reefs and rock platforms, in rock pools and among rocks and coral rubble over which water may surge. It usually roosts in mangrove branches or, rarely, in dense stands of other shrubs or on snags or driftwood. If mangroves are not present, it roosts on rocks that are sometimes partly submerged (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.64 Wood sandpiper (*Tringa glareola)*

The wood sandpipe is listed as migratory under the EPBC Act. It uses well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes (DCCEEW n.d.). It forages on moist or dry mud at the edges of wetlands, either along shores, among open scattered aquatic vegetation, or in clear shallow water (Higgins and Davies 1996).

This species breeds across Eurasia, and most of the EAAF population spends the non-breeding season in south-east Asia (DCCEEW n.d.). It is the most abundant migratory shorebird in non-coastal areas of Asia, but only a small proportion of the Asian population reaches Australia. Its movements within Australia are poorly known; most records of presence occur in August–April (DCCEEW n.d.) .

No internationally important sites or BIAs were identified for this species within Project Area or EMBA.

7.6.4.65 Common greenshank (*Tringa nebularia*)

The common greenshank is listed as endangered and migratory under the EPBC Act. It inhabits all types of wetlands and coastal habitats, typically those with mudflats, saltmarsh, mangroves or seagrass, and has the widest distribution of any shorebird in Australia (DCCEEW n.d.). Its diet is mainly molluscs, crustaceans, insects, and occasionally fish and frogs (DCCEEW n.d.).

It is a frequent key species within the NWMR (Advisian 2022). Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

No BIAs for this species were identified within the Project Area or EMBA.

7.6.4.66 Marsh sandpiper (*Tringa stagnatilis*)

The marsh sandpiper is listed as migratory under the EPBC Act. This species breeds from eastern Europe to eastern Siberia. The species migrates south for the boreal winter to non-breeding areas from Africa, across southern Asia to Australia (DCCEEW n.d.).

Within Australia, the marsh sandpiper is found on coastal and inland wetlands throughout the country. They usually forage in shallow water at the edge of wetlands, and have been recorder roosting or loafing on tidal mudflats, near low saltmarsh, and around inland swamps (Higgins and Davies 1996).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Port Hedland Saltworks.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.67 Common redshank (*Tringa tetanus*)

The common redshank is listed as migratory under the EPBC Act. This species breeds in Iceland, the British Isles, Scandinavia. During the non-breeding season, the common redshank is found throughout Asia and Australia, particularly China (Bamford et al. 2008).

Within Australia, it has a wide spread distribution throughout the country. They are found in sheltered coastal wetlands such as bays, river estuaries, lagoons, inlets and saltmarsh. They have been observed feeding in shallow water, on wet bare mud or sand, or on algal deposits, round the edges of wetlands, near rocks or samphire, and tend to roost on small elevated areas such as estuarine sandbars and muddy islets surrounded by water (Higgins and Davies 1996).

There are no identified internationally important sites or BIAs for this species in the Project Area or EMBA.

7.6.4.68 Painted button-quail (Houtman Abrolhos) (*Turnix varius scintillans*)

The painted button-quail (Houtman Abrolhos) is listed as endangered under the EPBC Act. They occur on a number of islands in the Houtman Abrolhos island group off the Western Australian coast. The painted button-quail (Houtman Abrolhos) occurs in four separate populations, due to isolation of separate islands, and as such these populations are thought to represent genuine subpopulations given the very low probability of genetic exchange (breeding) between them (DCCEEW n.d.).They can occur in all available habitats in the Houtman Abrolhos, and occasionally forage in the sub-littoral zone and around fishing camps (DCCEEW n.d.).

The habitat that is critical to the survival of the painted button-quail (Houtman Abrolhos) includes islands of the Houtman Abrolhos (DCCEEW 2023d). The species is most commonly observed in open grasslands on low sand dunes and open shrublands on flats, and occasionally forages in the sub-littoral zone.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.4.69 Terek sandpiper (*Tringa nebularia*)

The terek sandpiper is listed as vulnerable and migratory under the EPBC Act. In Australia, the terek sandpiper has a primarily coastal distribution, with occasional records inland (DCCEEW n.d.).

It mostly forages in the open on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons. It prefers to roost in or among mangroves, perching in branches or roots up to 2 m from the ground, or beneath them in the shade on hot days (Marchant and Higgins 1990). The main breeding range for this species is in northern Russia (DCCEEW n.d.) During non-breeding periods, it occurs in coastal Africa, Asia and Australasia (DCCEEW n.d.).

Within the NWMR, these internationally important sites were identified for this species (Bamford et al. 2008):

- Eighty Mile Beach
- Roebuck Bay.

No BIAs for this species have been identified within the Project Area or EMBA.

7.6.5 Seasonal Sensitivities for Protected Species

Table 7-17 lists the key seasonal sensitivities for protected migratory species identified as potentially occurring within the Project Area.

Table 7-17: Key seasonal sensitivities for protected migratory species identified as occurring within the Project Area

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish, sharks and rays												
Great white shark – northern migration (to North West Cape) (DSEWPaC 2013c)												
Southern bluefin tuna (Hobday et al. 2015)												
Whale shark – foraging/ aggregation (Ningaloo Coast) (TSSC 2015f)												
Whale shark – northern and southern migration (NWMR) (TSSC 2015f)												

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
***Marine reptiles*[1]**												
Flatback turtle, Pilbara coast genetic stock – hatching		○	○									
Flatback turtle, Pilbara coast genetic stock – nesting	●	○	○							○	●	●
Green turtle, NWS genetic stock – hatching	○	●	●	○	○							
Green turtle, NWS genetic stock – nesting	●	●	○									
Hawksbill turtle WA genetic stock – hatching	●	●	○	○	○	○	○	○	○	○	○	●
Hawksbill turtle WA genetic stock – nesting	●	○	○	○	○	○	○	○	○	●	●	●
Leatherback turtle – hatching	○	○										
Leatherback turtle – nesting	○											○
Mammals												
Fin whale						○	○	○	○	○		
Humpback whale – northern migration (TSSC 2015d; Double et al. 2010)						○	●	●	○			
Humpback whale – southern migration (TSSC 2015d; Double et al. 2010)									●	●	○	
Sei whale – migration (DEH 2005)						○	○	○	○	○		
East Indian Ocean (EIO) pygmy blue whale – northern migration (Double et al. 2012; 2014)				○	●	●	○					
East Indian Ocean (EIO) pygmy blue whale – southern migration (Double et al. 2012; 2014)	○									○	●	●
Seabirds and shorebirds												
Eastern curlew – non-breeding (NWMR)(DCCEEW 2023e)	○	○	○	○			○	○	○	○	○	○
Red knot – non-breeding season (NWMR) (DCCEEW 2024a)	○	○	○	○				○	○	○	○	○
Wedge-tailed shearwater – various breeding sites (DSEWPaC 2012e)	○	○	○	○				○	○	○	○	○

○	Species may be present in the Project Area
●	Peak period. Presence of animals is reliable and predictable each year

1. Information regarding seasonal occurrence of marine turtles has been taken from the Recovery Plan for Marine Turtles in Australia 2017–2027 (CoA 2017b).

7.7 Key Ecological Features

KEFs are elements of the Commonwealth marine environment that are considered to be important for a marine region's biodiversity or ecosystem function and integrity. KEFs have been identified by the Australian Government based on advice from scientists about the ecological processes and characteristics of the area.

KEFs meet one or more of these criteria:

- a species, group of species, or a community with a regionally important ecological role (e.g. a predator; prey that affects a large biomass or number of other marine species)
- a species, group of species or a community that is nationally or regionally important for biodiversity
- an area or habitat that is nationally or regionally important for:
  - enhanced or high productivity (such as predictable upwellings – an upwelling occurs when cold nutrient-rich waters from the bottom of the ocean rise to the surface)
  - aggregations of marine life (such as feeding, resting, breeding or nursery areas)
  - biodiversity and endemism (species that only occur in a specific area)
- a unique seafloor feature, with known or presumed ecological properties of regional significance.

KEFs within the Project Area and EMBA are described in Table 7-18 and shown in Figure 7-38.

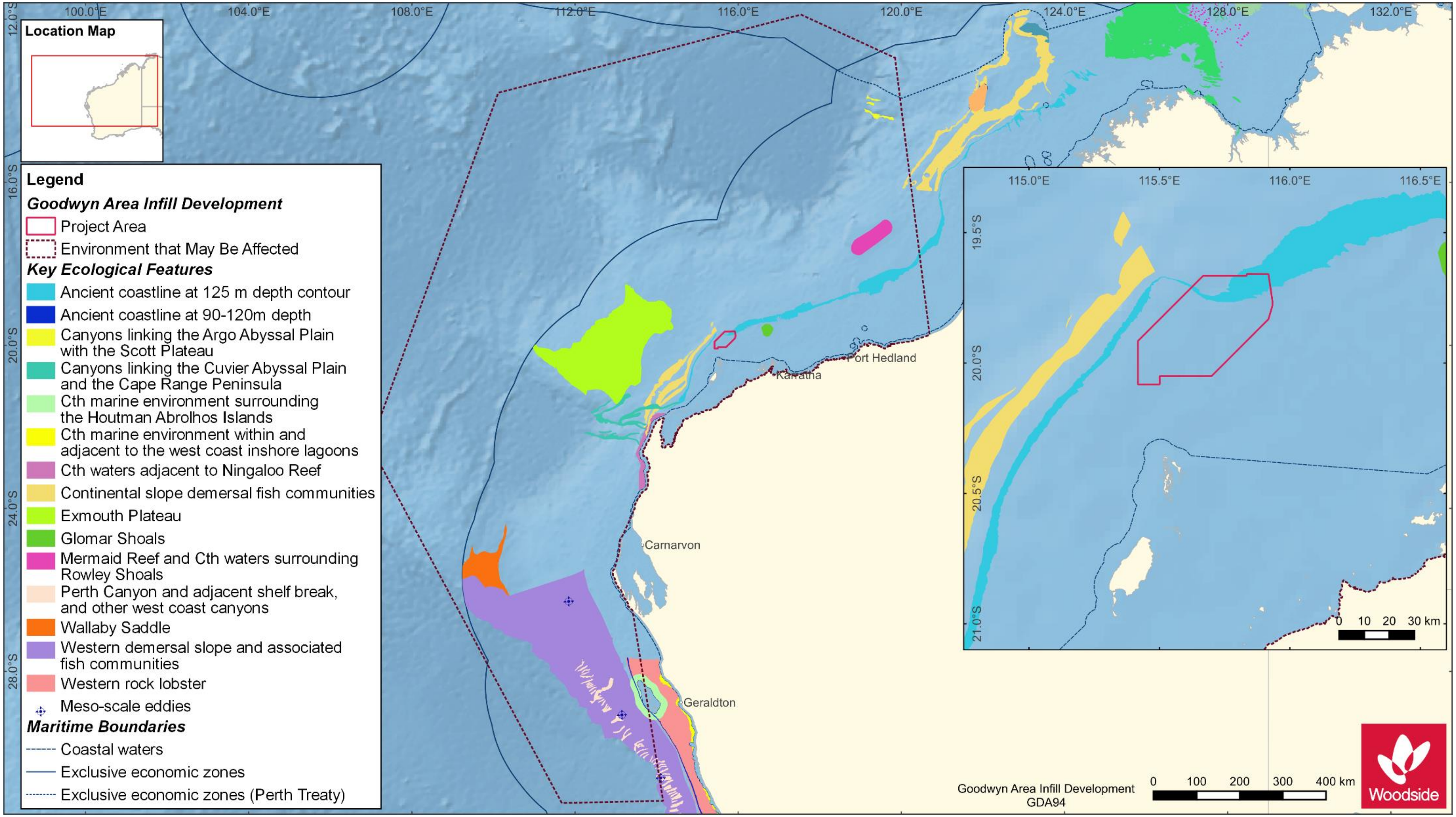


Figure 7-38: Key ecological features within the Project Area and EMBA

Table 7-18: Key ecological features within the Project Area and EMBA

KEF	Values	Description	Approx. distance and direction (km)	
			Project Area	EMBA
Ancient coastline at 125 m depth contour	Unique seafloor feature with ecological properties of regional significance Provides areas of hard substrate and therefore may provide sites for higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment	Several steps and terraces as a result of Holocene sea level changes occur in the region, with the most prominent of these features occurring as an escarpment along the NWMR and Sahul Shelf at a water depth of 125 m. The Ancient Coastline is not continuous throughout the NWMR and coincides with a well-documented eustatic stillstand at about 130 m worldwide (Falkner et al. 2009b). Where the Ancient Coastline provides areas of hard substrate, it may contribute to higher diversity and enhanced species richness relative to soft sediment habitat (Falkner et al. 2009b). Parts of the Ancient Coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly comprising soft sediment. The escarpment type features may also potentially facilitate mixing within the water column due to upwelling, providing a nutrient-rich environment. Although the Ancient Coastline adds additional habitat types to a representative system, the habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner et al. 2009b).	Overlap	Overlap
Ancient coastline between 90 and 120 m depth	Relatively high productivity and aggregations of marine life, and high levels of biodiversity and endemism The feature creates topographic complexity that may facilitate benthic biodiversity and enhanced biological productivity	Benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment, such as in the western Great Australian Bight, where the seafloor is dominated by sponge communities of significant biodiversity and structural complexity.	~870 km south-west	Overlap
Canyons linking the Argo Abyssal Plain with the Scott Plateau	Facilitates nutrient upwelling, creating enhanced productivity and encouraging diverse aggregations of marine life	Interactions with the Leeuwin Current and strong internal tides are thought to result in upwelling at the canyon heads, thus creating conditions for enhanced productivity in the region (Brewer et al. 2007). As a result, aggregations of whale sharks, manta rays, humpback whales, sea snakes, sharks, predatory fishes and seabirds are known to occur in the area due to its enhanced productivity (Sleeman et al. 2007).	~675 km north-east	Overlap

KEF	Values	Description	Approx. distance and direction (km)	
			Project Area	EMBA
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	Unique seafloor feature with ecological properties of regional significance The feature is an area of moderately enhanced productivity, attracting aggregations of fish and higher-order consumers such as large predatory fish, sharks, toothed whales and dolphins Likely to be important due to their historical association with sperm whale aggregations	The canyons are associated with upwelling as they channel deep water from the Cuvier Abyssal Plain up onto the slope. This nutrient-rich water interacts with the Leeuwin Current at the canyon heads (DSEWPaC 2012b). Aggregations of whale sharks, manta rays, seasnakes, sharks, large predatory fish, and seabirds are known to occur in this area.	~170 km south-west	Overlap
Commonwealth marine environment surrounding the Houtman Abrolhos Islands	High levels of biodiversity and endemism within benthic and pelagic habitats	The Houtman Abrolhos Islands and surrounding reefs support a unique mix of temperate and tropical species, resulting from the southward transport of species by the Leeuwin Current over thousands of years. The Houtman Abrolhos Islands are the largest seabird breeding station in the eastern Indian Ocean. They support more than one million pairs of breeding seabirds.	~905 km south-west	Overlap
Commonwealth waters adjacent to Ningaloo Reef	High productivity and diverse aggregations of marine life The Commonwealth waters adjacent to Ningaloo Reef and associated canyons and plateau are interconnected and support the high productivity and species richness of Ningaloo Reef, which is globally significant as the only extensive coral reef in the world that fringes the west coast of a continent	The Leeuwin and Ningaloo currents interact, leading to areas of enhanced productivity in the Commonwealth waters adjacent to Ningaloo Reef. Aggregations of whale sharks, manta rays, humpback whales, seasnakes, sharks, large predatory fish, and seabirds are known to occur in this area (DSEWPaC 2012b).	~215 km south-west	Overlap
Continental slope demersal fish communities	High biodiversity of demersal fish assemblages, including high levels of endemism	The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the Australian continental slope (DSEWPaC 2012b). The continental slope between North West Cape and the Montebello Trough has more than 500 fish species, 76 of which are endemic, which makes it the most diverse slope bioregion in Australia (Last et al. 2005). The slope of the Timor Province and the Northwest	~15 km north-west	Overlap

KEF	Values	Description	Approx. distance and direction (km)	
			Project Area	EMBA
		Transition also contains >500 species of demersal fishes of which 64 are considered endemic (Last et al. 2005), making it the second richest area for demersal fishes throughout the whole continental slope. Demersal fish species occupy two distinct demersal biomes associated with the upper slope (225–500 m water depths) and the mid-slope (750–1,000 m). Although poorly known, it is suggested that the demersal slope communities rely on bacteria and detritus-based systems comprising infauna and epifauna, which in turn become prey for a range of teleost fishes, molluscs and crustaceans (Brewer et al. 2007). Higher-order consumers may include carnivorous fishes, deepwater sharks, large squid, and toothed whales (Brewer et al. 2007). Pelagic production is phytoplankton-based, with hot spots around oceanic reefs and islands ((Brewer et al. 2007).		
Exmouth Plateau	Unique seafloor feature with ecological properties of regional significance, which apply to both benthic and pelagic habitats Likely to be an important area of biodiversity as it provides an extended area offshore for communities adapted to depths of ~1,000 m	The Exmouth Plateau is a large, mid-slope, continental margin plateau that lies off the north-west coast of Australia. It ranges in depth from ~500 m to >5,000 m and is a major structural element of the Carnarvon Basin (Miyazaki and Stagg 2013). The large size of the Exmouth Plateau and its expansive surface may modify deepwater flow and be associated with the generation of internal tides; both of which may subsequently contribute to the upwelling of deeper, nutrient-rich waters closer to the surface (Brewer et al. 2007). Satellite observations suggest that productivity is enhanced along the northern and southern boundaries of the plateau (Brewer et al. 2007). Sediments on the plateau suggest that biological communities include scavengers, benthic filter feeders and epifauna (DSEWPaC 2012b). Fauna in the pelagic waters above the plateau are likely to include small pelagic species and nekton attracted to seasonal upwellings, as well as larger predators such as billfishes, sharks and dolphins (Brewer et al. 2007). Protected and migratory species (including whale sharks and cetaceans) are also known to pass through the region.	~112 km west	Overlap
Glomar Shoal	An area of high productivity and aggregations of marine life including commercial and recreational fish species	Glomar Shoal is a submerged littoral feature ~150 km north of Dampier on the Rowley Shelf at depths of 33–77 m (Falkner et al. 2009b). Studies by Abdul Wahab et al. (2018) found a number of hard coral and sponge species in water depths <40 m. 170 different species of fishes were detected with greatest species richness and abundance in shallow	~65 km East	Overlap

KEF	Values	Description	Approx. distance and direction (km)	
			Project Area	EMBA
		habitats (Abdul Wahab et al. 2018). Fish species present include several commercial and recreational species (e.g. Rankin cod, brownstripe snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish) (Falkner et al. 2009a; Fletcher and Santoro 2009). These species have recorded high catch rates associated with Glomar Shoal, indicating that the shoal is likely to be an area of high productivity.		
Meso-scale eddies	High productivity and aggregations of marine life	Driven by interactions between currents and bathymetry, persistent meso-scale eddies form in predictable locations within the meanders of the Leeuwin Current. They are important transporters of nutrients and plankton communities and are likely to attract a range of organisms from the higher trophic levels, such as marine mammals, seabirds, tuna and billfish. The eddies play a critical role in determining species distribution, as they influence the southerly range boundaries of tropical and subtropical species, the transport of coastal phytoplankton communities offshore and recruitment to fisheries	~765 km south-west	Overlap
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	Regionally important in supporting high species richness, higher productivity and aggregations of marine life	The Mermaid Reef and Commonwealth waters surrounding the Rowley Shoals KEF is adjacent to the 3 nm State waters limit surrounding Clerke and Imperieuse reefs and includes the Mermaid Reef Marine Park (Section 7.8.6). The reefs have a distinctive biophysical environment in the region, with steep and distinct reef slopes and associated fish communities. In evolutionary terms, the reefs may play a role in supplying coral and fish larvae to reefs further south via the southward flowing Indonesian Throughflow. Their coral communities and fish assemblages differ from similar habitats in eastern Australia (Done et al. 1994).	~365 km North-east	Overlap
Perth Canyon and adjacent shelf break, and other west coast canyons	An area of higher productivity that attracts feeding aggregations of deep-diving mammals and large predatory fish. It is also recognised as a unique seafloor feature with ecological properties of regional significance	The Perth Canyon is the largest known undersea canyon in Australian waters. Deep ocean currents rise to the surface, creating a nutrient-rich cold-water habitat attracting feeding aggregations of deep-diving mammals, such as pygmy blue whales and large predatory fish that feed on aggregations of small fish, krill and squid.	~930 km South-west	Overlap
Small pelagic fish of the SWMR	A species group that has a regionally important ecological role	This species group is considered important for ecological functioning and integrity, providing critical links between primary production and higher predators. Collectively, they are an important prey item for a diverse	~680 km south-west (to the SWMR)	Overlap (within SWMR)

KEF	Values	Description	Approx. distance and direction (km)	
			Project Area	EMBA
		range of species, including tuna, whales, dolphins, seals, sea lions and numerous seabirds. This KEF has not been spatially defined.		
Wallaby Saddle	High productivity and aggregations of marine life Represents almost the entire area of this type of geomorphic feature in the NWMR. It is a unique habitat that neither occurs anywhere else nearby (within hundreds of kilometres) nor with as large an area (Falkner et al. 2009b)	The Wallaby Saddle may be an area of enhanced productivity. Historic whaling records show evidence of sperm whale aggregations in the area, possibly due to the enhanced productivity of the area and aggregations of baitfish (DSEWPaC 2012b).	~710 km South-west	Overlap
Western demersal slope and associated fish communities	Provides important habitat for demersal fish communities and supports species groups that are nationally or regionally important to biodiversity	A diverse assemblage of demersal fish species >400 m deep is dominated by relatively small benthic species such as grenadiers, dogfish and cucumber fish. Unlike other slope fish communities in Australia, many of these species display unique physical adaptations to feed on the seafloor (such as a mouth position adapted to bottom feeding), and many do not appear to migrate vertically in their daily feeding habits.	~680 km South-west	Overlap
Western rock lobster	A species that plays a regionally important ecological role	This species is the dominant large benthic invertebrate in the region. It plays an important trophic role in many of the inshore ecosystems of the SWMR. Western rock lobsters are an important part of the food web on the inner shelf, particularly as juveniles.	~880 km South-west	Overlap

7.8 Protected Places

Protected places include World Heritage Properties, National Heritage Places, Commonwealth Heritage Properties, Wetlands of International Importance, Australian Marine Parks, State Marine Parks and Reserves, and the Australian Whale Sanctuary. Table 7-19 summarises the protected places identified within the Project Area, and EMBA. Further details are provided in the following subsections.

Table 7-19: Established protected places that overlap with the Project Area or EMBA

Place	Park zone and IUCN category[1]	Approx. distance and direction	
		Project Area	EMBA
AMPs			
Abrolhos Marine Park	Habitat Protection Zone IV	~700 km south-west	Overlap
	Multiple Use Zone VI	~860 km south-west	Overlap
	National Park Zone II	~925 km south	Overlap
	Special Purpose Zone VI	~850 km south	Overlap
Argo–Rowley Terrace Marine Park	Multiple Use Zone VI	~367 km north-east	Overlap
	Special Purpose Zone (Trawl) VI	~381 km north-east	Overlap
	National Park Zone II	~513 km north-east	Overlap
Carnarvon Canyon Marine Park	Habitat Protection Zone IV	~550 km south-west	Overlap
Dampier Marine Park	Habitat Protection Zone IV	~112 km east	Overlap
	National Park Zone II	~130 km south-east	Overlap
	Multiple Use Zone VI	~135 km south-east	Overlap
Eighty Mile Beach	Multiple Use Zone VI	~315 km east	Overlap
Gascoyne Marine Park	Multiple Use Zone VI	~187 km south-west	Overlap
	Habitat Protection Zone IV	~330 km south-west	Overlap
	National Park Zone II	~400 km south-west	Overlap
Kimberley Marine Park	Multiple Use Zone VI	~610 km north-east	Overlap
Mermaid Reef National Park	National Park Zone II	~465 km north-east	Overlap
Montebello Marine Park	Multiple Use Zone VI	Overlap	Overlap
Ningaloo Marine Park	Recreational Use Zone IV	~215 km south-west	Overlap
	National Park Zone II	~345 km south-west	Overlap
Shark Bay Marine Park	Multiple Use Zone VI	~525 km south-west	Overlap
State Marine Protected Areas			
Marine Parks			
Barrow Island Marine Park	Western Barrow Island Sanctuary Zone (IUCN Ia)	~72 km south	Overlap
Montebello Island Marine Park	Southern Montebellos Sanctuary Zone (IUCN Ia)	~25 km south	Overlap
	Montebellos General Use Zone (IUCN II)	~23 km south	Overlap
	Northern Montebellos Sanctuary Zone (IUCN Ia)	~25 km south	Overlap
	Northern Montebellos Special Purpose Zone (Benthic Protection) (IUCN IV)	~25 km south	Overlap

Place	Park zone and IUCN category[1]	Approx. distance and direction	
		Project Area	EMBA
	Site J Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site A Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site B Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site C Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site D Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site G Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site H Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site I Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site O Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Site P Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
	Willy Nilly Lagoon Sanctuary Zone (IUCN Ia)	~25 km south	Overlap
	Stephenson Channel Recreation Zone (IUCN II)	~23 km south	Overlap
	Southern Montebellos Recreation Zone (IUCN II)	~23 km south	Overlap
	Claret Bay Special Purpose Zone (Pearling) (IUCN VI)	~30 km south	Overlap
Eighty Mile Beach Marine Park	Kurtamparanya Sanctuary Zone (IUCN VI)	~370 km east	Overlap
	Eighty Mile Beach General Use Zone (IUCN VI)	~370 km east	Overlap
	Wallal Recreation Zone (IUCN VI)	~490 km east	Overlap
	Banningarra Creek Special Purpose Zone (Shore-based Activities) (IUCN VI)	~370 km east	Overlap
	Pananykarra Special Purpose Zone (Shore-based Activities) (IUCN VI)	~385 km east	Overlap
	Pananykarra Sanctuary Zone (IUCN VI)	~385 km east	Overlap
	Malamalajungunya Special Purpose Zone (Mangrove Protection) (IUCN VI)	~370 km east	Overlap
	Paruwuturr Special Purpose Zone (Cultural Heritage) (IUCN VI)	~370 km east	Overlap
Ningaloo Marine Park	General Use (IUCN II)	~216 km south-west	Overlap
	Lighthouse Bay Sanctuary (IUCN Ia)	~227 km south-west	Overlap
	Lighthouse Bay Special Purpose Zone (Shore Based Activities) (IUCN II)	~230 km south-west	Overlap
	Recreation Area (IUCN II)	~216 km south-west	Overlap
	Jurabi Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Lighthouse Bay Special Purpose Zone (Shire Based activities) (IUCN II)	~216 km south-west	Overlap
	Murat Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Bundegi Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Jurabi Special Purpose Zone (Shore Based Activities) (IUCN II)	~216 km south-west	Overlap
	Tantabiddi Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap

Place	Park zone and IUCN category[1]	Approx. distance and direction	
		Project Area	EMBA
	Murat (North) Special Purpose Zone (Shore Based Activities) (IUCN II)	~216 km south-west	Overlap
	Murat (South) special Purpose Zone (Shore Based Activities) ((IUCN II)	~216 km south-west	Overlap
	Mangrove Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Lakeside Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Mandu Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Mandu Special Purpose Zone (Benthic Protection) (IUCN IV)	~272 km south-west	Overlap
	Osprey Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Osprey (north) Special Purpose Zone (Shore Based Activities) (IUCN II)	~285 km south-west	Overlap
	Winderabandi Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Cloates Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Cloates Special Purpose Zone (Shore Based Activities) (IUCN II)	~335 km south-west	Overlap
	Unassigned (IUCN IV)	~272 km south-west	Overlap
	Winderabandi Special Purpose Zone (Shore Based Activities) (IUCN II)	~216 km south-west	Overlap
	Unassigned (IUCN II)	~216 km south-west	Overlap
	Bateman Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Maud Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Maud Special Purpose Zone (Shore Based Activities) (IUCN II)	~380 km south-west	Overlap
	Pelican Sanctuary Zone (IUCN Ia)	~227 km south-west	Overlap
	Pelican (south) Special Purpose Zone (Shore Based Activities) (IUCN II)	~405 km south-west	Overlap
	Pelican (north) Special Purpose Zone (Shore Based Activities) (IUCN II)	~395 km south-west	Overlap
	Cape Farquhar Sanctuary Zone (IUCN Ia)	~425 km south-west	Overlap
	Gnaraloo Bay Sanctuary Zone (IUCN Ia)	~455 km south-west	Overlap
	3 Mile Sanctuary Zone (IUCN Ia)	~460 km south-west	Overlap
	Turtles Sanctuary Zone (IUCN Ia)	~475 km south-west	Overlap
Rowley Shoals Marine Park	General Use (IUCN II)	~375 km north-east	Overlap
	Imperieuse Recreation Zone (IUCN II)	~375 km north-east	Overlap
	Clerk Outer Reef Recreation Zone (IUCN II)	~375 km north-east	Overlap
	Imperieuse Sanctuary Zone (IUCN Ia)	~381 km north-east	Overlap
	Clerk Sanctuary Zone (IUCN Ia)	~381 km north-east	Overlap
	Clerk Lagoon Recreation Zone (IUCN II)	~375 km north-east	Overlap
	General Use (IUCN II)	~375 km north-east	Overlap
	Unassigned (IUCN IV)	~393 km north-east	Overlap

Place	Park zone and IUCN category[1]	Approx. distance and direction	
		Project Area	EMBA
Shark Bay Marine Park	General Use (IUCN II)	~620 km south-west	On Border
Marine Management Areas			
Barrow Island	IUCN VI MMA	~40 km south	Overlap
Muiron Island	IUCN VI MMA	~198 km south-west	Overlap
	South Muiron Conservation Area (IUCN Ia) MMA	~198 km south-west	Overlap
	North Muiron Conservation Area (IUCN Ia) MMA	~198 km south-west	Overlap
	Conservation Area (IUCN Ia) MMA	~198 km south-west	Overlap
Other sensitive areas			
Abrolhos Islands Fish Habitat Protection Area	Unassigned (IUCN IV)	~920 km south	Overlap
Terrestrial National Parks			
Cape Range National Park	National Park (IUCN II)	~257 km south-west	Overlap
Dirk Hartog Island National Park	National Park (IUCN II)	~650 km south-west	Overlap
Houtman Abrolhos Islands National Park	National Park (IUCN II)	~927 km south-west	Overlap
Murujuga National Park	National Park (IUCN II)	~120 km south-east	Overlap
Indigenous Protected Areas (IPAs)[2]			
Nyangumarta Warrarn IPA	Unassigned (IUCN VI)	~435 km east	Overlap

1. Conservation objectives for IUCN categories include:

Ia: Strict Nature Reserve

Ib: Wilderness Area

II: National Park

III: Natural Monument or Feature

IV: Habitat/Species Management Area

V: Protected Landscape/Seascape

VI: Protected area with sustainable use of natural resources – allow human use but prohibits large-scale development.

IUCN categories for the Marine Park are provided and, in brackets, the IUCN categories for specific zones within each Marine Park as assigned under the North-west Marine Parks Network Management Plan 2018 (DNP 2018a) and South-west Marine Parks Network Management Plan 2018 (DNP 2018b).

2. Refer to Section 7.9.5 for a description of this IPA.

7.8.1 World Heritage Properties

World Heritage Properties are those sites that hold universal value that transcends any value they may be held by any one nation. These sites and their qualities are detailed in the Convention concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention)—Australia is a founding member.

The list of Australia's World Heritage Properties (DCCEEW 2021c) and World Heritage Areas: Australia spatial dataset (DCCEEW 2022a) show that there are no World Heritage Properties within the Project Area. Table 7-20 summarises the values of the identified World Heritage Properties within the EMBA.

The Murujuga Cultural Landscape was also added to Australia's World Heritage Tentative List in 2020, and the World Heritage nomination dossier was submitted for consideration in 2023. The boundaries of the Cultural Landscape, Outstanding Universal Values are yet to be finalised.

Table 7-20: World Heritage Properties within the EMBA

World Heritage Property	Description	Values	Approx. distance and direction (km)	
			Project Area	EMBA
The Ningaloo Coast	The Ningaloo Coast World Heritage Property lies within the Ningaloo AMP and was included on the World Heritage List in 2011.	Universal values of the Ningaloo Coast World Heritage Property include high marine species diversity and abundance; in particular, Ningaloo Reef supports both tropical and temperate marine reptiles and mammals. Inscribed under Natural Criteria vii and x.	~200 km south-west	Overlap
Shark Bay, Western Australia	The Shark Bay World Heritage Property is adjacent to the Shark Bay AMP and was included on the World Heritage List in 1991.	Universal values of the Shark Bay World Heritage Property include large and diverse seagrass beds, stromatolites and populations of dugong and threatened species. Inscribed under Natural Criteria vii, viii, ix and x.	~560 km south-west	Overlap

7.8.2 National Heritage Places

The National Heritage List is Australia's list of natural, historic, and Indigenous places of outstanding significance to the nation. The National Heritage List Spatial Database (DCCEEW 2023j) describes the place name, class (Indigenous, natural, historic), and status.

A search of the National Heritage List Spatial Database (DCCEEW 2023j) shows that there are no National Heritage Places within the Project Area. Table 7-21 summarises the values of the identified National Heritage Places within the EMBA.

Table 7-21: National Heritage Places within the EMBA

National Heritage Places	Description	Values	Approx. distance and direction	
			Project Area	EMBA
Natural				
The Ningaloo Coast	The Ningaloo Coast National Heritage Place comprises the same area included in the Ningaloo Coast World Heritage Property (refer Section 7.8.1) and was established on the National Heritage List in 2010.	The Ningaloo Coast contains one of the best developed nearshore reefs in the world, and is home to rugged limestone peninsulas, spectacular coral and sponge gardens and whale sharks. The Ningaloo Coast meets the national heritage listing criteria a, b, c, d, and f.	~200 km south-west	Overlap
Shark Bay, Western Australia	The Shark Bay National Heritage Place comprises the same area included in the Shark Bay World Heritage Property (refer Section 7.8.1) and was established on the National Heritage List in 2007.	The national heritage place has a number of exceptional natural features, including one of the largest and most diverse seagrass beds in the world, colonies of stromatolites and rich marine life including a large population of dugongs. It also provides a refuge for several globally threatened species. Shark Bay meets the national heritage listing criteria a, b, c, d, e, f, g, h and i.	~560 km south-west	Overlap

National Heritage Places	Description	Values	Approx. distance and direction	
			Project Area	EMBA
Indigenous				
Dampier Archipelago (including Burrup Peninsula)	The Dampier Archipelago (including the Burrup Peninsula) contains one of the densest concentrations of rock engravings in Australia with some sites containing thousands or tens of thousands of images.	The rock engravings comprise images of avian, marine and terrestrial fauna, schematised human figures, figures with mixed human and animal characteristics and geometric designs. At a national level it has an exceptionally diverse and dynamic range of schematised human figures some of which are arranged in complex scenes. The fine execution and dynamic nature of the engravings, particularly some of the composite panels, exhibit a degree of creativity that is unusual in Australian rock engravings.	~650 km south-west	Overlap
Historic				
Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos	The *Batavia* and its associated sites hold an important place in the discovery and delineation of the WA coastline. The wreck of the Batavia, and other Dutch ships like her, convinced the VOC (Dutch East India Company) of the necessity of more accurate charts of the coastline and resulted in the commissioning of Vlamingh's 1696 voyage.	Because of its relatively undisturbed nature the archaeological investigation of the wreck itself has revealed a range of objects of considerable value as well as to artefact specialists and historians.	~945 km south-west	Overlap
Dirk Hartog Landing Site 1616 – Cape Inscription Area	The naval battle fought between the Australian warship HMAS Sydney II and the German commerce raider HSK Kormoran off the WA coast during World War II was a defining event in Australia's cultural history. HMAS Sydney II was Australia's most famous warship of the time and this battle has forever linked the stories of these warships to each other. The loss of HMAS Sydney II along with its entire crew of 645 following the battle with HSK Kormoran, remains as Australia's worst naval disaster.	The shipwreck sites of HMAS Sydney II and HSK Kormoran have outstanding heritage value to the nation because of their importance in a defining event in Australia's cultural history and for their part in development of the process of the defence of Australia.	~650 km south-west	Overlap
HMAS *Sydney* II and HSK *Kormoran* Shipwreck Sites	The battle between the Australian warship HMAS *Sydney* II and the German commerce raider HSK *Kormoran* off the WA coast during World War II was a defining event in Australia's cultural history. HMAS *Sydney*	The shipwreck sites of HMAS *Sydney* II and HSK *Kormoran* have outstanding heritage value to the nation because of their importance in a defining event in Australia's cultural history and for their part in development of the process of the defence of Australia.	~800 km south-west	Overlap

National Heritage Places	Description	Values	Approx. distance and direction	
			Project Area	EMBA
	II was Australia's most famous warship of the time and this battle has forever linked the stories of these warships. The loss of HMAS *Sydney* II (and its entire crew of 645) following the battle with HSK *Kormoran (which also sank after battle and more than 80 German sailors died)*, remains Australia's worst naval disaster.			

7.8.3 Commonwealth Heritage Places

Commonwealth Heritage Places are a collection of sites owned or controlled by the Australian Government, which are recognised for their Indigenous, historical and/or natural values. Some of these sites are owned or controlled by the Department of Defence or by government agencies relating to maritime safety, customs, and communication.

A search of the Commonwealth Heritage List (DCCEEW 2021b) and the Commonwealth Heritage List Spatial Database (CoA 2022a) shows that there are no Commonwealth Heritage Places within the Project Area. Table 7-22 summarises the values of the identified Commonwealth Heritage Places within the EMBA.

Table 7-22: Commonwealth Heritage Places within the EMBA

Commonwealth Heritage Places	Description	Values	Approx. distance and direction	
			Project Area	EMBA
Natural				
Learmonth Air Weapons Range Facility	Learmonth Air Weapons Range Facility Commonwealth Heritage Place is located within Cape Range and Adjacent Coastal Plain. The site was listed as a Commonwealth Heritage Place in 2004.	The Learmonth Air Weapons Range Facility is regionally important for the diversity of its subterranean fauna. Cape Range peninsula, of which the Learmonth Air Weapons Range Facility is a part, contains a rich and diverse troglobitic subterranean fauna community. The caves and subterranean waterways (and the associated hydrological system) of the Cape Range and surrounding coastal plain are of critical importance in maintaining the rich and unique troglobitic fauna of the peninsula. The geomorphology of Cape Range is of considerable importance in documenting sea level and landform changes since the late Cenozoic.	~307 km south-west	Overlap[1]

Commonwealth Heritage Places	Description	Values	Approx. distance and direction	
			Project Area	EMBA
Mermaid Reef – Rowley Shoals	The Mermaid Reef – Rowley Shoals Commonwealth Heritage Place is located within the boundary of the Mermaid Reef Marine National Nature Reserve. The site was listed as a Commonwealth Heritage Place in 2004.	The Mermaid Reef – Rowley Shoals Commonwealth Heritage Place is regionally important for the diversity of its fauna and, together with Clerke and Imperieuse reefs, has biogeographical significance due to the presence of species which are at, or close to, the limits of their geographic ranges, including fishes known previously only from Indonesian waters. Rowley Shoals is important for benchmark studies as one of the few places off WA's north-west coast that has been the site of major biological collection trips by the WA Museum.	~470 km north-east	Overlap
Ningaloo Marine Area	The Ningaloo Marine Area Commonwealth Heritage Place is located within the Commonwealth waters of the Ningaloo Marine Park (refer to Section 7.8.6). The site was listed as a Commonwealth Heritage Place in 2004.	The Ningaloo Marine Area Commonwealth Heritage Place provides a migratory pathway for humpback whales and foraging habitat for whale sharks, and is an important breeding area for billfish and manta ray. The Ningaloo Marine Area provides opportunities for scientific research relating to aspects of the area's unique features including tourism (marine ecology, whales, turtles, whale sharks, fish and oceanography).	~215 km south-west	Overlap
Indigenous				
None identified within the Project Area or EMBA.				
Historic				
HMAS *Sydney* II and HSK *Kormoran* Shipwreck Sites	As per Table 7-21.	As per Table 7-21.	~800 km south-west	Overlap

1. Identified as overlapping the EMBA based on GIS analysis, but is located inland and thus is not expected to be exposed to activities associated with the Goodwyn Area Infill Development.

7.8.4 Wetlands of International Importance

Australia has 67 Ramsar wetlands that cover >8.3 million ha. Ramsar wetlands are those that are representative, rare, or unique wetlands, or that are important for conserving biological diversity.

The List of Wetlands of International Importance held under the Ramsar Convention and the Ramsar Wetlands of Australia spatial dataset (DCCEEW 2023l) shows there are no Ramsar wetlands within the Project Area. Table 7-23 summarises the values of the one Ramsar wetland identified within the EMBA.

Table 7-23: Wetlands of International Importance (Ramsar) within the EMBA

Wetlands of International Importance (Ramsar)	Description	Values	Approx. distance and direction (km)	
			Project Area	EMBA
Eighty-mile Beach	The Eighty Mile Beach Ramsar site covers an area of 1250 km^2, located along a long section of the Western Australian coastline adjacent to the Eighty Mile Beach AMP.	The Eighty Mile Beach Ramsar site includes saltmarsh and a raised peat bog more than 7000 years old. The site contains the most important wetland for waders in north-western Australia, supporting up to 336,000 birds, and is especially important as a land fall for waders migrating south for the austral summer.	~400 km east	Overlap

7.8.5 Australian Whale Sanctuary

The Australian Whale Sanctuary was established to protect all whales and dolphins found in Australian waters. Under the EPBC Act all cetaceans (whales, dolphins, and porpoises) are protected in Australian waters.

The Australian Whale Sanctuary includes all Commonwealth waters from the 3 nm Coastal Waters limit out to the boundary of the EEZ (i.e. out to 200 nm and further in some places). Within the Sanctuary it is an offence to kill, injure, or interfere with a cetacean.

7.8.6 Australian Marine Parks

Australian Marine Parks (AMPs), formally known as Commonwealth Marine Reserves, are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of National Parks (DNP) is responsible for managing AMPs (supported by Parks Australia) and is required to publish management plans for them. Under section 362 of the EPBC Act, other parts of the Australian Government must not perform functions or exercise powers in relation to these parks that are inconsistent with management plans.

The southern extent of the Project Area partially overlaps with one AMP—the Montebello Marine Park. An additional ten AMPs overlap with the EMBA. The values of the identified AMPs within the Project Area or EMBA are described in Table 7-24 and shown in Figure 7-39.

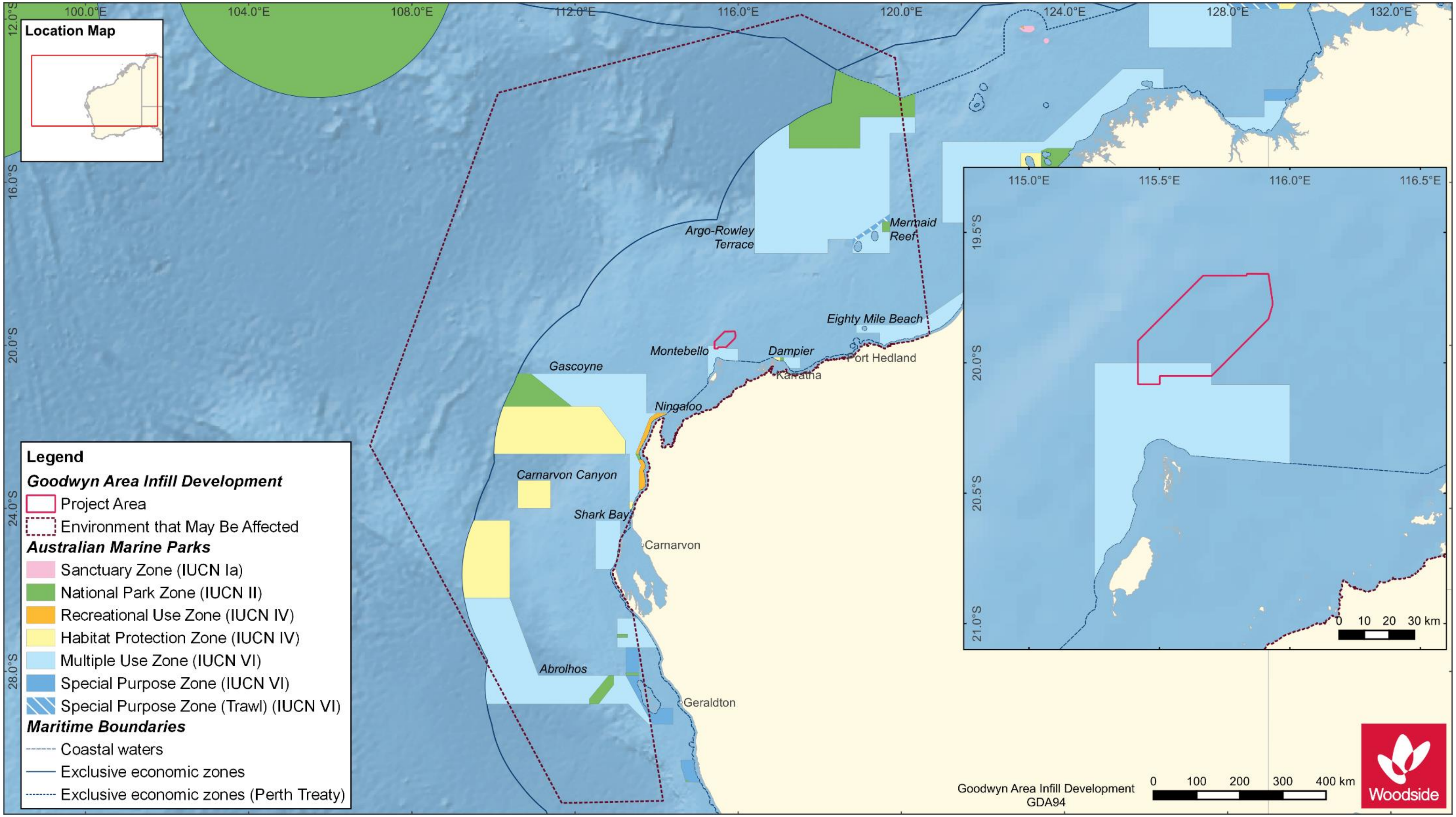


Figure 7-39: Australian Marine Parks

Table 7-24: Summary of the Commonwealth AMPs within the Project Area or EMBA

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
Montebello	Multiple Use Zone (VI)	***Description*** The Montebello Marine Park is offshore from Barrow Island and 80 km west of Dampier, WA, extending from the WA state water boundary, and is adjacent to the Barrow Island and Montebello Islands Marine Parks. The Marine Park covers an area of 3413 km² and water depths range from <15 m to 150 m.	Overlap	Overlap
		Natural values The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells and internal tides. The bioregion includes diverse benthic and pelagic fish communities. A key ecological feature of the Marine Park is the ancient coastline at the 125 m depth contour. The Marine Park supports a range of species listed under the EPBC Act. BIAs within the Marine Park include breeding habitat for seabirds, internesting, foraging, mating, and nesting habitat for marine turtles, a migratory pathway for humpback whales and foraging habitat for whale sharks.		
		Cultural values Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. As noted in the North-west Marine Park Management Plan (DNP 2018a), there is limited information about the cultural significance of this Marine Park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Pilbara region.		
		Heritage values No international, Commonwealth or national listings apply to the Marine Park; however it is adjacent to the WA Barrow Island and the Montebello–Barrow Island Marine Conservation Reserves, which have been nominated for national heritage listing. The Marine Park contains two known shipwrecks listed under the UCH Act: *Trial* (wrecked in 1622 and the earliest known shipwreck in Australian waters) and *Tanami* (unknown date).		
		Social and economic values Tourism, commercial fishing, mining and recreation are important activities in the Marine Park.		
Dampier	Habitat Protection Zone (IV)	***Description*** The Dampier Marine Park is ~10 km north-east of Cape Lambert and 40 km from Dampier, WA, extending from the WA state water boundary. The Marine Park covers an area of 1252 km² and water depths range from <15 m to 70 m.	~112 km east	Overlap

<table>
<tr><th rowspan="2">AMP</th><th rowspan="2">IUCN Zones</th><th rowspan="2">Description and Values[1]</th><th colspan="2">Approx. distance and direction</th></tr>
<tr><th>Project Area</th><th>EMBA</th></tr>
<tr><td rowspan="5"></td><td rowspan="5">National Park (Zone II)
Multiple Use (Zone VI)</td><td>The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Dampier Marine Park on 9 October 2017.</td><td rowspan="5"></td><td rowspan="5"></td></tr>
<tr><td>Natural values
The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales.
The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include breeding and foraging habitat for seabirds, internesting habitat for marine turtles and a migratory pathway for humpback whales.</td></tr>
<tr><td>Cultural values
Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. The Ngarluma, Yindjibarndi, Yaburara, and Mardudhunera people have responsibilities for Sea Country in the Marine Park.
The native title holders for these people are represented by the Ngarluma Aboriginal Corporation and Yindjibarndi Aboriginal Corporation. These Prescribed Body Corporates (PBCs) represent Traditional Owners with native title over coastal areas adjacent to the Marine Park are the points of contact for their respective areas of responsibility for Sea Country in the Marine Park.
The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Pilbara and Yamatji regions.</td></tr>
<tr><td>Heritage values
No international, Commonwealth or national listings applied to the Marine Park at the commencement of this Plan; however, the Marine Park is ~10 km north of the Dampier Archipelago (including Burrup Peninsula) national heritage listing, which has significant Indigenous heritage values including rock art sites.</td></tr>
<tr><td>Social and economic values
Port activities, commercial fishing and recreation, including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.</td></tr>
<tr><td>Mermaid Reef</td><td>National Park Zone (II)</td><td>Description
The Mermaid Reef Marine Park is ~280 km north-west of Broome, WA, adjacent to the Argo–Rowley Terrace Marine Park and ~13 km from the WA Rowley Shoals Marine Park. The Marine Park covers an area of 540 km² and water depths range from <15 m to 500 m.</td><td>~465 km north-east</td><td>Overlap</td></tr>
</table>

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
		The Marine Park was originally proclaimed under the Commonwealth *National Parks and Wildlife Conservation Act 1975* on 10 April 1991 as the Mermaid Reef Marine National Nature Reserve, and proclaimed under the EPBC Act on 14 December 2013 and renamed Mermaid Reef Marine Park on 9 October 2017.		
		Natural values The Marine Park includes examples of ecosystems representative of the Northwest Transition—an area of shelf break, continental slope, and the majority of the Argo Abyssal Plain. Together with Clerke and Imperieuse reefs, Mermaid Reef is a biodiversity hotspot and key topographic feature of the Argo Abyssal Plain. A key ecological feature of the Marine Park is the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals—an area of enhanced productivity and high species richness thought to be facilitated by internal wave action generated by internal tides in the lagoon. Ecosystems of the Marine Park are associated with emergent reef flat, deep reef flat, lagoon, and submerged sand habitats. The Marine Park supports a range of species, including species listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include breeding habitat for seabirds and a migratory pathway for the pygmy blue whale.		
		Cultural values Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years.		
		Heritage values No international or national listings applied to the Marine Park at the commencement of this Plan.		
		Commonwealth heritage Mermaid Reef–Rowley Shoals was established on the Commonwealth Heritage List in 2004, meeting Commonwealth heritage listing criteria A, B, C and D. The Marine Park contains one known shipwreck listed under the UCH Act: *Lively* (wrecked in 1810).		
		Social and economic values Tourism, recreation, and scientific research are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.		
Argo–Rowley Terrace	Multiple Use Zone (VI) National Park Zone (II)	***Description*** The Argo–Rowley Terrace Marine Park is ~270 km north-west of Broome, WA, and extends to the limit of Australia's EEZ. The Marine Park is adjacent to the Mermaid Reef Marine Park and the WA Rowley Shoals Marine Park. The Marine Park covers an area of 146,003 km^2, with water depths ranging between 220 m and 6000 m.	~367 km north-east ~513 km north-east	Overlap

<table>
<tr><th rowspan="2">AMP</th><th rowspan="2">IUCN Zones</th><th rowspan="2">Description and Values[1]</th><th colspan="2">Approx. distance and direction</th></tr>
<tr><th>Project Area</th><th>EMBA</th></tr>
<tr><td rowspan="5"></td><td rowspan="5">Special Purpose Zone (Trawl) (VI)</td><td>The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Argo–Rowley Terrace Marine Park on 9 October 2017.</td><td rowspan="5">~381 km north-east</td><td rowspan="5"></td></tr>
<tr><td>Natural values
The Marine Park includes examples of ecosystems representative of:
• Northwest Transition—an area of shelf break, continental slope, and most of the Argo Abyssal Plain. Key topographic features include Mermaid, Clerke and Imperieuse reefs which collectively are a biodiversity hotspot
• Timor Province—an area dominated by warm, nutrient-poor waters. Canyons are an important feature in this area of the Marine Park and are generally associated with high productivity and aggregations of marine life.
Key ecological features of the Marine Park are:
• Canyons linking the Argo Abyssal Plain with the Scott Plateau—an area likely to result in upwelling of nutrient-rich water and aggregations of marine life
• Mermaid Reef and Commonwealth waters surrounding Rowley Shoals—an area of enhanced productivity and high species richness, thought to be facilitated by internal wave action generated by internal tides.
The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act.
BIAs within the Marine Park include resting and breeding habitat for seabirds and a migratory pathway for the pygmy blue whale.</td></tr>
<tr><td>Cultural values
Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. At the commencement of this plan (DNP 2018a) there is limited information about the cultural significance of this Marine Park.</td></tr>
<tr><td>Heritage values
No international, Commonwealth or national listings applied to the Marine Park at the commencement of this Plan.
The Marine Park contains two known shipwrecks listed under the UCH Act: Alfred and Pelsart (both wrecked in 1908).</td></tr>
<tr><td>Social and economic values
Commercial fishing and mining are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.</td></tr>
</table>

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
Ningaloo	Recreational Use Zone (IV) National Park Zone (II)	***Description*** The Ningaloo Marine Park stretches ~300 km along the west coast of the Cape Range Peninsula, WA, and is adjacent to the WA Ningaloo Marine Park and Gascoyne Marine Park. The Marine Park covers an area of 2435 km² and water depths range from 30 m to >500 m. The Marine Park was originally proclaimed under the Commonwealth *National Parks and Wildlife Conservation Act 1975* on 20 May 1987 as the Ningaloo Marine Park (Commonwealth Waters), and proclaimed under the EPBC Act on 14 December 2013; it was renamed Ningaloo Marine Park on 9 October 2017.	~215 km south-west ~345 km south west	Overlap
		Natural values The Marine Park includes examples of ecosystems representative of: • Central Western Shelf Transition—continental shelf of water depths up to 100 m, and a significant transition zone between tropical and temperate species • Central Western Transition—characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species • Northwest Province—an area of continental slope comprising diverse and endemic fish communities • Northwest Shelf Province—a dynamic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides. This bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales. Key ecological features of the Marine Park are: • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula—an area resulting in upwelling of nutrient-rich water and aggregations of marine life • Commonwealth waters adjacent to Ningaloo Reef—an area where the Leeuwin and Ningaloo currents interact, resulting in enhanced productivity and aggregations of marine life • Continental slope demersal fish communities—an area of high diversity among demersal fish assemblages on the continental slope. Ecosystems represented in the Marine Park are influenced by interaction of the Leeuwin Current, Leeuwin Undercurrent and the Ningaloo Current. The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include, breeding and or foraging habitat for seabirds, internesting habitat for marine turtles, a migratory pathway for humpback whales, foraging habitat and migratory pathway for pygmy blue whales, breeding, calving, foraging and nursing habitat for dugong, foraging habitat for whale sharks.		

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
		Cultural values Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. The Gnulli people have responsibilities for Sea Country in the Marine Park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.		
		Heritage values The Marine Park is within the Ningaloo Coast World Heritage Property, which is recognised for its outstanding universal heritage values and for meeting world heritage listing criteria vii and x. In addition to the Marine Park, the world heritage area includes the WA Ningaloo Marine Park, the Muiron Islands, the WA Cape Range National Park and other terrestrial areas. The area is valued for high terrestrial species endemism, marine species diversity and abundance, and the interconnectedness of large-scale marine, coastal and terrestrial environments. The area connects the limestone karst system and fossil reefs of the ancient Cape Range to the nearshore reef system of Ningaloo Reef, to the continental slope and shelf in Commonwealth waters. The Ningaloo Coast overlaps the Marine Park and was established on the National Heritage List in 2010, meeting the national heritage listing criteria A, B, C, D, and F. The Ningaloo Marine Area (Commonwealth waters) was established on the Commonwealth Heritage List in 2004, meeting Commonwealth heritage listing criteria A, B and C. The Ningaloo Marine Area overlaps the Marine Park. The Marine Park contains more than 15 known shipwrecks listed under the UCH Act.		
		Social and economic values Tourism and recreation, including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.		
Carnarvon Canyon	Habitat Protection Zone (IV)	***Description*** The Carnarvon Canyon Marine Park is ~300 km north-west of Carnarvon, WA. It covers an area of 6177 km² and water depths range from 1500 m to 6000 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Carnarvon Canyon Marine Park on 9 October 2017.	~550 km South-west	Overlap
		Natural values The Marine Park includes examples of ecosystems representative of the Central Western Transition—a bioregion characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species. It includes the Carnarvon Canyon, a single-channel canyon covering the entire depth range of the Marine Park. Ecosystems of the Marine Park are influenced by tropical and temperate currents, deepwater environments and		

<table>
<tr><th rowspan="2">AMP</th><th rowspan="2">IUCN Zones</th><th rowspan="2">Description and Values[1]</th><th colspan="2">Approx. distance and direction</th></tr>
<tr><th>Project Area</th><th>EMBA</th></tr>
<tr><td></td><td></td><td>proximity to the continental slope and shelf. The soft-bottom environment at the base of the Carnarvon Canyon is likely to support species that are typical of the deep seafloor (e.g. holothurians, polychaetes and sea pens).
The Marine Park supports a range of species, including those listed as threatened, migratory, marine or cetacean under the EPBC Act. There is limited information about species' use of this Marine Park.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Cultural values
Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Heritage values
No international, Commonwealth or national heritage listings applied to the Marine Park at the commencement of this plan.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Social and economic values
Commercial fishing is an important activity in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.</td><td></td><td></td></tr>
<tr><td>Gascoyne</td><td>National Park Zone (II)
Multiple Use Zone (VI)
Habitat Protection Zone (IV)</td><td>Description
The Gascoyne Marine Park is ~20 km off the west coast of the Cape Range Peninsula, WA, adjacent to the Ningaloo Reef Marine Park and the WA Ningaloo Marine Park, and extends to the limit of Australia's EEZ. The Marine Park covers an area of 81,766 km² and water depths range between 15 m and 6000 m.
The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Gascoyne Marine Park on 9 October 2017.</td><td>~400 km south-west
~187 km south-west
~330 km south-west</td><td>Overlap</td></tr>
<tr><td></td><td></td><td>Natural values
The Marine Park includes examples of ecosystems representative of:
• Central Western Shelf Transition—continental shelf with water depths up to 100 m, and a significant transition zone between tropical and temperate species
• Central Western Transition—characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species
• Northwest Province—an area of continental slope comprising diverse and endemic fish communities.
Key ecological features of the Marine Park are:
• Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula—an area resulting in upwelling of nutrient-rich water and aggregations of marine life</td><td></td><td></td></tr>
</table>

<table>
<tr><th rowspan="2">AMP</th><th rowspan="2">IUCN Zones</th><th rowspan="2">Description and Values[1]</th><th colspan="2">Approx. distance and direction</th></tr>
<tr><th>Project Area</th><th>EMBA</th></tr>
<tr><td></td><td></td><td>• Commonwealth waters adjacent to Ningaloo Reef—an area where the Leeuwin and Ningaloo currents interact resulting in enhanced productivity and aggregations of marine life
• Continental slope demersal fish communities—an area of high diversity of demersal fish assemblages on the continental slope
• Exmouth Plateau—a regionally and nationally unique deep-sea plateau in tropical waters.
• Ecosystems represented in the Marine Park are influenced by the interaction of the Leeuwin Current, Leeuwin Undercurrent and the Ningaloo Current.
The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act.
BIAs within the Marine Park include breeding habitat for seabirds, internesting habitat for marine turtles, a migratory pathway for humpback whales, and foraging habitat and migratory pathway for pygmy blue whales.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Cultural values
Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. The Gnulli people have responsibilities for Sea Country in the Marine Park.
The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Heritage values
The Ningaloo Coast was listed as an area of outstanding universal value under the World Heritage Convention in 2011, meeting world heritage listing criteria vii and x. The Ningaloo Coast World Heritage Property is adjacent to the Marine Park.
The Ningaloo Marine Area (Commonwealth waters) was established on the Commonwealth Heritage List in 2004, meeting the Commonwealth heritage listing criteria A, B and C. The Ningaloo Marine Area is adjacent to the Marine Park.
The Ningaloo Coast was established on the National Heritage List in 2010, meeting the national heritage listing criteria A, B, C, D, and F and is adjacent to the Marine Park.
The Marine Park contains more than five known shipwrecks listed under the UCH Act.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Social and economic values
Commercial fishing, mining and recreation are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.</td><td></td><td></td></tr>
</table>

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
Shark Bay	Multiple Use Zone (VI)	***Description*** The Shark Bay Marine Park is ~60 km offshore from Carnarvon, WA, adjacent to the Shark Bay world heritage property and national heritage place. The Marine Park covers an area of 7443 km², extending from the WA state water boundary, and water depths range between 15 m and 220 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Shark Bay Marine Park on 9 October 2017.	~525 km South-west	Overlap
		Natural values The Marine Park includes examples of ecosystems representative of: • Central Western Shelf—a predominantly flat, sandy and low-nutrient area, in water depths 50–100 m. The bioregion is a transitional zone between tropical and temperate species • Central Western Transition—characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species. Ecosystems represented in the Marine Park are influenced by the Leeuwin, Ningaloo and Capes currents. The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include breeding habitat for seabirds, internesting habitat for marine turtles, and a migratory pathway for humpback whales. The Marine Park and adjacent coastal areas are also important for shallow-water snapper.		
		Cultural values Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. The Gnulli and Malgana people have responsibilities for Sea Country in the Marine Park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.		
		Heritage values No international, Commonwealth or national heritage listings applied to the Marine Park at the commencement of this plan, but the Marine Park is adjacent to the Shark Bay, WA World Heritage Property and Shark Bay, WA National Heritage Place. The Marine Park contains ~20 known shipwrecks listed under the UCH Act.		

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
		Social and economic values Tourism, commercial fishing, mining and recreation, including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.		
Abrolhos	Habitat Protection Zone (IV) Multiple Use (Zone VI) National Park (Zone II) Special Purpose (Zone VI)	***Description*** The Abrolhos Marine Park is adjacent to the Houtman Abrolhos Islands, WA, covering a large offshore area extending from the WA state water boundary to the edge of Australia's EEZ. The Marine Park is ~27 km south-west of Geraldton, WA, and extends north to ~330 km west of Carnarvon. The northernmost part of the shelf component of the Marine Park, north of Kalbarri, is adjacent to the Shark Bay World Heritage Area. The Marine Park covers an area of 88,060 km² and water depths range from <15 m to 6000 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Abrolhos Marine Park on 9 October 2017.	~700 km south-west	Overlap
		Natural values The Marine Park includes examples of ecosystems representative of: • Central Western Province—characterised by a narrow continental slope incised by many submarine canyons and the most extensive area of continental rise in any of Australia's marine regions. A significant feature within the area are several eddies that form off the Leeuwin Current at predictable locations, including west of the Houtman Abrolhos Islands • Central Western Shelf Province—a predominantly flat, sandy and low-nutrient area, in water depths 50–100 m. Significant seafloor features of this area include a deep hole and associated area of banks and shoals offshore from Kalbarri. The area is a transitional zone between tropical and temperate species • Central Western Transition—a deep ocean area characterised by large areas of continental slope, a range of significant seafloor features including the Wallaby Saddle, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species • Southwest Shelf Transition—a narrow continental shelf that is noted for its physical complexity. The Leeuwin Current has a significant influence on the biodiversity of this nearshore area as it pushes subtropical water southward along the area's western edge. The area contains a diversity of tropical and temperate marine life including a large number of endemic fauna species. Key ecological features of the Marine Park are: • Commonwealth marine environment surrounding the Houtman Abrolhos Islands—the islands are among Australia's most important seabird breeding sites, with extensive foraging grounds in Commonwealth waters. The islands and surrounding reefs support a unique mix of temperate and tropical species, resulting from the southward movement of species by the Leeuwin Current		

<table>
<tr><th rowspan="2">AMP</th><th rowspan="2">IUCN Zones</th><th rowspan="2">Description and Values[1]</th><th colspan="2">Approx. distance and direction</th></tr>
<tr><th>Project Area</th><th>EMBA</th></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td>• Demersal slope and associated fish communities of the Central Western Province—an area that provides important habitat for demersal fish communities and is characterised by high species diversity and endemism
• Mesoscale eddies—important transporters of nutrients and plankton communities that form at predictable locations off the western and south-western shelf break
• Perth Canyon and adjacent shelf break, and other west coast canyons—unique seafloor features contribute to ecologically important events of localised productivity and aggregations of marine life
• Western rock lobster—plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western rock lobsters are an important part of the food web on the inner shelf, particularly as juveniles
• Ancient coastline between 90 m and 120 m depth—high benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment
• Wallaby Saddle—a unique seafloor feature that is associated with enhanced biological productivity in an area of generally low productivity. The saddle is the site of upwellings of deeper, more nutrient-rich waters and aggregations of marine species including large predators such as sperm whales.
The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include foraging and breeding habitat for seabirds, foraging habitat for Australian sea lions and white sharks, and a migratory pathway for humpback and pygmy blue whales.
The Marine Park is adjacent to the northernmost Australian sea lion breeding colony in Australia, which is on the Houtman Abrolhos Islands.</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Cultural values
Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years.
The Nanda and Naaguja People have responsibilities for Sea Country in the Marine Park. Traditional Owners have strong stories that connect ocean and land. Artefacts from ancestors are abundant on islands in the adjacent state marine park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.</td></tr>
<tr><td>Heritage values
No international heritage listings applied to the Marine Park at the commencement of this Plan; however, the Marine Park is adjacent to the WA Shark Bay World Heritage Property, listed as an area of outstanding universal value under the World Heritage Convention in 1991, meeting world heritage listing criteria vii, viii, ix, and x. No Commonwealth or national heritage listings applied to the Marine Park at the commencement of this Plan; however, the Marine Park is adjacent to the WA Shark Bay National Heritage Place.</td></tr>
</table>

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
		The Marine Park contains 11 known shipwrecks listed under the UCH Act. The *Zuytdorp* (wrecked in 1712) historic shipwreck protected zone lies in state waters adjacent to the northernmost part of the shelf component of the Marine Park, north of Kalbarri. The HMAS *Sydney* II and HSK *Kormoran* Shipwreck Sites (1941) lie at 2500 m depth ~75 km east of the northern part of the Marine Park. This site is on the National Heritage List and is an historic shipwreck protected zone. The *Batavia* (wrecked on the adjacent Abrolhos Islands in 1629) Shipwreck Site and Survivor Camps Area are on the National Heritage List.		
		Social and economic values Tourism, commercial fishing, mining, recreation including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.		
Eighty Mile Beach	Multiple Use (Zone VI)	***Description*** The Eighty Mile Beach Marine Park is located ~74 km north-east of Port Hedland, adjacent to the Western Australian Eighty Mile Beach Marine Park. The Marine Park covers an area of 10,785 km² and a water depth ranges between less than 15 m and 70 m.	~315 km east	Overlap
		Natural values The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales. The Marine Park supports a range of species listed under the EPBC Act. Biologically important areas within the Marine Park include breeding, foraging and resting habitat for seabirds, internesting and nesting habitat for marine turtles, foraging, nursing and pupping habitat for sawfish and a migratory pathway for humpback whales.		
		Cultural values Sea Country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their Sea Country for tens of thousands of years. The Sea Country of the Nyangumarta, Karajarri and Ngarla people extends into Eighty Mile Beach Marine Park. Sea Country is culturally significant and important to their identity. They have an unbroken, deep spiritual connection to their Sea Country, with traditional practices continuing today. Staple foods of living cultural value for the Nyangumarta, Karajarri and Ngarla people include saltwater fish, turtles, dugong, crabs and oysters. Access to Sea Country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities. The native title holders for the Nyangumarta, Karajarri and Ngarla people are represented by the Karajarri Aboriginal Corporation, Nyangumarta Karajarri Aboriginal Corporation, Nyangumarta Warrarn Aboriginal Corporation, and		

AMP	IUCN Zones	Description and Values[1]	Approx. distance and direction	
			Project Area	EMBA
		Wanparta Aboriginal Corporation. These PBCs represent traditional owners with native title over coastal area adjacent to the Marine Park. They are the points of contact for their respective areas of responsibility for Sea Country in the Marine Park. The Kimberley Land Council and the Yamatji Marlpa Aboriginal Corporation are the Native Title Representative Bodies for Kimberley and Pilbara regions.		
		Heritage values The Marine Park contains three known shipwrecks listed under the Historic Shipwrecks Act 1976: Lorna Doone (wrecked in 1923), Nellie (wrecked in 1908), and Tifera (wrecked in 1923). No international, Commonwealth or national listings apply to the Marine Park.		
		Social and economic values Tourism, commercial fishing, pearling and recreation are important activities in the Marine Park.		

1. Source (DNP 2018a)

7.8.7 State Marine Protected Areas

State marine protected areas, proclaimed under the *Conservation and Land Management Act 1984* (WA) (CALM Act), are located in state waters and vested in the WA Conservation and Parks Commission.

There are no State marine protected areas within the Project Area; however there are within the EMBA. These are described in Table 7-25.

Table 7-25: Summary of State marine protected areas within the EMBA

State Marine Protected Area	IUCN Zones	Description and Values	Approx. distance and direction (km)	
			Project Area	EMBA
Barrow Island Marine Park Barrow Island Marine Management Area	Sanctuary Zone (IUCN Ia) MMA, Unassigned (IUCN VI)	The Montebello Islands Marine Park, Barrow Island Marine Park and Barrow Island Marine Management Area are located off the north-west coast of WA, ~1,600 km north of Perth, and cover areas of ~583 km^2, 42 km^2 and 1,147 km^2, respectively. The Montebello/Barrow islands marine conservation reserves have very complex seabed and island topography, resulting in a myriad of different habitats, subtidal coral reefs, macroalgal and seagrass communities, subtidal soft-bottom communities, rocky shores and intertidal reef platforms, which support a rich diversity of invertebrates and finfish. The reserves are important breeding areas for several species of marine turtles and seabirds, which use the undisturbed sandy beaches for nesting. Humpback whales migrate through the reserves and dugongs occur in the shallow warm waters (DEC and MPRA 2007a).	~40 km south	Overlap
Montebello Islands Marine Park	Special Purpose Zone (IUCN VI) Conservation Park (IUCN II) General Use Zone (IUCN II) Special Purpose Zone (Pearling) (IUCN VI) Special Purpose Zone (Benthic Protection) Recreation Zone (IUCN II) Sanctuary Zone (IUCN Ia) Unassigned (IUCN II)	Refer to description above.	~23 km south	Overlap
Muiron Islands Marine Management Area	MMA, Conservation Area (IUCN Ia) MMA Unassigned (IUCN VI)	The Ningaloo Marine Park and Muiron Islands Marine Management Area are located off North West Cape. WA, ~1,200 km north of Perth, and cover areas of ~2,633 km^2 and 286 km^2, respectively. The Muiron Islands Marine Management Area contain a very diverse marine environment, with coral reefs, filter-feeding communities and macroalgal beds. In addition, the Muiron Islands are important seabird and green turtle nesting areas (CALM 2005).	~198 km south-west	Overlap

State Marine Protected Area	IUCN Zones	Description and Values	Approx. distance and direction (km)	
			Project Area	EMBA
Eighty Mile Beach Marine Park	Sanctuary Zone (IUCN VI) General Use Zone (IUCN VI) Recreation Zone (IUCN VI) Special Purpose Zone (Shore-based Activities) (IUCN VI) Special Purpose Zone (Mangrove Protection) (IUCN VI) Special Purpose Zone (Cultural Heritage) (IUCN VI)	Eighty Mile Beach Marine Park covers ~2000 km^2 stretching across 220 km of coastline between Port Hedland and Broome. Eighty Mile Beach Marine Park is one of the world's most important feeding grounds for small wading birds that migrate to the area each summer, travelling from countries thousands of kilometres away. The marine park is a major nesting area for flatback turtles which are found only in northern Australia. Sawfishes, dugongs, dolphins and millions of invertebrates inhabit the sand and mud flats, seagrass meadows, coral reefs and mangroves (DPAW 2014).	~370 km east	Overlap
Ningaloo Marine Park	Sanctuary Zone (IUCN Ia) Special Purpose Zone (Shore Based Activities) (IUCN II) General use (IUCN II) Special Purpose Zone (Benthic Protection) (IUCN IV) Recreation Area (IUCN II) Unassigned (IUCN II) Unassigned (IUCN IV)	The Ningaloo Marine Park and Muiron Islands Marine Management Area are located off North West Cape, WA, ~1,200 km north of Perth, and cover areas of ~2,633 km^2 and 286 km^2, respectively. Ningaloo Reef is the largest fringing coral reef in Australia. Temperate and tropical currents converge in the Ningaloo region resulting in highly diverse marine life including spectacular coral reefs, abundant fishes, and species with special conservation significance such as turtles, whale sharks, dugongs, whales and dolphins. The region has diverse marine communities including mangroves, algae and filter-feeding communities and has high water quality. These values contribute to the Ningaloo Marine Park being regarded as WA's premier marine conservation icon (CALM 2005).	~216 km south-west	Overlap
Rowley Shoals Marine Park	Recreation Zone (IUCN II) Sanctuary Zone (IUCN Ia) General Use (IUCN II) Unassigned (IUCN IV)	The three coral atolls of the Rowley Shoals Marine Park comprise shallow lagoons inhabited by diverse corals and abundant marine life, each covering around 80 km^2 at the edge of Australia's continental shelf. Further offshore, the seafloor slopes away to the abyssal plain, some 6,000 m below. Undersea canyons slice the slope; these features are commonly associated with diverse communities of deepwater corals and sponges and create localised upwellings that aggregate pelagic species like tunas and billfish (DEC and MPRA 2007b).	~375 km north-east	Overlap
Shark Bay Marine Park	General Use (IUCN II)	Shark Bay Marine Park covers an area of ~7487 km^2, located adjacent to the Shark Bay World Heritage Property and National Heritage Place. The region contains an outstanding example of Earth's evolutionary history in the stromatolites and hypersaline environment of Hamelin Pool. There are significant ongoing geological and biological processes in both the	~620 km south-west	On Border

State Marine Protected Area	IUCN Zones	Description and Values	Approx. distance and direction (km)	
			Project Area	EMBA
		marine and terrestrial environments of Shark Bay. The Faure Sill and Wooramel Seagrass Bank are examples of the many superlative natural phenomena or features to be found in the World Heritage Area. The World Heritage Area provides the habitat of a number of rare and threatened species with many others at the limit of their range. Shark Bay is also noted for its natural beauty and in particular the diversity of its land and seascapes. Shark Bay is renowned for its marine fauna, including the dugong which is estimated to be one of the largest populations in the world. Humpback whales use the Bay as a staging area in their migration along the coast. Green and loggerhead turtles occur in the Bay with Dirk Hartog Island providing an important nesting site for loggerheads in Western Australia.		

7.9 Cultural Features and Heritage Values

7.9.1 Background

Woodside recognises the 'environment' for the purpose of the evaluation required under the Environment Regulations includes:

- the heritage value of places
- the social, economic, and cultural features of the broader environment.

In this section, the heritage value of places within the Project Area and EMBA, and the cultural features of the Project Area and EMBA are described.

In line with The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance (Australia ICOMOS 2013) (Burra Charter) and associated practice notes, Woodside understands heritage value to refer to the cultural significance of a place to an individual or group. A cultural feature, by contrast, is understood to be comparable to the Burra Charter term “fabric” and refer to a place’s elements, fixtures, contents and objects which have cultural values. Although these features are necessarily physical, the place they inhabit or comprise may have tangible or intangible dimensions (Australia ICOMOS 2013).

Note: As defined in Section 7.1, the EMBA for this OPP has been developed based on the outcome of stochastic spill modelling for the worst-case credible unplanned hydrocarbon release events, and then further broadened to incorporate a spatial buffer (a minimum of ~50 km) and extended inshore along most of the Pilbara and Gascoyne coast.

7.9.2 First Nations People

As a starting point for understanding social and cultural features of the environment for First Nations groups, Woodside uses the existing systems, such as native title, to identify First Nations groups that may have functions, interests or activities that may be affected. To that end, Woodside identifies native title representative bodies and nominated representative entities, as well as native title claims, determinations, and Indigenous Land Use Agreements (ILUAs) which the EMBA overlaps. Native title claims, determinations, and ILUAs are defined under the *Native Title Act 1993* (Cth) (Native Title Act). While acknowledging that cultural features and heritage values may exist outside of the native title framework, Woodside considers this to be the broadest extent over which First Nations groups have claimed native title rights and interests.

Native title claims are applications made to the Federal Court under the Native Title Act for a determination or decision about native title in a particular area. A claim is made by a native title claim group which asserts it holds native title rights and interests in an area of land and/or water, according to its traditional laws and customs. By making a claim, the native title claim group seeks a decision that native title exists so that its native title rights and interests are recognised by the common law of Australia. This is called a native title determination. A determination is a decision by a recognised body, such as the Federal Court or High Court of Australia, that native title either does or does not exist in relation to a particular area (Native Title Tribunal).

A requirement to establishing a positive determination of native title in court is proving that there is an organised society that occupied the land and/or waters at the time of British annexation. The requirement of an ‘organised society’ is set out by Justice Toohey in the historic judgment of *Mabo v Queensland (No 2) [1992] HCA 23; (1992) 175 CLR 1* (‘Mabo’). Justice Toohey had the following to say (at 187):

> *it is inconceivable that Indigenous inhabitants in occupation of land did not have a system by which land was utilized in a way determined by that society. There must, of course, be a society sufficiently organized to create and sustain rights and duties…*

Therefore, Woodside understands that native title rights and interests are held communally by an organised society, that native title claims are understood to represent the area over which First Nations groups are claiming these rights and interests, and that native title determinations provide clarity on where native title rights and interests are found to either exist or not exist. Where native title rights or interests are determined to exist they will be held by a Registered Native Title Body Corporate (RNTBC) (section 57, Native Title Act) in trust or as agent for native title holders.

ILUAs are voluntary agreements between native title parties and other people or bodies about the use and management of land and/or waters and are registered by the Native Title Registrar in the Register of ILUAs. An ILUA can be made over areas where:

- native title has been determined to exist in at least part of the area
- a native title claim has been made
- where no native title claim has been made.

While registered, ILUAs operate as a contract between the parties, including relevant native title holders (Native Title Tribunal).

The Native Title Act provides for a representative Aboriginal/Torres Strait Islander body (Native Title Representative Body; NTRB) to be recognised by the Commonwealth Minister for an area. NTRBs have specialist functions set out in the Native Title Act within the area for which they are the NTRB. However, the functions of a NTRB are such that they do not hold details on the cultural features or heritage values of an area and therefore do not inform Woodside's understanding of heritage values or cultural features.

The coastal native title determinations, claims, and ILUAs that overlap with the EMBA are identified in Table 7-26 and Figure 7-40.

7.9.3 Coastally Adjacent First Nations Groups

Woodside understands that First Nations groups are keenly aware of the extent of their rights, interests and responsibilities for Country, and these are generally discrete, defined areas, including areas of sea (Smyth 2007). To identify cultural features and heritage values which may exist outside of native title claim, determination, and ILUA areas, Woodside has also identified native title claims, determinations and ILUAs coastally adjacent to the EMBA to be an instructive means of identifying potentially relevant First Nations groups (Table 7-26).

That said, Woodside understands from engagement with stakeholders that extending a native title group's responsibility to areas which those groups have elected to not include in their claims or ILUAs can have significant cultural consequences for First Nations groups and individuals. This may also, over time, build expectations in the broader First Nations community that a group is responsible for maintaining environmental values in areas for which they do not hold traditional knowledge. Woodside also acknowledges that a First Nations group's relative proximity to the Project Area or EMBA is not necessarily a meaningful indicator of the connection of First Nations groups to the area, and providing advice over such areas can be culturally dangerous.

A summary of native title claims, determinations and ILUAs overlapping or coastally adjacent to the EMBA is set out in Table 7-26 and shown in Figure 7-40. Claims and determinations have not been differentiated in this table, as it is acknowledged that either of these may indicate the existence of rights and interests.

Table 7-26: Summary of native title claims, determinations and ILUAs which overlap or are coastally adjacent to the EMBA

Claim / Determination / ILUA	Registered Native Title Body Corporate	Overlap with EMBA	Coastally Adjacent to EMBA
Claim / Determination			
Bardi and Jawi	Bardi and Jawi Niimidiman Aboriginal Corporation	No	Yes
Bindunbur	Gogolanyngor Aboriginal Corporation, Nimanburr Aboriginal Corporation, Nyul Nyul PBC Aboriginal Corporation	No	Yes
Gnulli, Gnulli #2 and Gnulli #3 – Yinggarda, Baiyungu and Thalanyji People	Nganhurra Thanardi Garrbu Aboriginal Corporation (NTGAC), Yinggarda Aboriginal Corporation (YAC)	Yes	Yes
Jabirr Jabirr/Ngumbari	Gogolanyngor Aboriginal Corporation	No	Yes
Karajarri People (Area A and Area B)	Karajarri Traditional Lands Association (Aboriginal Corporation)	No	Yes
Kariyarra	Kariyarra Aboriginal Corporation	Yes	Yes
Malgana Part A	Malgana Aboriginal Corporation	No	Yes
Nanda People Part B, Malgana 2 and Malgana 3	Malgana Aboriginal Corporation, Nanda Aboriginal Corporation	No	Yes
Nanda People and Nanda #2	Nanda Aboriginal Corporation	No	Yes
Ngarla and Ngarla #2 (Determination Area A)	Wanparta Aboriginal Corporation	Yes	Yes
Ngarluma People	Ngarluma Aboriginal Corporation (NAC)	No	Yes
Ngarluma/Yindjibarndi	Yindjibarndi Aboriginal Corporation, NAC	Yes	Yes
Nyangumarta People (Part A)	Nyangumarta Warrarn Aboriginal Corporation	No	Yes
Nyangumarta-Karajarri Overlap Proceeding (Yawinya)	Nyangumarta Karajarri Aboriginal Corporation	No	Yes
Rubibi Community	Yawuru Native Title Holders Aboriginal Corporation	No	Yes
South West Settlement	No representative body specified	No	Yes
Thalanyji	Buurabalayji Thalanyji Aboriginal Corporation (BTAC)	No	Yes
Yaburara & Mardudhunera People	Wirrawandi Aboriginal Corporation (WAC)	Yes	Yes
Yamatji Nation	Bundi Yamatji Aboriginal Corporation	No	Yes

Claim / Determination / ILUA	Registered Native Title Body Corporate	Overlap with EMBA	Coastally Adjacent to EMBA
ILUA			
Alinta-Kariyarra Electricity Infrastructure ILUA	No representative body specified	Yes	Yes
Anketell Port, Infrastructure Corridor and Industrial Estates Agreement	NAC	Yes	Yes
Ashburton Salt Project Indigenous Land Use Agreement (Body Corporate Agreement)	BTAC	No	Yes
Bardi Jawi Conservation Estate ILUA	Bardi and Jawi Niimidiman Aboriginal Corporation	No	Yes
Brickhouse and Yinggarda Aboriginal Corporation ILUA	YAC	No	Yes
Cape Preston Project Deed (YM Mardie ILUA)	WAC	Yes	Yes
Cape Preston West Export Facility	WAC	No	Yes
Eco Beach ILUA	Yawuru Native Title Holders Aboriginal Corporation	No	Yes
FMG – Kariyarra Land Access ILUA	No representative body specified	Yes	Yes
Gnaraloo Indigenous Land Use Agreement	NTGAC	No	Yes
Great Sandy Desert Project ILUA – Infrastructure	Karajarri Traditional Lands Association (Aboriginal Corporation)	No	Yes
Karajarri Traditional Lands Association KSCS Eighty Mile Beach ILUA	Karajarri Traditional Lands Association (Aboriginal Corporation)	No	Yes
Kariyarra and State ILUA	Kariyarra Aboriginal Corporation	No	Yes
KM & YM Indigenous Land Use Agreement 2018	WAC, Robe River Kuruma Aboriginal Corporation	Yes	Yes
Kuruma Marthudunera and Yaburara and Coastal Mardudhunera Indigenous Land Use Agreement	No representative body specified	Yes	Yes
Macedon ILUA	BTAC	No	Yes
Malgana Tamala Pastoral Lease Agreement	Malgana Aboriginal Corporation	No	Yes
Malgana Woodleigh Carbla Pastoral Lease Agreement	Malgana Aboriginal Corporation	No	Yes
Malgana Wooramel Pastoral Lease Agreement	Malgana Aboriginal Corporation	No	Yes
Ngarla Pastoral ILUA	Wanparta Aboriginal Corporation	No	Yes
Ngarla PBC KSCS ILUA	Wanparta Aboriginal Corporation	No	Yes
Ningaloo Conservation Estate ILUA	NTGAC	Yes	Yes

Claim / Determination / ILUA	Registered Native Title Body Corporate	Overlap with EMBA	Coastally Adjacent to EMBA
NKAC KSCS Eighty Mile Beach ILUA	Nyangumarta Karajarri Aboriginal Corporation	No	Yes
Nyangumarta PBC KSCS ILUA	Nyangumarta Warrarn Aboriginal Corporation	Yes	Yes
Nyangumarta Warrarn Aboriginal Corporation & Mandora Pastoral Lease ILUA	Nyangumarta Warrarn Aboriginal Corporation	No	Yes
Nyangumarta Warrarn Aboriginal Corporation & Wallal Downs Pastoral Lease ILUA	Nyangumarta Warrarn Aboriginal Corporation	No	Yes
Quobba – Yinggarda Pastoral ILUA	YAC	No	Yes
RTIO Kuruma Marthudunera People ILUA	Robe River Kuruma Aboriginal Corporation	Yes	Yes
RTIO Ngarluma Indigenous Land Use Agreement (Body Corporate Agreement)	NAC	Yes	Yes
Yamatji Nation Agreement	Bundi Yamatji Aboriginal Corporation	No	Yes
Yawuru Area Agreement ILUA	No representative body specified	No	Yes
Yawuru Nagulagun / Roebuck Bay Marine Park ILUA	Yawuru Native Title Holders Aboriginal Corporation	No	Yes
Yawuru Prescribed Body Corporate ILUA – Broome	Yawuru Native Title Holders Aboriginal Corporation	No	Yes
Yued Indigenous Land Use Agreement	Yued Aboriginal Corporation	No	Yes

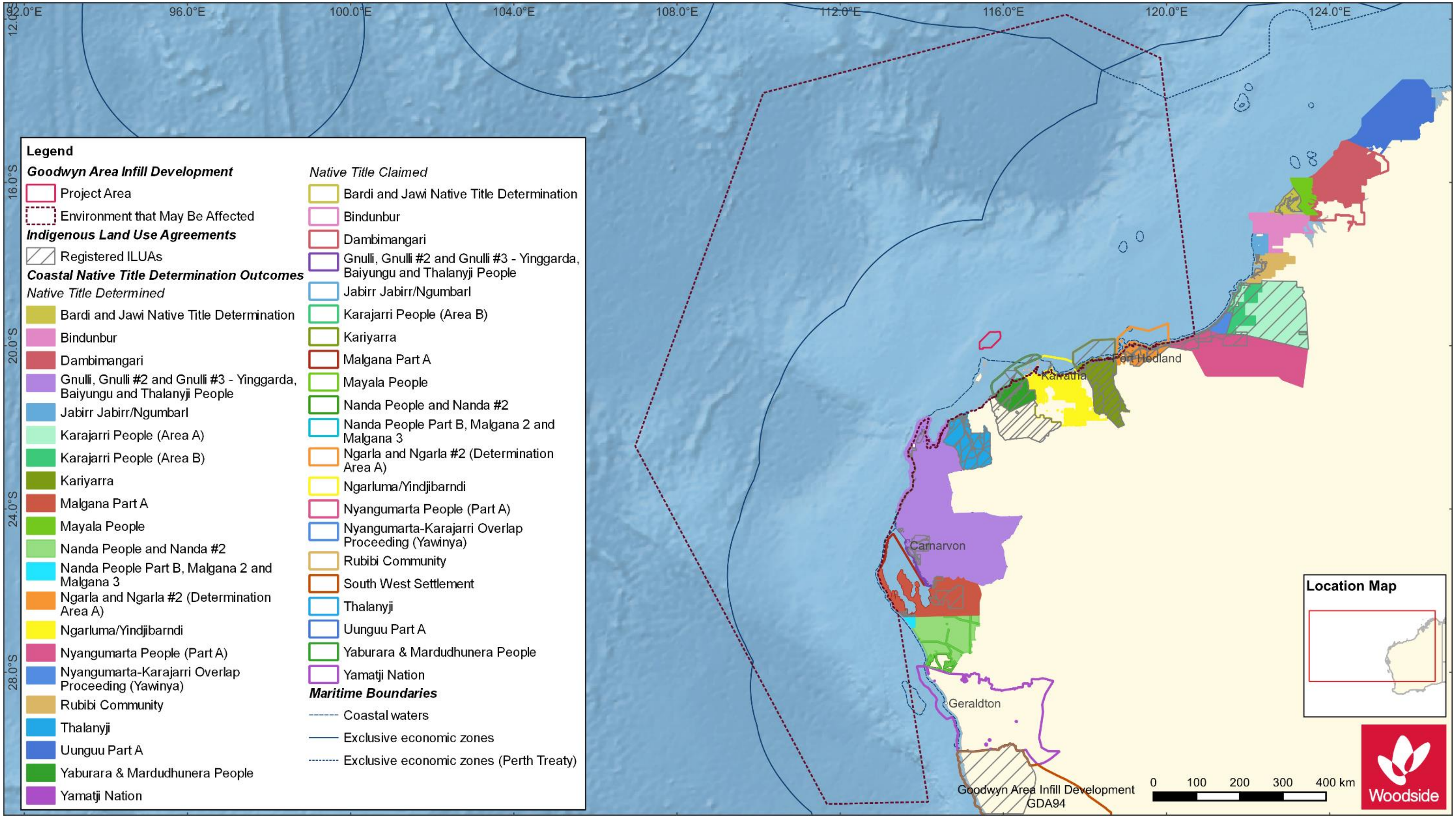


Figure 7-40: Coastal native title claims and determinations, and ILUAs, in the vicinity of the EMBA

7.9.4 Marine Parks

Woodside acknowledges that Commonwealth and State Marine Park Management Plans have sought to recognise cultural values of First Nation groups. AMPs describe this framework in the following way: 'when making decisions about what can occur in marine parks and what action we will take to protect AMPs, we take values into account'. AMP summarises these values as natural values, cultural values, heritage values, and socio-economic values. Woodside considers the management plans of marine parks that overlap the Project Area and the EMBA to determine whether cultural features and heritage values have been identified and whether there are specified representative bodies referenced regarding potential cultural features and heritage places.

The Project Area overlaps features of the Montebello AMP. The EMBA overlaps features of a further ten AMPs under the South-West Marine Parks Network Management Plan 2018 (DNP 2018b) and North-West Marine Parks Network Management Plan 2018 (DNP 2018a). The Project Area does not overlap any State marine protected areas, however the EMBA overlaps twelve State marine protected areas. Where these plans specify identifiable representative bodies—including but not limited to RNTBCs—it is considered that these bodies may hold knowledge of heritage values or cultural features for the marine area beyond those addressed in the marine park management plans. Eight identifiable representative bodies were specified for the AMPs overlapped by the EMBA (Table 7-27).

The marine park management plans did note for the Abrolhos, Dampier, Gascoyne, Montebello, Ningaloo, and Shark Bay AMPs that the Yamatji Marlpa Aboriginal Corporation (YMAC) is the relevant NTRB, and that for Eighty Mile Beach AMP both YMAC and Kimberley Land Council (KLC) are NTRBs.

Values of the AMPs and State marine protected areas, including cultural values, which are identified within existing plans are described in Section 7.8.

Table 7-27: Summary of Commonwealth and State marine parks which overlap with the Project Area or EMBA

Marine Park	Project Area Overlap	EMBA Overlap	First Nations Representative Bodies
Australian Marine Parks			
Abrolhos AMP	No	Yes	No identifiable body specified.
Argo–Rowley Terrace AMP	No	Yes	No identifiable body specified.
Carnarvon Canyon AMP	No	Yes	No identifiable body specified.
Dampier AMP	No	Yes	NAC, Yindjibarndi Aboriginal Corporation
Eighty Mile Beach AMP	No	Yes	Karajarri Traditional Lands Association, Nyangumarta Karajarri Aboriginal Corporation, Nyangumarta Warrarn Aboriginal Corporation, Wanparta Aboriginal Corporation.
Gascoyne AMP	No	Yes	No identifiable body specified.
Mermaid Reef AMP	No	Yes	No identifiable body specified.
Montebello AMP	Yes	Yes	No identifiable body specified.
Ningaloo AMP	No	Yes	No identifiable body specified.
Shark Bay AMP	No	Yes	No identifiable body specified.
State Marine Parks and Marine Management Areas			
Barrow Island Marine Management Area	No	Yes	No identifiable body specified.
Barrow Island Marine Park	No	Yes	No identifiable body specified.

Marine Park	Project Area Overlap	EMBA Overlap	First Nations Representative Bodies
Eighty Mile Beach Marine Park	No	Yes	Karajarri Traditional Lands Association, Nyangumarta Warrarn Aboriginal Corporation, Wanparta Aboriginal Corporation and Nyangumarta Karajarri Aboriginal Corporation
Montebello Island Marine Park	No	Yes	No identifiable body specified.
Muiron Island Marine Management Area	No	Yes	No identifiable body specified.
Ningaloo Marine Park	No	Yes	NTGAC
Rowley Shoals Marine Park	No	Yes	No identifiable body specified.
Shark Bay Marine Park	No	Yes	No identifiable body specified.
State National Parks			
Cape Range National Park	No	Yes	No identifiable body specified.
Dirk Hartog Island National Park	No	Yes	Malgana Aboriginal Corporation, Nanda Aboriginal Corporation (as the “Malgana and Nanda Native Title Working Groups”)
Houtman Abrolhos Islands National Park	No	Yes	No identifiable body specified.
Murujuga National Park	No	Yes	Murujuga Aboriginal Corporation (MAC)

In the management plans for AMPs it is noted that “[s]ea country is valued for Indigenous cultural identity, health and wellbeing” (DNP 2018a; 2018b). Cultural identity is understood to refer to the fact that “essence of being a 'Saltwater' person is ontological rather than merely technological. That is, it is about how people relate spiritually to the sea and engage with spiritual forces that created it, the marine flora and fauna and people” (McDonald and Phillips 2021).

The South-West Marine Parks Network Management Plan 2018 (DNP 2018b) also notes that cultural features of the Abrolhos AMP include strong stories that connect ocean and land. The plan also references artefacts located outside of the AMP, on islands in the adjacent State protected areas.

The North-West Marine Parks Network Management Plan 2018 (DNP 2018a) also notes that cultural features of the Eighty Mile Beach AMP include traditional practices continuing today, staple foods of living cultural value and that access to Sea Country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities. Management of cultural features within marine ecosystems, including food sources, is discussed in Section 7.9.6.

Both management plans for the AMPs identify shipwrecks within the AMPs and overlap with World, National and Commonwealth heritage lists (DNP 2018a; 2018b). These are addressed in Sections 7.9.8, 7.8.1, 7.8.2, and 7.8.3. Shipwrecks and plane wrecks are also noted in several state management plans (DEC and MPRA 2007a; DPAW 2014; DBCA 2020c).

The Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area (CALM 2005) notes the aesthetic values of the seascape as a cultural value and that “[p]anoramic vistas of turquoise lagoon waters, reefs, beaches, breaking surf and the blue open ocean beyond the reef line are major attractions of the reserves”. In particular, the plan notes that “[i]nappropriate structures along the coastline, on the islands and in the surrounding waters have the potential to degrade the aesthetic values of the reserves. Coastal developments and maritime infrastructure projects must therefore be planned with careful consideration of this issue”. As the offshore project described in this OPP does not include the addition of any structures within these parks, no impacts on the aesthetic values of these parks are anticipated.

The Eighty Mile Beach Marine Park Management Plan (DPAW 2014) notes that “Traditional owners maintain connection to their traditional coastal and sea country through identity and place, family networks, spiritual practice and resource gathering.”

The Shark Bay Marine Reserves Management Plan (CALM 1996) notes that “Aboriginal sites including open shell middens, quarries, rock shelters, artefact shelters, burials and stone arrangements have been recorded at Shark Bay” and “[s]mall numbers of dugongs and green turtles are hunted.”

The Murujuga National Park Management Plan (DEC 2013), relating to terrestrial land, reports “a very high density of Aboriginal heritage sites with highly significant heritage values” and “some of the most significant petroglyph sites in Australia with associated cultural and mythological values and archaeological material”. The potential for comparable material to exist in the EMBA is discussed in Section 7.9.6.

7.9.5 Indigenous Protected Areas

IPAs are areas of land and sea managed by First Nations groups as protected areas for biodiversity conservation through voluntary agreements with the Australian Government. IPAs are an essential component of Australia’s National Reserve System, which is the network of formally recognised parks, reserves, and protected areas across Australia. There are currently (as of September 2023) 82 dedicated IPAs over 85 million ha, which account for >50% of the National Reserve System (DCCEEW 2023g). The IPA Program is administered by the National Indigenous Australians Agency in partnership with the DCCEEW.

No IPAs were identified within the Project Area. One IPA was identified within the EMBA—the Nyangumarta Warrarn IPA (Unassigned [IUCN VI]) (Table 7-19).

The Nyangumarta Warrarn IPA was declared in 2015 and includes the following areas:

- Pirra Country—the Great Sandy Desert area, covering about 26,561 km² (exclusive possession Native Title), and Walyarta Conservation Park
- Jurrar Country—Kujungurru Warrarn Conservation Park, Kujungurru Warrarn Nature Reserve, and Eighty Mile Beach Marine Park intertidal area.

Nyangumarta are the Traditional Owners and Native Title holders of the land and waters within and surrounding the Nyangumarta Warrarn IPA, and their relationship to Country is rich and complex (NWAC and YMAC 2022). For Nyangumarta, Country has cultural significance (including the songs, stories and dances) which define the distinct rights and responsibilities pertaining to each individual depending on their standing within the society. Nyangumarta want to manage Country for conservation and community benefits (NWAC and YMAC 2022). The values below represent what the important things on Country are for Nyangumarta people:

- Marrngumili (Nyangumarta law and culture)
- Yinta (important sites)
- Governance and partnerships
- Nyangumarta people and pathways
- Pirra Ngurra (Desert Country)
- Jurrar Ngurra (Saltwater Country).

7.9.6 Sea Country Values

‘Sea Country’ can be defined as the area of sea over which a First Nations group has interests, cultural value, connection, and use. It has been noted that “the saltwater peoples of the north-west are associated with discrete clan estates or tribal areas, often referred to in contemporary Aboriginal

English as ‘saltwater country’ or ‘sea country’. Country refers to more than just a geographical area: it is shorthand for all the values, places, resources, stories and cultural obligations associated with that geographical area” (Smyth 2007). “Sea country is valued for Indigenous cultural identity, health and wellbeing” (DNP 2018a; 2018b). Cultural identity is understood to refer to the fact that “essence of being a 'Saltwater' person is ontological rather than merely technological. That is, it is about how people relate spiritually to the sea and engage with spiritual forces that created it, the marine flora and fauna and people” (McDonald and Phillips 2021).

In terms of seascape extent, McNiven (2004) suggests that “[f]or those mainland groups whose exploitation of the sea was limited to littoral resources, it is likely that seascapes extended no more than c. 20–30 km out to sea, out to the horizon and the limit of human visibility. … However, in some coastal places, clouds that can be seen well over 100 km out to sea are imbued with spiritual significance. For those groups with elaborate canoe technology, seascapes extend well over the horizon.” While there is some evidence of traditional watercraft in Australia’s North West, the recorded evidence is limited to travel across inland rivers (Barber and Jackson 2011) or travel between coastal islands (Paterson et al. 2020).

Woodside recognises the potential for marine ecosystems to include cultural features as well as environmental values. The link between environmental protection and cultural heritage protection is illustrated in the Australian Government’s IPAs Program. The IPAs program provides for “areas of land and sea managed by Indigenous groups as protected areas for biodiversity conservation…IPAs deliver environmental benefits…Managing IPAs also helps Indigenous communities protect the cultural values of their country for future generations…” (DCCEEW 2023g). This intrinsic link concept is also described by MAC (2021) as cited in Woodside (2023c), as it relates to the values of the marine environment that are of cultural importance to MAC based on engagement with their Elders and Murujuga Land and Sea Unit Rangers. Elders were clear that all living things in Mermaid Sound are connected and that Mermaid Sound and Dampier Archipelago (Murujuga) are considered one place where the entire environment and all ecosystems hold both cultural and environmental value, with these types of values (cultural and environmental) intrinsically linked (MAC 2021 as cited in Woodside 2023d).

Cultural features of coastal areas may include marine species that travel many thousands of kilometres through areas with similar cultural values to multiple First Nation language groups. Some species may travel as far as 5,000 km from Antarctica to the Kimberley region of Western Australia (Double et al. 2010; 2012), passing First Nation language groups along the entire west coast of Australia. Distribution and migratory patterns of migratory species are described in Section 7.6.

Sea Country values within the Project Area and EMBA have been defined using multiple lines of evidence including:

- desktop assessment of sea country values from publicly available sources
- specific studies including ethnographic surveys and archaeological heritage assessments
- engagement with First Nations groups and individuals (undertaken as part of the development of the Goodwyn Area Infill Geophysical and Geotechnical Survey EP and other NWS Woodside EPs with similar EMBAs; Section 8.4.1).

The process for identifying First Nations groups who may have interests and connection in Sea Country are set out in Section 7.9.3.

7.9.6.1 Desktop Assessment of Sea Country Values

7.9.6.1.1 Cultural features and heritage values identified in publicly available literature

Publicly available sources were assessed for any records of previously identified Sea Country values or cultural features that may overlap with the Project Area or EMBA. Where cultural features or Sea

Country values were identified these are summarised in Table 7-28 according to the First Nations groups (where identified or inferable) who hold these values.

All cultural features and heritage values restricted to onshore locations above the highest astronomical tide (HAT) or inland waters have been excluded in Table 7-28. This is on the basis that the Project Area (~140 km from Karratha) does not intersect onshore sites, while the EMBA is predicted to extend up to HAT where there is shoreline contact from an unplanned hydrocarbon release (Sections 9.2.6 and 9.2.7). Where the geographical extent of a cultural feature or heritage value is not specified or unclear it has been included for completeness.

Table 7-28: Cultural features and heritage values identified in publicly available literature

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
Bardi and Jawi	**Feature**: the offspring of Bardi and Jawi men inhabit the phenomenal world as incarnations of pre-existent spirit beings called ray or raya which live in specific locations throughout Bardi and Jawi territory including waterholes, springs, trees and rocks on the land or in the sea	*Sampi on behalf of the Bardi and Jawi People v State of Western Australia* [2010] FCAFC 26	No	Possible (unspecified)
	Feature: mythologically important places		Possible (unspecified) Unlikely given distance from Project Area	Possible (unspecified)
	Feature: resources including dugong, turtle and trochus shell		Possible (turtles) Other resources (No)	Possible
	Value: activities of mythological beings in the sea area		Possible (unspecified) Unlikely given distance from Project Area	Possible (unspecified)
	Value: Traditional knowledge of the sea and the features within		Possible (unspecified) Unlikely given distance from Project Area	Possible (unspecified)
	Value: The lands and seas and cultural forms and practices making up the body of customary law were created and bequeathed via generations of human forebears by supernatural beings, inamunonjin, who had occupied and/or traversed the Dampier Peninsula-Buccaneer Archipelago region prior to direct human experience of the world.		No	No
	Value: The inamunonjin shaped features of the physical environment and imbued them with their eternal numinal essence. They named sites and set the boundaries of traditional territories and introduced the religious resources such as songs, dances, designs, objects, myths and rituals through which their activities would continue to be celebrated and affirmed. They instituted the basic rules of customs regulating social order.		No	Possible (unspecified)

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: access to the sea around the coast of the mainland of the Dampier Peninsula and among the islands for hunting and fishing		No	No
	Value: access to the sea around the coast of the mainland of the Dampier Peninsula and among the islands for travelling		No	No
	Value: Nobody may access Alarm Shoals as this includes a very significant sacred site and is a very dangerous spiritual place		No	No
	Value: Lalariny, a rock feature in the vicinity of Thomas Bay, has a close association with a particular spiritual being and "nobody should go there"; people who do may be afflicted by a form of physical discomfort.		No	No
	Interest: environmental characteristics of the sea.		Possible (unspecified) Unlikely given distance from Project Area	Possible (unspecified)
	Feature: red ochre	*Sampi v Western Australia* [2005] FCA 777 (10 June 2005)	No	Possible (unlikely as predominantly a terrestrial feature)
	Feature: pearl shell		No	Possible
	Value: fishing		No	No
	Feature: feather		No	No
	Value: Reefs (important food-gathering places for Bardi Jawi people and visitors). Not only do these reefs provide sustenance, they are also culturally significant. Together the corals, algae and single-celled animals called zooxanthellae keep this fragile ecosystem stable.	(Oades and Meister 2013)	No	No
	Value: resource collection at One Arm Point (reef)		No	No
	Value: resources including Banyjarr, (clam and abalone), Noomool (seagrass), Abalone, Banyjarr (clam shell), Alngir (trochus), Goowarn (pearl shell), and Bluebone (Goorlan). Aarli (fish) and fish stocks as they are the most important food for the Bardi Jawi people. Goorlil (turtle) is, second only to Aarli, the most		Possible (fish, turtle, sting ray) No (other resources)	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	important form of protein for the Bardi Jawi people. Odorr (dugong) has always played a major role in Bardi Jawi culture. Joord (mullet), Barnamb (stingray), Ngarrangg (mud crab).			
	Feature: seagrass meadows (a fertile ecosystem where turtles and dugong feed; are often present on the more sheltered sandy flats).		No	Possible
	Feature: Mangroves (provide a buffer zone to the mainland, with their own ecology. They are key to keeping the intertidal plant and animal habitat healthy)		No	Possible
	Feature: Sunday Island (burial sites on the island and Dreamtime stories cross over the island)		No	No
	Value: access to Sea Country		No	No
	Value: sustainable fishing of fish, turtle and dugong		No	Possible
	Feature: saltwater including coral reefs communities, sea grass, saltmarsh communities, mangroves and macroalgae.	(DBCA 2022a)	No	Possible
	Feature: whales, dolphins, estuarine crocodiles, sea and shore birds.		Possible (except for crocodiles)	Possible
	Value: Shark Dreamtime associated with saltwater including how the hammerhead came into existence.		Possible Unlikely given distance from Project Area	Possible (unspecified)
	Value: access to Sea Country including Manaing access to Woolardgoon Special Purpose Zone (cultural protection) – Packer Island; Bool Special Purpose Zone (cultural protection) – Thomas Bay; Jilany Creek Special Purpose Zone (cultural protection); Arnbarnani Special Purpose Zone (cultural protection) – Cape Leveque Island; Oorroondoorroon Special Purpose Zone (cultural protection) – Alarm Shoals; Birimbir Special Purpose Zone (cultural protection) – Hunter Creek; Iinalang Special Purpose Zone (cultural protection) – Sunday Island Group; Noobooloon Special Purpose Zone (cultural protection) – Catamaran Bay; Garrambany Special Purpose Zone (cultural protection) – Chunelarr Creek; Maljin Special Purpose Zone		No	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	(cultural protection) – Cygnet Bay; Garramal Special Purpose Zone (cultural protection) – Cunningham Point.			
	Value: cultural activities using marine resources including dugong hunting, turtle hunting, turtle egg collecting, Seabird egg collecting, Spearing fish, Reef trapping fish, Herding fish, Line fishing, Collecting fish in stone fish traps, Poisoning fish, Gathering shellfish and other marine resources.	(Smyth 2007)	No	No
	Value: Dreaming stories and songlines associated with ancestral beings that travelled Sea Country creating and naming the marine environment. The ancestral performed rituals northward through the islands where certain named ritual sites were located. These rituals passed through the Dampier Peninsula and travelled south along the coast to Broome, La Grange and south-east into the interior.		No	No
	Feature: islands, reefs, sandbanks and marine species		Possible (unlikely due to distance from Project Area)	Possible
Gnulli (Baiyungu, Thalanyji, Yinggarda)	**Feature**: resources including marine animals	*Peck on behalf of the Gnulli Native Title Claim Group v State of Western Australia* [2019] FCA 2090	Possible (unspecified)	Possible (unspecified)
	Value: traditional knowledge holds that ancestors live on the land and in the water; therefore, people have obligations to access and care for these places (e.g. keeping them clean)		Possible (unspecified)	Possible (unspecified)
	Feature: heritage sites in the Ningaloo region include shell middens, artefact scatters, skeletal material/burial sites, camps, meeting places, hunting places and water sources	(Deloitte Access Economics 2020)	No	Possible (unspecified, but likely refers to onshore areas above HAT)
	Feature: resources including gajalbu (emu), bundgurdi (kangaroo), bardurra (bush turkey), majun (marine turtles), turtle eggs, bilygurumarda (osprey), fish, shellfish and plants		Possible (turtles, fish) No (other resources)	Possible (turtles, turtle eggs, fish, shellfish) No (other resources)
	Feature: mudflats, mangroves and sand dunes provide a critical breeding ground for marine and terrestrial wildlife		No	Possible (mudflats, mangroves)
	Value: the Ningaloo region contains cultural heritage dating back at least 32,000 years, including ceremonial Thalu sites		No	Possible (unspecified, but likely refers to onshore areas above HAT)

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: connection to Country is important to the Traditional Owners' spirituality and religion		Possible (unspecified)	Possible (unspecified)
	Value: caring for Country—"[t]he southern coastal reserves along the Ningaloo Coast are jointly managed by Traditional Owners and the DBCA. The Joint Management Body ensures that the Traditional Owners have an opportunity to make decisions about environmental management and land use". This document also includes information that is marked that cannot be copied, reproduced or used without consent.		No	Possible (shoreline accumulation areas)
	Feature: resources including mangrove crabs, gastropods, shellfish, dugong, turtle	(Morse 1993)	Possible (turtles, dugong) No (other resources)	Possible (all)
Jabirr Jabirr and Ngumbarl	**Feature**: Dreaming stories relating to inland areas associated with the headwaters of creeks running west through Jabirr Jabirr country	(NNTT 2015)	No (onshore location)	No (onshore location)
	Feature: During Bugarrlgarra (the Dreaming), a snake travelled from Nurrugun (Carnot Bay) in Jabirr Jabirr country down to Ngumbarl country and across into Yawuru country. When this snake crossed Willie Creek he changed his name and his kinship group ("skin").		No	No
	Value: Sites along the coast point to protracted economic and spiritual use of the land and include artefact scatters, middens, burials and/or ceremonial sites, sites of mythological and historical significance, fish traps and gender-restricted sites		No	No
	Value: coastal areas used for hunting, fishing and camping		No	No
	Value: Traditional knowledge of the 'changes in seasons which rests on the relationships between the living things within a particular area'		No	No
	Value: There is a song cycle that runs from One Arm Point to Bidyadanga which makes up the northern tradition. The song line is like a vein that … goes underground at the coast and then comes back to the surface.	(NNTT 2008)	No	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: Lurujarri Dreaming Trail that travels from Coulumb Point to Gantheume Point. It traces part of the song line that maintains the living memory of people who have been here for thousands of years. We visit traditional hunting, fishing and camping places and teach people about the Dreamtime stories of the trail, the names and uses of plants and the significance of areas and sacred sites. This educational trail is an important aspect of keeping the traditional law and culture of this area alive.		No	No
	Features: Lurujarri Dreaming Trail locations include Ngunungurrukun (Coconut Well) Judinnang (the ocean reef) and the Lurujarri (coastal dunes) Gudurlwarany (Brolga) Lindalinda (Jabiru) Galbany (mullet) and Walgawalga (salmon) wader birds that have flown from northern Europe on their annual migration route Wirrkinymirri (Willie Creek) saltwater crocodiles. Linygoorr will usually feed on Wangkaja (mangrove crab) and fish Biyalbiyal (mangrove) trunks grubs (witchetty grubs) called Bina Nuwirrar (Barred Creek) Wirrar is the name of the rock formation that runs from the mouth of Nuwirrir (the inlet) into the bush. Yunguru (snake) Nimanburr (flying foxes) rest during the day in the mangroves and emerge out at sundown to feed on the Garnboor (freshwater paperbark) and Murrga (saltwater paperbark – tea tree) flowers. The Song Cycle on the coast of the Dampier Peninsula has its 'birthplace' north of One Arm Point, from whence it travels to the south of Bidyadanga, the exit place.	(Goolarabooloo 2019)	Possible (fish) No (others)	Possible (fish, mangroves, saltwater crocodiles)

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
Kariyarra	**Value**: traditional knowledge recalls that a salt water serpent lives in the sea and brings fish to shore	(Zaunmayr 2016)	Possible (unspecified)	Possible (unspecified)
Malgana	**Feature**: resources including bobtail, long-tail, kangaroo, emu, pink-grey galah, mull-hawk, bird eggs (shags [cormorants], seagull, divers), turtle eggs, dugongs, turtle, mullet, bluebone, whiting, snapper, oysters, mussels, crabs, prawns, scallops, cockles, little ‘redies’, black snapper and mallee fowl.	*Oxenham on behalf of the Malgana People v State of Western Australia* [2018] FCA 1929	Possible (turtles, dugong, fish) No (other resources)	Possible (turtles, turtle eggs, dugong, fish, invertebrates) No (other resources)
	Value: access to Country		No	Possible (unspecified)
	Feature: resources including dugong, green and loggerhead turtles and sharks	(Statton et al. 2021)	Possible (turtles, dugong, sharks)	Possible (turtles, dugong, sharks)
	Value: traditional knowledge maintains records of freshwater seeps in the submerged landscape		Possible (unspecified but unlikely due to distance to Project Area)	Possible (unspecified)
	Feature: resources including fish, shellfish, turtles and dugong.	(Briggs and Green 2008)	Possible (turtles, dugong, fish)	Possible (turtles, dugong, fish, shellfish)
	Feature: archaeological sites		Possible	Possible
	Feature: green sea turtles, dugongs, shags and bottlenose dolphins are species of cultural significance	(Sinclair 2021)	Possible (turtles, dugong, dolphins, seabird)	Possible (turtles, dugong, dolphins, seabird)
	Value: sharing and controlling the sharing of knowledge	(Lyons, Harkness, and Raisbeck-Brown and Malgana Aboriginal Corporation Board, Rangers, and Malgana Elders 2021)	Possible (unspecified, but unlikely due to location of Project Area)	Possible
Nanda	**Value**: access to Country resulting in physical and mental health	*Drury on behalf of the Nanda People v State of Western Australia* [2018] FCA 1849	Possible (unspecified, but unlikely due to location of Project Area)	Possible (unspecified)
	Value: Water serpents must not be disturbed in pools		No	No
	Value: traditional knowledge recalls that a water serpent swam down the Murchison River towards the sound of the ocean’s	(Kalbarri Visitor Centre 2023)	No	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	waves and created a tunnel to the sea. Scared by the waves, the serpent swam back up the Murchison.			
	Value: traditional knowledge recalls that the turtle used to live on the land, but became trapped in the sea due to its greed for berries in the water	(Capewell 2020)	Possible (turtles)	Possible (turtles)
	Value: traditional knowledge recalls that creation ancestors danced at the mouth of the river at Kalbarri and established the Law	(Murdock 2010)	No	No
Ngarda-Ngarli (Mardudhunera, Ngarluma, Wong-Goo-Tt-Oo, Yaburara and/or Yindjibarndi)	**Feature**: archaeological sites on Murujuga	(DEH 2006)	No	Possible
	Feature: ceremonial sites		No	Possible (unspecified)
	Feature: dreaming sites		Possible (unspecified)	Possible (unspecified)
	Value: traditional knowledge recalls that the sea is a source of creation for flying foxes	(DEC 2013)	Possible (unspecified)	Possible (unspecified)
	Value: petroglyphs are understood as permanent signs left by ancestral beings		Possible (submerged)	Possible
	Value: petroglyphs depict the law		Possible (submerged)	Possible
	Value: cultural obligations to look after places of special potency		Possible	Possible
	Value: petroglyphs are important in initiation and education		Possible (submerged)	Possible (submerged)
	Value: the sea is acknowledged a starting point for songlines, including the flying fox songline	(MAC 2023a)	Possible (unspecified)	Possible (unspecified)
	Feature: resources including fishes, turtles and dugong	(Water Corporation 2019)	Possible (turtles, dugong, fish)	Possible (turtles, dugong, fish)
	Value: traditional knowledge recalls a sea serpent which travelled from the coast to inland pools		Possible (unspecified)	Possible (unspecified)
	Value: traditional knowledge recalls a water serpent from the ocean now lives in an inland pool. He created many sites and punishes law breakers.	(Barber and Jackson 2011)	Possible (unspecified)	Possible (unspecified)
	Value: In a separate account a sea serpent punishing people was driven back to the sea by a freshwater serpent		Possible (unspecified)	Possible (unspecified)

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: traditional knowledge recalls Manggan created the seas	(NAC n.d.)	Yes	Yes
	Value: traditional knowledge recalls Pannawonica Hill being carried from the sea near Barrow Island or Murujuga by a spirit bird	(Hook et al. 2004)	Possible (unspecified)	Possible (unspecified)
	Value: traditional knowledge recalls Murujuga is where ancestral beings emerged from the sea and brought the Law	(AHC 2012)	Possible (unspecified)	Possible (unspecified)
	Feature: Submerged First Nations archaeological sites in Cape Bruguieres channel	(Benjamin et al. 2020)	No	Yes
	Feature: Submerged First Nations archaeological sites in Cape Flying Foam Passage	(Benjamin et al. 2023)	No	Yes
	Value: traditional knowledge recalls Maarga (creation ancestors) lifted the land and sky out of the ocean	(Milroy and Revell 2013; Japingka Aboriginal Art 2023)	Possible (unspecified)	Possible (unspecified)
	Feature: submerged waterholes related to the Kangaroo songline	(Kearney, O'Leary, and Platten 2023)	Possible	Possible
	Value: traditional knowledge holds that Songlines continue beyond the current coast and across the submerged landscape		Possible (unspecified)	Possible (unspecified)
	Value: songlines are captured through storytelling, rock art, songs and dance, and in the landmarks themselves	(Bainger 2023)	Possible (unspecified)	Possible (unspecified)
	Value: Murujuga is the start of many songlines, including the Seven Sisters		Possible (unspecified)	Possible (unspecified)
	Value: songlines at Murujuga date back to times when the sea-level was lower	(MAC 2023b)	Possible (unspecified)	Possible (unspecified)
	Feature: rock art	(Weerianna Street Media Production 2017)	Possible (submerged)	Possible (submerged)
	Feature: sacred sites		Possible (unspecified)	Possible (unspecified)
	Feature: resources including fish, turtles	(Leach 2020)	Possible (turtles, fish)	Possible (turtles, fish)
	Feature: fish traps exist throughout the archipelago		No	Possible
	Feature: shell middens exist on coastal margins		No	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Feature: submerged archaeological sites		Possible	Possible
	Value: Law emerged from the sea and travelled inland		Possible (unspecified)	Possible (unspecified)
	Feature: resources including mangrove seeds, turtles, turtle eggs)	(Smyth 2007)	Possible (turtles) No (other resources)	Possible (turtles, turtle eggs, mangrove seeds)
	Value: it is recalled that ceremonies were conducted on islands		No	Possible (unspecified)
	Feature: archaeological sites on Murujuga	(McDonald 2015; 2023)	No	Possible (submerged)
	Feature: archaeological sites on Enderby Island.	(McDonald, Reynen, Blunt, Ditchfield, Dortch, et al. 2022)	No	Possible (unspecified, but likely refers to onshore areas above HAT)
	Feature: archaeological sites on Rosemary Island	(McDonald, Reynen, Blunt, Ditchfield, Monks, et al. 2022)	No	Possible (unspecified, but likely refers to onshore areas above HAT)
	Feature: petroglyph and other archaeological sites at Murujuga	(Dortch et al. 2019)	No	Possible (submerged)
	Feature: archaeological evidence of the use of resources including fish, turtles, marine mammals, crocodiles, crabs and sea urchins		Possible (albeit unlikely)	Possible (submerged, highly unlikely for most evidence of faunal use to survive inundation)
Ngarla	**Value**: traditional knowledge recalls that Solitary Island is the petrified form of the ancestral octopus Marnmulkura	(Wanparta Aboriginal Corporation 2022)	No	Possible
	Value: people access waters	*Brown (on behalf of the Ngarla People) v State of Western Australia* [2007] FCA 1025	No	Possible
	Value: use the waters for subsistence		No	Possible
Nimanburr	**Feature**: Places of cultural importance, including Yarp, Flora, Dora Springs, Jinardi (Turtle Point), Repulsive Point. Piridi, Patterson, Milli Milli Lakes, Common Ground at Bungaduk and top of Milli Milli, Lake Louisa, Valentine Island, Tower Hill, Reserve Hill, Bobbie's Creek, La Djardarr Bay and Old Mission, and Ladogen Pool.	(Marshall 2020)	No	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: Valentine Island is a culturally-significant site for Nimanburr people. Only Traditional Owners and community members should be going to this island as there are concerns for the cultural integrity of the site and the cultural safety of the unauthorised visitors.		No	No
Nyangumarta and Karajarri	**Feature**: Resources including Pirrala (Threadfin Salmon), Ulu (Bluebone Groper), Yilany (Mangrove Jack), Wangkaja (Mudcrab), Janga (Oyster) and Riji/Jakuli (Pearl Shell) which has important cultural and ceremonial value. Karajarri coastal waters contain great numbers of wild pearl shell	(Karajarri Traditional Lands Association 2014)	Possible (Fish)	Possible
	Feature: Saltwater habitats, including Wintirri (sandy beaches, dunes and cliffs), Wangku (rocky headlands), Puntu (intertidal mudflats/freshwater seepages), Parnany (reefs) and Wankurru (deep sea), hold cultural importance		No	Possible
	Value: Saltwater habitats provide resources including food resources. An integral part of keeping people healthy on country and maintaining elements of traditional lifestyle is the sustainable harvesting of food resources from Jurrar (coastal country).		No	Possible
	Value: management of access to coastal areas prevents degradation to landscapes, cultural sites and biodiversity values		No	Possible
	Value: There is a desire to educate visitors and inform them of the importance of coastal areas		No	Possible
	Value: Beaches, tidal creeks, bays, reefs and sea-grass beds are breeding and feeding grounds for threatened and migratory sea turtle species such as the Olive Ridley, Hawksbill Turtle, Loggerhead Turtle and Green Turtle. Dugongs and Snubfin Dolphin inhabit the near-shore areas.		Possible (turtles only)	Possible
	Value: Caring for Country including maintaining cultural sites in coastal and inland areas such as fish traps, Ceremonial Increase sites, ceremonial areas and Pulany (mythical Serpent) sites		No	Possible
	Value: The Wirntirri (sea grass beds) and beaches are important environments for Wilarr (particularly Flatback and Green Turtles)		No (seagrass and beaches)	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: Areas of Parnany (reef), Wirntirri (sea grass) and Wurrja (seaweed) along the Karajarri coastline provide important habitats for fish and other marine species that contribute to the diet of Karajarri people		No	Possible
	Value: Fishtraps and middens along the Karajarri coast show the historic cultural importance of saltwater resources.		No	Possible (unspecified)
	Value: Fishtraps are still in use today and require ongoing maintenance		No	Possible (unspecified)
	Value: Karajarri want their protocols on country followed by visitors so that their laws and customs are respected. Without respecting what Karajarri want on their country visitors are believed to be putting their own health and that of traditional owners at risk.		No	Possible
	Value: The Kuwaiyinpijala ritual involves spraying spring water from the mouth to cautiously introduce oneself to the Pulany (mythical watersnakes) which reside in springs and Jilas.		No	No (onshore ritual)
	Value: When deemed necessary, Pirrka (Lawmen) or Yiliwirri (rainmakers) are able to interact with Pulany, some of which are considered 'cheeky' or dangerous, particularly to children, and unpredictable.		No	Possible
	Value: connection to Country and Sea Country, deponents describe the expanse of the claim area, including both land and sea as 'Karajarri country', the country of their predecessors and themselves, and of having the right to speak for the country. several of the deponents speak of having stories in relation to, and responsibility to look after, the sea and coastline within the claim area.	(NNTT 2000)	No	Possible
	Feature/Value: 'The Pukarrikarrajanka Dreaming', and spiritual beings continue to inhabit specific places including area Eighty Mile Beach Marine Park, which contains spiritually significant water sites for both the Karajarri and Nyangumarta people. Many of these sites are described as being inhabited by pulany (spirit	(DPAW 2014)	No	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	snakes/water snakes/serpents) who reside in permanent water sources, and may also reside in the sea.			
	Features: Reefs, coastal creeks, mangroves and intertidal flats in and adjacent to the marine park are particularly important for resource usage. Fish traps and shell middens along the coast show the historical importance of saltwater resources.		No	Possible
	Value: Stories, songlines and sites are embedded within the Eighty Mile Beach and Cape Keraudren areas and remain a powerful spiritual force for the Karajarri, Nyangumarta and Ngarla people. Land, sea and Aboriginal culture are interconnected.		No	Possible
	Value: cultural obligation to protect and educate visitors on Eighty Mile Beach, transmit cultural knowledge to the next generation and uphold cultural protocols (including performing a water blowing ceremony known as wirripilipini “blowing the water”).		No	Possible
	Feature/Value: resource collection at thalu sites. Eighty Mile Beach contains important cultural sites including special sites known as ‘increase sites’, located throughout Karajarri country. Adjacent to the marine park there is an increase site for catfish.		No	Possible
	Value: Customary use of the area includes camping, nature appreciation, fishing, hunting and other harvesting activities. Limited hunting of turtle (predominantly collection of turtle eggs) also occurs. As well as fish, for the Karajarri people, pinka (baler shells) are an important sea country resource. The Karajarri people describe how baler shells are left near water sources inland from the coast to mark places where water can be found by traditional owners and other Aboriginal people passing through the area.		No	Possible
	Feature: Four special purpose zones (cultural heritage) are included in the marine park zoning scheme to provide increased recognition and protection of culturally significant sites along Eighty Mile Beach including pulany (which refers to both spirit snakes and marine water snakes) and other important heritage sites.		No	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Interest: water		Unlikely due to distance to Project Area	Yes
	Feature: archaeological sites at Eight Mile Beach including pinka (large baler shells) used to scoop and carry water for drinking, wiluru (like an oil stone) used for sharpening spear heads, axes, and flakes, and kurtanyanu and jungari (grinding stones). At coastal soaks, springs and jila, there were always shell middens of oysters, cockles and other shell fish. Significantly, most of the latter sites were in use until recent times. The springs and other ephemeral surface water sources, such as the lakes formed in claypans after rainfall, and coastal springs support a variety of birds, marsupials, insects such as karratu and reptiles. The Karajarri and other TOs continue to exploit these resources seasonally and are essential to Karajarri environmental and cultural requirements	(Yu 1999)	No	Possible
	Value: strong spiritual relationship to water; connection to Sea Country		No	Possible
	Features: The Karajarri assert that they and their ancestors have lived in the region of La Grange since time immemorial and traditionally moved between camps along the coastal creeks, the inland bush and into the desert country. Knowledge of the location, size and condition of their water sources was essential for survival as they traversed the country from inland to coast. Relationships between coastal ecology and land ecology including salt water and fish, such as mullet and bream).		No	No
	Value: Pukarrikarra Dreamtime, Ngurrara Country, Pulany (both mythical serpents and marine water snakes; both who can reside in the sea), Ngapa kunangkul (living water); water sources and their significance		No	Possible
	Features: Important cultural features are not just surface phenomena, such as hills, trees, animals, creeks, bays and so on. They also include subterranean features and activities, for example groundwater and its flow, or rock formations and associated activity such as earth tremors. (This implies that things that cause or impact upon subterranean features (such as earth		Unlikely due to distance from Project Area	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	tremoring associated with mining) will have a huge impact on life and water).			
	Features: important areas including west Kimberley coast extending ~200 km inland towards the McLarty Hills. On a coastal north–south axis, the basin extends from Roebuck Plains to Salt Creek. Inland, the basin lies between the Edgar Ranges and Dragon Tree Soak (demonstrating the connection between the ocean and inland areas).		No	No
	Feature: resource collection including from ground water springs, coast old shell middens, fish traps and fishing (associated with the sea's fertility).	(Weir 2011)	No	Possible (fish traps/ fishing)
	Feature: Eighty Mile Beach important place for the movement of the Karajarri people in the claim area including coastal areas for ritual and economic purposes.	(NNTT 2009)	No	No
	Value: Eighty Mile Beach (strong connection to the place and surrounding waters)	(NWAC and YMAC 2022)	No	Yes
	Interest: Nyangumarta determined their Indigenous Protected Area (IPA) to promote biodiversity and to promote and protect cultural values, beliefs and practices.		No	Possible
	Value: The foundation for this is 'laid down' in the ancestral past known to Nyangumarta people as Pukarrikarra (The Dreamtime). The Ancestral Beings that travelled across the Nyangumarta land and seascapes are eternal; their power is both benign, everlasting, malevolent and resides in sacred objects, in songs and dances and in sites located throughout Nyangumarta Country. Country is to Nyangumarta a mythopoeic landscape/ seascape populated by songs, narratives, rituals, deceased persons and Ancestral Beings. Nyangumarta language is inscribed upon Nyangumarta Country. A supernatural essence dwells in and radiates from places where Ancestral Beings 'came up' and/or 'went in', bestowed names upon, or transformed themselves into features of the contemporary cultural and natural landscapes. These places are highly significant to Nyangumarta People.		No	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Feature: the coastline dotted with sites of special significance; several of these sites are associated with The Dreaming (Pukarrikarra).		No	Possible
	Value: majority of the Nyangumarta population live by the sea and use it for cultural and recreational purposes as well as supplementing the household diet through fresh fish such as whiskered salmon, black tipped reef shark, saw fish, stingrays and oysters.		No	Possible
	Value: important things on Country for Nyangumarta people including Nyangumarta Law and Culture, Important Sites, Governance and Partnerships, Nyangumarta People and Pathways, Desert Country and Saltwater Country. This is part of a holistic approach to land management where the landscape, plants and animals within Nyangumarta have been inseparable from Nyangumarta Lore, culture, language and traditional knowledge since creation-time. Nyangumarta see maintenance and protection of the law, culture, language and traditional knowledge as integral with the maintenance and protection of the natural environment.		No	Possible
	Feature: Many sites are believed to be created and inhabited by Pulany (powerful mythical water snakes) and how these places are approached and managed is important.		No	Possible
	Interest: to protect Country from the following threats – lack of knowledge transfer, wrong way visitation, inappropriate mining and development, difficulties in accessing country, feral animals and cattle damaging country, feral cats, lack of access to good water, wildfires burning, and cane toads.		No	Possible
Nyul Nyul	**Value**: Tjukurrpa (dreaming) story of the bilby travelling from the desert to the sea	(Indigenous Desert Alliance n.d.)	No	Unlikely due to distance from EMBA
	Feature: Middens near the coast	(Dobbs et al. 2015)	No	No
	Feature: Burial grounds near the coast		No	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Feature: Weedong, a large coastal lake located immediately behind sand dunes		No	No
	Feature: Boolamon is a coastal lake-like waterhole located south-west of Bobbis Creek		No	No
	Value: Access to Weedong for hunting animals including cattle, ducks, goanna, nimunburr (Black flying fox) and Jibalgurr (Little friarbird) and gathering Wirdamunga (Waterlily) for food.		No	No
	Value: Trees (including Garnboorr/Paperbark and Lardik) surrounding Weedong attract animal species hunted as food		No	No
	Value: Trees (including Garnboorr/Paperbark and Lardik) surrounding Weedong and provide indicators of important seasonal events		No	No
	Value: Women’s' sites at Weedong		No	No
	Value: Water flow on Dampier Peninsula for fish movements		No	No
	Value: Caring for Country including preserving routes for fish movement for breeding, and erecting signs		No	No
Thalanyji	**Feature**: resources including fish, shellfish, crabs, crustaceans, sea urchins, turtle, dugong and flora and fauna associated with mangrove communities	(CoA 2002)	Possible (fish, turtle, dugong, invertebrates)	Possible (fish, turtle, dugong, invertebrates, mangrove communities)
	Feature: archaeological sites on Barrow Island		No	Possible (shoreline accumulation areas)
	Value: connection to Country		Possible (unspecified)	Possible (unspecified)
	Feature: resources include turtles, eggs, fish, shellfish and plants	(DBCA and Nyinggulu Joint Management 2022)	Possible (fish, turtle)	Possible (fish, turtle, eggs, shellfish)
	Value: traditional knowledge recalls a water snake is located in inland waters	*Hayes on behalf of the Thalanyji People v State of Western Australia* [2008] FCA 1487	No	No
	Value: connection to Country.	(DBCA 2022b)	Possible (unspecified)	Possible (unspecified)

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: transfer of knowledge.		Possible (unspecified)	Possible (unspecified)
	Value: access to Country.		Possible (unspecified)	Possible (unspecified)
	Value: access to Barrow and possibly Montebello Islands	(Hook et al. 2004)	No	Possible
	Feature: artefact scatters are located in coastal sand dunes	(Archae-aus 2020)	No	Possible (shoreline accumulation areas)
	Feature: burials are located in coastal sand dunes		No	Possible (shoreline accumulation areas)
	Value: traditional knowledge recalls a water snake is located in inland waters		No	No
	Feature: archaeological sites are located on Barrow Island	(Ditchfield et al. 2018; Paterson 2017)	No	Possible (shoreline accumulation areas)
	Feature: archaeological sites are located at Barrow and Montebello Islands	(Dortch et al. 2019)	No	Possible (shoreline accumulation areas)
	Feature: archaeological evidence of the use of resources including fish, turtles, marine mammals, crocodiles, crabs and sea urchins		Possible (albeit unlikely)	Possible (submerged, highly unlikely for most evidence of faunal use to survive inundation)
	Feature: thalu ceremonial sites for the increase of turtle, shark, ray, fish, squid, octopus, hill kangaroo and emu	(DBCA 2022b)	No (ceremonial use) Possible (submerged thalu sites e.g. petroglyphs)	No (ceremonial use) Possible (submerged thalu sites e.g. petroglyphs)
	Feature: ceremonies		No	No
	Value: connection to Country.		Possible	Possible
	Value: transfer of knowledge		Possible	Possible
	Value: access to Country		Possible	Possible
Yawuru	**Feature**: Resources including bluebone, molluscs, fish, crustaceans, oysters, birrga-birrga (cockles), mulj (periwinkle), njiwa (green crab), umung-umung (hermit crab)	(Yawuru RNTBC 2014)	Possible (Fish) No (other resources)	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Feature: camp sites including middens and shells		No	No
	Feature: Snubfin Dolphin, fish including sharks and rays, and migratory birds		No	Possible
	Value: Yawuru country is a living cultural landscape.		No	No
	Value: The right to enjoy Yawuru country and to maintain customary practices		No	No
	Value: Yawuru are responsible for looking after Yawuru country		No	No
	Value: Yawuru traditional ecological knowledge is the foundation for ecologically sustainable resource management		Unlikely given distance to Project Area	Unlikely given distance to EMBA
	Value: Traditional knowledge allows people to "read the sea" and determine when it is a good day for collecting a resource.		No	No
	Value: ceremony involving song and corroboree would increase populations of fish, oysters and grubs		No	No
	Value: Reefs and sea-grass beds provide habitats for dugong and sea turtle species including Hawksbill Turtle, Loggerhead Turtle, Green Turtle and Flatback Turtle		No (reefs and seagrass beds)	Possible
	Value: Monsoon vine is a culturally important source of bush food, materials and medicine.		No	Possible
	Value: Mangrove communities provide nursery grounds for culturally important fish and crab species, roosting and feeding sites for megabat and microbat populations, and important habitat for numerous bird species.		No	Possible
	Value: Niyamarri (sand dunes) carry many of the stories of ancestral beings that formed Country, revealed in songlines that cross the Australian continent.		No	No
	Value: sand dunes defend Country from the tidal surges that come with wet season cyclones: "They are also important for cyclone protection, a windbreak for the town".		No	No

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Value: sand dunes at Beacon Hill were filled with middens, artefacts, shells and grinding stones.		No	No
	Value: There were three places in the Beacon Hill sand dunes that should never be touched for cultural reasons		No	No
	Interest: evidence of resource collection in coastal areas including fishing, crabbing and cockling as well as the obtaining of bush medicine and bush tucker.	*Rubibi Community v State of Western Australia (No 7)* [2006] FCA 459	No	No
	Feature: law ground at Kunin (northern part of Yawuru community)		No	No
	Value: access to and management of Country including the waters. The right to walk on Country, fish and hunt	(DBCA 2023)	No	No
	Value: cultural obligations to respect the Dreaming and spirits and to continue cultural traditions.		No	No
	Interest: Joint management of the Yawuru Conservation Estate (comprises four different parks, managed holistically and collaboratively by the Yawuru joint management team at DBCA under the direction of two joint management bodies (JMBs), marine and terrestrial). The JMBs comprise the Yawuru Native Title Holders Aboriginal Corporation RNTBC, DBCA and (for terrestrial conservation parks) the Shire of Broome. The four parks are: Guniyan Binba Conservation Park; intertidal area of north Cable Beach and Willie Creek; Yawuru Birragun Conservation Park; lands adjacent to Willie Creek and Roebuck Bay; Yawuru Minyirr Buru Conservation Park; lands within Broome townsite including Minyirr Park; and, Yawuru Nagulagun/ Roebuck Bay Marine Park; intertidal and subtidal areas of Roebuck Bay.		No	No
	Feature: Nagulagun (Sea Country) includes all that lives in the sea: the fishes, turtles, dugongs, and their habitats. It is nagula (seawater), the seabed, barnany (the reefs), muri (tidal creeks), jani (white sandy beaches), the sand bars that cross Roebuck Bay, the seagrass meadows, jabarlbarl (mudflats and claypans) and all the life they support. It is the currents and tides. Gamirda-gamirda (shorebird) habitat; jani and intertidal flats; The	(DBCA 2020a)	Possible (fish, turtles)	Possible

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	Wirrjinmirr/Willie Creek wetlands system; Gundurung (mangroves); Salt flats; Nimalaica/Nimmalarragun wetland; Ngunungurrukum/Coconut Wells lagoon.			
	Value: cultural activities including knowledge of saltwater jurru (metaphysical serpent-like beings), fish-traps, dolphins and whales, dugong and turtle, fish, stingray, shellfish, coral reef, mangroves, mudflats (calcium carbonate) and the intertidal areas.		No	No
Unspecified	**Feature**: the ocean can include sacred sites and songlines	(Smyth 2008)	Possible (unspecified)	Possible (unspecified)
	Value: people have kin relationships to important animals, plants tides and currents		Possible (unspecified)	Possible (unspecified)
	Feature: archaeological sites in submerged landscapes	(Bradshaw 2021)	Possible	Possible
	Value: sea country has customary law defining ownership and management rights and responsibilities	(Muller 2008)	Possible (unspecified)	Possible (unspecified)
	Value: knowledge of Sea Country	(Kearney, O'Leary, and Platten 2023)	Possible (unspecified)	Possible (unspecified)
	Value: connection to Sea Country		Possible (unspecified)	Possible (unspecified)
	Value: care for Sea Country		Possible (unspecified)	Possible (unspecified)
	Value: the extent of Sea Country is determined by the travels of dreaming ancestors. This is recorded and conveyed through songlines.		Possible (unspecified)	Possible (unspecified)
	Feature: archaeological sites indicate that islands were occupied prior to sea level rise	(DBCA 2020c)	Possible	Possible (submerged)
	Value: sea country includes values, places, resources, stories and cultural obligations	(Smyth 2007)	Possible	Possible
	Value: activities relating to resources included: dugong hunting turtle hunting turtle egg collecting seabird egg collecting spearing fish		Possible (activities and fauna present)	Possible (activities and fauna present)

First Nations Group	Features and Values	Source	Potential for Overlap	
			Project Area	EMBA
	reef trapping fish herding fish line fishing collecting fish in stone fish traps poisoning fish gathering shellfish and other marine resources.			
	Value: people have kinship relationships with every plant and animal	(Juluwarlu 2004)	Likely to occur	Likely to occur
	Value: certain species, including fish and seafood, must not be eaten during initiation rituals due to their sacredness to the creation being Barrimirndi. Breaking this law may lead to cyclones.		No	No
	Feature: tangible and intangible heritage.	(Macfarlane and McConnel 2017)	Possible (unspecified)	Possible (unspecified)
	Feature: archaeological evidence of varied occupation and adaptation.		Possible	Possible
	Value: a distinct way of life centred around the use of limited water and coastal resources.		No	Possible (unspecified)

7.9.6.2 Studies of Cultural Features and Heritage Values

7.9.6.2.1 First Nations Archaeological Heritage Assessment

Woodside understands that communal cultural connection may exist between First Nations people and land and waters. It is understood from the onshore archaeological record that First Nations people have occupied the Australian continent for at least 65,000 years (Clarkson et al. 2017) and in many places maintain a strong continuing connection that is said to extend back in First Nations cosmology to the beginning of time.

It is understood that the sea level has risen significantly during the 65,000 years of First Nations occupation, and areas that were once inhabited are now submerged on the continental shelf (Veth et al. 2020; UWA 2021). Woodside also understands that, at its lowest level during First Nations occupation, sea level was between 125 m (O'Leary, Paumard, and Ward 2020; Veth et al. 2020; Williams et al. 2018) and 130 m below current levels (Benjamin et al. 2020; 2023; UWA 2021). Archaeological material preserved on the 'Ancient Landscape' has the potential to provide further information about the earliest periods of human occupation (Veth et al. 2020; UWA 2021).

Recent archaeological discoveries demonstrate that the now submerged landscape was occupied and inhabited, and can retain archaeological material from this time (Benjamin et al. (2020; 2023); see Ward et al. (2022) for an opposing view).

In recognition of this, Woodside considers the Ancient Landscape between the mainland and the ancient coastline at 125 m depth contour KEF (see Section 7.7 for a description of the KEF) as an area where potential First Nations archaeological material may exist on the seabed, as this covers the full extent of this possible First Nations occupation. The Project Area predominantly occurs on the Ancient Landscape but the north-east extent of the Project Area also extends beyond the furthest extent of the Ancient Landscape (i.e. ~6–13 km beyond the ancient coastline KEF). Archaeological material on the Ancient Landscape is a relevant matter for the Goodwyn Area Infill Development as there is overlap between the Project Area and the Ancient Landscape, and potential for seabed disturbance from planned activities and therefore potential for impacts to archaeological material.

Known First Nations heritage places including archaeological sites may be protected subject to declarations under the ATSIHP Act, UCH Act, or EPBC Act. Woodside is not aware of any registered or recorded First Nations archaeology within Commonwealth waters.

The WA Department of Planning, Lands and Heritage (DPLH) maintains a register of registered sites and heritage places including middens, burial, ceremonial [sites], artefacts, rock shelters, mythological [sites] and engraving sites. A search of DPLH's Aboriginal Cultural Heritage Inquiry System was undertaken, which showed 576 registered sites in the EMBA (Appendix D). These included sites along the coast of the North West Cape, Murujuga (Burrup Peninsula), and other mainland coastal areas, registered for artefacts, ceremonial, mythological, middens, and rock shelters.

Existing Research and Desktop Assessment

In Australia until recently, the consideration of submerged archaeological sites has generally focused on the sub-discipline of maritime archaeology with connection to Australian First Nations archaeology through studies of First Nations fish-traps, whaling stations and shipwreck survivor camps. However, with the exception of First Nations fish traps in intertidal zones, the consideration of First Nations heritage sites submerged by post-glacial sea-level rise has only recently been considered (Mott 2019).

There has been long and continuous occupation of the coastal Pilbara region as evidenced by scientific studies (Balme et al. 2009; J. McDonald et al. 2018; Veth et al. 2017). Petroglyph motifs feature a range of subject matter with many examples depicting extinct fauna and early stylistic techniques (McNickle 1984; McDonald 2005; Mulvaney 2009; 2010; 2013).

In order to assess and define potential for preservation of submerged Late Pleistocene and Holocene sediment bodies that may contain preserved archaeological deposits, modelling on continental shelf development in the Dampier Archipelago has been undertaken. Note: The Dampier Archipelago is ~100 km from the Project Area for the Goodwyn Area Infill Development. Analysis and modelling between the Last Glacial Maximum, through the Holocene marine transgression and up to the present day has shown that archaeological materials, if present, would most likely be evident in deposits associated with the early phases of inundation of the Dampier Archipelago, dating from around 9 to 7 ka before present (BP) (Ward et al. 2013). In contrast, the study proposes that coastal archaeology older than about 12 ka BP, when the post-glacial sea levels were below about 50 m, will have been exposed to a phase of faster tidal currents on the continental shelf, and hence eroded or poorly preserved (Ward et al. 2013).

A paper examining terrestrial analogy as a predictive tool for targeting submerged archaeological sites, provides several key elements to consider when examining the potential for identifying and managing submerged First Nations heritage sites (Veth et al. 2020). Analysis of more than 2,500 known archaeological sites from the Dampier Archipelago reveals that the vast majority are rock art sites, but these are interspersed by a significant number of artefact scatters, myriad stone structures, shell middens, and quarry and reduction areas. The majority of these sites are focused on coastal and interior valleys, associated uplands, and coastal embayments. While over two thirds of sites occur on granophyre and basalt substrates, the others are located on quaternary sediments. Regional research on nearby continental islands shows that use of these environments can be expected to pre-date sea-level rise (Veth et al. 2020).

Through the Deep History of Sea Country (DHSC) project, researchers undertook a systematic and hierarchical approach to underwater investigation of the submerged landscapes at Murujuga (Dampier Archipelago). The researchers looked at the previously recorded First Nations heritage sites from terrestrial surveys and used principles of geological, geomorphological and environmental associations to extrapolate to submerged landscapes. Where possible, the research considered submerged landscape principles as comparable but recognised that a range of factors may affect direct comparisons. A major constraint to any comparative studies is the shortage of marine stratigraphic, paleo-environmental, or geochronological data, and thus comparisons were initially divided into hard (crystalline) rock and soft (sedimentary) rock contexts, with the relative age of a potential site or deposit based on bathymetry (i.e. depth below modern sea level) and morphological setting. These essentially inform and delineate prospective target areas for broad-scale underwater mapping (Veth et al. 2020).

The sites considered most likely to survive inundation, based on the review of existing literature, were logically the more robust forms including:

- midden and artefacts within cemented dunes, relict water holes, and beach rock deposits
- quarry outcrops, extraction pits, and associated reduction debris in fine-grained volcanic outcrops
- curvilinear stone structures and standing stones sitting on volcanic pavements and jammed into volcanic rock piles
- lag deposits of artefacts and possibly midden on hardpan in suitable landscape contexts with good preservation conditions (e.g. shallow declination shorelines in sheltered passages of the inner archipelago or on the leeward side of hard-rock/fringing reef cause-ways adjacent to the outer islands)
- small overhangs and shelters with preserved deposits, facing away from the dominant wave and wind action (Veth et al. 2020).

Goodwyn Area Infill Geotechnical and Geophysical Survey

Comber Consultants were engaged by Woodside to undertake a desktop UCH assessment.

Based on searches of heritage registers and databases, there are no First Nations sites or places registered within the Project Area (Nutley 2023b). The closest location of a known area of First Nations significance is registered terrestrial sites on Campbell Island (within Montebello Islands), ~38 km south of the Project Area

A review of historic sea level changes and seabed morphology suggests that a complex coastal landscape of ridge lines, hills and an estuarine channel may have been present within the Project Area ~52–20 kya (Nutley 2023b). Given the complex landforms, and duration of exposure, these areas would have had high potential for the accumulation of significant deposits of archaeological materials as well as for the development of complex cultural and spiritual association (Nutley 2023b).

The desktop assessment noted that legacy geophysical data was not designed to identify archaeological artefacts, and consequently an assessment of archaeological potential (i.e. the likelihood of a site to contain archaeological deposits that are protected by the provisions of the UCH Act or EPBC Act) was unable to be completed (Nutley 2023b). However, Woodside is committed to undertaking a review of further[33] geophysical and geotechnical data within areas where planned activities will interact with the seabed, to assist in identifying any indicators of First Nations cultural heritage (Section 9.3.6). The results of these assessments will also be incorporated into the subsequent EPs for the Goodwyn Area Infill Development.

Woodside's Scarborough Project

The trunkline for the Scarborough Project traverses the southern extent of the Project Area for the Goodwyn Area Infill Development, and the EMBA for both offshore projects overlap (Figure 7-41). As such, relevant studies related to First Nations archaeological heritage have been summarised in Table 7-29.

Table 7-29: Summary of archaeological heritage assessments undertaken for the Scarborough Project

Study	Summary
Geotechnical sampling	Geotechnical sampling along the proposed Scarborough trunkline route has shown that sediments are predominantly comprised of soft silty sands and therefore those landforms other than the first are highly unlikely to be present along the pipeline alignment. Rocks such as the dolerites, gabbros and other volcanic rocks on which Murujuga rock art is found are not present along the Scarborough trunkline route.
First Nations heritage desktop investigation	Integrated Heritage Services was engaged by Woodside to conduct a First Nations heritage desktop investigation and initial ethnographic consultations with First Nations representatives, for the offshore and landfall component of the proposed Scarborough Project (Mott 2019). Subsequent to the finalisation of Mott (2019), the conclusions of Veth et al. (2020) were tested through direct inspection with DHSC divers which led to the discovery of two locations with First Nations UCH (Benjamin et al. 2020) in Flying Foam Passage and Cape Bruguieres in State waters[34]. This demonstrated the potential for UCH to exist on the NWS and highlighted the need to assess the potential impacts of offshore developments on submerged heritage landscapes (UWA 2021). MAC was consulted during the development of the Scarborough Project (Nearshore Component) Dredging and Spoil Disposal Management Plan (DSDMP) (Woodside 2023c). As a part of the DSDMP consultation, MAC advised that DHSC had identified two areas[35] considered "culturally prospective": *The first is the Madeline [sic] Shoals, which… is formed of the same igneous geology as the other areas of the archipelago where sub-tidal archaeological sites have been found. The second area is a 3 km wide relict submerged paleo beach barrier system that extends across the northern entrance to Mermaid Sound, over which the proposed '*Scarborough*' trunk line route passes. This is an area of hard grounds… with high potential to contain Aboriginal lithic materials cemented within the deposits.*

[33] Woodside is proposing to undertake geophysical and geotechnical surveys on the NWS, including the Project Area for the proposed Goodwyn Area Infill Development. These surveys are the scope of a separate EP that will be submitted to NOPSEMA and area not part of the activities within scope of this OPP.

[34] Both sites are within the broadened EMBA for the Goodwyn Area Infill Development (see Section 7.1); but are not within the areas predicted to exposed during hydrocarbon spills (see Figure 9-10 and Figure 9-11 in Sections 9.2.6 and 9.2.7 respectively).

[35] Both areas are within the broadened EMBA for the Goodwyn Area Infill Development (see Section 7.1); but are not within the areas predicted to exposed during hydrocarbon spills (see Figure 9-10 and Figure 9-11 in Sections 9.2.6 and 9.2.7 respectively).

Study	Summary
Trunkline First Nations cultural heritage assessment	Following the recommendations of Mott (2019), Woodside engaged with the DHSC project from mid-2019. Woodside subsequently engaged researchers from the then-concluded DHSC project based at the University of Western Australia (UWA) to assess the prospectivity for archaeological sites along the Scarborough trunkline route and adjacent areas, beginning at the Burrup Peninsula and ending at the edge of the continental shelf in consultation with MAC (UWA 2021). The UWA First Nations UCH assessment along the proposed Scarborough trunkline route developed a predictive model for the potential for UCH to be located within the submerged landscapes along the Scarborough trunkline route (UWA 2021). The middle shelf landscape (water depths 35–75 m) assessment, which includes areas within the Montebello Marine Park, noted that "[t]he mid shelf is flat, relatively featureless and covered by a thick layer of recent marine sediments" (UWA 2021). Two "low relief beach ridge and beach barrier features", within water depths of 47–48 m and outside the Goodwyn Area Infill Development's Project Area, that were identified were considered to predate the 65,000 years of scientifically verified occupation of the Australian continent and "[t]herefore, they are likely to have a low prospectivity for cultural heritage being captured in these durable surfaces at formation, and similarly low potential for subsequently deposited cultural material having survived initial inundation and subsequent marine pedogenic forces" (UWA 2021). The assessment also identified within the Scarborough EMBA "two mounds which are interpreted as low relief hills of an unknown geology" (UWA 2021). The outer shelf (water depths of 75–130 m), which may include the Goodwyn Area Infill Development's Project Area, possesses a highly prospective cultural landscape (UWA 2021), including "several locations at the outer edge of the continental shelf where the reconstructed submerged landscapes are assessed as having high potential for significant heritage being present... These high potential landscape features are especially notable to the north of the proposed Scarborough pipeline. If submerged heritage was to be encountered here, it would be of high significance, ." This includes landforms with "increased heritage sensitivity (i.e. karst depressions, tidal channels) in proximity to the pipeline" (UWA 2021). The Scarborough EMBA, and the Goodwyn Area Infill Development EMBA, also include areas of the inner shelf (in water depths of 0–30 m of water) where "development proposal is likely to have nil or very low impact on any places with heritage values. (UWA 2021). The inner shelf includes "submerged barrier systems which outcrop at the seabed" (UWA 2021). The assessment noted these were dated "between 80,000 to 130,000 years BP and 186,000 to 245,000 years BP. Given these early ages it is unlikely that these barriers formed as an active cultural landscape and therefore these are unlikely to be prospective for encapsulated archaeological evidence. While it is possible that people may have occupied these exposed landscapes at any time in the last 65,000 years, the absence of water or other attractors associated with these identified low relief limestone-ridge landscapes lowers this potential, while their exposed nature makes for low survival chances of artefactual deposits laid on these exposed hard surfaces" (UWA 2021). The inner shelf includes "no palaeochannels, relict waterholes, clay pan features, or igneous rock outcrops – such as can be observed in other parts of the Dampier Archipelago – that have been identified as hosting or potentially hosting cultural heritage sites" (UWA 2021). "[t]he palaeochannels of the Maitland River and Nicoll River are identifiable on the seabed to the south of Enderby Island and the east of the Archipelago on the inner shelf" (UWA 2021).
Trunkline route SSS review	At the request of MAC, a review of existing SSS data for the Scarborough trunkline route on the Ancient Landscape was undertaken by a maritime archaeologist (Nutley 2022), with a particular but not exclusive focus on submerged fish traps. This review included the barrier systems identified in UWA (2021) in the mid- and inner shelf. This review identified numerous clusters of depressions which are "certainly naturally occurring features" and "none of them appear to be archaeological in nature" but requested further advice on what these represented to better understand the landscape and whether these were permanent features such as karsts. Woodside was able to confirm from existing data and previous investigation that these depressions in sandy sediments are a result of marine life and moving fluids. The report concluded: "No indication of stone structures such as fish traps, or hut foundations could be detected in the inner reef, middle shelf or outer shelf areas. In the middle shelf and outer shelf there were no indicators of former riverbeds, creek lines or lakes with which such feature may be associated" (Nutley 2022).

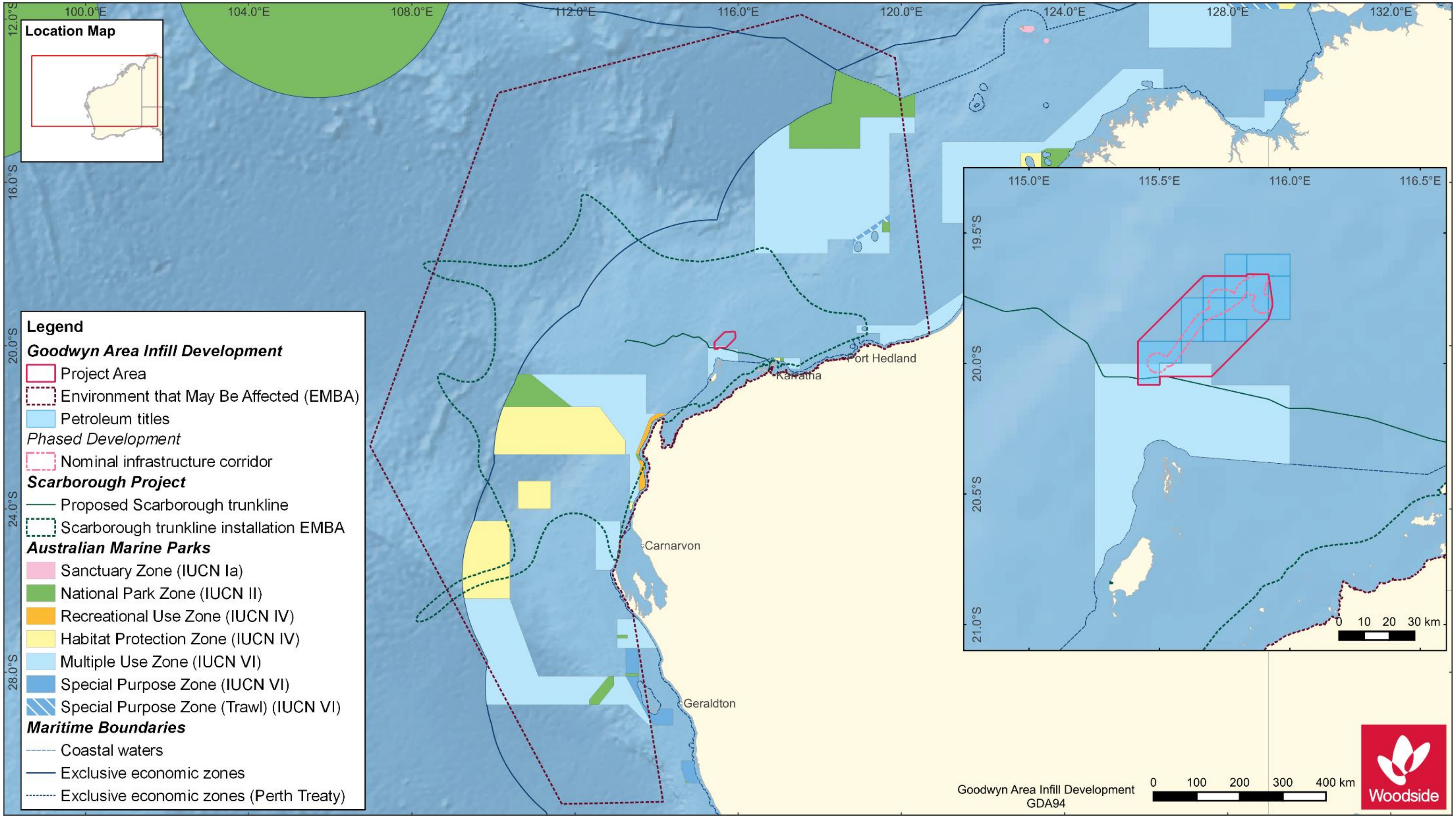


Figure 7-41: Goodwyn Area Infill Development (Project Area and EMBA) and Scarborough Project (proposed trunkline route and EMBA for trunkline installation)

7.9.6.2.2 First Nations Ethnographic Heritage Assessments

Ethnographic surveys are a form of heritage survey conducted by anthropologists or ethnographers to understand cultural features of heritage significance and heritage values within a landscape. This is distinguished from archaeological survey (which focusses on the material remains of human culture) and consultation (which is not confined to an assessment of heritage, is not limited to values of a landscape and may be conducted without an ethnographic methodology).

Ethnographic surveys are "undertaken to identify First Nations cultural heritage sites and values that are identifiable as tangible and intangible elements that are important to the First Nations people of the State, and are recognised through social, spiritual, historical, scientific or aesthetic values, as part of First Nations tradition. To achieve this, an ethnographic survey is undertaken with a First Nations person or persons who in accordance with First Nations tradition, holds particular knowledge about the First Nations cultural heritage and has traditional rights, interests and responsibilities in respect of the First Nations cultural heritage" (Mott 2023).

Cultural jurisdiction is essential to ensure ethnographic survey participants "in accordance with Aboriginal tradition, hold particular knowledge about the Aboriginal cultural heritage", and may be established through a number of mechanisms, including recognition through the determination of Native Title rights, or through land access agreements including ILUAs or ILUA-like agreements. As ethnographic surveys are dependent on the participation of traditional knowledge holders, it is not possible to meaningfully conduct ethnographic surveys proactively over areas for which cultural jurisdiction is not established or unclear.

An ethnographic survey may determine both the tangible and intangible cultural heritage which may be associated with features. Typical results from ethnographic surveys may include the identification of songlines, ceremonial places such as 'thalu' sites for managing environmental resources, or places where activities such as birthing, initiation or other significant activities are performed.

Woodside's Scarborough Project

The trunkline for the Scarborough Project traverses the southern extent of the Project Area for the Goodwyn Area Infill Development, and the EMBA for both offshore projects overlap (Figure 7-41). As such, relevant studies related to First Nations ethnographic heritage have been summarised in Table 7-30.

Table 7-30: Summary of ethnographic heritage assessments undertaken for the Scarborough Project

Study	Summary
Preliminary desktop assessment and ethnographic inspection	The 2019 survey was undertaken to support the Scarborough Project, with members of all five Traditional Custodian groups of Murujuga (Mardudhunera, Ngarluma, Wong-Goo-Tt-Oo, Yaburara and Yindjibarndi) invited through PBC for Ngarda Ngarli people (including NAC and WAC) and MAC, who met on Country with heritage consultants. The aim of this aspect of the work was "to undertake an initial ethnographic site visit to consult with traditional owners to discuss the current research undertaken by others on submerged landscapes generally, and to seek specific feedback on the nature of the proposed pipeline plans including the pipe landfall area, adjacent to a significant Aboriginal heritage site" (Mott 2019). Participants were provided with a map of the Scarborough Project, extending more than 400 km offshore, and asked to identify any values in the surrounding landscape. No cultural features or heritage values were identified in the Scarborough EMBA through this survey (Mott 2019),noting there are overlaps between the Scarborough and the Goodwyn Area Infill Development EMBAs.
Ethnographic consultation	The 2020 survey was undertaken to support the Scarborough Project with MAC as representatives of Traditional Custodians for the onshore and nearshore aspects of the Scarborough Project. MAC appointed their preferred heritage consultants to meet on Country with the MAC Circle of Elders to discuss the project and identify any cultural values (McDonald and Phillips 2021). The resulting report is owned by MAC and was approved by the Circle of Elders prior to being provided to Woodside. Representatives from the Mardudhunera, Ngarluma, Yaburara, Yindjibarndi and Wong-

Study	Summary
	Goo-Tt-Oo peoples—all five First Nations groups represented by MAC (MAC 2023c)—participated in this survey (McDonald and Phillips 2021). The scope of works for this survey defines the purpose of this survey as follows: *The ethnographic consultation aims at providing an understanding of the cultural heritage values associated with the submerged landscape.* *Specifically, the survey and reporting will provide Woodside an understanding of the cultural values within the coastal, nearshore and offshore proposed Scarborough trunkline and associated works areas.* The scope of the assessment was informed by the Scarborough Project's development footprint, however a landscape-scale approach was undertaken, considering heritage values that may be identified by participants well beyond this footprint. No boundary was imposed on the participants, and participants were not restricted in the types of heritage value they were encouraged to identify. As an indication of the breadth of the cultural landscape that the survey considered, cultural features and heritage values were identified more than 60 km from the development footprint. It was noted that some traditional knowledge of ethnographic values may have been lost through the effects of colonisation generally, and as a result of the Flying Foam Massacre in particular (McDonald and Phillips 2021). It is not appropriate or practical to request Traditional Custodians to list all ethnographic values onshore which they have not identified as potentially impacted, however some identified in the report included stories related to Eaglehawk Island and several sites at Withnell Bay several kilometres from the Scarborough Project's footprint, onshore. Some of these sites have spiritual connections throughout the landscape including to Cape Preston and Depuch Island.

7.9.6.3 Feedback to Inform Existing Environment

A summary of the topics/interests and values raised by First Nations groups through engagement undertaken by Woodside as part of Woodside's broader activities on the NWS[36] is summarised below.

First Nations cultural values are communally held. This is reflected in Vision 3 of Dhawura Ngilan that "Aboriginal and Torres Strait Islander heritage is managed... according to community ownership" (Heritage Chairs of Australia and New Zealand 2020). Dhawura Ngilan also specifically notes that "Aboriginal and Torres Strait Islander... intangible knowledge systems, which are held in songlines and language, are endangered. This knowledge is held by Elders and the community...". Through consultation RNTBCs and nominated representative corporations have identified or raised topics relating to environmental values of cultural interest. Woodside recognises the deep spiritual and cultural connection to the environment that First Nations people hold.

Additional cultural values and broader interests in the environment are known and have been shared with Woodside in the course of consultation on NWS EPs. These cultural values and broader interests that are known to exist within or adjacent to the EMBA are identified below:

- migratory marine animals, including whales and whale sharks
- fish, including species of sharks and rays
- octopus
- turtles
- dugongs
- plankton
- seagrass

[36] Consultation for the OPP includes a formal public comment period (see Phase 2 consultation in Section 8.4). As part of Phase 2, Woodside will contact all identified stakeholders (Table 8-1), including First Nations, to notify them of the publication of the OPP and feedback mechanism.

- songlines
- shorelines, particularly in the region from Willigabi (on the coast near Northampton) to Shark Bay, Hamelin Pool, and Yaringa
- where saltwater and freshwater meet
- freshwater (rivers)
- saltwater (ocean)
- archaeological sites on nearshore islands (Ashburton region of the south-west Pilbara)
- Jarrkunpungu/Solitary Island (nearshore island north of Port Headland that is linked to a Ngarla Dreaming story)
- presence of mythic creatures (snakes/serpents)
- UCH
- cultural obligation to care for Sea Country

Woodside is committed to ongoing engagement with First Nations people to further understand cultural values. Should feedback be received (including any relevant new information on cultural values), it will be assessed and, where appropriate, incorporated into the subsequent EPs for the Goodwyn Area Infill Development.

7.9.6.4 Summary of Cultural Features and Heritage Values

Woodside has developed a robust understanding of cultural features and heritage values through examination of publicly available information, studies, and consultation. Table 7-31 consolidates the cultural features and heritage values identified in Sections 7.9.4 to 7.9.6, and confirms whether there is any potential for these to exist within the Project Area or EMBA for the Goodwyn Area Infill Development.

As cultural features are physical elements of a place, these can generally be assessed for impacts; where a feature is avoided, it is not impacted. Heritage values relate less to what is significant and more to why something is significant; interaction between heritage values and the Project Area can only be reliably informed by consultation with First Nations people where they are willing to share the necessary knowledge. Assessment of heritage values beyond cultural features alone is addressed in Section 9.3 subject to these caveats.

Table 7-31: Summary of cultural features and heritage values

Cultural Feature or Heritage Value	Context	Potential for Overlap	
		Project Area	EMBA
Archaeological Heritage and Landscapes			
Coastal/ island archaeological sites	Coastal archaeological sites include shell middens, artefact scatters, skeletal material/burial sites, camps, meeting places, hunting places and water sources.	No	Possible (shoreline accumulation areas)
Petroglyphs	Petroglyphs are a form of rock art. Petroglyphs are a prominent feature particularly at Murujuga where it is found on hard, volcanic rock.	Possible (submerged)	Possible
Fish traps	Stone arrangements constructed in intertidal areas which fill with fish at high tide and trap them at low tide	Possible (submerged)	Possible
Submerged archaeological sites	The Ancient Landscape extends between 125 m and 130 m below current sea level. Ancient occupation of	Possible	Possible

Cultural Feature or Heritage Value	Context	Potential for Overlap	
		Project Area	EMBA
	this area may have left traces through now submerged archaeological sites.		
Rivers, waterholes, tidal channels and seeps	Water sources on the Ancient Landscape which may be culturally significant or archeologically prospective. Traditional knowledge retains knowledge of some water sources on the Ancient landscape and some submerged waterholes are related to a Kangaroo songline.	Possible	Known to occur
Submerged calcarenite ridges/ paleo beach barrier systems	Calcarenite ridges that have formed at former coastal sand dunes have the potential to encase and preserve artefacts from disturbance during inundation where these formed following human occupation.	Possible	Known to occur
Submerged hills	Hills on the Ancient Landscape which may be culturally significant or archeologically prospective. As sea level rose these hills would have become islands and eventually submerged.	Possible	Known to occur
Madeleine Shoals	Archaeologically prospective location on the submerged landscape, including igneous geology which has the potential to include rock art.	No	Known to occur
Karst depressions/ Ravines and valleys between submerged ridges	Natural depressions with the potential to contain artefacts displaced during inundation.	Possible	Possible
Intangible Values			
Songlines	Publicly available literature has noted songlines continue beyond the coast and across the submerged landscape	Possible (unspecified)	Possible (unspecified)
Creation / dreaming sites, sacred sites and ancestral beings	Publicly available literature talks to creation/dreaming and ancestral beings, including water serpents, connected to or originating from the sea generally.	Possible (unspecified)	Possible (unspecified)
Ceremonial sites	Places where ceremony (e.g. thalu ceremonies) are performed. All identified ceremonial sites are located onshore.	No	Possible (unspecified)
Cultural obligations to care for Country	Cultural obligation to care for the environmental values of Sea Country. Exclusion of Traditional Custodians from Sea Country or decision making processes may inhibit ability to care for Country.	Possible (unspecified)	Possible (unspecified)
Knowledge of Country / customary law and transfer of knowledge	The preservation and transmission of knowledge is dependent on the preservation of the environment generally. Exclusion of Traditional Custodians from Sea Country may inhibit the transfer of knowledge.	Possible (unspecified)	Possible (unspecified)
Connection to Country	Connection to Country is described in publicly available literature as “important to the Traditional owners’ spirituality and religion”. Connection to Country may be damaged where people are displaced or disrupted (e.g. during colonisation) or where there is a loss of technical skills or environmental knowledge	Possible (unspecified)	Possible (unspecified)
Access to Country	Limitations on Traditional Custodians accessing or enjoying areas of Sea Country	Possible (unspecified)	No (no limitations on access

Cultural Feature or Heritage Value	Context	Potential for Overlap	
		Project Area	EMBA
			beyond the Project Area)
Kinship systems and totemic species	Traditional Custodians have connection to species through kinship and totemic systems. An individual may have obligation to care for or not consume a species to which they are kin.	Possible (unspecified)	Possible (unspecified)
Resource collection	Fishing, hunting, gathering of marine species including marine mammals, marine reptiles, fish and invertebrates.	Possible (unspecified)	Possible (unspecified)
Marine Ecosystem and Species			
Marine species	Generally raised in engagement with First Nations and literature	Possible	Possible
Marine mammals: Whales	Generally raised in in engagement with First Nations Thalu species of totemic importance Linked to songlines and dreaming stories Humpback whales in particular	Possible	Possible
Marine mammals: Dolphins	Culturally important species	Possible	Possible
Marine mammals: Dugongs	Culturally important species Used as a resource	Possible	Possible
Marine reptiles: Marine turtles	Culturally important species and migration There are Thalu ceremonies associated with turtles Turtles and turtle eggs as a resource	Possible	Possible
Marine reptiles: Sea snakes	Culturally important species	Possible	Possible
Fish: Fish, sharks and rays	Culturally important species Used as a resource There are Thalu ceremonies associated with increasing fish stocks Fish, including bream and sting rays are totemic species Fish, including sharks and rays raised as a natural environment interest	Possible	Possible
Cephalopods: Squid and Octopus	Thalu species of totemic importance Resource	Possible	Possible
Seabirds	Culturally important species Birds (including shags, seagulls and osprey) and bird eggs as a resource	Possible	Possible
Benthic habitats: Coral	Culturally important with regard to connection to habitats and use of reefs for resources	Possible	Yes
Benthic habitats: Seagrass	Culturally important species Protection of animals.	No	Yes
Benthic habitats: Macroalgal communities	Interest only, raised as a natural environment interest.	Yes	Yes
Benthic habitats: Epifauna and infauna	Interest only, subtidal soft bottom communities raised as a natural environment interest.	Yes	Yes

Cultural Feature or Heritage Value	Context	Potential for Overlap	
		Project Area	EMBA
Shoreline habitats: Mangroves	Mangrove seeds as resource Critical breeding ground for marine and terrestrial wildlife. Mangroves would have provided shelter, crabbing, digging for shellfish, could be turtle nurseries	No	Possible
Shoreline habitats: Intertidal sand/ mudflat communities	Interest only, raised as a natural environment interest.	No	Possible
Shoreline habitats: Rocky shores	Interest only, raised as a natural environment interest.	No	Possible
Shorelines	Interest only, raised as a natural environment interest.	No	Possible
Marine Parks or Coastal Reserves	Interest and responsibility to manage	Yes	Yes

7.9.6.4.1 Further Context: Archaeological Heritage

No archaeological sites have been identified beyond terrestrial or intertidal areas, with the exception of two sites at Murujuga in Cape Bruguieres Channel and Flying Foam Passage (Benjamin et al. 2020; 2023). Further, it is recognised that there is the potential for submerged archaeological sites on the Ancient Landscape which occurs in the Project Area and is overlapped by the EMBA.

Archaeological sites identified onshore with the potential to exist in intertidal or submerged locations include petroglyphs, fish traps and artefact scatters or burials contained within sand dunes. As archaeological sites, these features have archaeological value which relates to the preservation of their fabric (i.e. the tangible features) and their context (i.e. their location and relationship to other archaeological and natural features). Archaeological sites may also have intangible dimensions (Australia ICOMOS 2013) cultural value that exist in addition to their archaeological or scientific value and are assessed separately.

Certain landscapes have been identified as archaeologically prospective on the submerged Ancient Landscape, including:

- submerged water sources (rivers, waterholes, tidal channels and seeps) which have an increased likelihood of use or habitation as past generations used the associated resources (UWA 2021)
- submerged calcarenite ridges younger that human occupation of the continent which may have formed over and protected artefacts in situ (Veth et al. 2020)
- prominent landscape features (e.g. hills, particularly of igneous rock formations) that may have been foci for cultural activity (UWA 2021)
- Karst depressions and other “catch points” where artefacts may accumulate following disturbances caused by inundation (UWA 2021; Nutley 2022; 2023a).

7.9.6.4.2 Further Context: Intangible Cultural Heritage

Intangible cultural heritage has been identified through engagement with First Nations people as culturally important. Cultural knowledge, as expressed through songlines, dreaming, dance and other cultural practices, can be associated with tangible objects and physical sites that are culturally important to First Nations people (Ardler 2021; Bursill et al. 2007). Intangible cultural heritage can also be embodied in the practices, representations, expressions, knowledge, uses and skills associated with physical sites (UNESCO 2003). As a result, physical features may have intangible dimensions (Australia ICOMOS 2013).

In terms of identified cultural features and heritage values related to intangible values summarised in Table 7-31, see below some additional context:

- **Songlines**: Oral Songlines are often described by First Nations people as the law of the land and make up part of the Dreaming (Neale and Kelly 2020). Songlines are viewed in Western academia as a framework for relating people to land and consist of a series of invisible, interconnected routes across the landscape that mark significant sites for First Nations people (Higgins 2021). Songlines demonstrate First Nations peoples' strong connections to land by revealing sacred knowledge that is place-specific (Roberts 2023). The land's physical features are instrumental in maintaining songlines because this is how ancestral spirits journeyed through, and interacted with, the physical landscape leaving sacred knowledge behind. The interconnection between the physical and spiritual is where songlines become intrinsically tied to significant places across Country. As a result, geographical landforms are recorded within songlines and become sacred places. Such landforms can include inter alia: rocks, mountains, rivers, caves and hills (Higgins 2021). Songlines can become lost, fragmented or broken when there is a loss of Country or forced removal from Country (Neale and Kelly 2020). Physical sites that have been identified as comprising a component of a songline are important to protect to prevent the fragmenting or breaking apart of songlines and loss of sacred cultural knowledge.
  In Australia, songlines can stretch thousands of kilometres, making up a complex and organic network of stories containing cultural knowledge of First Nations communities across the land (Neale and Kelly 2020). Songlines can also extend out to Sea Country and contain cultural knowledge that is tied to geographic features, atmospheric phenomena and marine plants and animals. Often songlines containing references to a seascape or Sea Country make mention of mythical events occurring around marine life, fishing areas, submerged rocks or coral. Songlines that embody seascapes can reflect how a group may relate to, or value, Sea Country—for example connections to nearby islands that they once inhabited in their songlines (Smyth and Isherwood 2016). Songlines can also be used as proof of long-standing connection to land and support a legal entitlement to land rights (Higgins 2021). Examples where songlines contain strong references to Sea Country are more common in Pacific Islander and Torres Strait Islander communities, who often refer to seascapes and skylines in their songlines in order to communicate sacred knowledge that assists in safe navigation of the ocean (Neale and Kelly 2020).
- **Creation/dreaming sites, sacred sites and ancestral beings**: The only sources located by Woodside with detailed descriptions of the location ancestral beings or creation/ dreaming/ sacred sites placed these on land or within inland water sources such as rivers or pools. However, some ancestral beings are noted to live within or originate from the sea generally, and some creation stories talk to the creation of features from or in the sea. Additionally, every place on shore or at sea must be assumed to have been created on some level in First Nations cosmology.
- **Cultural obligations to care for Country**: Caring for Country collectively refers to the cultural obligations of individuals and groups, as well as rituals and ceremonies required for the physical and spiritual health of the environment. In the literature reviewed by Woodside, caring for Country was noted to include, but is not limited to, maintenance of the physical environment and ecosystem. It may also have cultural, spiritual and ritual dimensions such as caring for ancestral beings or ensuring cultural safety. Thalu are places where increase ceremonies are performed to enhance or maintain populations of plants, animals or phenomena. All mentions of active ceremonial sites were confined to onshore locations, though the values may extend offshore (e.g. where a thalu relates to marine species populations).
- **Knowledge of Country/customary law and transfer of knowledge**: Knowledge of and familiarity with the features of Sea Country is itself a value. The inherent potential for restricted or secret knowledge makes this difficult to assess even through consultation with First Nations

people. However, aspects such as limitations on access to sites or disruption/relocation of First Nations communities may have implications for the preservation of First Nations knowledge. Further, connection to Country may be damaged where people are displaced or disrupted (e.g. during colonisation) or where there is a loss of technical skills or environmental knowledge (McDonald and Phillips 2021). Transfer of knowledge includes continuing traditional practices to pass on practical skills. This transfer of knowledge may be integral to managing a group's intangible cultural heritage (UNESCO 2003).

- **Connection to Country**: Describes the multi-faceted relationship between First Nations people and the landscape, which is envisioned as having personhood and spirit. It is also an aspect of personal identity for many First Nations people. In the case of Sea Country this can mean identifying as a Saltwater person, where "essence of being a 'Saltwater' person is ontological… it is about how people relate spiritually to the sea and engage with spiritual forces that created it, the marine flora and fauna and people" (McDonald and Phillips 2021).
- **Access to Country, including Sea Country**: Is necessary for the continuation of other values including caring for Country and the transfer of traditional knowledge. Being on Country can be an important way of expressing or maintaining connection to Country (Australian Indigenous Health*Info*Net n.d.). Access is also a value in its own right, as a continuation of traditional Sea Country access and use.
- **Cultural Safety:** refers to respecting local Lore and culturally significant areas to protect individuals from cultural harm. There are many cultural implications for those (Aboriginal and non-Aboriginal) who do not follow cultural advice or access Country in culturally inappropriate ways. Cultural safety may include observing gender restricted areas, respecting significant places and restricted areas as well as following the advice from those with cultural authority.
- **Kinship systems and totemic species**: Individuals may have kinship to specific species (Smyth 2008; Juluwarlu 2004) and/or a responsibility to care for species (Muller 2008). Kinship arises from totemic associations within First Nations "skin group" systems. It is forbidden for an individual to kill or eat a species who is from the same "skin group" (Juluwarlu 2004). They may also have certain obligations linked to the discussion of caring for Country below. It is assumed that marine species may have kinship/totemic relationships to First Nations people, but it is understood that these relationships do not prohibit people outside of that "skin group" from hunting or eating that same species (Juluwarlu 2004).
- **Resource collection**: A number of marine species are identified through consultation and literature as important resources, particularly as food sources. In addition to their immediate value as sustenance, the gathering and preparation of these resources is informed by cultural knowledge, and an inability to use these resources may result in a loss of ability to transfer that knowledge to future generations.

7.9.6.4.3 Further Context: Marine Ecosystems and Species

Engagement with First Nations groups have raised that they have a general interest in environmental management and ecosystem health (i.e. natural environment interest). This includes marine mammals, marine reptiles, fish, seabirds, benthic and shoreline habitats, and marine parks, which are described in Sections 7.5, 7.6, and 7.8.

In terms of identified cultural features and heritage values related to marine ecosystems and species summarised in Table 7-31, see below some additional context:

- **Marine mammals**: Whales, and in particular humpback whales, have been identified through engagement with First Nations groups as culturally important species, with totemic importance including their populations, biodiversity, and migration patterns.
- **Marine reptiles**: Turtles and sea snakes have been identified through engagement with First Nations groups as culturally important species, with turtles identified as a resource. First

Nations people that identify marine reptiles as species of totemic importance or integral to songlines may place high cultural value on their protection. Note the only songline related to marine reptiles (turtles) was shared by MAC (2021) as cited in Woodside (2023d). Cultural knowledge of turtles at a population level (turtle migration, behaviour, and the related marine environment) may all be important in ensuring the continuation of cultural functions and activities that remain valuable to First Nations people (Fijn 2021; Delisle et al. 2018).

- **Fish and cephalopods**: Fish and squid have been identified through consultation with First Nations groups as a culturally important species, with fish generally being identified as a resource. First Nations may identify cultural values associated with fish species as important to maintaining both tangible (physical cultural sites) and intangible (cultural knowledge) cultural heritage. Tangible cultural heritage associated with fish can include important cultural sites such as midden sites, fish traps and thalu sites. While the octopus is an important totem to Ngarla People and features in the creation story of Solitary Island. There are increase ceremonies / rituals for species of squid and octopus to enhance or maintain populations. Thalu are places where these increase ceremonies are performed.
- **Seabirds**: Seabirds, and in particular shags, have been identified through literature as a culturally significant species (Sinclair 2021), as well as a resource (seabird eggs; Smyth (2007)).
- **Benthic habitats**: Through engagement, First Nations groups identified benthic habitats as valuable for their ecological values, including corals attracting fish and seagrass providing shelters for fauna, as well as an important resource for dugongs. Additionally, coral is valued by MAC for its aesthetic values.
- **Shoreline habitats**: Through consultation, First Nations groups identified shoreline habitats as valuable for their ecological values, including mangroves for providing shelter to marine invertebrates, which are identified resources, and potential nursery for turtles. Literature also notes that mangroves are also valued for the flora and fauna they are associated with and support (CoA 2002), and Smyth (2007) reports that mangrove seeds are used as a resource by Ngarda-Ngarli.

7.9.7 Historic Sites of Significance

Places of historic cultural significance are protected under Commonwealth, State, and local regimes.

Places inscribed on the National or World Heritage lists are protected through various provisions of the EPBC Act (these areas are described in Section 7.8.1 and 7.8.2 respectively). Places listed on the Commonwealth Heritage List are described in Section 7.8.3.

Historic places may also be protected under the *Heritage Act 2018* (WA); under section 129 the alteration, demolition, damage, despoilment or removal of objects from a registered place is prohibited. Protection of heritage by local government typically emanates from local planning schemes produced under Part 5 of the *Planning and Development Act 2005* (WA). Historical sites of significance and heritage value are found along adjacent foreshores of the NWMR and SWMR.

7.9.8 Historic Underwater Heritage

The remains of vessels and aircraft in Commonwealth waters, along with any associated article, are automatically protected under the UCH Act after 75 years. This applies whether the existence or location of the article is known or unknown, as per section 16 of the Act. Other articles of UCH may be declared for protection as outlined in section 17 of the Act. Remains and relics of any ship lost, wrecked, or abandoned in WA waters before 1900 are protected by the *Maritime Archaeology Act 1973* (WA).

A search of the Australasian Underwater Cultural Heritage Database (DCCEEW 2021a), which records all known shipwrecks, aircraft, relics and other UCH in Australian waters, indicated that there are no sites within the Project Area. Within the EMBA, ~223 known shipwrecks or other heritage sites were identified.

The Montebello Marine Park contains two known shipwrecks protected under the UCH Act—the *Trial* (wrecked in 1622, the earliest known shipwreck in Australian waters) and *Tanami* (unknown date) (DNP 2018a).

Comber Consultations were engaged by Woodside to undertake a desktop UCH assessment. The assessment covered four areas on the NWS; of these Area A is in approximately the same location as the Project Area for this OPP. The desktop assessment indicated:

- based on searches of heritage registers and databases, there are no shipwrecks or other items of UCH registered within the Project Area
- the closest location of a protected shipwreck (>75 years old) is the sailing vessel *Trial*, located at Trial Rocks, ~23 km south of the Project Area (Nutley 2023b).

Woodside is committed to undertaking a review of further[37] geophysical and geotechnical data within areas where planned activities will interact with the seabed, to assist in identifying any indicators of UCH (including First Nations UCH). The results of these assessments will also be incorporated into the subsequent EPs for the Goodwyn Area Infill Development.

7.10 Socioeconomic Environment

7.10.1 Commercial Fisheries

7.10.1.1 Commonwealth Managed Fisheries

The Australian Fisheries Management Authority (AFMA) manages fisheries on behalf of the Australian Government and is bound by objectives under the *Fisheries Management Act 1991* (Cth). Fisheries typically operate 3–200 nm offshore (i.e. to the extent of the Australian Fishing Zone [AFZ]). Commonwealth fisheries generated an estimated gross value of production (GVP) of A$438 million in 2019–2020, accounting for 28% of wild-catch fisheries GVP in Australia (A$1.58 billion) (Patterson et al. 2021).

Several Commonwealth fishery management areas intersect with the Project Area or EMBA (Table 7-32). No interaction between Commonwealth fisheries and activities within the Project Area are expected to occur.

[37] Woodside is proposing to undertake geophysical and geotechnical surveys on the NWS, including the Project Area for the proposed Goodwyn Area Infill Development. These surveys are the scope of a separate EP that will be submitted to NOPSEMA and are not part of the activities within scope of this OPP (see exclusion for exploration and appraisal activities in Section 1.4.2).

Table 7-32: Commonwealth-managed fisheries

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
North West Slope Trawl Fishery (NWSTF)	***Management area***	The NWSTF operates off north-western Australia from 114°E to 125°E, and from ~200 m isobath to the outer limit of the AFZ.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area.
	Key species	The primary species landed in the NWSTF is the Australian scampi (*Metanephrops australiensis*), with smaller quantities of velvet scampi (*M. velutinus*) and Boschma's scampi (*M. boschmai*). A quantity of prawns is also harvested each season, and squid is becoming an increasingly significant component of the catch. Mixed snappers (*Lutjanidae*) and redspot emperor (*Lethrinus lentjan*) have historically been an important component of the NWSTF catch.	x	There is no potential for interaction with this fishery.	✓	Recent active fishing effort intersects with the EMBA (ABARES 2021).
	Fishing methods	Demersal trawl				
	Fishing depth	Typically 350–600 m				
	Fishing activity	Fishing commenced in the NWSTF in 1985. The number of active vessels peaked at 21 during the 1986–1987 season, decreasing to 1–6 vessels per year since the 2005–2006 season. Fishing for scampi occurs over soft, muddy sediments or sandy habitats, using demersal trawl gear on the continental slope. Fishing effort increased from 151 days and 2,869 trawl-hours during the 2018–2019 season to 306 days and 5,903 trawl-hours during the 2019–2020 season. Scampi stock are classified as not overfished and not subject to overfishing.				
	Active licences and/or vessels	During the 2019–2020 season, there were seven permits and six active vessels operating within the NWSTF.				
Southern Bluefin Tuna Fishery (SBTF)	***Management area***	The SBTF covers the entire EEZ around Australia, out to 200 nm from the coast.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area.
	Key species	The fishery targets southern bluefin tuna (*Thunnus maccoyii*).	x	No recent fishing effort has been recorded within the Project Area (ABARES 2021),	x	No recent fishing effort has been recorded within the EMBA (ABARES 2021), therefore no
	Fishing methods	Longline and purse-seine fishing				
	Fishing depth	Southern bluefin tuna is a pelagic species, which can be found to depths of 500 m (AFMA 2023b).				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Fishing activity	Most of the Australian fishing effort is by purse-seine vessels in the Great Australian Bight and waters off SA during summer months, and by longline off the NSW coastline during winter months. The number of vessels in the purse-seine fishery has been fairly stable, ranging from 5 to 8 since the 1994–1995 fishing season. Since 2011, most fishing has occurred in the east of the Bight, closer to Port Lincoln, resulting in shorter towing distances to bring the fish to aquaculture farms for growing before harvest. The Southern Bluefin Tuna Fishery is shared amongst countries. Australia currently has a 35% share of the total global allowable catch. Although wild capture fishing in Australia to sell directly to market can occur anywhere throughout the fishery's range, currently most of that quota is value-added through ranching (on-growing the wild captured fish for an extra 5–6 months). Ranching requires significant infrastructure, a resident labour force, plus proximity to a fishery able to supply a large quantity of natural feed/sardines (>40,000 t). North-west WA is critically important regardless of how the quota is fished because of its proximity to the single spawning ground of this global roaming species. Young fish (1–4 years of age) move from the spawning ground in the north-east Indian Ocean into the Australian EEZ and southwards along the WA coast. The stock is classified as not overfished.		therefore no interaction is expected.		interaction is expected.
	Active licences and/or vessels	During the 2019–2020 season, there were seven purse-seine vessels, 23 longline vessels.				
Western Skipjack Tuna Fishery (WSTF)	***Management area***	The combined western and eastern skipjack tuna fisheries encompass the entire Australian EEZ. The WSTF extends westward from the SA / Victorian border across the Great Australian Bight and around the west coast of WA to the Cape York Peninsula in Queensland.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area.
	Key species	The fishery targets Western skipjack tuna (*Katsuwonus pelamis*).	x	This fishery is not active, therefore no interaction is expected.	x	This fishery is not active, therefore no interaction is expected.
	Fishing methods	Purse-seine gear (~98% of catch) and occasional pole and line.				
	Fishing depth	Western skipjack tuna is a pelagic species that can be found to depths of 260 m (AFMA 2023a).				
	Fishing activity	The WSTF has not been actively fished since the 2008–2009 fishing season.				
	Active licences and/or vessels	No active vessels operating since 2009.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
Western Tuna and Billfish Fishery (WTBF)	***Management area***	The WTBF extends to the Australian EEZ boundary in the Indian Ocean.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area.
	Key species	Key species caught in the WTBF include bigeye tuna (*Thunnus obesus*), Yellowfin tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*) albacore (*Thunnus alalonga*), and striped marlin (*Kajikia audax*).	x	No recent fishing effort has been recorded within the Project Area (ABARES 2021), therefore no interaction is expected.	✓	Recent active fishing effort intersects with the EMBA (ABARES 2021).
	Fishing methods	Fishers mainly use pelagic longline fishing gear to catch the targeted species. Minor line (including handline, troll, rod and reel) can also be used.				
	Fishing depth	Species have a broad depth distribution, with tuna occurring at 150–300 m, striped marlin at 150 m and swordfish at up to 600 m (BRS 2008).				
	Fishing activity	The fishery operates in Australia's EEZ and high seas of the Indian Ocean. Fishing effort in recent years has been concentrated off south-west WA, with occasional activity off SA. Effort in the WTBF was relatively low (<20 vessels) from the mid-1980s to the mid-1990s. Effort increased in the late 1990s, peaking at 50 active vessels in 2000, but then declined rapidly. Since 2005, fewer than 5 vessels have been active in the fishery each year.				
	Active licences and/or vessels	During the 2019–2020 season, there were 2 pelagic longline vessels, and 1 minor line vessel.				
Small Pelagic Fishery (SPF)	***Management area***	The SPF extends westward from the Queensland / NSW border across the Great Australian Bight and to the southern coast of WA.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area.
	Key species	The key target species in the east and west subareas are blue mackerel (*Scomber australasicus*), jack mackerel (*Trachurus declivis*) and redbait (*Emmelichthys nitidus*).	x	There is no potential for interaction with this fishery.	x	No recent fishing effort has been recorded within the EMBA (ABARES 2021), therefore no interaction is expected.
	Fishing methods	The fishery includes purse-seine and midwater trawl fishing vessels.				
	Fishing depth	Information not available.				
	Fishing activity	Most historical fishing effort (before 2015) occurred off the east coast of Tasmania. The operation of a factory freezer trawler between the 2014 and 2017 fishing seasons led to increased catches, reaching a peak of around 12,000 t in 2015–16.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		Catches have subsequently increased when another midwater trawler operation began in the east subarea in 2016–17 and reached 14,111 t in 2020–21.				
	Active licences and/or vessels	During the 2019–2020 season, there were 3 purse seine vessels and 1 midwater trawl.				

^ *Source: (Patterson et al. 2021)*

7.10.1.2 State Managed Fisheries

State commercial fisheries are managed by the WA Department of Primary Industries and Regional Development (DPIRD) under the *Fish Resources Management Act 1994* (WA), Fisheries Resources Management Regulations 1995, relevant gazetted notices and licence conditions, and applicable Fishery Management Plans.

Several State fishery management areas intersect with the Project Area or EMBA (Table 7-33). Interaction between State fisheries and activities within the Project Area may occur for three of these fisheries—Mackerel Managed Fishery, Pilbara Line Fishery, and Pilbara Trap Managed Fishery (Table 7-33, Figure 7-42 to Figure 7-44).

Table 7-33: State-managed fisheries

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
Abalone Managed Fishery	***Management area***	The Abalone Managed Fishery includes all coastal waters from the WA/SA border to the WA/NT border. The fishery is concentrated on the south coast and the west coast.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • greenlip abalone (*Haliotis laevigata*) • brownlip abalone (*Haliotis rubra conicopora*) • Roe's abalone (*Haliotis roei*)	x	As the depths of the Project Area are >40 m and as there was no fishing effort reported overlapping the Project Area between 2017 and 2022 (DPIRD 2022), no interaction with this fishery is anticipated.	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Diverse				
	Fishing depth	Distribution to 5 m depth for Roe's abalone and 40 m depth for greenlip / brownlip abalone (Fletcher and Santoro 2011).				
	Fishing activity	Previous years' catches based on State of the Fisheries annual reports provided by DPIRD: • 2020: – total commercial greenlip/brownlip abalone catch was 36 t whole weight (greenlip 24.7 t; brownlip 11.3 t), the lowest catch since 1969 – Roe's abalone: 18.2 t whole weight • 2019: – total commercial greenlip/brownlip abalone catch: 50 t whole weight – Roe's abalone: 47 t whole weight.				
	Active licences and/or vessels	26 vessels in Roe's abalone fishery (WAFIC 2024b). 17 vessels in the commercial greenlip/brownlip abalone fishery. Only a proportion of these were active in 2020.				
Mackerel Managed Fishery	***Management area***	The commercial Mackerel Managed Fishery extends from the West Coast Bioregion to the WA/NT border. There are three managed fishing areas: Area 1: Kimberley (121° E to the WA/NT border); Area 2: Pilbara (114° E to 121° E) and Area 3: Gascoyne (27° S to 114° E) and West Coast (Cape Leeuwin to 27° S).	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets:	✓		✓	

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		• Spanish mackerel (*Scomberomorus commerson*) • grey mackerel (*S. semifasciatus*) • other species from the genus Scomberomorus		Recent active fishing effort intersects with the Project Area (Figure 7-42).		Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Trolling, bait or lure cast, jigging.				
	Fishing depth	Information not available.				
	Fishing activity	Most of the catch is taken from Kimberley and Pilbara waters, reflecting the tropical distribution of mackerel species. Most fishing activity occurs around the coastal reefs of the Dampier Archipelago and Port Hedland area, with the seasonal appearance of mackerel in shallower coastal waters most likely associated with feeding and gonad development before spawning. Based on State of the Fisheries annual reports provided by DPIRD, catch trends are: 290 t (2020), 291 t (2019), 214 t (2018; the lowest on record (Lewis, Blay, and Watt 2020), 283 t (2017), 276 t (2016), 302 t (2015) and 322 t (2014).				
	Active licences and/or vessels	There are 18 licences in the fishery. 16 vessels fished in the 2020 season. Within the Project Area, <3 active vessels were recorded as present between 2012 and 2021 (DPIRD 2022).				
Marine Aquarium Fish Managed Fishery	***Management area***	The Marine Aquarium Fish Managed Fishery can operate in all State waters. The fishery is typically active in the intertidal and nearshore waters, particularly between Esperance to Broome, Perth to Busselton, Karratha to Port Headland, the Gascoyne Region and around Albany (Smith, Newman, and Cliff 2010)	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	Finfish, hard coral, soft coral, tridacnid clams, syngnathids (seahorses and pipefish), other invertebrates (including molluscs, crustaceans, echinoderms etc.), algae, seagrasses and ‘live rock’. The resource potentially includes >1,500 species of marine aquarium fishes.	x	As the depths of the Project Area are >30 m and as there was no fishing effort reported overlapping the Project Area	x	As there was no fishing effort reported overlapping the EMBA between 2017 and 2022 (DPIRD 2022), no interaction
	Fishing methods	The fishery is diver-based, which typically restricts effort to safe diving depths (<30 m).				
	Fishing depth	Information not available.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Fishing activity	Total catch for the Marine Aquarium Fish Managed Fishery in 2020 was 89,925 fish, 32.12 t of coral, live rock and living sand, and <20 L of marine plants and live feed.		between 2017 and 2022 (DPIRD 2022), no interaction with this fishery is anticipated.		with this fishery is anticipated.
	Active licences and/or vessels	11 out of 12 licences were active in 2020.				
Onslow Prawn Managed Fishery	***Management area***	The Onslow Prawn Managed Fishery encompasses a portion of the continental shelf off the Pilbara coast.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • western king prawns (*Penaeus esculentus*) • brown tiger prawns (*Penaeus esculentus*) • blue endeavour prawns (*Metapenaeus endeavouri)*.	x	As the there was no fishing effort reported overlapping the Project Area between 2017 and 2022 (DPIRD 2022), no interaction with this fishery is anticipated.	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Low-opening, otter prawn trawl systems.				
	Fishing depth	Information not available.				
	Fishing activity	In 2020, the total landings for the Onslow Prawn Managed Fishery in were less than the target catch range of 60 t. 13 days of fishing took place in 2020 by one boat.				
	Active licences and/or vessels	One vessel active in 2020.				
Pilbara Crab Managed Fishery	***Management area***	The Pilbara Crab Managed Fishery covers inshore waters from Onslow to Port Hedland (between longitudes 115° 5′ 60″ E and 120° E), with most activity around Nickol Bay. Areas of the fishery north and east of Exmouth and nearshore are currently closed as per Schedule 2 of the Draft Management Plan for the Pilbara Crab Managed Fishery (DPIRD 2018).	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area.
	Key species	Blue swimmer crab (*Portunus armatus*).	x	As the depths of the Project Area are >50 m, and as there was no	✓	Recent active fishing effort intersects with
	Fishing methods	Hourglass traps				
	Fishing depth	Up to 50 m deep (Johnston, Yeoh, and Fisher 2020).				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Fishing activity	Previous years' catches based on State of the Fisheries annual reports provided by DPIRD: 0.6 t (2020), 19.3 t (2019). Note: The 2020 catch accounted for <0.1% of the state commercial catch of 713.5 t for that year. Fishing only occurred for one month due to the COVID-19 pandemic and associated changes in market demands.		fishing effort reported overlapping the Project Area between 2017 and 2022 (DPIRD 2022),no interaction with this fishery is anticipated.		EMBA (DPIRD 2022).
	Active licences and/or vessels	No information available currently.				
Pilbara Fish Trawl (Interim) Managed Fishery	***Management area***	The Pilbara Trawl (Interim) Managed Fishery, which is part of the Pilbara Demersal Scalefish Fisheries, is a high intensity fishery divided into two zones in an area governed by Schedule 5 (prohibited to trawling). In addition to the Prohibited Trawl Fishing area, no fish trawl units are allocated for use in Zone 1 or Areas 3 and 6 of Zone 2 (which comprises six management areas).	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets more than 50 scalefish species. The main demersal scalefish species landed by the fishery in the Pilbara region are bluespotted emperor, red emperor and rankin cod. The key species caught by the fishery include crimson snapper, bluespotted emperor trevally and threadfin bream.	x	As there was no fishing effort reported overlapping the Project Area between 2017 and 2022 (DPIRD 2022), no interaction with this fishery is anticipated.	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Demersal trawl. The fishery operates with standard stern trawling gear (single net with extension sweeps).				
	Fishing depth	50–200 m				
	Fishing activity	Based on State of the Fisheries annual reports provided by DPIRD, catch trends increased over the past reporting years, until the 2020 season: 2,087 t (2020), 2,142 t (2019), 1,996 t (2018), 1,780 t (2017), 1,529 t (2016), 1,172 t (2015) and 1,105 t (2014). The fishery landed 74% of total commercial catches of the demersal scalefish in the Pilbara in 2020. In 2008, following declining catch rates and relatively high levels of fishing mortality for red emperor in the western areas of the fishery, effort was reduced for the fishery in these areas. Increasing catch rates and fishing mortality spawning biomass estimates indicate that imposed effort reductions since 2008 have resulted in increased fish abundance and stock rebuilding in the fishery.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Active licences and/or vessels	Estimated two vessels in 2020.				
Pilbara Line Fishery	***Management area***	The Pilbara Line Fishery is part of the Pilbara Demersal Scalefish Fisheries. Boat licences are permitted to operate anywhere within 'Pilbara waters', bounded by a line commencing at the intersection of 21° 56′ S latitude and the high-water mark on the western side of the North West Cape on the mainland of WA; west along the parallel to the intersection of 21° 56′ S latitude and the boundary of the AFZ, and north to longitude 120°E.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area.
	Key species	The fishery's catch comprises ~45–50 different fish species. The fishery targets similar demersal species to the Pilbara Trap and Trawl fisheries, as well as some deeper offshore species such as ruby snapper and eightbar grouper.	✓	Recent active fishing effort intersects with the Project Area (Figure 7-43).	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Demersal long line.				
	Fishing depth	Information not available.				
	Fishing activity	Based on State of the Fisheries annual reports provided by DPIRD, catch trends have increased over the past reporting years: 167 t (2020), 148 t (2019), 93 t (2018), 143 t (2017), 126 t (2016), 97 t (2015) and 40 t (2014). The 2020 catch was 6% of the total catch by the Pilbara Demersal Scalefish Fishery.				
	Active licences and/or vessels	The Pilbara Line Fishery comprises nine licences. The fishery operates on an exemption basis that enables licence holders to fish for any nominated five-month block during the year (typically May–September). An estimated 5 vessels were active in 2020. Within the Project Area, a maximum of 3 active vessels were recorded as present between 2012 and 2021 (DPIRD 2022).				
Pilbara Trap Managed Fishery	***Management area***	The Pilbara Trap Managed Fishery, which is part of the Pilbara Demersal Scalefish Fisheries, covers the area from Exmouth northwards and eastwards to the 120°S line of longitude, and offshore as far as the 200 m isobath.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The main species landed by these fisheries are: • bluespotted emperor (*Lethrinus punctulatus*)	✓	Recent active fishing effort	✓	Recent active fishing effort

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		• red emperor (*Lutjanus sebae*) • rankin cod (*Epinephelus multinotatus*).		intersects with the Project Area (Figure 7-44).		intersects with EMBA (DPIRD 2022).
	Fishing methods	Demersal fish traps.				
	Fishing depth	~30–200 m isobath.				
	Fishing activity	Based on State of the Fisheries annual reports provided by DPIRD, catch trends increased over the past reporting years, until the latest season (2020): 584 t (2020), 680 t (2019), 563 t (2018), 573 t (2017), 495 t (2016), 510 t (2015) and 268 t (2014). The total 2020 catch made up 20% of the total catch by the Pilbara Demersal Scale Fishery.				
	Active licences and/or vessels	In the 2019 season, there were six licences in the Pilbara Trap Managed Fishery, with an estimated 3 vessels operating in 2020. Within the Project Area, <3 active vessels were recorded as present between 2012 and 2021 (DPIRD 2022).				
Specimen Shell Managed Fishery	***Management area***	The Specimen Shell Managed Fishery encompasses the entire WA coastline, but effort is concentrated in areas adjacent to population centres such as Broome, Exmouth, Shark Bay, Geraldton, Perth, Mandurah, and Albany. There are several closed areas where the fishery is not permitted to operate, including various marine parks and aquatic reserves, such as Ningaloo Marine Park. The Perth metropolitan area is also important because of its populations of two rare cowrie species.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The Specimen Shell Managed Fishery targets the collection of specimen shells for display, collection, cataloguing and sale. There is some focus of effort on mollusc families that are most popular with shell collectors, such as cowries, cones, murexes and volutes.	x	As the depths of the Project Area are >30 m and as there was no fishing effort reported overlapping the Project Area between 2017 and 2022 (DPIRD 2022), no	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022)).
	Fishing methods	The main methods are via hand collection by small groups of divers operating from small boats in shallow coastal waters, by wading along coastal beaches below the high-water mark or, in some instances, by use of remotely operated underwater vehicles.				
	Fishing depth	For collection by hand, (diver-based) this typically restricts effort to safe diving depths (<30 m).				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		ROV collection could enable depths up to 300 m (Hart et al. 2017).		interaction with this fishery is anticipated.		
	Fishing activity	Total number of specimen shells collected in 2020 was 4,258, across 206 species.				
	Active licences and/or vessels	There are 30 licences each with a maximum of 4 divers allowed in the water per licence at any one time; 15 of these fished in 2020.				
South-west Coast Salmon Managed Fishery	***Management area***	The South-west Coast Salmon Managed Fishery operates on various beaches south of the Perth metropolitan area and includes all WA waters north of Cape Beaufort (on the south coast of WA) except Geographe Bay.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • Western Australian salmon (*Arripis truttaceus*)	x	As there was no fishing effort reported overlapping the Project Area between 2017 and 2022 (DPIRD 2022), no interaction with this fishery is anticipated.	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Beach seine nets.				
	Fishing depth	Information not available.				
	Fishing activity	The South-west Coast Salmon Managed Fishery is part of the West Coast Nearshore and Estuarine Finfish Resource. The commercial catch for the entire West Coast Nearshore and Estuarine Finfish resource was 246.8 t in 2020, with 16.6 t of this catch associated with Western Australian salmon. In 2019, a catch of 147.8 t of Western Australian salmon was reported. This reduction in catch from the previous year is as a result of less demand due to COVID-19.				
	Active licences and/or vessels	Six licences.				
West Coast Deep Sea Crustacean Managed Fishery	***Management area***	The West Coast Deep Sea Crustacean Managed Fishery extends north from Cape Leeuwin to the WA/NT border in water depths >150 m within the AFZ.	✓	Overlaps with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets deepwater crustaceans: • crystal (snow) crab (*Chaceon albus*) • giant (king) crab (*Pseudocarcinus gigas*) • champagne (spiny) crab (*Hypothalassia acerba*)	x	As there was no fishing effort reported overlapping the Project Area	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		Catches are dominated by crystal crabs, of which 99% of their total allowable catch was landed in 2020.		between 2017 and 2022 (DPIRD 2022), no interaction with this fishery is anticipated.		
	Fishing methods	Baited pots, or traps, are operated in long-lines; 80–180 pots are attached to a main line marked by a float at each end.				
	Fishing depth	>150 m (mostly 500–800 m). Most of the commercial crystal crab catch is taken in depths of 500–800 m (WAFIC 2024d).				
	Fishing activity	Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 156.1 t (2020), 155.7 t (2019) and 168 t (2018).				
	Active licences and/or vessels	Five vessels were active in 2020.				
Abrolhos Islands and Mid West Trawl	***Management area***	The Abrolhos Islands and Mid-West Trawl Fishery operates around the Abrolhos Islands within the SWMR.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	Saucer scallops (*Ylistrum balloti*, formerly *Amusium balloti*)	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Trawl.				
	Fishing depth	Saucer Scallops occur in inshore waters around 40 m depth at the Abrolhos Islands (Newman et al. 2021).				
	Fishing activity	Previous years catch based on State of the Fisheries annual reports provided by DPIRD: The Abrolhos Islands and Mid-West Trawl Fishery landed 238.6 t meat weight (1192.8 t whole weight) in 2020, 159.1 t meat weight (795.6 t whole weight) in 2019 and 31.0 t meat weight (154.8 t whole weight) in 2018. Between 2011 and 2015, the annual pre-season surveys showed very low recruitment (1-year old), due to the 2011 extreme marine heatwave and subsequent poor pawning stock. The fishery was closed between 2011 and 2016.				
	Active licences and/or vessels	The fishery has 11 licenses, and 5 vessels operated in 2019.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
Broome Prawn Managed Fishery	***Management area***	The Broome Prawn Managed Fishery operates off Broome and forms part of the North Coast Prawn Fishery.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area.
	Key species	The fishery targets: • western king prawn (*Penaeus latisulcatus*) • coral prawns (*Metapenaeopsis sp*.)	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022)).
	Fishing methods	Trawling				
	Fishing depth	Typically 30–60 m, but can occur down to 100 m (DEH 2004).				
	Fishing activity	Extremely low fishing effort—only one boat undertook trial fishing to investigate whether catch rates were sufficient for commercial fishing. This resulted in negligible landings of western king prawns with no byproduct recorded.				
	Active licences and/or vessels	One vessel.				
Exmouth Gulf Prawn Managed Fishery	***Management area***	The Exmouth Gulf Prawn Managed Fishery operates within the sheltered waters of Exmouth Gulf. The fishery occupies a total area of 4,000 km², with only half of this area being trawled (Fletcher and Santoro 2015, 20)	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • western king prawn (*Penaeus latisulcatus*) • brown tiger prawn (*Penaeus esculentus*) • blue endeavour prawn (*Metapenaeus endeavouri*) • banana prawn (*Penaeus merguiensis*)	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	The fishery uses low-opening, otter prawn trawl systems.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 673 t (2020), 821 t (2019), 880 t (2018), 713 t (2017) and 822 t (2016).				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Active licences and/or vessels	The precise number of vessels is unreported. Eighteen people were employed in this fishery in 2020.				
Gascoyne Demersal Scalefish Managed Fishery	***Management area***	The Gascoyne Demersal Scalefish Managed Fishery is located between the southern Ningaloo Coast to south of Shark Bay, with a closure area from Point Maud to Tantabiddi (WAFIC 2024a).	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • pink snapper (*Chrysophrys auratus*) • goldband snapper (*Pristipomoides multidens*) • red emperor (*Lutjanus sebae*) • cod (*Gadus morhua*) • emperor (*Lethrinus miniatus*)	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Mechanised handlines.				
	Fishing depth	>20 m				
	Fishing activity	In 2019–2020, the total commercial catch reported was 207 t, comprising 40 t pink snapper, 102 t goldband snapper and 65 t of other mixed species				
	Active licences and/or vessels	In 2020, 10 vessels fished at some point during the season, 6 of which fished for more than 10 days during the traditional peak (pink snapper) season, typically with a crew of 2–3.				
Kimberley Crab Managed Fishery	***Management area***	The Kimberley Crab Managed Fishery is one of two small trap-based crab fisheries that operate in the North Coast Bioregion between Cambridge Gulf and Broome.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • brown mud crab (*Scylla olivacea*) • green mud crab (*Scylla serrata*).	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Trap.				
	Fishing depth	Information not available.				

<table>
<tr><th rowspan="2">Fishery</th><th rowspan="2" colspan="2">Description^</th><th colspan="4">Potential for interaction</th></tr>
<tr><th colspan="2">Project Area</th><th colspan="2">EMBA</th></tr>
<tr><td></td><td>Fishing activity</td><td>Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 1.5 t (2020), 3.2 t (2018) and 7.4 t (2019).
The combined commercial catch of blue swimmer crabs and mud crabs in the North Coast Bioregion for 2020 was 2.1 t, the lowest catch in 20 years. Catch rates declined slightly from 0.5–0.6 kg/traplift in 2017–2019, to 0.47 kg/traplift in 2020.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Active licences and/or vessels</td><td>There are three licenced commercial operators and three Aboriginal Bodies Corporate Exemption holders (Johnston, Harris, and Blazeski 2020). There is an allocation of 1200 units (equivalent to 600 traps) to each license and exemption holder.</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Nickol Bay Prawn Managed Fishery</td><td>Management area</td><td>The Nickol Bay Prawn Managed Fishery operates in nearshore and offshore waters of the Pilbara region along the NWS. Trawling has been reported to occur at several locations along the Pilbara coast east of the Burrup Peninsula, including within Nickol Bay.</td><td>x</td><td>Does not overlap with fishery management area.</td><td>✓</td><td>Overlaps with fishery management area</td></tr>
<tr><td>Key species</td><td>The fishery targets:
• banana prawn (Penaeus merguiensis)
• western king prawn (Penaeus latisulcatus)
• brown tiger prawn (Penaeus esculentus)
• blue endeavour prawn (Metapenaeus endeavouri)</td><td rowspan="5">x</td><td rowspan="5">N/A</td><td rowspan="5">✓</td><td rowspan="5">Recent active fishing effort intersects with EMBA (DPIRD 2022).</td></tr>
<tr><td>Fishing methods</td><td>Trawling.</td></tr>
<tr><td>Fishing depth</td><td>Information not available.</td></tr>
<tr><td>Fishing activity</td><td>Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 202.4 t (2020), 254 t (2019) and 81 t (2018).
Due to the lower abundance of banana prawns in 2020, fishing effort was reduced to 261 boat days compared to 353 in 2019.</td></tr>
<tr><td>Active licences and/or vessels</td><td>The precise number of vessels is unreported, although estimated employment in 2020 for all north coast prawn fisheries combined was 30–60 people.</td></tr>
<tr><td>Northern Demersal Scalefish</td><td>Management area</td><td>The Northern Demersal Scalefish Managed Fishery is part of the North Coast Demersal Resource. The Northern Demersal Scalefish Managed Fishery is divided into two fishing areas: Area 1 (inshore) and Area 2 (offshore). Area 1 permits line fishing only, between the high-water mark and the 30 m isobath.</td><td>x</td><td>Does not overlap with fishery management area.</td><td>✓</td><td>Overlaps with fishery</td></tr>
</table>

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
Managed Fishery		Area 2 permits handline, dropline and fish trap fishing methods and is further divided into zones. Zone A is an inshore area, Zone B comprises the area with most historical fishing activity, and Zone C is an offshore deep slope area representing waters >200 m deep.				management area
	Key species	The fishery targets: • goldband snapper (*Pristipomoides multidens*) • bluespotted emperor (*Lethrinus punctulatus*) • red emperor (*Lutjanus sebae*) • rankin cod (*Epinephelus multinotatus*)	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Line fishing, handline, dropline and fish trap fishing.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 1,419 t (2020; the second largest reported catch across the whole fishery), 1,507 t (2019) and 1297 t (2018). Most of the catch is landed from Zone B, with 1,249 t in 2020.				
	Active licences and/or vessels	Seven vessels fished in the 2020 fishing season, and at least 23 people (3–4 crew per vessel) were directly employed in the fishery.				
Octopus Interim Managed Fishery	***Management area***	The Octopus Interim Management Fishery operates from Kalbarri Cliffs in the north to Esperance in the south.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	*Octopus djinda*, which is closely related to *Octopus tetricus*.	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Passive shelter pots and active traps.				
	Fishing depth	In inshore waters to a depth of 70 m.				
	Fishing activity	Previous years' catch based on State of the Fisheries annual reports provided by DPIRD: Commercial catch for the Octopus Interim Management Fishery was 254 t in 2020, 453 t in 2019, 314 t in 2018, 257 t in 2017 and 252 t in 2016.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		The 45% catch reduction from 2019–2020 was due to COVID-19 related issues, with supply and trade route limitations interrupting the harvest over several months.				
	Active licences and/or vessels	25 vessels fished in 2020.				
Shark Bay Beach Seine and Mesh Net	***Management area***	The Shark Bay Beach Seine and Mesh Net Managed Fishery operates from Denham.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • Whiting (yellowfin *Sillago schomburgkii* and *goldenline S. analis*) • Sea mullet (*Mugil cephalus*) • Tailor (*Pomatomus saltatrix*) • Western yellowfin bream (*Acanthopagrus australis*)	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Beach seine and mesh net.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years catch based on State of the Fisheries annual reports provided by DPIRD: Total catch was 171 t in 2020, 175 t in 2019 and 176 t in 2018.				
	Active licences and/or vessels	In 2020, eight vessels operated in the fishery, employing around 14–16 fishers.				
Shark Bay Crab Managed Fishery	***Management area***	The Shark Bay Crab Managed Fishery operates within the NWMR. It is based primarily in Carnarvon but operates throughout the waters of Shark Bay.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	Blue swimmer crab (*Portunus armatus*)	x	N/A	✓	Recent active fishing effort intersects with
	Fishing methods	Trap and trawl.				
	Fishing depth	Information not available.				

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Fishing activity	Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 638 t (2019–2020), 529 t (2018–2019) and 518 t (2017–2018). Commercial fishing for blue swimmer crabs in Shark Bay was voluntarily halted by industry in 2012 to facilitate stock rebuilding (Chandrapavan et al. 2016). The 2019–2020 catch is the highest since fishing resumed in 2013.				EMBA (DPIRD 2022).
	Active licences and/or vessels	The precise number of vessels in the Shark Bay Blue Swimmer Crab Managed Fishery is unreported. There are five crab trap permits, which are consolidated onto three active vessels (WAFIC 2024c).				
Shark Bay Prawn Managed Fishery	***Management area***	The Shark Bay Prawn Managed Fishery operates within inner Shark Bay.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets: • western king prawns (*Penaeus latisulcatus*) • brown tiger prawns (*Penaeus esculentus*) • endeavour (*Metapenaeus endeavouri*) • coral prawns (*Metapenaeopsis* sp.).	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Low-opening, otter prawn trawl systems.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: 1,268 t (2020), 1,214 t (2019), 1,091 t (2018) and 1,608 t (2017).				
	Active licences and/or vessels	The precise number of vessels in the Shark Bay prawn managed fisheries is unreported.				
Shark Bay Scallop Managed Fishery	***Management area***	The Shark Bay Scallop Managed Fishery operates within inner Shark Bay.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	Saucer scallops (*Ylistrum balloti*)	x	N/A	✓	

<table>
<tr><th rowspan="2">Fishery</th><th rowspan="2" colspan="2">Description^</th><th colspan="4">Potential for interaction</th></tr>
<tr><th colspan="2">Project Area</th><th colspan="2">EMBA</th></tr>
<tr><td></td><td>Fishing methods</td><td>Low-opening, otter prawn trawl systems.</td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4">Recent active fishing effort intersects with EMBA (DPIRD 2022).</td></tr>
<tr><td></td><td>Fishing depth</td><td>Information not available.</td></tr>
<tr><td></td><td>Fishing activity</td><td>The Shark Bay Scallop Managed Fishery has been managed under a quota management framework since it reopened in 2015. Scallop landings for Shark Bay were 177.1 t meat weight (885.5 t whole weight) in 2020 and 339 t meat weight (1,694 t whole weight) in 2019.</td></tr>
<tr><td></td><td>Active licences and/or vessels</td><td>The precise number of vessels in the Shark Bay scallop managed fisheries is unreported.
Boats are licensed to take only scallops (11 Class A licenses) or scallops and prawns (18 Class B licenses).</td></tr>
<tr><td rowspan="5">West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery</td><td>Management area</td><td>The West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery is part of the Temperate Demersal Gillnet and Demersal Longline Fishery, which operates between 26° and 33° S, and the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery, which operates from 33° S to the WA/SA border.</td><td>x</td><td>Does not overlap with fishery management area.</td><td>✓</td><td>Overlaps with fishery management area</td></tr>
<tr><td>Key species</td><td>The fishery targets:
• gummy shark (Mustelus antarcticus)
• dusky shark (Carcharhinus obscurus)
• whiskery shark (Furgaleus macki)
• sandbar shark (C. plumbeus)
Scalefish are a byproduct.</td><td rowspan="4">x</td><td rowspan="4">N/A</td><td rowspan="4">✓</td><td rowspan="4">Recent active fishing effort intersects with EMBA (DPIRD 2022).</td></tr>
<tr><td>Fishing methods</td><td>Gillnet and longline.</td></tr>
<tr><td>Fishing depth</td><td>Information not available.</td></tr>
<tr><td>Fishing activity</td><td>Previous years’ values are from State of the Fisheries annual reports provided by DPIRD:
• Catches of elasmobranchs and fishing effort for the Temperate Demersal Gillnet and Demersal Longline Fishery peaked during the late 1980s and early 1990s and have stabilised at lower levels in recent years.
• Estimated annual value to the fishery was A$110,00 (2019–2020), A$200,000 (2018–2019) and A$300,00 (2017–2018).</td></tr>
</table>

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
	Active licences and/or vessels	Vessel numbers are unknown; however, 17 interim managed fishery permits were held in 2019. During 2019–2020, 4–6 skippers and crew were employed in this fishery.				
West Coast Demersal Scalefish (Interim) Managed Fishery	***Management area***	The West Coast Demersal Scalefish Interim Managed Fishery is the main commercial fishery that targets demersal species in the West Coast Bioregion. It encompasses the waters from just south of Shark Bay down to just east of Augusta and extends seaward to the 200 nm boundary. The fishery is divided into four inshore management areas and one offshore management area.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The resource comprises over 100 species, including: • Baldchin groper (*Choerodon rubescens*) • Dhufish (*Glaucosoma hebraicum*) • Pink snapper (*Pagrus auratus*).	x	N/A	✓	Recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Lines.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years catch based on State of the Fisheries annual reports provided by DPIRD: The West Coast Demersal Scalefish Interim Managed Fishery retained 227 t in 2020, 254 t in 2019 and 230 t in 2018. Management commenced to recover stocks for the West Coast Demersal Scalefish Resource in 2008. Landings since 2008 have been below the stock recovery benchmark of 450 t.				
	Active licences and/or vessels	33 West Coast Demersal Scalefish Interim Managed Fishery vessels operated in 2020 and employed up to four crew, excluding the skipper.				
West Coast Purse Seine Managed Fishery	***Management area***	Located in waters from Cape Bouvard extending to Lancelin.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	The fishery targets small pelagic finfish such as: • Scaly mackerel (*Sardinella lemuru*) • Pilchards (*Sardinops sagax*)	X	N/A	✓	Recent active fishing effort intersects with

Fishery	Description^		Potential for interaction			
			Project Area		EMBA	
		• Australian anchovy (*Engraulis australis*) • Yellowtail scad (*Trachurus novaezelandiae*) • Maray (*Etrumeus teres*).				EMBA (DPIRD 2022).
	Fishing methods	Purse seine.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years catch based on State of the Fisheries annual reports provided by DPIRD: The total combined catch taken by the West Coast Purse Seine Managed Fishery and developmental licensees was 493 t in 2020, 527 t in 2019 and 340 t in 2018.				
	Active licences and/or vessels	Five vessels in 2020.				
West Coast Rock Lobster Managed Fishery	***Management area***	The West Coast Rock Lobster Managed Fishery operates from Shark Bay south to Cape Leeuwin. The fishery is managed using zones, seasons and total allowable catch.	x	Does not overlap with fishery management area.	✓	Overlaps with fishery management area
	Key species	Western rock lobster (*Panulirus cygnus*)	x	N/A	x	No recent active fishing effort intersects with EMBA (DPIRD 2022).
	Fishing methods	Baited pots and by hand.				
	Fishing depth	Information not available.				
	Fishing activity	Previous years' catches are based on State of the Fisheries annual reports provided by DPIRD: The commercial fishing season begins on 15 January each year and runs for 12 months; however, due to Covid-19 related logistics and marketing issues, the commercial 2020/21 season was extended to 18 months, from 15 January 2020 to 30 June 2021. The West Coast Rock Lobster Managed Fishery recorded a commercial catch of 9,132 t (18-month 2020–2021 season), and, 6,397 t (2019) and 6,400 t (2018).				
	Active licences and/or vessels	239 vessels operated in 2020.				

^ *Source: (Newman et al. 2021)*

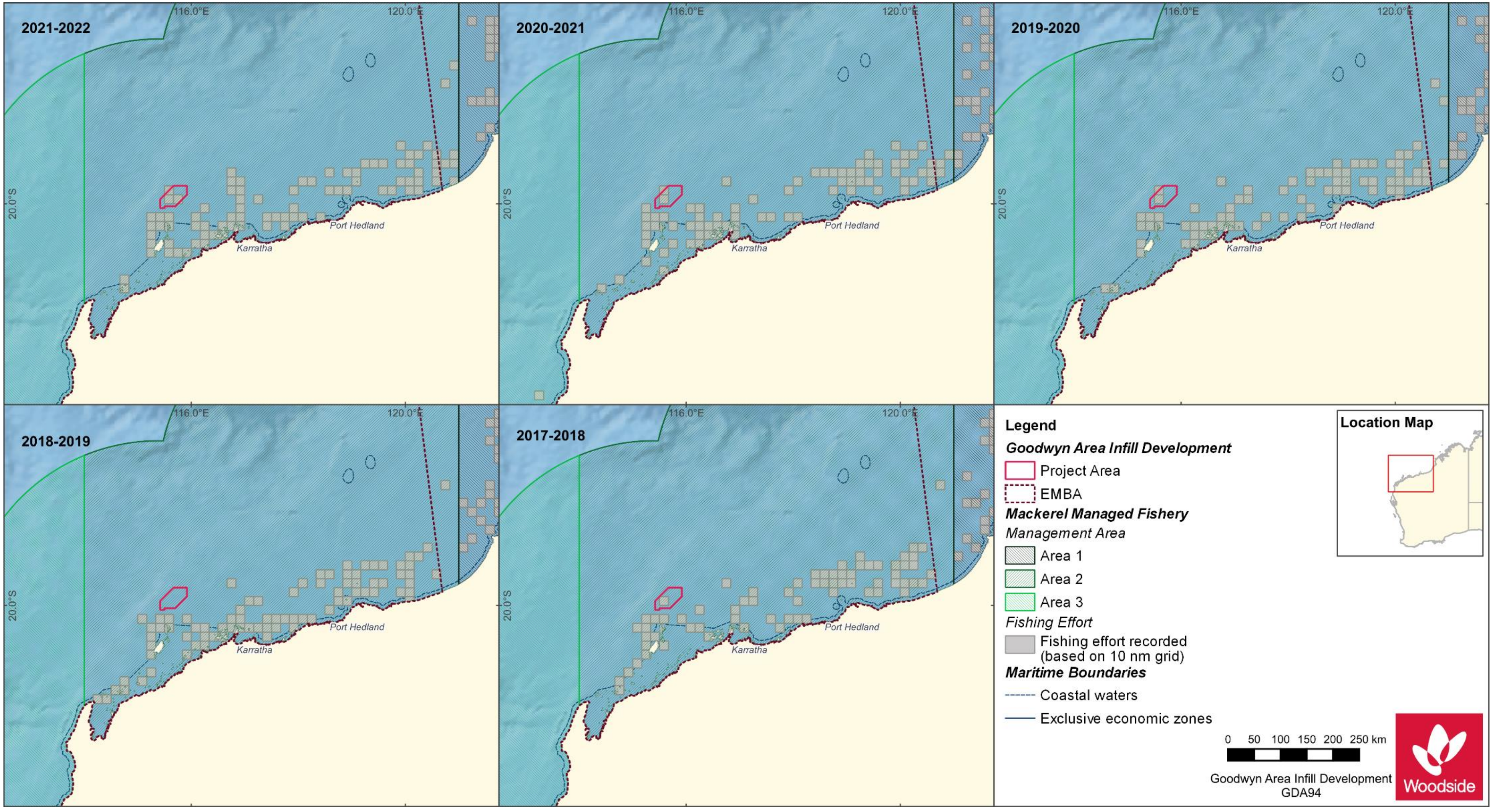


Figure 7-42: Mackerel Managed Fishery—fishery management area and fishing effort within vicinity of the Project Area

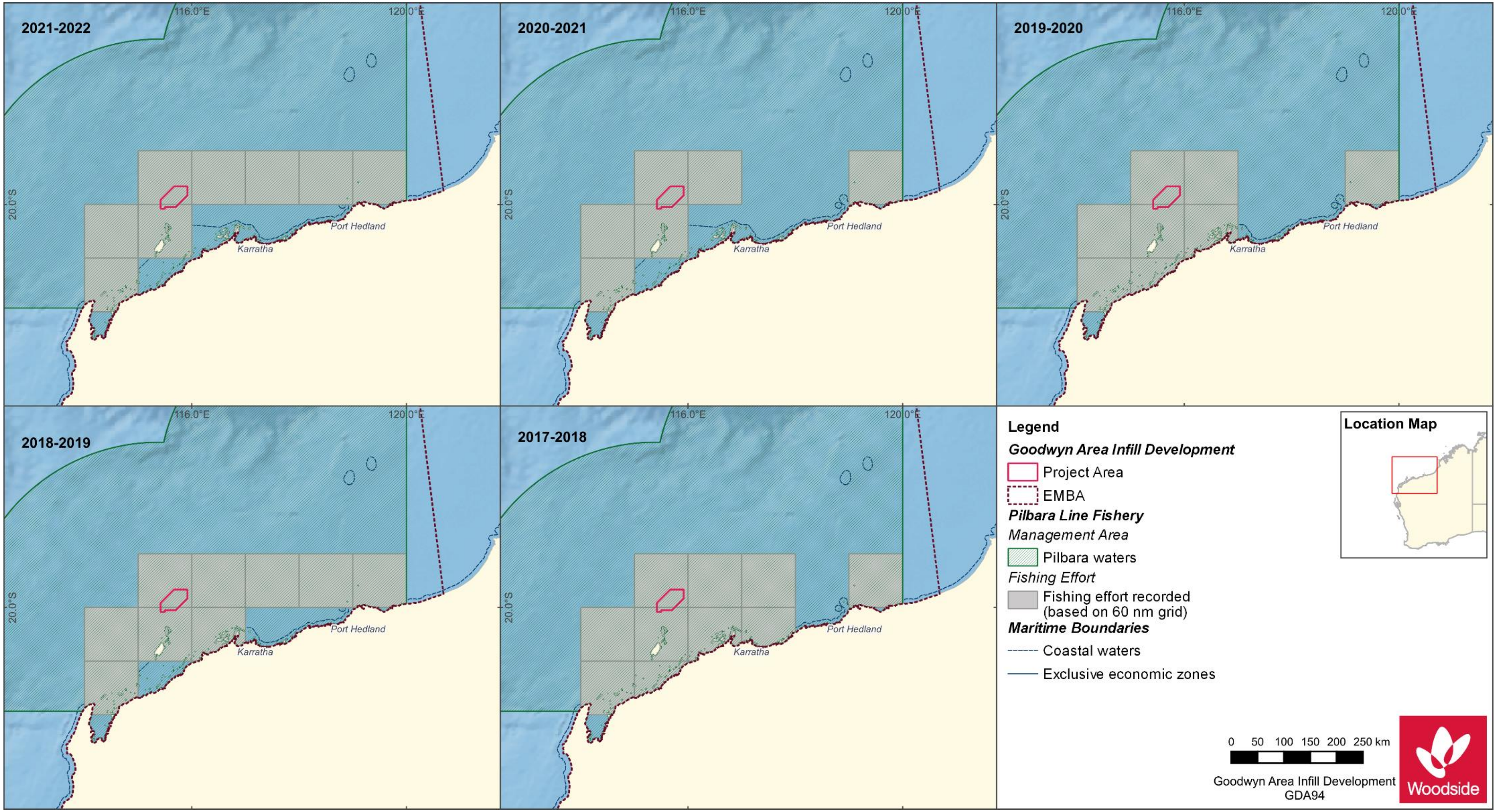


Figure 7-43: Pilbara Line Fishery—fishery management area and fishing effort within vicinity of the Project Area

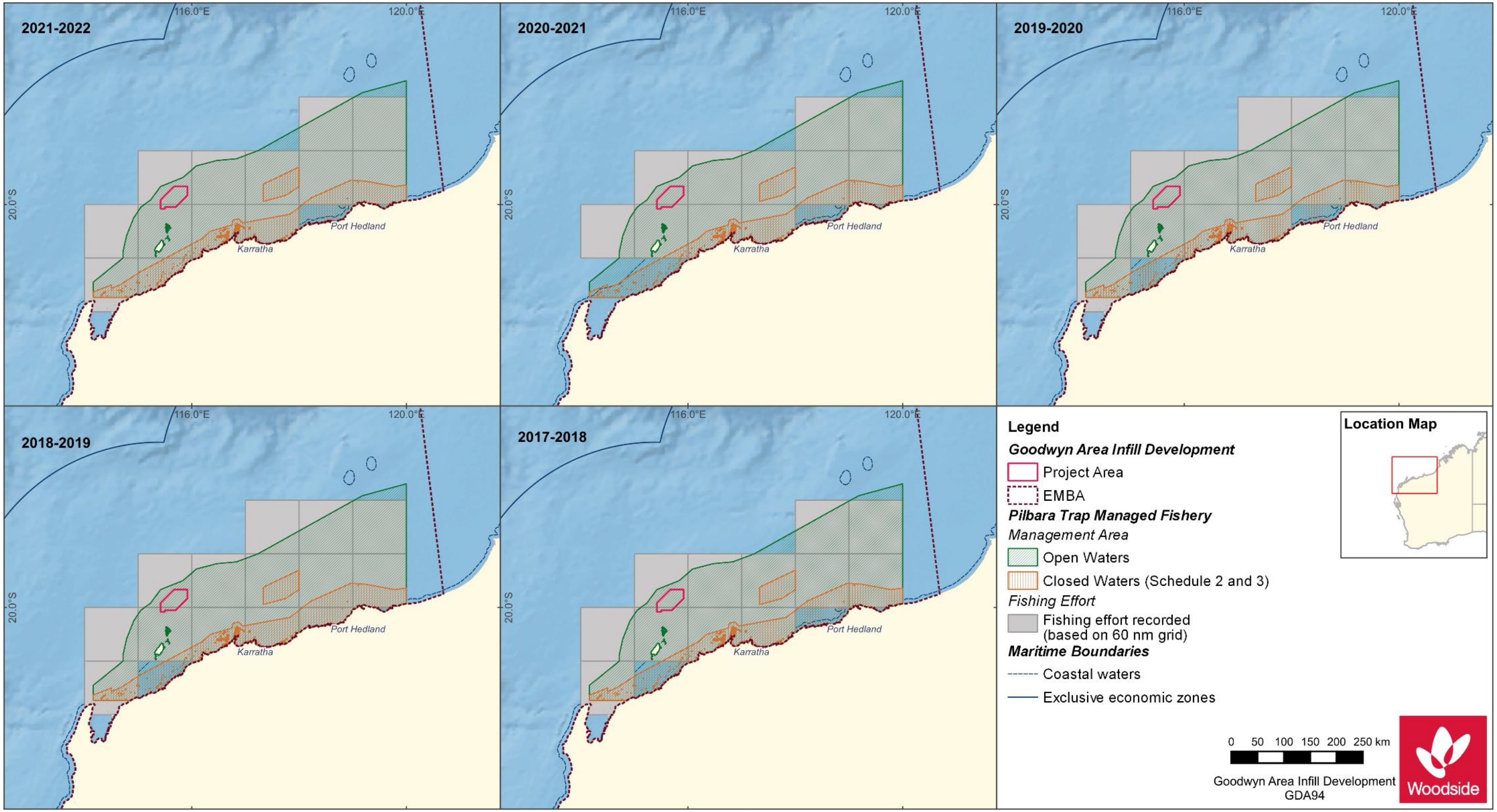


Figure 7-44: Pilbara Trap Managed Fishery—fishery management area and fishing effort within vicinity of the Project Area

7.10.1.3 Aquaculture

Aquaculture operations in WA's north-west are typically restricted to inland and shallow coastal waters. Aquaculture activities are described below for those fishery bioregions that intersect with the EMBA.

The Project Area does not intersect with any known aquaculture areas.

7.10.1.3.1 North Coast Bioregion

Aquaculture activities in the North Coast bioregion is dominated by pearl production from the *Pinctada maxima* species (Newman et al. 2021). A large number of pearl oysters for seeding are obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and around the Dampier Peninsula (Newman et al. 2021). Primary spawning of the pearl oyster occurs from mid-October to December.

Other aquaculture developments in this bioregion include emerging producers of coral and live rock species for aquariums, as well as barramundi (*Lates calcarifer*) farms and microalgae culturing (Newman et al. 2021).

7.10.1.3.2 Gascoyne Coast Bioregion

In the Gascoyne Coast bioregion, aquaculture activities are focused on the blacklip oyster (*Pinctada margaritifera*) (Newman et al. 2021). Several hatcheries supply *P. margaritifera* juveniles to the bioregion's developing black pearl farms.

Other aquaculture developments in this bioregion include emerging producers of coral, live rock species and edible oysters (Newman et al. 2021).

7.10.1.3.3 West Coast Bioregion

Aquaculture activities in the West Coast bioregion are focused on blue mussels and edible oysters (mainly in Cockburn Sound), and marine algae for beta-carotene production (beta-carotene is used as a food additive and as a nutritional supplement). Offshore marine finfish production is also being developed, initially focusing on yellowtail kingfish, although planning for the nursery has been impacted by the COVID-19 pandemic (Newman et al. 2021).

There is also an emerging black pearl industry (from the *Pinctada margaritifera* oyster) in the Abrolhos Islands (Newman et al. 2021), as well as expansion in the production of Akoya pearls (small white pearls from *Pinctada fucata martensii*), *Pinctada albina* (small, yellow pearls) and *Pteria penguin*, which are often used to produce half (mabe) pearls in pink and bluish shades.

Aquaculture licences for producing coral and live rock (pieces of old coral reefs colonised by marine life, such as beneficial bacteria, for aquariums) at the Abrolhos Islands have also been issued and other applications are being assessed.

7.10.2 Traditional Fisheries

Traditional or customary fisheries are typically restricted to shallow coastal waters and/or areas with structures, such as reefs.

Customary fishing applies to person who has a traditional connection with the area being fished, and is fishing for personal, domestic, ceremonial, educational or non-commercial needs. A Customary Fishing Policy has been incorporated into the *Fish Resources Management Act 1994* (WA), which allows for customary fishing by applicable persons to occur within a sustainable fisheries management framework. Customary fishing does not apply to other species of marine fauna (e.g. crocodile, turtle, or dugong).

Under amendments made in 2012 to the *Conservation and Land Management Act 1984* (WA) Aboriginal people can undertake customary activities which includes hunting (except in marine sanctuary zones or marine nature reserves) for dugong, turtle, or crocodiles in WA.

Dugong, fish, and marine turtles that move between coastal and Commonwealth waters are important components of the culture and diet of Aboriginal people. Aboriginal people continue to actively manage their Sea Country in coastal waters of WA, in order to protect and manage the marine environment, its resources and cultural values.

Due to the offshore location of the Project Area, there are no traditional or customary fisheries anticipated within the Project Area.

7.10.3 Tourism and Recreation

Recreation and tourism activities within the Pilbara are of high social value. Recreational and tourism activities within the Project Area are expected to be limited and infrequent due to its distance offshore and water depths. The Montebello Islands (~30 km from the Project Area) are the closest location for tourism; some charter boat operators take visitors to these islands (DEC and MPRA 2007a).

A review of FishCube data (DPIRD 2022) for tour operators confirmed that charter boat operators within the region are concentrated around coastal waters. This data indicated that <3 licences were recorded in the Project Area between 2012 and 2022. Tour operator activity within the Project Area typically occurred between July and November, however does not indicate that there was any fish catch associated with the activity.

The Gascoyne, Pilbara and Kimberley regions, which are located within the vicinity of the EMBA, are popular visitor destinations for Australian and international tourists. These regions are discussed further in the following subsections.

7.10.3.1 Gascoyne region

Tourism is one of the major industries of the Gascoyne region and contributes significantly to the local economy in terms of income and employment. In 2018–2019, the Ningaloo region (Ningaloo Reef and the surrounding coastal region, Exmouth Gulf, communities of Exmouth and Coral Bay, and adjacent proposed southern coastal reserves and pastoral leases) contributed an estimated A$110 million in value added to the WA economy (Deloitte Access Economics 2020). Ningaloo's economic contribution to WA is attributed to four key types of economic activity: tourism expenditure by international, interstate and WA visitors to the Ningaloo region; commercial fishing in the Exmouth Gulf; recreational activities involving the reef by residents of the Ningaloo region; and management and research relating to the reef (Deloitte Access Economics 2020). More than 90% of this value added is attributed to the domestic and international tourists who visit Ningaloo each year (Deloitte Access Economics 2020). The COVID-19 pandemic disrupted the tourism industry of the Gascoyne region, particularly by reducing availability of the overseas workforce. However, the region has not had to shut down since early 2020 and interstate tourism numbers grew from 2020 to 2021 (Gascoyne Development Commission 2021).

The main marine nature-based tourist activities within the Gascoyne Region are concentrated around and within the Ningaloo Coast World Heritage Property (~200 km south-west of the Project Area). Activities undertaken include recreational fishing, snorkelling and scuba diving and wildlife watching and encounters (including whale sharks, manta rays, humpback whales and turtles) (Schianetz et al. 2009).

Recreational fishing in the Gascoyne region is mainly concentrated around coastal waters, and includes beach and cliff fishing, embayment and shallow-water boat angling, and offshore boat angling for demersal and larger pelagic species (e.g. off Ningaloo Reef) (Newman et al. 2021). Some recreational fishing has historically taken place at Rankin Bank and the Glomar Shoal (~3 km west and 60 km east of the Project Area respectively). However, due to the distance from access nodes, such as Dampier and Onslow (~120 km and 175 km from the Project Area at the closest point respectively) recreational fishing effort is expected to be restricted to relatively large vessels and hence is considered to be low.

7.10.3.2 Pilbara region

Recreation and tourism activities within the Pilbara are of high social value. Tourism is a key economic driver for the Pilbara with more than 1 million visitors to the region every year, generating A$413 million in gross revenue annually (Pilbara Development Commission 2021). Tourism visitation continued to grow in 2021 when international border restrictions encouraged intrastate travel (Pilbara Development Commission 2021).

Recreational fishing within the Pilbara region tends to be concentrated in State waters adjacent to population centres. Recreational fishing is known to occur around the Dampier Archipelago, with several boat-launching ramps around Dampier and Karratha (Williamson, Sumner, and Malseed 2006). Once at sea, charter vessels may also frequent the waters surrounding the Montebello Islands. Some recreational fishing has historically taken place at Rankin Bank and the Glomar Shoal.

7.10.3.3 Kimberley region

Tourism is one of the main industries in the Kimberley region (others include resources, construction, agriculture and retail). COVID-19 caused financial vulnerability for the tourism industry in 2020–2021 (Kimberley Development Commission 2021).

Recreation and tourism activities—such as recreational fishing, diving, snorkelling, wildlife watching and boating—in the Kimberley region occur predominantly in WA State waters (extending offshore 3 nm from the mainland), adjacent to coastal population centres (e.g. Broome), with a peak in activity during the dry season.

Primary dive locations in the Kimberley region include the Rowley Shoals, including Mermaid Reef AMP, Scott Reef, Seringapatam Reef, Ashmore Reef AMP and Cartier Island.

7.10.4 Commercial Shipping

Commercial shipping traffic is high within the NWMR; vessel activities include commercial fisheries, tourism (such as cruises), international shipping, and oil and gas operations. There are 12 ports adjacent to the NWMR, including the major ports of Dampier, Port Hedland and Broome, which are operated by their respective port authorities. These ports handle large tonnages of iron ore and petroleum exports, as well as salt, manganese, feldspar chromite and copper (DEWHA 2008b).

In 2012, the Australian Maritime Safety Authority (AMSA) introduced a network of marine fairways across the NWMR to reduce the risk of vessel collisions with offshore infrastructure. The fairways are intended to direct large vessels (such as bulk carriers and LNG ships trading to the major ports) into pre-defined routes to keep them clear of existing and planned offshore infrastructure (AMSA 2013).

Although one of these fairways overlaps the eastern end of the Project Area (Figure 7-45), vessel traffic within the Project Area is relatively low. Vessel tracking data suggest vessel traffic is higher to immediately to the west and north-east of the Project Area, likely associated with existing oil and gas facilities (e.g. GWA, NRC, Pluto, and Wheatstone platforms). Vessel traffic is also higher further south of the Project Area, where the increased traffic is likely associated with servicing the resource industry and ports at Barrow Island, Onslow and Dampier.

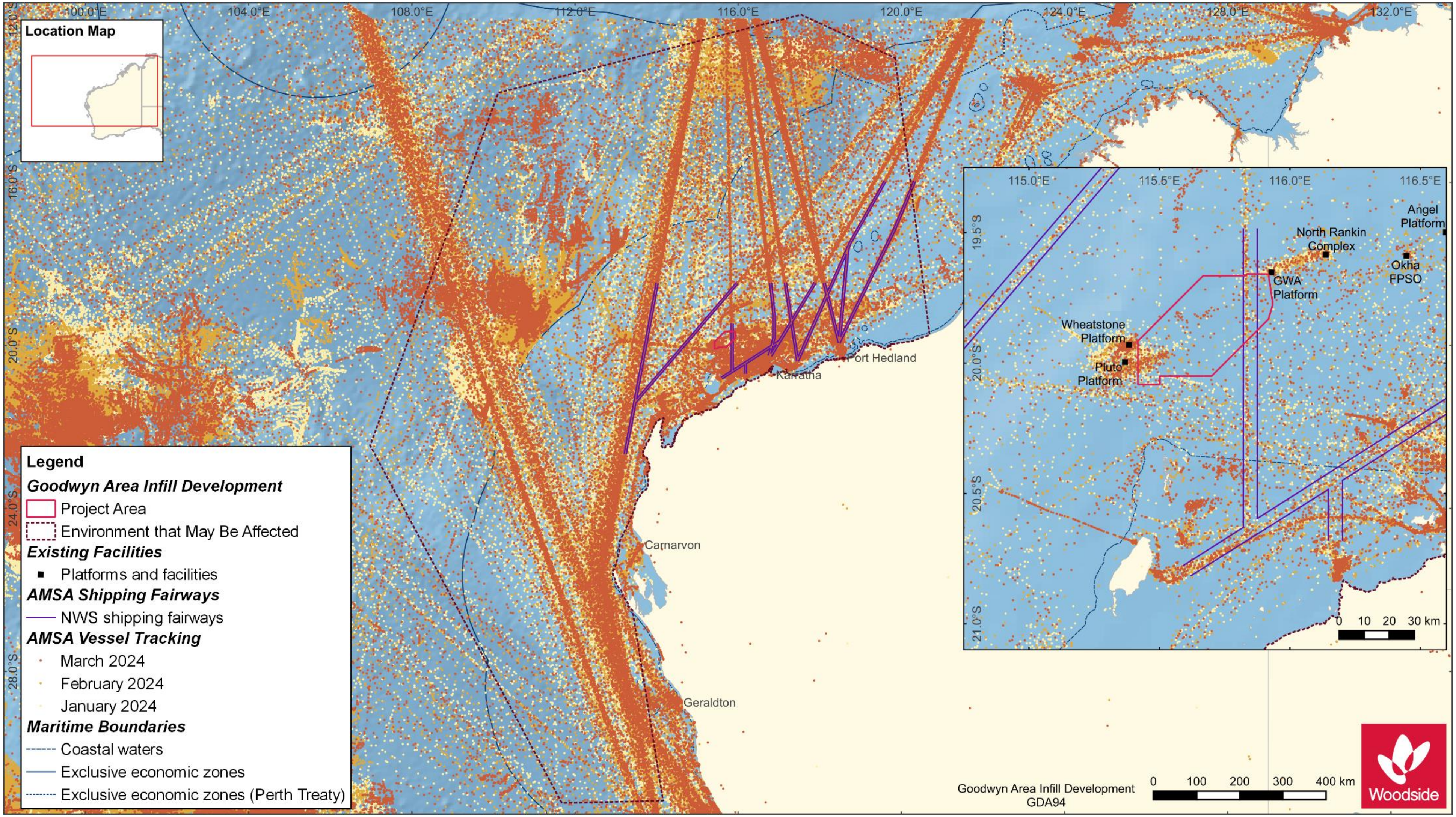


Figure 7-45: AMSA shipping fairways and vessel tracking information within the vicinity of the Project Area and EMBA

7.10.5 Petroleum Activities

The NWMR supports a number of industries, including petroleum exploration and production. Offshore of WA there are several sedimentary petroleum basins, including the Northern and Southern Carnarvon basins, Perth, Browse, Roebuck, and Bonaparte basins (Geoscience Australia 2023). Of these, the Northern Carnarvon, Browse and Bonaparte basins hold large quantities of gas and comprise most of Australia's reserves of natural gas (DEWHA 2008b), which is reflected by the level of development in the area.

In addition to the NWS Project, other petroleum projects within the vicinity of the Project Area include Woodside's Pluto LNG Project, Chevron Australia's Wheatstone Project and Gorgon Gas Development, and Santos' Varanus Island Hub. Petroleum facilities within 50 km of the Project Area are shown in Table 7-34.

Table 7-34: Other petroleum facilities within 50 km of the Project Area

Facility Name and Operator	Distance and direction from Project Area to the facility
GWA platform (Woodside)	~2 km north-east
Wheatstone platform (Chevron)	~3.5 km west
Pluto platform (Woodside)	~5 km west
North Rankin Complex (Woodside)	~25 km north-east
Campbell platform (Santos)[1]	~40 km south
Reindeer (Santos)	~46 km south-east

1. Platform is not operational and is proposed to be removed in 2024 (Santos 2023).

7.10.6 Defence

Key Australian Department of Defence (DoD) operational areas and facilities areas of the NWMR for training and operational activities, include:

- Taylor Barracks (Karratha), the headquarters of the Pilbara regiment, which is one of three Regional Force Surveillance Units conducting surveillance and reconnaissance of remote areas of northern Australia (DoD 2022)
- two Royal Australian Air Force (RAAF) bases which are used for exercises
  - RAAF Learmonth was established to provide support for land, air and sea operations
  - the air training area associated with the Learmonth base extends over the offshore region
  - the air force also maintains the Commonwealth Heritage listed Learmonth Air Weapons Range Facility, which is between Ningaloo Station and the Cape Range National Park
  - RAAF Curtin on the north coast of WA south-east of Derby and ~170 km east of Broome, which provides land, air and sea operational support for Australia's north
- the Naval Communications Station Harold E. Holt, which is ~6 km north of Exmouth. The main role of the station is to communicate at very low frequencies (19.8 kHz) with Australian and United States submarines and ships in the eastern Indian Ocean and the western Pacific Ocean (DEWHA 2008b)
  - Harold E Holt Area A also includes the Point Murat Navy Pier, and the waters extending 400 m around the pier (DoD 2020).

No defence areas overlap the Project Area. The offshore training area associated with RAAF Learmonth base and the Point Murat Navy Pier do intersect with the EMBA.

8 CONSULTATION

8.1 Overview

Woodside has a portfolio of quality oil and gas assets and more than 35 years of operating experience. We have a strong history of working with local communities, the relevant regulators and a broad range of persons and organisations to understand the potential risks and impacts from our proposed activities and to develop appropriate measures to manage them.

Stakeholder consultation and engagement is an integral component of the environmental impact and risk assessment and environmental authorisation process for OPPs.

This section describes Woodside's approach, to stakeholder consultation broadly, and for the development of Goodwyn Area Infill Development specifically.

Woodside's objectives for stakeholder consultation are to:

- improve stakeholder awareness and understanding of the Goodwyn Area Infill Development
- provide stakeholders with opportunities to obtain information about the Goodwyn Area Infill Development including the physical, ecological, socioeconomic, and cultural environment that may be affected, the potential impacts or risks that may occur, and the prevention and mitigation measures proposed to avoid or minimise those impacts
- gain feedback from stakeholders on their concerns about the development of Goodwyn Area Infill Development and where possible, address stakeholder concerns through further activities, or by implementing additional mitigation measures.

8.2 Stakeholder Identification

The process for stakeholder consultation as undertaken by Woodside included the identification of stakeholders and their relevance to the project. Table 8-1 presents a preliminary summary of stakeholders and stakeholder groups that are interested in, or likely to be affected by the Goodwyn Area Infill Development. This list is not exhaustive and additional stakeholders may be identified as part of the ongoing consultation.

Stakeholders identified include stakeholders known as a result of Woodside's ongoing activities in WA, as well as those identified through engagements with regulators, government agencies, desktop research, and regional contacts.

Table 8-1: Identified stakeholders

Stakeholders	
Australian Government	
Australian Fisheries Management Authority (AFMA)	National Offshore Petroleum Titles Administrator (NOPTA)
Australian Hydrographic Office (AHO)	Office of Federal Minister for Resources and Northern Australia
Australian Maritime Safety Authority (AMSA)	Office of Shadow Minister for Environment
Department of Climate Change, Energy, the Environment and Water (DCCEEW)	Office of Shadow Minister for Resources
Department of Defence	Director of National Parks
Department of Industry, Science and Resources (DISR)	Senator Pat Dodson
Federal Minister for Environment; Member for Durack	Shadow Minister for Environment; Water
National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)	Department of Agriculture, Fisheries and Forestry (DAFF)

Stakeholders	
Australian Border Force (ABF)	
WA State Government	
Department of Biodiversity, Conservation and Attractions (DBCA)	Department of Primary Industries and Regional Development (DPIRD)
Ningaloo Coast World Heritage Advisory Committee (NCWHAC)	Department of Transport (DoT)
Department of Jobs, Tourism, Science and Innovation (DJTSI)	Department of Water and Environmental Regulation (DWER)
Department of Energy, Mines, Industry Regulation and Safety (DEMIRS)	Environmental Protection Authority Services
Department of Planning, Lands and Heritage (DPLH)	Department of Water and Environmental Regulation (DWER)
Department of Primary Industries and Regional Development (DPIRD)	Department of Primary Industries and Regional Development (DPIRD)
Department of Transport (DoT)	Pilbara Ports Authority (PPA)
Traditional Owner Groups, Local Government, Community, Educational Institutions, and Environmental Non-Government Organisations (eNGOs)	
Australian Conservation Foundation (ACF)	Buurabalayji Thalanyji Aboriginal Corporation
Australian Institute of Marine Science (AIMS)	Karajarri Traditional Lands Association (Aboriginal Corporation)
Australian Marine Conservation Society (AMCS)	Kariyarra Aboriginal Corporation
Broome Chamber of Commerce and Industry	Kimberley Land Council
Cape Conservation Group (CCG)	Malgana Aboriginal Corporation
City of Greater Geraldton	Murujuga Aboriginal Corporation
City of Karratha	Nganhurra Thanardi Garrbu Aboriginal Corporation (NTGAC)
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Ngarluma Aboriginal Corporation
Conservation Council of Western Australia (CCWA)	Ngarluma Yindjibarndi Foundation Ltd
Exmouth Community Liaison Group (CLG)	Nyangumarta Karajarri Aboriginal Corporation
Greenpeace Australia Pacific (GAP)	Nyangumarta Warrarn Aboriginal Corporation RNTBC
Karratha Community Liaison Group	Robe River Kuruma Aboriginal Corporation
Onslow Chamber of Commerce and Industry	Save our Songlines (SOS)
Protect Ningaloo	South West Land and Sea Council
Shire of Ashburton	Wanparta Aboriginal Corporation
Shire of Broome	Wirrawandi Aboriginal Corporation (WAC)
Shire of East Pilbara	Yamatji Marlpa Aboriginal Corporation
Shire of Shark Bay	Yawuru Native Title Holders Aboriginal Corporation
Shite of Carnarvon	Yawuru Native Title Holders Aboriginal Corporation
Shite of Exmouth	Yindjibarndi Aboriginal Corporation
Town of Port Headland	Yinggarda Aboriginal Corporation
Western Australian Marine Science Institution (WAMSI)	Yued Aboriginal Corporation

Stakeholders	
Industry	
Australian Marine Oil Spill Centre (AMOSC)	Chamber of Minerals and Energy of Western Australia (CME)
Australian Energy Producers (AEP)	Oil and gas operators
Fisheries	
Australian Southern Bluefin Tuna Association (ASBTIA)	Pearl Producers Association (PPA)
Charter boat operators and recreational fishers	Recfishwest
Western Rock Lobster Council	Tuna Australia
Commonwealth Fisheries Association (CFA)	Western Australia Fishing Industries Council (WAFIC)
Marine Tourism WA	WA Game Fishing Association
State commercial fisheries, including: • Nickol Bay and Onslow Prawn Fisheries • Pilbara Trap, Line and Trawl Fishery • Exmouth Gulf Prawn Managed Fishery • West Coast Rock Lobster Fishery • WA North Coast Shark Managed Fishery • Marine Aquarium Managed Fishery • South West Coast Salmon Managed Fishery • Mackerel Managed Fishery (Area 2) • Pilbara Crab Managed Fishery • West Coast Deep Sea Crustacean Managed Fishery • Specimen Shell Managed Fishery • Pearl Oyster Managed Fishery • Land Hermit Crab Fishery • Western Australian Sea Cucumber Fishery	Commonwealth commercial fisheries, including: • North West Slope Trawl • Southern Bluefin Tuna • Western Tuna and Billfish Fishery • Western Deepwater Trawl Fishery • Western Skipjack Fishery

8.3 Stakeholder Mapping to Impacts and Risks

As a part of ongoing stakeholder consultation, the relevant stakeholders will be provided information relating to their specific functions, interests, and activities. An initial assessment of the stakeholders' functions, interests and activities has been undertaken based on previous work with these stakeholders in the region and the preliminary impact assessment conducted for the offshore project.

Woodside proposes to undertake a proactive stakeholder consultation process in support for the development of the OPP and subsequent future approvals for the Goodwyn Area Infill Development:

- regular stakeholder assessment processes will be undertaken, informed by current and future NWSJV consultation activities by Woodside to identify relevant stakeholders whose functions, interests or activities may be affected by the Goodwyn Area Infill Development and seek their feedback, as required
- all stakeholders identified in the EMBA will be contacted by Woodside at the commencement of the public comment period to provide feedback on the OPP via the NOPSEMA process
- feedback already provided by stakeholders who have been contacted for other NWS Woodside EPs within the EMBA will be considered in the preparation of the OPP
- Woodside will also proactively seek to engage with Traditional Custodian representative bodies and people identified as part of the EMBA process to seek their feedback on the proposed offshore project

- Woodside will communicate to all stakeholders during the OPP consultation process that their feedback will also be sought for the subsequent Construction, Exploration and updated GWA Facility Operations EP.

Functions, interests and activities have been mapped to the identified impacts and risks (as described in Section 9) in Table 8-2 and outlined by stakeholder group in Table 8-3. This will continue to be reviewed and updated as the assessment progresses and in response to the stakeholder feedback received.

Table 8-2: Stakeholder impact and risk mapping

Receptor Group	Receptor	Impact or Risk	Australian Government	State Government	Traditional Owner Groups, Local Government, Community, Educational Institutions, and eNGOs	Industry	Fisheries
Physical environment	Marine sediments	Change to sediment quality	✓	✓			
	Water quality	Change to water quality	✓	✓			
	Air quality	Change to air quality	✓	✓	✓		
Habitats and biological communities	Planktonic communities	Potential changes to habitats and biological communities	✓	✓	✓		
		Potential injury or mortality to fauna	✓	✓	✓		
		Potential changes to ecosystems	✓	✓	✓		
	Offshore habitats and biological communities	Potential changes to habitats and biological communities	✓	✓	✓		
		Potential changes to ecosystems	✓	✓	✓		
	Nearshore and coastal habitats and biological communities	Potential changes to habitats and biological communities	✓	✓	✓		
		Potential changes to ecosystems	✓	✓	✓		
Protected species	Fish, sharks, and rays	Potential changes to fauna behaviour	✓	✓	✓		✓
		Potential injury or mortality to fauna	✓	✓	✓		✓
	Marine reptiles	Potential changes to fauna behaviour	✓	✓	✓		
		Potential injury or mortality to fauna	✓	✓	✓		
	Marine mammals	Potential changes to fauna behaviour	✓	✓	✓		
		Potential injury or mortality to fauna	✓	✓	✓		

Receptor Group	Receptor	Impact or Risk	Australian Government	State Government	Traditional Owner Groups, Local Government, Community, Educational Institutions, and eNGOs	Industry	Fisheries
	Seabirds and migratory shorebirds	Potential changes to fauna behaviour	✓	✓	✓		
		Potential injury or mortality to fauna	✓	✓	✓		
Key ecological features	Key ecological features	Potential changes to habitats and biological communities	✓	✓	✓		
		Potential changes to ecosystems	✓	✓	✓		
Protected places	Australian Marine Parks	Potential changes to the values and sensitivities of protected places	✓	✓	✓		
	State marine protected areas	Potential changes to the values and sensitivities of protected places	✓	✓	✓		
	Wetlands of international importance (Ramsar wetlands)	Potential changes to the values and sensitivities of protected places	✓	✓	✓		
Socioeconomic and cultural environment	Cultural features and heritage values	Potential changes to cultural values or features	✓	✓	✓		
	Commercial fisheries	Potential changes to the functions, interests, or activities of other users	✓	✓	✓		✓
	Traditional fisheries	Potential changes to the functions, interests, or activities of other users	✓	✓	✓		✓
	Tourism and recreation	Potential changes to the functions, interests, or activities of other users	✓	✓	✓	✓	✓
	Commercial shipping	Potential changes to the functions, interests, or activities of other users	✓	✓	✓	✓	

Receptor Group	Receptor	Impact or Risk	Australian Government	State Government	Traditional Owner Groups, Local Government, Community, Educational Institutions, and eNGOs	Industry	Fisheries
	Petroleum activities	Potential changes to the functions, interests, or activities of other users	✓	✓	✓	✓	
	Defence	Potential changes to the functions, interests, or activities of other users	✓	✓	✓	✓	

Table 8-3: Stakeholder aspect mapping

Aspect	Australian Government	State Government	Traditional Owner Groups, Local Government, Community, Educational Institutions, and eNGOs	Industry	Fisheries
Planned Activities					
Physical Presence: Interaction with other Marine Users	✓	✓	✓	✓	✓
Physical Presence: Disturbance to the Seabed	✓	✓	✓		
Routine Emissions: Light Generation	✓	✓	✓		
Routine Acoustic Emissions: Continuous Sound Generation	✓	✓	✓		✓
Routine Acoustic Emissions: Impulsive Sound Generation	✓	✓	✓		✓
Routine and Non-routine Emissions: Atmospheric	✓	✓	✓		
Routine and Non-routine Emissions: Greenhouse Gases	✓	✓	✓		
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	✓	✓	✓		

Aspect	Australian Government	State Government	Traditional Owner Groups, Local Government, Community, Educational Institutions, and eNGOs	Industry	Fisheries
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	✓	✓			
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	✓	✓	✓		
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	✓	✓	✓		
Downstream Discharges: Produced Water	✓	✓	✓		
Unplanned Events					
Physical Presence: Interaction with Marine Fauna	✓	✓	✓		
Physical Presence: Introduction of Invasive Marine Species	✓	✓	✓	✓	
Physical Presence: Unplanned Seabed Disturbance	✓	✓	✓		
Unplanned Release: Hazardous and Non-hazardous Solid Wastes	✓	✓	✓		
Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment)	✓	✓	✓		
Unplanned Hydrocarbon Release: Gas and Condensate	✓	✓	✓	✓	✓
Unplanned Hydrocarbon Release: Marine Fuel	✓	✓	✓	✓	✓

8.4 Stakeholder Consultation Approach

Woodside is undertaking a phased program of consultation:

- **Phase 1:** preliminary consultation undertaken during the impact and risk assessment process and preparation of the OPP
- **Phase 2**: formal consultation undertaken during the public comment process of the draft OPP
- **Phase 3**: ongoing consultation during project planning and execution.

8.4.1 Phase 1: Preliminary Consultation

Preliminary consultation is focused on key relevant stakeholders. It primarily aims to:

- introduce stakeholders to the development
- inform stakeholders of the work being undertaken to assess impacts relevant to their functions, interests and activities
- provide them with the opportunity to comment on the baseline assumptions made in relation to interactions with the Goodwyn Area Infill Development and add new or different information
- inform them of the project timeframes and the mechanisms by which they can receive further updates or provide additional comment
- be provided with a point of contact or other information source for the project.

Preliminary consultation commenced in 2023 and is built on the broader consultation and engagement process that Woodside has in place for the NWS region. It will be undertaken up until the point of formal consultation under the OPP process.

Phase 1 consultation activities include these tasks:

- review feedback from Goodwyn Area Infill Geophysical and Geotechnical Survey EP and other NWS Woodside EPs with similar EMBAs
- identify any new stakeholders not identified in previous EP engagements with similar EMBAs
- engage with NOPSEMA and Director of National Parks

A summary of the Phase 1 consultation activities undertaken to date are provided in Table 8-4, which includes consultation undertaken up until the point of formal public release of the OPP draft (Phase 1).

Table 8-4: Summary of Phase 1 stakeholder consultation

Date	Activity	Stakeholder	Summary of Engagement
17 Nov 2022	Goodwyn Area Infill Development—Briefing	NOPSEMA	• Provided NOPSEMA with an overview of the proposed Goodwyn Area Infill Development • Summarised outcomes of preliminary screening assessments for key environmental sensitivities, aspects, impacts and risks • Summarised proposed studies and analyses to support OPP
21 Dec 2022	Goodwyn Area Infill Development—Proposed Studies		• Provided NOPSEMA with additional detail on proposed scope of modelling and environmental studies
30 May 2023	Goodwyn Area Infill Development—Update		• Provided NOPSEMA with an update on the proposed Goodwyn Area Infill Development • Brief on proposed approach to stakeholder consultation and understanding of cultural features and heritage values
18 Jul 2023	Goodwyn Area Infill Development—Indirect Consequences		• Discussed with NOPSEMA a proposed approach to assessing indirect consequences within the OPP
22 Nov 2023	Goodwyn Area Infill Development—Update		• Provided NOPSEMA with an update on the proposed Goodwyn Area Infill Development • Confirmed approach taken within the OPP downstream emissions and discharges, stakeholder consultation, and cultural features and heritage values • Confirmed approach for assessment of potential impacts and risks to Montebello Marine Park • Provided an update on proposed future environmental monitoring
16 Jun2023	Goodwyn Area Infill Development—Briefing	Director of National Parks	• Provided DNP with an overview of the proposed Goodwyn Area Infill Development • Summarised environmental aspects with interactions with the Montebello Marine Park • Summarised outcomes of studies undertaken to support impact and risk evaluation to the Montebello Marine Park

8.4.2 Phase 2: Formal OPP Consultation (Public Comment)

The OPP assessment process includes the publication of the OPP on the NOPSEMA website and a period of public consultation which gives all relevant and interested stakeholders an opportunity to review and provide comment. Phase 2 consultation also enables engagement with those stakeholders that were not identified to be potentially impacted by the proposed Goodwyn Area Infill Development, and as such were not consulted with in Phase 1.

The formal public comment period of an OPP is undertaken for a period of at least four weeks (as required by regulation 9(5)(b)(ii) of the Environment Regulations) and as determined by NOPSEMA.

All public comment is provided to NOPSEMA who provide a copy of the comments received to Woodside for their consideration to update the OPP. Following the public comment period, Woodside prepares a consultation report and final OPP for assessment by NOPSEMA.

8.4.3 Phase 3: Ongoing Consultation

On acceptance of the OPP, Woodside will continue to consult with relevant persons during the preparation of EPs, and execution of Goodwyn Area Infill Development.

Consultation is a formal requirement for EPs under regulations 25 and 22(15) of the Environment Regulations. Accordingly, Woodside will conduct further stakeholder assessment and consultation with relevant persons to inform decision-making and planning for the petroleum activities being undertaken as a part of this offshore project.

Relevant persons identified for consultation in support of the petroleum activities (within an activity-specific EP) will be monitored and updated as required, with any feedback given consideration for future activities.

All proposed engagement and consultation will be planned for in a Stakeholder Engagement Plan, and outcomes of consultation will be tracked and recorded by Woodside.

9 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

9.1 Planned Activities

9.1.1 Physical Presence: Interaction with other Marine Users

9.1.1.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in interactions with other marine users are described in the following table. The two main sources of physical presence and the potential for interaction with other marine users for the Goodwyn Area Infill Development are the new subsea infrastructure and the use of vessels and/or a MODU during the activities (drilling, installation, operations, and decommissioning).

Activity Group	Description
Drilling and Completions	Up to 8 wells (Table 5-1) may be drilled within the Project Area as part of the Goodwyn Area Infill Development. Each production well will have a wellhead installed, and the physical presence of this infrastructure will remain for the duration of field life. Wellheads (and any associated seabed infrastructure such as guide bases or mud mats) occupy a small area on the seabed, typically <10 m^2; the area will vary between wells. The height above the seabed for each wellhead can also vary but is typically ~2–5 m.
Subsea Installation and Pre-commissioning	Subsea infrastructure (e.g. flowlines and manifolds) will be installed in the Project Area within the nominal infrastructure corridor (Figure 5-2), and it will remain for the duration of field life. Infrastructure is located predominantly around drill centres, except for the longer Wilcox flowline that connects the Wilcox field to the LPA PLET. Individually, infrastructure takes up a relatively small area on the seabed. The total estimated infrastructure footprint for the Goodwyn Area Infill Development is ~0.04 km^2 (Sections 5.2.1 and Section 5.2.2).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Their presence within the Project Area is temporary (e.g. a MODU and support vessels would be present for ~1–3 months per well during drilling; Section 5.3.1). The number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). A 500 m safety exclusion zone will be requested around the MODU and the installation vessel/s during their respective activities.

9.1.1.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Potential changes to the functions, interests, or activities of other users							✓

9.1.1.3 Consequence Evaluation

9.1.1.3.1 Potential changes to the functions, interests, or activities of other users

Receptor Group	Consequence Evaluation
Commercial Fisheries	The potential for interaction with commercial fisheries may occur from the physical presence of subsea infrastructure and/or MODUs and vessels. **Subsea infrastructure** Any potential interaction with subsea infrastructure is limited to where those fishing activities interact with the seafloor. No Commonwealth-managed commercial fisheries are active within the Project Area (Section 7.10.1.1). Of the active State-managed commercial fisheries within the Project Area (Section 7.10.1.2), only one (Pilbara Trap Managed Fishery) uses a fishing method that would interact with the seafloor. Although the Project Area is within the area open for fishing, fishing effort is typically low with <3 vessels present within the 60 nm fishery grid blocks that intersect with the Project Area (Figure 7-44). Subsea infrastructure has been in place within the Project Area since the 1990s when production for the GWA Facility commenced (Section 1.4.2.1). To date, no incidences of commercial fishing activities interacting with the subsea infrastructure have been communicated to Woodside. Consequently, the addition of new subsea infrastructure within a similar area is not expected to result in an impact to commercial trap fishing operations (e.g. via loss of catches or damage to fishing equipment). Any deviation required for trap deployment around the subsea infrastructure is not expected to substantially affect to the functions, interests, or activities of the commercial fishery. **MODU/vessels** The presence of the MODU and/or vessels within the Project Area has the potential to result in an interaction with commercial fishing vessels. As described above, the number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). Vessels will move within the Project Area, but the MODU will be stationary during active drilling operations (~1–3 months per well). A 500 m safety exclusion zone around the MODU and installation vessels may result in minor course deviation for fishing vessels. As identified in Section 7.10.1.2, three State-managed commercial fisheries may be active within the Project Area: Pilbara Trap Managed Fishery (as described above), Pilbara Line Fishery, and Mackerel Managed Fishery. Fishing effort is typically low—during the last five seasons (2017–2022, the Pilbara Line Fishery had <3–5 vessels within the 60 nm fishery grid blocks that intersect with the Project Area, and the Mackerel Managed Fishery recorded ≤3 vessels present within the 10 nm fishery grid blocks that intersect with the Project Area. Given the low number of vessels, and if required, only minor deviation around MODU or project vessels, the physical presence of the MODU and support vessels is not expected to substantially affect the functions, interests, or activities of the commercial fisheries. Therefore, the physical presence of the MODU, vessels, or subsea infrastructure within the Project Area is expected to have no lasting effect on commercial fisheries, and thus the consequence level is ranked as F.
Tourism and Recreation	The potential for interaction with tourism and recreation may occur from the physical presence of MODUs and vessels. Tourism and recreational activities are expected to be limited in the Project Area because of the water depths (generally >70 m, except around banks or shoals) and the distance from the mainland. Some

Receptor Group	Consequence Evaluation
	fishing tour operators may be active within the Project Area, but recent effort is low (typically <3 active licences; Section 7.10.3). Charter fishing that did occur was within the southern part of the Project Area in the vicinity of the Montebello Marine Park and within fishery grid blocks known to contain shallow bathymetric features (such as banks and shoals). Given the limited tourism and recreation activities, and if required, only minor deviation around MODU or project vessels, the physical presence of the MODU and other project vessels is not expected to substantially affect tourism and recreation functions, interests, or activities. Therefore, the physical presence of the MODU and vessels within the Project Area is expected to have no lasting effect on tourism and recreation, and thus the consequence level is ranked as F.
Shipping	The potential for interactions with commercial shipping may occur from the physical presence of MODUs and vessels. As described above, the number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). Although the vessels will move within the Project Area, the MODU will be stationary during active drilling operations (~1–3 months per well). A 500 m safety exclusion zone around the MODU and installation vessel may result in minor course deviation for commercial shipping vessels. Although one of the NWS shipping fairways intersects with the eastern part of the Project Area, commercial shipping vessel activity within the remainder of the Project Area is relatively low compared to elsewhere on the NWS (Section 7.10.4). There are higher densities of vessel activities just to the east and west of the Project Area, where the GWA and Pluto platforms are located. Given the number of commercial shipping vessels, and if required, only minor deviation around MODU or project vessels, the physical presence of the MODU and/or project vessels is not expected to substantially affect the functions, interests, or activities of these commercial shipping vessels. Therefore, the physical presence of the MODU and vessels within the Project Area is expected to have no lasting effect on commercial shipping, and thus the consequence level is ranked as F.
Petroleum Industry	The potential for interactions with other petroleum activities may occur from either the physical presence of subsea infrastructure or the presence of MODUs and vessels. The proposed Wilcox flowline route, from Wilcox to the LPA PLET, crosses over a fibre-optic cable that connects to Chevron Australia's Wheatstone platform. However, no environmental aspect is generated from this interaction; therefore, it is not evaluated further. All petroleum titles within the Project Area are operated by Woodside and activities related to these titles are under Woodside's operation control. No known interaction with third-party petroleum activities is expected to occur within the Project Area, and therefore it is not evaluated further.

9.1.1.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1), and the predicted consequences of potential impacts from Physical Presence: Interaction with other Marine Users, these have been determined as lower-order impacts (Table 4-4) and as such, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-01**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth) and any subsequent marine orders • **CM-02**: If property is accepted to be decommissioned in situ, this activity must comply with the *Environmental Protection (Sea Dumping) Act 1981* (Cth)
Good Industry Practice	• **CM-03**: Establish and maintain a 500 m safety exclusion zone around the MODU and installation vessel/s for the duration of the relevant petroleum activity • **CM-04**: Remove all property above the mudline unless a comparative assessment demonstrates an equal or better environmental outcome for an alternative decommissioning approach, and this has been accepted within an EP submitted under the Environment Regulations

9.1.1.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence
Potential changes to the functions, interests, or activities of other users	Commercial fisheries							✓	A	F
	Tourism and recreation							✓		F
	Commercial shipping							✓		F
	Petroleum activities							✓		–

9.1.1.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Physical Presence: Interaction with other Marine Users aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-01**, **AL-02**, and **AL-03**, as defined in Table 4-3 (and shown below in Section 9.1.1.7). As described in the consequence evaluation (Section 9.1.1.3), the predicted impact would cause no lasting effects to other marine users and as such is not expected to substantially affect their functions, interests, or activities in the area. Therefore, the predicted level of impact for these receptors is better than the acceptable levels (**AL-01**, **AL-02**, **AL-03**).
Impact and Risk Classification, and Decision Type	The impacts arising from the physical presence of subsea infrastructure, MODU, or vessels within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) the legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.1.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.1) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with other marine users arising from the offshore project – this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.1.4) • Precautionary Principle – the impact consequence rating for this aspect is no lasting effect (F); therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with the predicted environmental impact and the anticipated effectiveness of management measures

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– not considered applicable for this aspect.</td></tr>
<tr><td>Internal Context</td><td colspan="2">No specific Woodside management processes or procedures were deemed relevant for this aspect.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with other marine users arising from the offshore project</td></tr>
<tr><td rowspan="4">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Navigation Act 2012 (Cth)
Notice to Mariners</td><td>The requirements of this Act and any subsequent marine orders are incorporated into the key control measures (Section 9.1.1.4).</td></tr>
<tr><td>Environmental Protection (Sea Dumping) Act 1981 (Cth)
Sea dumping permits</td><td>The requirements of this Act (specifically in relation to property accepted to be decommissioned in situ within the title area) are incorporated into the key control measures (Section 9.1.1.4).</td></tr>
</table>

9.1.1.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level(s), and encompass either the acceptable level(s) or the predicted environmental impact (Section 4.9).

The EPO relevant to the Physical Presence: Interaction with other Marine Users aspect is shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-01: No interference with fishing within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder **AL-02**: No interference with navigation within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder **AL03**: No interference with other lawful marine users within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder	**EPO-01**: No interference with other marine users to a greater extent than is necessary for the exercise of rights and performance of duties as conferred to the titleholder

9.1.2 Physical Presence: Disturbance to the Seabed

9.1.2.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in disturbance to the seabed are described in the following table. The two main sources of seabed disturbance for the Goodwyn Area Infill Development are the new subsea infrastructure and the MODU mooring systems in place during drilling activities.

Activity Group	Description
Drilling and Completions	Seabed disturbance from drilling and completion activities will occur during: • geotechnical sampling • acoustic positioning (LBL arrays). Estimates of seabed disturbance from MODU anchoring is described under Field Activities Support below. Wellheads and Xmas trees (and associated connections/equipment) are included in the infrastructure footprint described under Subsea Installation below. Geotechnical sampling may be required before installing MODU mooring systems (Section 5.3.2). Depending on the sampling method, typical seabed disturbance footprints could range from ~5 m^2 for penetrometer testing, and ~1–25 m^2 per core sample, which incorporates sample collection and associated frames/equipment. As described in Section 5.3.11, an LBL array may be in place at each well location. A single LBL transponder may have a footprint of ~0.1 m^2. An array of these transponders will be deployed near the well spud location. The seabed disturbance footprints associated with geotechnical sampling and acoustic positioning are intended to occur within the nominal infrastructure corridor (Figure 5-2) for the phased development, and within the Project Area for potential future development. The seabed disturbance footprint associated with geotechnical sampling may occur within ~4 km of the proposed drilling location.
Subsea Installation and Pre-commissioning	As described in Sections 5.2.1 and Section 5.2.2, the subsea infrastructure may include wellheads, Xmas trees, flowlines, EHUs, manifolds, PLETs, FLETs, ILTs, UTAs, EFLs, HFLs, flexible pipe jumpers, rigid spools, subsea intensifiers, cooling skids, pressure protection systems, and accumulator modules. Stabilisation, span mitigation, buckling mitigation and walking mitigation (e.g. concrete mattresses, pipe clamping mattresses, buckle initiators, grout bags, sand bags, rock installation) may also be required. The estimated infrastructure footprint associated with the subsea infrastructure (for both the phased development and potential future development) is estimated to be ~0.04 km^2 (Table 5-5, Table 5-6), which represents ~0.002% of the total Project Area. An estimated infrastructure disturbance area, which takes into consideration that displacement of the flowlines and/or EHUs may occur over time, is ~1.99 km^2 (Table 5-5, Table 5-6); this represents ~0.12% of the Project Area. The infrastructure footprint and infrastructure disturbance area are intended to occur within the Project Area (for both the phased development any potential future development). As described in Section 5.4.2, an LBL array or a USBL transponder may be used during installation activities. Single USBL transponders may have a footprint of ~0.2 m^2; LBL transponders are as described above. During installation, temporary wet storage of equipment or infrastructure may be required.
Start-up and Operations	During operations, subsea IMMR activities may interact with the seabed, including, but not limited to: • removing marine growth • well interventions or workovers • span rectification • repairing or replacing infield infrastructure. The area of seabed disturbance depends on the nature and scale of the IMMR activity; span rectification activities typically create the largest areas of seabed disturbance. Woodside's operational experience on the NWS indicates these activities are typically restricted to relatively short (tens of metres) linear sections of flowline, with a disturbed area up to ~100 m^2.

Activity Group	Description
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. If subsea infrastructure is removed, the total seabed disturbance is expected to be similar to that of the drilling and installation phases and be within the same areas of previous seabed disturbance. Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities (MODUs, Vessels, ROVs)	**MODU Positioning** The drilling phase will be supported by MODUs. The seabed disturbance footprint for a mooring or footing system will vary depending on the MODU type chosen (Section 5.7.1.1). If a moored or hybrid MODU is used, its 8- to 12-point anchoring system could result in seabed disturbance of up to 13,000 m^2 (0.013 km^2), including allowances for the anchor footprint and disturbance from anchor chains (NERA 2018). The seabed disturbance footprint associated with a moored MODU may occur up to ~4 km from the proposed drilling location. If a jack-up MODU with spudcan footings is selected, the seabed disturbance may be smaller (~950 m^2; estimate based on three footings of 20 m diameter). For the up to 8 wells (Table 5-1) that may be drilled within the Project Area, this gives a seabed disturbance from MODU mooring systems of ~0.008–0.10 km^2, which represents up to 0.006% of the total Project Area. Seabed disturbance from MODU mooring systems is intended to occur within the nominal infrastructure corridor for phased development (Figure 5-2), and within the Project Area for any potential future development. **Vessels** Vessels will be used during all phases. Vessels will use DP; therefore, anchoring (and seabed disturbance) is not expected to occur (Section 5.7.2). However, anchoring may be required in an emergency. A vessel using a single anchor could result in seabed disturbance of up to ~1,300 m^2 (NERA 2018). **ROVs** ROV activities may temporarily disturb the seabed and suspend sediment when they are close to, or occasionally on, the seabed. ROV use close to or on the seabed is limited to that required for effective and safe subsea activities. The footprint of a typical ROV is <5 m^2.

9.1.2.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Change to water quality			✓				
Potential changes to habitats and biological communities					✓		
Potential changes to the values and sensitivities of protected places					✓		

9.1.2.3 Consequence Evaluation

9.1.2.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Seabed disturbance has the potential to result in a localised and temporary decline in water quality due to an increase in suspended sediment. After a period, suspended sediments settle and the turbidity in the water column returns to pre-disturbance levels. Displacing naturally occurring sediments during project activities will likely result in low and highly localised (within tens of metres of the disturbance area) increases in turbidity levels at the seabed; these will quickly disperse in the oceanic marine environment due to prevailing hydrodynamic conditions. Any reduction in water quality will be temporary and will be limited to the waters close to the seabed immediately surrounding the disturbance area. Low levels of sediment deposition will likely be naturally reworked into surface sediment layers through bioturbation. Sediment loads are not expected to be significant due to the relatively small footprint for each activity. Each activity near the seabed is likely to cause a single brief disturbance resulting in a transient plume of suspended sediment, within an area of predominantly soft sand habitat. Therefore, seabed disturbance associated with activities within the Project Area is expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.1.2.3.2 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Offshore Habitats and Biological Communities	The potential for changes to benthic habitats and communities may occur from either a temporary seabed disturbance (e.g. sampling or positioning) or the physical presence of subsea infrastructure for the duration of the Goodwyn Area Infill Development. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). The subsea infrastructure footprint has been estimated as ~0.04 km^2, with an infrastructure disturbance area (i.e. allowing for displacement of flowlines/EHUs over time) of ~1.99 km^2. This estimated extent of direct seabed disturbance is considered small in relation to the extent of the soft sediment habitats, which are broadly represented within the Project Area and the wider NWMR. Physical disturbance in soft sediment habitats can disrupt the sediment structure and lead to the death or emigration of resident biota (Dernie et al. 2003). Experiments on the effects of physical disturbance to the habitat and fauna of a sheltered sandflat showed that benthic recovery occurred within ~64 days and ~208 days post-disturbance for a lower and higher intensity disturbance, respectively (Dernie et al. 2003). Sedimentation can bury marine pipelines, and a study in the NWS region found that the movement of currents and internal waves against the seabed provided the mechanism for this sedimentation process (Leckie et al. 2015). Seven years of field survey measurements of a subsea pipeline indicated significant lowering of the pipeline into the seabed due to sediment mobility and scour, with most movement occurring within two years of pipelay (Leckie et al. 2015). Sustained ambient tidal and soliton currents was likely the reason for this burial, not large storms. Biological activity (e.g. tunnelling under equipment by crustaceans and demersal fish) also contributed to embedment. Studies on the effects of sediment movements associated with anthropogenic structures on the seabed (e.g. shipwrecks, artificial reefs) indicate impacts are limited to within 10 m of the structure (Smiley 2006; Lewis and Pagano 2015). Given the predominant soft sediment habitat within the Project Area, any scouring and accretion around the subsea infrastructure is expected to remain localised with no lasting effects to benthic habitats and communities. Disturbance due to infrastructure installation also includes replacing some soft sediment habitat with hard substrate (e.g. flowlines, wellheads), which is an uncommon substrate in the mid and outer NWS region. Over time, sessile benthic biota (e.g. sponges, gorgonians) is expected to colonise this hard substrate, which may then support higher biodiversity benthic fauna than soft

Receptor	Consequence Evaluation
	sediment habitats. Therefore, the presence of subsea infrastructure may lead to ecological communities establishing in this area that would not have existed here otherwise. For example, pipeline infrastructure has been shown to support more diverse fish assemblages and benthic biota (McLean et al. 2017); these communities are relatively diverse compared to the open water and soft sediment habitats in the broader Project Area. Similarly, analysis of habitats on wellheads and associated infrastructure on the NWS indicates the presence of fish assemblages and colonising invertebrate habitats (McLean et al. 2018). Wellheads in waters 135–175 m deep showed an abundance of reef-dependent and transient pelagic species; however, the number of species declined markedly in water depths of >350 m (McLean et al. 2018). A similar decline in the abundance of invertebrates (e.g. ascidians, black/octocorals, sponges) was also observed with increasing water depths (McLean et al. 2018). The artificial habitat associated with subsea infrastructure will have either no adverse environmental impact or a low level of positive environmental impact through increased biological diversity. Rankin Bank and Wilcox Shoal both occur within the Project Area (Section 7.5.3.6) but are not within a direct infrastructure footprint for the Goodwyn Area Infill Development. Wilcox Shoal is ~1 km south-east of the phased development nominal infrastructure corridor, and Rankin Bank is ~5 km north-west of the proposed tie-in at LPA. Given the distances to installation activities, and that any resuspended sediment is expected to remain localised, neither Rankin Bank or Wilcox Shoal are expected to be exposed to suspended sediments from project activities. There is a smaller shoal feature (~3.5 km north-east of nominal Wilcox wells; Figure 5-2) that is within the phased development nominal infrastructure corridor and consequently could be at risk of exposure from suspended sediments depending on the specific location and nature of any project activities. Therefore, seabed disturbance within the Project Area is not expected to result in a consequence greater than minor disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as D.
Key Ecological Features	The potential for changes to a KEF may occur from either temporary seabed disturbance (e.g. sampling or positioning) or the physical presence of subsea infrastructure throughout the life of the Goodwyn Area Infill Development. The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF (Figure 9-1). The phased development nominal infrastructure corridor intersects with ~133 km^2 of the 16,190 km^2 KEF (i.e. ~0.82% of the KEF). Note: not all of the nominal infrastructure corridor would be subject to seabed disturbance. Any interaction with the KEF is restricted to the northern part of the Project Area, associated with project activities within WA-5-L, WA-6-L, WA-23-L, and WA-24-L. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). Physical habitat modification is listed as a pressure within the Marine Bioregional Plan for the NWMR, but has not been identified a pressure of concern for this KEF (DSEWPaC 2012b). Therefore, seabed disturbance within the KEF is not expected to result in a consequence greater than minor disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as D.

9.1.2.3.3 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The potential for changes to the Montebello Marine Park may occur from seabed disturbance from geotechnical sampling or MODU positioning. No top hole sections for production wells or other subsea infrastructure will occur within the boundary of the marine park, but it is possible that the MODU mooring system may extend within the marine park boundary, depending on the type of MODU selected for activities at Wilcox reservoir. The Project Area partially overlaps the Montebello Marine Park (Figure 9-1). The phased development nominal infrastructure corridor intersects with ~27 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~0.79% of the marine park). Note: not all of the nominal infrastructure corridor would be subject to seabed disturbance. Any interaction with the Montebello Marine Park is

Receptor	Consequence Evaluation
	restricted to the southern part of the Project Area, associated with project activities within WA-7-R. The values of the Montebello Marine Park (as described in Table 7-24) include ecosystems representative of the Northwest Shelf Province, including areas of ancient coastline. Benthic habitat surveys within the northern section of the marine park indicate that it has a relatively flat and sandy seabed with variable coverage of benthic epifauna (e.g. sponges, corals) (Section 7.5.3.7; (Advisian 2019)). This is not dissimilar to the benthic habitats and communities expected to occur throughout most of the Project Area, which are broadly represented throughout the NWMR (Section 7.5.3.1). As described above, recovery of benthic habitats after physical disturbance are expected to occur up to ~64 days and ~208 days (for a lower and higher intensity disturbance, respectively) (Dernie et al. 2003). Therefore, seabed disturbance within the Montebello Marine Park is not expected to result in a consequence greater than minor and short-term disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as D.

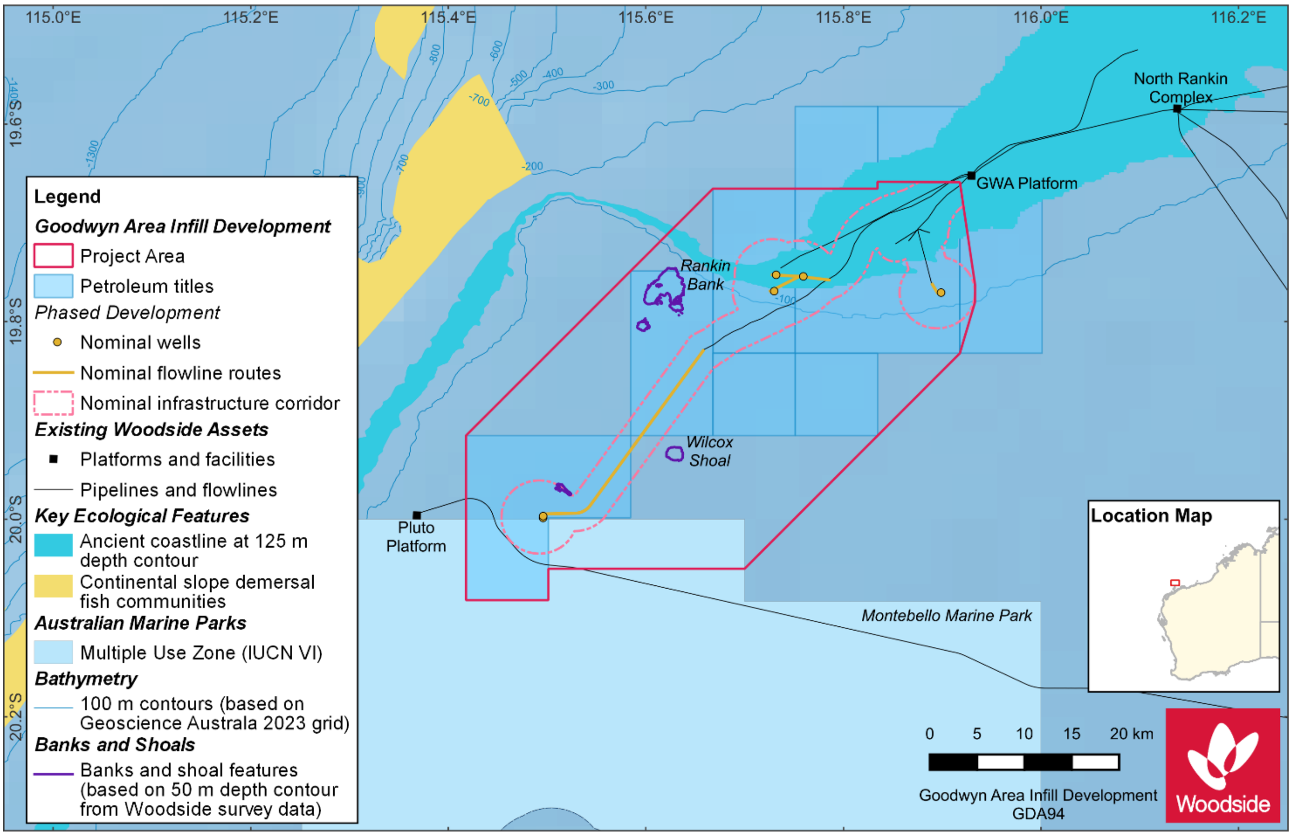


Figure 9-1: Phased development nominal infrastructure corridor overlap with ancient coastline KEF and Montebello Marine Park

9.1.2.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Physical Presence: Disturbance to the Seabed, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-02**: If property is accepted to be decommissioned in situ, this activity must comply with the *Environmental Protection (Sea Dumping) Act 1981* (Cth)
Good Industry Practice	• **CM-04**: Remove all property above the mudline unless a comparative assessment demonstrates an equal or better environmental outcome for an alternative decommissioning approach, and this has been accepted within an EP submitted under the Environment Regulations • **CM-05**: Undertake project-specific Mooring Design Analysis • **CM-06**: Undertake project-specific Basis of Well Design, which includes assessing seabed sensitivity
Professional Judgement	• **CM-07**: Consider and implement appropriate adaptive management measures during the EP process to reduce impacts on banks and shoals to ALARP • **CM-08**: Subsea installation activities will not occur on identified shoals within the Project Area • **CM-09**: Top hole locations will not occur within 500 m of identified shoals within the Project Area

9.1.2.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*
Change to water quality	Physical environment			✓					A	F
Potential changes to habitats and biological communities	Offshore habitats and biological communities					✓				D
	Key ecological features					✓				D
Potential changes to the values and sensitivities of protected places	Australian Marine Parks					✓				D

9.1.2.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Physical Presence: Disturbance to the Seabed aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect, are **AL-04** and **AL-05**, as defined in Table 4-3 (and shown below in Section 9.1.2.7). As described in the consequence evaluation (Section 9.1.2.3), the predicted impacts range from no lasting effect on water quality, to minor impacts to benthic habitats and communities, and as such are not expected to substantially affect the biodiversity, ecosystem function, or integrity of the marine area. Therefore, the predicted level of impact to these receptors is better than the acceptable level (**AL-04)**. In addition, given the level of impact predicted (minor, short-term) to features within the Montebello Marine Park, these effects would not prevent the long-term

<table>
<tr><th>Acceptability Criteria</th><th>Demonstration</th></tr>
<tr><td></td><td>protection and conservation of marine park values. Therefore, the predicted level of impact for this receptor is better than the acceptable level (AL-05).</td></tr>
<tr><td>Impact and Risk Classification, and Decision Type</td><td>The impacts arising from seabed disturbance within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and thus are considered ‘broadly acceptable’. These impacts are considered to be managed to an acceptable level by meeting (where they exist) the legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the Goodwyn Area Infill Development (Section 9.1.2.4).</td></tr>
<tr><td>Principles of ESD</td><td>These principles of ESD were considered for this aspect:
• Integration Principle
– the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.2) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations
– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding seabed disturbance arising from the offshore project
– this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.2.4)
• Precautionary Principle
– the highest impact consequence rating for this aspect is minor (D); therefore, no potential for serious or irreversible environmental damage is expected
– although serious or irreversible environmental damage is not predicted to occur, there is some scientific uncertainty around the presence of hard substrate within the part of the ancient coastline at 125 m depth contour KEF that intersects with the Project Area, and the presence of First Nations heritage values and cultural features within the Project Area; therefore, Key Control Measures are included in this OPP that commit Woodside to undertaking studies to further support the decisions presented within the environmental impact and risk assessment decision
• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.2) impact analysis
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.</td></tr>
<tr><td>Internal Context</td><td>No specific Woodside management processes or procedures were deemed relevant for this aspect.</td></tr>
<tr><td>External Context</td><td>During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding seabed disturbance arising from the offshore project</td></tr>
<tr><td>Other Requirements</td><td>Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.
<table>
<tr><th>Requirement</th><th>Demonstration</th></tr>
<tr><td>Marine bioregional plan for the North-west Marine Region
No specific strategies or actions identified.</td><td>N/A</td></tr>
</table></td></tr>
</table>

Acceptability Criteria	Demonstration	
	North-west Marine Parks Network Management Plan 2018 No specific zone rules identified.	N/A

9.1.2.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level of the predicted environmental impact (Section 4.9).

The EPOs relevant to the Physical Presence: Disturbance to the Seabed aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-02**: No adverse effects greater than a D consequence (minor, not affecting ecosystem function) to benthic habitats and communities from planned seabed disturbance during the petroleum activity
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.3 Routine Emissions: Light Generation

9.1.3.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in light generation are described in the following table.

Activity Group	Description
Drilling and Completions	During drilling and completion activities, artificial light will be emitted from flaring during well unloading (Section 5.3.10). The wells will be unloaded to host (i.e. the GWA platform) or to the MODU. Flaring during well unloading will be of short duration (typically occurs for ~1–2 days per well). Measurements of natural gas flares have shown peak spectral signatures typically within the invisible infrared range (750–900 nanometres), with lower levels of light emitted within the lower (and visible) wavelength ranges (Hick 1995; Pendoley 2000). Flow rates did not appear to change the spectral signature of gas flares (Hick 1995; Pendoley 2000). For light emissions associated with MODU and vessel operations, refer to Field Support Activities below.
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Their presence within the Project Area is temporary (e.g. a MODU would be present for ~1–3 months per well during drilling). The number of vessels in the Project Area will vary depending on activity, but is

Activity Group	Description
	expected to be greatest for short-term project phases (e.g. drilling, installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). External lighting on the MODU and vessels is required for navigation and safe operating conditions. Lighting ensures a safe working environment across 24-hour operations and communicates the presence (i.e. via navigation lights) of the MODU and support vessels to other marine users. Typically, lighting is bright white light (i.e. metal halide, halogen, fluorescent) and is not dissimilar to lighting used for other offshore activities, including fishing and shipping. The spectral signatures associated with MODU lighting are estimated as 530–620 nanometres (SKM and ERM 2008). **Concurrent Activities** During drilling operations, a MODU and up to two support vessels (one standby vessel, and another resupply vessel) may be present in-field. The vessel undertaking resupply is only present for a short duration (e.g. ~8 hours) and intermittent (e.g. 1–2 times per week, depending on the frequency of resupply required). The indicative schedule for the Goodwyn Area Infill Development may have drilling and subsea installation activities occurring concurrently (Section 5.1.1). When there is both drilling and subsea installation activities occurring within the Project Area, the MODU (and support vessels) may not always be in close proximity to the installation vessel (i.e. the spatial areas exposed to artificial light would not overlap), or where they are in close proximity, the activity overlap would only occur for a short (e.g. in the order of days) duration. Light emissions from the adjacent vessels/MODU sources would result in a slightly greater overall spatial area being exposed, as well as cumulative emissions in the area between the MODU/vessels (noting that light intensity is inversely proportional to the distance from the source, and therefore the overlap in emissions is typically not occurring for the highest light intensities).

9.1.3.1.1 Modelling and Exposure Assessment

As described above, artificial light emissions from the Goodwyn Area Infill Development include multiple sources related to different activities during different phases. For the impact assessment, the largest sources of artificial light (MODU and installation vessel operation) was selected for modelling because this represents the greatest spatial extent of potential impacts.

Based on Woodside's previous modelling and monitoring campaigns for similar activities on the NWS, these lighting analogues were selected for the impact assessment for the Goodwyn Area Infill Development:

- a drilling rig during drilling activities at the Torosa field (ERM 2010; Woodside 2014)
- a pipelay vessel associated with the Scarborough trunkline (Pendoley Environmental 2020b; Woodside 2020b).

The scenarios and outputs of each modelling study are summarised below.

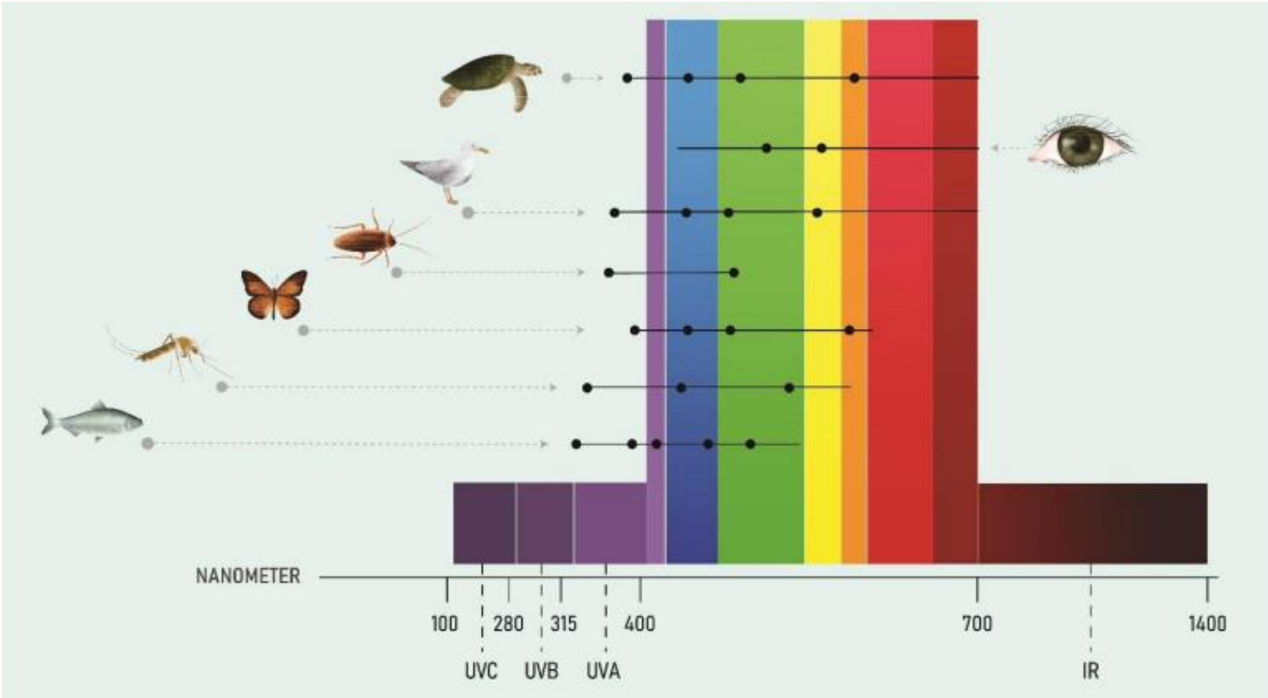
Describing Light

Light is a form of energy that is emitted over a specific band of frequencies and wavelengths of the electromagnetic spectrum. The visible range for humans is ~400–700 nanometres. Fauna perceive light differently to humans, and their visible spectrum can vary between ~300 and >700 nanometres depending on the species (Figure 9-2). For fauna, being sensitive to light within a specific range of wavelengths means that they can perceive light at that wavelength, and it is likely they will respond to that light source (DCCEEW 2023k).

Humans and fauna use photoreceptor cells (cones and rods) in the eye to detect light. Photopic vision, which occurs in bright conditions, activates the cones and allows the eye to see colour. Scotopic vision, which occurs in low light conditions, activates rods and allows the eye to see in shades of grey. Scotopic vision is more sensitive to shorter wavelength light than photopic vision (DCCEEW 2023k). Nocturnal species rely on scotopic vision and therefore can be sensitive to changes in light at this high-energy short wavelength end of the spectrum (i.e. ultraviolet/violet/blue light).

Radiometry detects and measures electromagnetic radiation. With respect to optics, radiometry detects and measures radiant energy within the light (ultraviolet, violet, infrared) portion of the electromagnetic spectrum. Photometry is a subset of radiometry that applies to the visible light spectrum; its measured values are weighted to the typical response of a human eye. As humans and fauna perceive light differently, radiometric measurements are more biologically relevant because they account for the energy emitted across all light wavelengths (DCCEEW 2023k).

One of the modelling studies summarised below is based on photometric quantities, while the other uses radiometric quantities to describe light.



Source: (DCCEEW 2023k)

Notes: Horizontal lines = ability to perceive light; dots = peak sensitivity to light

Figure 9-2: Ability to perceive light and peak sensitivities to light for humans and fauna

Light Modelling (MODU)

ERM undertook light modelling to inform the impact assessment associated with artificial light emissions from a MODU during drilling activities (ERM 2010). Inputs to this modelling assessment were from monitoring data collected during a drilling campaign at the Torosa South-1 well (SKM and ERM 2008). This monitoring data demonstrated that illuminance levels attenuated to below 1.00 lux at a distance of ~300 m from the drill rig, and to ~0.03 lux at a distance of ~1.4 km from the drill rig (SKM and ERM 2008).

The MODU for the Goodwyn Area Infill Development is expected to be lit to a similar light level required for safe navigation and operation, and thus the light emissions from the MODU are expected to be comparable to those of the drilling rig used for the Torosa South-1 well illuminance modelling undertaken by ERM (2010). Using the modelling results from ERM (2010) is considered appropriate to support the impact assessment for artificial light emissions for the Goodwyn Area Infill Development.

Scenario

The study included a scenario for an operating drilling rig using both functional and navigational lighting.

Exposure Criteria

There are currently no published or accepted thresholds at which artificial light may impact fauna.

Typical illuminance (light intensity) values from natural light sources are described in Table 9-1. The minimum threshold used to describe a change in ambient light conditions within this artificial light assessment is an illuminance equivalent to a new moon (moonless clear night sky; 0.001 lux), beyond this threshold no impact to light sensitive fauna is assumed. This threshold (0.001 lux) was selected because fauna undertake nocturnal activities under the natural range of full moon (0.1 lux) to new moon (0.001 lux) without known adverse impacts.

Photometric measurements (illuminance) are biased towards the human eye, therefore the use of this threshold is considered conservative because a quarter moon radiance (a radiometric measurement) is the biologically relevant threshold in the pipelay vessel modelling below.

Table 9-1: Natural light illuminance

Illuminance	Description
100,000–130,000 lux	Direct sunlight
10,000–20,000 lux	Full daylight, indirect sunlight
1,000 lux	Overcast day
100 lux	Very dark day
10 lux	Twilight
1 lux	Deep twilight
0.1 lux	Full moon
0.01 lux	Quarter moon
0.001 lux	Moonless clear night sky (new moon)
0.0001 lux	Moonless overcast night sky

Source: (ERM 2010)

Modelling Outputs

Modelling of a drilling rig at the Torosa field predicted that illuminance levels at various distances from the rig were:

- >0.1 lux up to 0.8 km (comparable to ambient light levels during full moon to twilight)
- 0.01–0.1 lux between 0.8 and 1.2 km (comparable to ambient light levels during a quarter moon to full moon night sky)
- 0.01–0.001 lux between 1.2 and 12.6 km (comparable to ambient illuminance levels between a moonless clear night sky and a quarter moon)
- <0.001 lux at distances >12.6 km (i.e. no measurable change to the ambient illuminance levels).

The 12.6 km distance to no measurable (photometric) change from ambient conditions was applied as a buffer around the nominal well locations to determine the predicted artificial light exposure areas for use in the impact assessment. These distances in relation to marine turtle and seabird BIAs are shown in Figure 9-3 and Figure 9-4.

It is acknowledged that the distance predicted for MODU's is likely conservative as it was based on available photometric light measurements, and using a lower criteria of 0.001 lux (equivalent to new moon) rather than a higher 0.01 lux (equivalent to a quarter moon).

Light Modelling (Pipelay Vessel)

Light modelling was undertaken for the pipelay vessel to predict the extent of biologically relevant light spill (Pendoley Environmental 2020b). The modelling used the ILLUMINA model, which is a three-dimensional model that accounts for both line of sight and atmospheric scattering, allowing light attenuation over distance and light glow extent to be modelled.

Light emissions from the installation vessel are expected to be comparable to that of the pipeline vessel used in this previous light modelling undertaken by Pendoley (2020b). The installation vessel is expected to be lit to a similar level required for safe navigation and operations. Therefore, using modelling results from Pendoley (2020b) is considered appropriate to support the impact assessment for artificial light emissions for the Goodwyn Area Infill Development.

Scenario

The study included two scenarios for the pipelay vessel, both near the Dampier Archipelago. Specifics of the vessels' light inventories were input into the ILLUMINA model.

Exposure Criteria

In the absence of any published or generally accepted units of measurement, or scale, for measuring the impact of artificial light on marine fauna, moonlight was selected as a proxy and the light model output (radiance, in units of $W/m^2/sr$) was converted to units of full moon equivalents (Pendoley Environmental 2020b). Table 9-2 lists the potential impact criteria for marine turtles based on radiance thresholds relative to moon radiance.

Table 9-2: Potential impact criteria for marine turtles to artificial light emissions

Proportion of radiance of a full moon[1]	Description
1–10	Light or light glow visible and impact likely; represents a very bright light equivalent to up to 10 times the radiance of one moon. This light radiance will override the moderating influence of the ambient full moon at the time of exposure.
0.1–1	Light or light glow visible and behavioural impact possible, depending on ambient moon phase at the time of exposure, which will influence the visibility of the artificial light sources. Artificial lights will be more visible to marine turtles under a first quarter moon than under a full moon.
0.01–0.1	Light or light glow visible but behavioural impact unlikely (i.e. not biologically relevant). Equivalent to the light output from the first quarter moon to new moon.
<0.01	Light or light glow is considered ambient and no impact expected; equivalent to a new moon.

1. Where 10 equals the radiance of ten full moons and 0.01 equals a 100th the radiance of one full moon.

Modelling Outputs

Modelling of a pipelay vessel predicted that light radiance levels were:

- 10 × full moon ~0.2 km from the vessel
- 1 × full moon ~0.6 km from the vessel
- 0.1 × full moon ~1.8 km from the vessel
- 0.01 × full moon ~5.7 km from the vessel.

The results show that ~5.7 km from the pipelay vessel radiance has reduced to ambient conditions. At distances ~1.8–5.7 km from the pipelay vessel, light may be visible, but is not expected to be biologically relevant and result in behavioural impacts. At distances of less than ~1.8 km from the pipelay vessel, the level of radiance is considered biologically important and behaviour impacts may occur (Pendoley Environmental 2020b).

The 1.8 km distance was applied as a buffer around the phased development nominal infrastructure corridor to determine the predicted artificial light exposure areas for use in the impact assessment. These distances in relation to marine turtle and seabird BIAs are shown in Figure 9-3 and Figure 9-4.

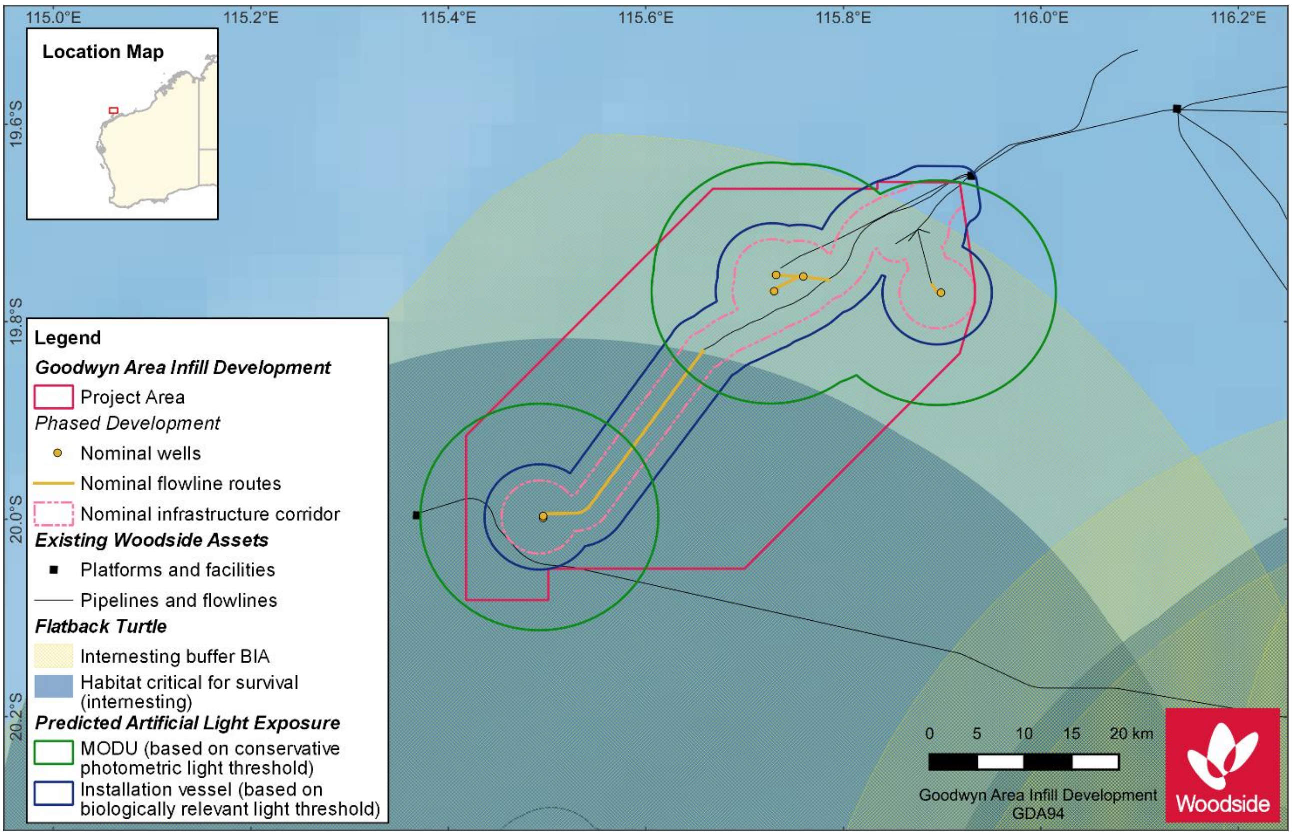


Figure 9-3: BIAs and habitat critical for survival for flatback turtles with the predicted artificial light exposure areas from MODU and installation vessel operations

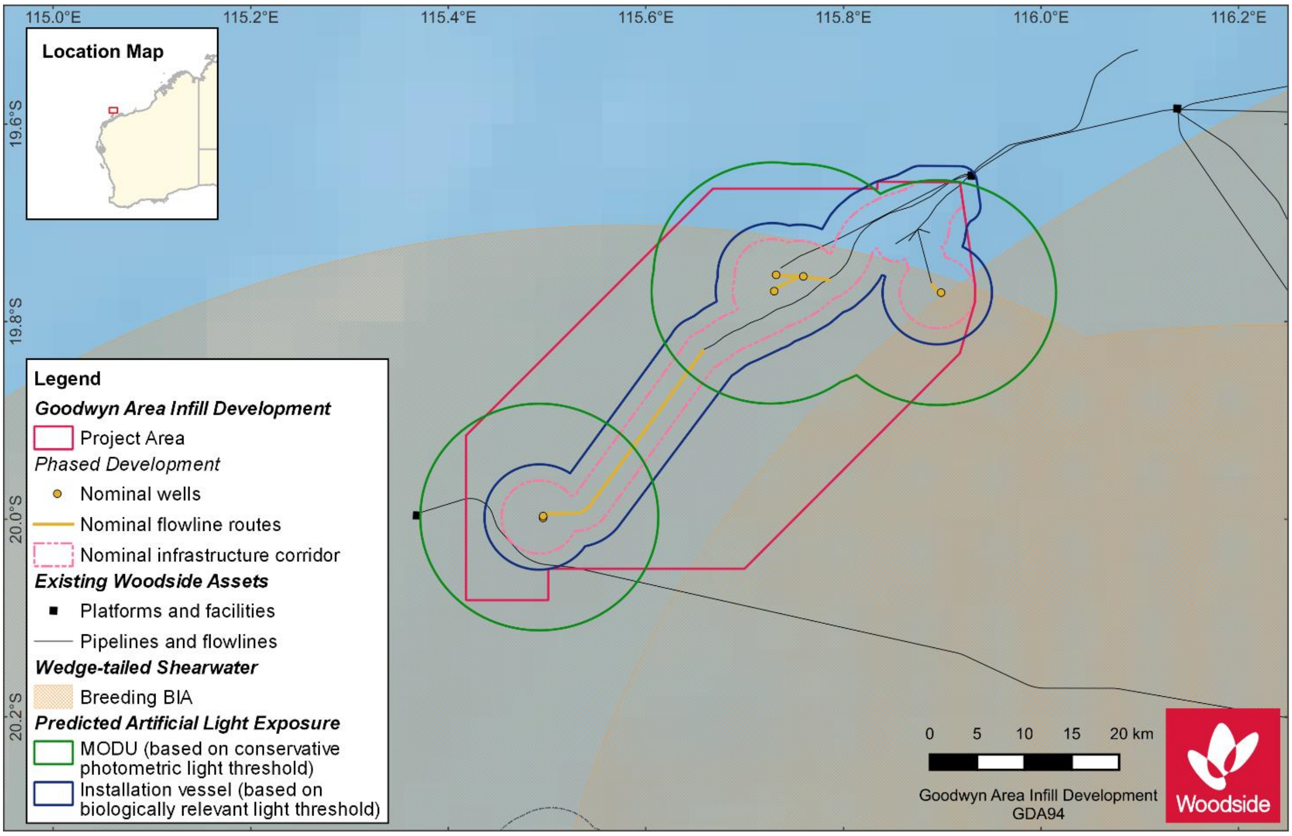


Figure 9-4: BIAs for wedge-tailed shearwaters with the predicted artificial light exposure areas from MODU and installation vessel operations

9.1.3.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Potential changes to fauna behaviour						✓	
Potential changes to the functions, interests, or activities of other users							✓
Potential changes to the values and sensitivities of protected places					✓		

9.1.3.3 Consequence Evaluation

9.1.3.3.1 Potential changes to fauna behaviour

Receptor	Consequence Evaluation
Fish, Sharks, and Rays	Artificial light may result in varied ecological changes to fish, including: • changing predatory behaviour and abundance (Bolton et al. 2017; Marangoni et al. 2022) • altering hatching success (Fobert, Burke da Silva, and Swearer 2019)

Receptor	Consequence Evaluation
	• acting as an attractant for plankton (Keenan, Benfield, and Blackburn 2007) • altering circadian behavioural rhythms (Marangoni et al. 2022). As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. One BIA—a foraging BIA for whale sharks—also intersects with the Project Area. Whale sharks are known to aggregate at Ningaloo between March and July. Following this aggregation period, they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). Light is not identified as a key threat for the whale shark (TSSC 2015f). Southern bluefin tuna (listed as conservation dependent under the EPBC Act) have a spawning ground between Java and northern WA, which extends into the northern part of the Project Area (Figure 7-16, Section 7.6.1.16). Although adult southern bluefin tuna may be present in the area, this species is not commercially targeted within WA (Section 7.10.1.1). Commercially targeted species that may occur within the Project Area include pelagic (e.g. mackerel) and demersal species (e.g. emperors) (Section 7.10.1.1). Because the source of artificial light is above the surface and the waters within the Project Area are deep (generally >70 m, except around banks or shoals), demersal fish species are not expected to be exposed to artificial light sources. Artificial light within the Project Area is not expected to affect whale shark or pelagic fish species in significant numbers because no known aggregation areas occur within the Project Area and the presence of these species would be seasonal, transitory, and/or of a short duration. Lighting from a MODU or vessel may result in aggregations of fish, but these aggregations are localised and temporary, and no long-term changes to fish species composition or abundance are expected to occur. Therefore, the artificial light emissions from the MODU and vessels within the Project Area is expected to have no lasting effect on fish, and thus the consequence level is ranked as F.
Marine Reptiles	Artificial light may result in behavioural changes to marine turtles, particularly around nesting beaches—adult females and emerging hatchlings use different light cues to orient to nesting and/or ocean locations (CoA 2017b; DCCEEW 2023k; Marangoni et al. 2022). The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies light emissions as a key threat to marine turtles because it can disrupt critical behaviours, such as nesting, hatchling orientation, sea finding, and dispersal behaviour. As identified in Section 7.6.2, several marine reptile species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. An internesting buffer BIA for the flatback turtle and internesting habitat critical to the survival of the flatback turtle intersect with the Project Area. The Recovery Plan (CoA 2017b) defines the habitat critical to the survival of a species for nesting for each species at a stock level. The closest nesting habitat critical to the survival of flatback turtles is the Montebello Islands—at its closest, the Project Area is ~30 km from these islands. Because the predicted light exposure area from the MODU and vessels is expected to range ~1.8–12.6 km (Figure 9-3), no coastal areas (and therefore no adult nesting turtles or turtle hatchlings) are expected to be exposed. The Recovery Plan (CoA 2017b) defines the habitat critical to the survival of a species for internesting as a distance 60 km seaward from nesting habitat critical to the survival of flatback turtles. A study by Whittock et al. (2016a) indicates that the internesting behaviour of flatback turtles on the NWS appears more spatially restricted than the Recovery Plan suggests. This study reported that during their internesting periods flatback turtles prefer habitats closer to the coast (maximum 27.8 km; mean <6.1 km) and at relatively shallow depths (maximum <44 m, mean <10 m). The preference for shallow (<40 m water depth) internesting habitat is also supported by other studies (Dobbs 2007; Guinea, Sperling, and Whiting 2006; Pendoley Environmental 2010). This suggests that although the Project Area does overlap with some internesting habitat critical to the survival of flatback turtles and an internesting buffer BIA, because it is offshore (~30 km from the Montebello Islands) and has deep waters (generally >70 m, except around banks or shoals), it is considered unlikely that flatback turtles would aggregate within the Project Area during their internesting period. Further, Pendoley Environmental (2020a) found no published or anecdotal evidence to suggest that internesting turtles are impacted by light from offshore vessels. Therefore, no changes to internesting behaviour due to light emissions from the MODU and vessels are expected.

Receptor	Consequence Evaluation
	Additionally, peak spectral emissions from MODU or vessel lighting and gas flares from the Goodwyn Area Infill Development are not within the most sensitive range for turtle species. Therefore, artificial light emissions from the MODU and vessels within the Project Area are not expected to have a lasting effect on marine turtles, and thus the consequence level is ranked as F.
Seabirds and Migratory Shorebirds	High levels of marine lighting can attract and disorient seabird species resulting in behavioural changes (e.g. circling light sources leading to exhaustion or disrupted foraging) (Longcore and Rich 2004; Gaston et al. 2014; Rich and Longcore 2006). The most vulnerable life stages for seabirds and migratory shorebirds are nesting adults or fledglings, which are considered vulnerable to artificial lighting within ~20 km of their nests (DCCEEW 2023k). The 20 km distance is a precautionary limit based on observed effects of sky glow on fledgling seabirds grounded in response to artificial light 15 km away (DCCEEW 2023k). No emergent land exists in the Project Area that could be used for roosting or nesting habitat—the closest coast is the Montebello Islands (~30 km south). Because the predicted light exposure area from the MODU and vessels is expected to range ~1.8–12.6 km), no coastal areas (and therefore no nesting adult birds or fledglings) are expected to be exposed. As identified in Section 7.6.4, several bird species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area, and a breeding BIA for the wedge-tailed shearwater intersects with the Project Area. Wedge-tailed shearwaters are seasonal visitors, typically present between mid-August to April in the Pilbara. They forage either relatively close to breeding islands or over a large area, depending on prey availability (Section 7.6.4.6). Their fledglings are predominantly impacted by onshore lighting sources, which can override sea-finding cues and attract them further inland, preventing them from reaching the sea (Mitkus et al. 2016; Telfer et al. 1987). Artificial light can also impact important behaviour of nesting adults (e.g. adult nest attendance, maintaining nest sites) or confuse them, resulting in injury or death if birds collide with structures (Cianchetti-Benedetti et al. 2018; Rodríguez et al. 2017). The Project Area is ~30 km from the nearest emergent land, therefore no impacts to adult nesting or fledgling wedge-tailed shearwaters are expected. In all seabirds, their photopic vision (light-adapted) is most sensitive in the long wavelength range (590–740 nanometres, orange to red) while their scotopic (dark-adapted) vision is more sensitive to short wavelengths (380–485 nanometres, violet to blue) (DCCEEW 2023k). The eyes of wedge-tailed shearwaters have a high proportion of cones that are sensitive to shorter wavelengths (DCCEEW 2023k). For the Goodwyn Area Infill Development, peak spectral emissions from both MODU or vessel lighting and gas flares are not expected to occur within these lower and more sensitive wavelength bands of blue, violet and ultraviolet light (i.e. not within the sensitive ranges for scotopic vision). Anthropogenic disturbance and artificial lighting is identified as a threat within the Wildlife Conservation Plan for Migratory Shorebirds (CoA 2015c). Nocturnally active migratory shorebirds may be affected by light spill and alter their normal behaviour as a result. How birds are attracted to light is not proven, but it is proposed that artificial lighting may override the internal magnetic compass of migratory shorebirds or nocturnal seabirds (Gauthreaux and Belser 2006). However, Marquenie et al. (2013) estimated that a change in migratory behaviour of birds was limited to <5 km from the source. Therefore, this type of impact is expected to be spatially restricted to the immediate vicinity of the MODU and vessels and affect only individuals, not populations. Therefore, artificial light emissions from the MODU and vessels within the Project Area are not expected to have a lasting effect on seabirds and migratory shorebirds, and thus the consequence level is ranked as F.
Fish, Sharks, and Rays ***Marine Reptiles*** ***Seabirds and Migratory Shorebirds***	**Concurrent Activities** As detailed in Section 9.1.3.1 there is the potential for concurrent MODU and vessel operations within the Project Area for the Goodwyn Area Infill Development. For concurrent MODU/vessel activities not occurring within proximity of each other, multiple individual (i.e. not overlapping) light exposure areas may occur. However, given the offshore location of the Project Area (~30 km north of the Montebello Islands) and the seasonal and transitory nature of the presence of marine fauna within the Project Area, the cumulative impact of multiple light exposure areas is not expected to adversely affect the biological behaviours of marine fauna within the Project Area to an extent greater than already assessed above. For concurrent MODU/vessel activities occurring within proximity of each other, a slightly larger overall light exposure area may occur for the duration of the activity. For example, if single installation vessel has a ~3.6 km diameter (i.e. 1.8 km radius) biologically relevant light exposure area, then two vessels within ~0.5 km of each other, could create up to a ~4.1 km diameter exposure area. Within the area of overlap light intensity would also be slightly higher (noting that

Receptor	Consequence Evaluation
	light intensity is inversely proportional to the distance from the source). Concurrent activities within proximity of each other (and therefore the overlapping light exposure areas) would only occur for a short duration. Given the offshore location of the Project Area (~30 km north of the Montebello Islands) the seasonal and transitory nature of the presence of marine fauna within the Project Area, and the limited duration of concurrent activities within close proximity, the cumulative impact of slightly larger light exposure areas and/or areas of increased light intensity is not expected to adversely affect the biological behaviours of marine fauna within the Project Area to an extent greater than already assessed above.

9.1.3.3.2 Potential changes to the functions, interests, or activities of other users

Receptor	Consequence Evaluation
Commercial Fisheries	The Project Area intersects with 3 State-managed commercial fisheries—Mackerel Managed Fishery, Pilbara Line Fishery, and Pilbara Trap Managed Fishery. Based on recent fishing effort, these fisheries are expected to be active within the Project Area (Section 7.10.1.2). The key species associated with these fisheries include pelagic (e.g. mackerel) and demersal (e.g. emperors) fish. The potential for changes to the function, interests, or activities of commercial fisheries from artificial light emissions within the Project Area may occur as an indirect consequence of an impact to the relevant fish species (i.e. commercial fish stocks). However, as described in the consequence evaluations above, artificial light emissions within the Project Area are not expected to result in a lasting effect to pelagic and demersal fish. Therefore, impacts to commercial fisheries are not considered credible and are not evaluated further.

9.1.3.3.3 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from artificial light emissions within the Project Area may occur as an indirect consequence of an impact to the marine fauna identified as a value of the Montebello Marine Park. However, as described in the consequence evaluations for the marine fauna groups above, artificial light emissions within the Project Area are not expected to result in a lasting effect to marine fauna. Therefore, the consequence of potential changes to the values of the Montebello Marine Park has been ranked as F.

9.1.3.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine Emissions: Light Generation, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	No controls were identified.
Good Industry Practice	• **CM-10**: Limit lighting to the minimum required for navigational and safety requirements, except for emergency events • **CM-11**: Manage lighting in accordance with Woodside's Offshore Seabird Management Plan • **CM-12**: Consider and implement appropriate light mitigation and management measures (e.g. as described in the National Light Pollution Guidelines for Wildlife) during the EP process to reduce impacts to marine fauna to ALARP

9.1.3.5 Impact Analysis Summary

Impact	Receptor	Environmental Value: Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Evaluation: Decision Type	Consequence
Potential changes to fauna behaviour	Fish, sharks, and rays						✓		A	F
	Marine reptiles						✓			F
	Seabirds and migratory shorebirds						✓			F
Potential changes to the functions, interests, or activities of other users	Commercial fisheries							✓		–
Potential changes to the values and sensitivities of protected places	Australian Marine Parks						✓			F

9.1.3.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine Emissions: Light Generation aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect, are **AL-05**, **AL-06**, **AL-07**, and **AL-08**, as defined in Table 4-3 (and shown below in Section 9.1.3.7). As described in the consequence evaluation (Section 9.1.3.3), the predicted impact would not cause lasting effects to marine fauna and subsequently would not result in impacts at a population level that would prevent their long-term recovery or survival. Therefore, the predicted level of impact for these receptors is better than the acceptable levels (**AL-06**, **AL-07**). Given the level of impact predicted for marine fauna, no lasting effects were predicted to occur to the values (natural, cultural, heritage, or socioeconomic) of the Montebello Marine Park such that it would prevent the long-term protection and conservation of marine park values. Therefore, the predicted level of impact for this receptor is better than the acceptable level (**AL-05**). Although modelling suggests the predicted artificial light exposure area intersects with an internesting buffer BIA and internesting habitat critical for the survival of flatback turtles, recent studies suggest that the Project Area does not represent habitat likely to be used by flatback turtles during their internesting period. Further, Pendoley Environmental (2020a) found no published or anecdotal evidence to suggest that internesting turtles are impacted by light from offshore vessels. Therefore, no changes to internesting behaviour due to light emissions from the MODU and vessels are expected. Therefore, the predicted level of impact to threatened species with a recovery plan is equal to or better than the acceptable level (**AL-08**). Further demonstration against the relevant management actions from the Marine Turtle Recovery Plan are provided below within the 'Other Requirements' component of this demonstration of acceptability.
Impact and Risk Classification,	The impacts arising from artificial light emissions within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and thus are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td>and Decision Type</td><td colspan="2">(where they exist) the legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.3.4).</td></tr>
<tr><td>Principles of ESD</td><td colspan="2">These principles of ESD were considered for this aspect:
• Integration Principle
– the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.3) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations
– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with marine fauna arising from the offshore project
– this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.3.4)
• Precautionary Principle
– the impact consequence rating for this aspect is no lasting effect (F); therefore, no potential for serious or irreversible environmental damage is expected
– there is little scientific uncertainty associated with predicted environmental impact and the anticipated effectiveness of management measures
• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– The existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.3) impact analysis
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.</td></tr>
<tr><td>Internal Context</td><td colspan="2">This Woodside management process or procedure was deemed relevant for this aspect:
• Seabird Management Plan for Offshore Facilities.
Control measures related to this management process or procedure have been described for this aspect (Section 9.1.3.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding artificial light emissions arising from the offshore project.</td></tr>
<tr><td rowspan="3">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>National Light Pollution Guidelines for Wildlife
Undertake an environmental impact assessment</td><td>This section (Section 9.1.3) assesses the impacts of artificial light emissions.
Consideration of control measures (as identified within the mitigation toolboxes for marine turtles, seabirds, and migratory shorebirds within the guideline) will be undertaken as required during EP development (as per the key control measure for adaptive management identified above).
Therefore, the Goodwyn Area Infill Development is not considered to be</td></tr>
</table>

Acceptability Criteria	Demonstration	
		inconsistent with the National Light Pollution Guidelines (DCCEEW 2023k).
	Recovery Plan for Marine Turtles in Australia *Management action A1.5*: Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of marine turtles *Management action A1.5*: Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue *Management action A8.1*: Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats	The predicted artificial light exposure area intersects with an internesting buffer BIA and internesting habitat critical for the survival of flatback turtles. However, studies on internesting behaviour and internesting habitat suitability for flatback turtles suggest that the Project Area does not represent habitat likely to be used by flatback turtles during their internesting period. Given the distance to nesting areas, and the key control measures in place, the continued use of habitat critical to the survival of a species and BIAs without displacement or disruption to biologically important behaviours is expected. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Recovery Plan for Marine Turtles in Australia (CoA 2017b).
	Wildlife Conservation Plan for Seabirds No specific action identified.	N/A
	Wildlife Conservation Plan for Migratory Shorebirds No specific action identified.	N/A
	Conservation Advice *Rhincodon typus* Whale Shark *Conservation action*: Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts	This section (Section 9.1.3) assesses the impact of, and considers key control measures for, artificial light emissions. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Conservation Advice *Rhincodon typus* Whale Shark (TSSC 2015f).
	Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A
	North-west Marine Parks Network Management Plan No specific zone rules identified.	N/A

9.1.3.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPO relevant to the Routine Emissions: Light Generation aspect is shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-06: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery	**EPO-04**: No adverse effects greater than an F consequence (localised, no lasting effect) to marine fauna from artificial light emissions during the petroleum activity

AL-07: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	
AL-08: No adverse effect from the petroleum activity that is inconsistent with any threatened species recovery plan made or adopted under the EPBC Act	**EPO-05**: The petroleum activity will not be undertaken in a manner that is inconsistent with any threatened species or community recovery plan, or threat abatement plan, as made or adopted under the EPBC Act
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.4 Routine Acoustic Emissions: Continuous Sound Generation

9.1.4.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in continuous sound generation are described in the following table. The two main sources of continuous sound[38] are the vessels and/or a MODU that will be used during all drilling, installation, operations, and decommissioning activities.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (for MODU operations, refer to Field Support Activities below).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	Continuous sound emissions will be generated when operating the wellheads and subsea infrastructure associated with the Goodwyn Area Infill Development. The continuous sound produced by an operational wellhead was measured by McCauley (2002). The broadband sound level was 113 dB re 1 µPa, which was only marginally above the ambient sound levels under rough sea conditions. Several wellheads would have to be very close (<50 m apart) before their combined signals would increase the total sound field (for comparison, two adjacent sources only increase the total sound field by 3 dB). Hence, if multiple wellheads are in a small area, the broadband sound level near the wellheads could be ~113 dB re 1 µPa, but is expected to drop to background levels within <200 m of the wellhead. Based on the measurements of sound produced by wellheads acoustics discussed in McCauley (2002), which included sound produced by operational flowlines, the sound produced along a flowline or an export pipeline may be similar to that for wellheads, with the radiated sound field falling to ambient levels within ~100 m of the flowline. Woodside carried out acoustic measurements on sound generated by operating choke valves associated with the Angel facility (JASCO 2015). These measurements indicated choke valves produce continuous (non-impulsive) sound, and the frequency and intensity of sound emitted depends on the rate of production from the well. Sound intensity at low production rates (16% and 30% choke positions) was ~154–155 dB re 1 µPa, with higher production rates (85% and 74% choke positions) resulting in lower sound levels (141–144 dB re 1 µPa). Sound from operating choke valves was broadband in nature, with most acoustic energy concentrated above 1 kHz; this sound was considered minor compared to sound generated by vessels using thrusters in the area.
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP.

[38] Use of continuous sound here refers to non-impulsive sounds. Examples of continuous (non-impulsive) sound sources include vessels thrusters.

Activity Group	Description
	Continuous sound emissions could occur due to subsea cutting activities; however, studies of subsea cutting (e.g. Quijano and McPherson 2021 as cited in Woodside 2022) indicate the sound is typically not discernible from general vessel operations. Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities (MODU, Vessels, Helicopters, ROV)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. The vessels and MODU (if a hybrid MODU is selected; Section 5.7.1) will operate on DP, and therefore will generate underwater sound from using propellors and thrusters. Excluding the DP source, vessels produce low-frequency sound (i.e. below 1 kHz) from machinery operations, hydrodynamic flow sound around the hull, and propeller cavitation (Ross 1987; 1993). Tugboats, crew boats, supply ships and many research vessels in the 50–100 m size class typically have broadband source level of 165–180 dB re 1 µPa (Gotz et al. 2009). In comparison, underwater sound levels generated by large ships can produce levels >190 dB re 1 µPa (Gotz et al. 2009) and vessels up to 20 m size class typically 151–156 dB re 1 µPa (Richardson et al. 1995). A typical broadband source level for a stationary MODU using DP has been estimated at ~187 dB re 1 µPa. Underwater sound emissions from MODUs primarily originate from on-board equipment vibrations, although some emissions are transmitted directly into the water through drill string vibrations and potentially from interaction between drill bits and the seafloor (Austin, Hannay, and Bröker 2018). Typical SPLs for drilling units have been reported as 169–175 dB re 1 µPa (Austin, Hannay, and Bröker 2018). Underwater sound emissions from ROV thrusters and propulsion have a lower frequency, but are intermittent and minimal (when compared to other sound sources for the Goodwyn Area Infill Development) and therefore are not discussed further. Helicopters will likely be used during the drilling and installation phases (Section 5.7.3). These will generate sound within the atmosphere, which may penetrate into the ocean. Sound emitted from helicopter operations is typically <500 Hz (Richardson et al. 1995). Richardson et al. (1995) report that helicopter sound is audible in air for four minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. Estimates of SPL for helicopters range from 149–162 dB re 1 µPa @ 1 m (Richardson et al. 1995; WDCS 2004). **Concurrent Activities** During drilling operations, a MODU and up to two support vessels (one standby vessel, and another resupply vessel) may be present in-field. The vessel undertaking resupply is only present for a short duration (e.g. ~8 hours) and intermittent (e.g. 1–2 times per week, depending on the frequency of resupply required). The underwater sound emissions from a MODU and up to two support vessels are included within acoustic modelling described below in Section 9.1.4.1.1. The indicative schedule for the Goodwyn Area Infill Development may have drilling and subsea installation activities occurring concurrently (Section 5.1.1). When there is both drilling and subsea installation activities occurring within the Project Area, the MODU (and support vessels) may not always be in close proximity to the installation vessel (i.e. the ensonified areas from sound emissions from the vessels would not overlap), or where they are in close proximity, the activity overlap would only occur for a short duration. For example, if an installation vessel (rather than the MODU) was used to install the Xmas tree, these concurrent drilling and installation activities are expected to take ~2–3 days and be in close proximity of each other. Underwater sound emissions from the adjacent MODU and installation vessel would result in a slightly greater overall spatial area being ensonified, as well as cumulative emissions in the area of overlap between the MODU and installation vessel.

9.1.4.1.1 Modelling and Exposure Assessment

As described above, acoustic emissions from the Goodwyn Area Infill Development include multiple sources of continuous sound related to different activities from different phases of the offshore project. For the impact assessment, the highest source of continuous sound (MODU and installation vessel operation) was selected for modelling as this represents the greatest spatial extent of potential impacts.

Based on Woodside's previous modelling campaigns for similar activities on the NWS, these continuous sound analogues were selected for the Goodwyn Area Infill Development:

- drilling from an anchored MODU and associated support vessel operations at JULA-P (Stroot, Koessler, and McPherson 2022)
- drilling from a DP MODU and associated support vessel operations at XNA02 (Wecker et al. 2022).

Woodside also commissioned JASCO Applied Sciences to conduct acoustic modelling to inform the impact assessment associated with underwater sound exposure from a construction vessel (Muellenmeister, Connell, and Koessler 2023) (Appendix E).

All of the above acoustic modelling studies were undertaken by JASCO Applied Sciences, and as such the sound propagation models used in the studies was consistent. An overview of the modelling method and validation can be found in Appendix B.2–B.4 of the Muellenmeister, Connell, and Koessler 2023 modelling report that is attached as Appendix E to this OPP. While the environmental parameters (bathymetry, sound speed profile, and geoacoustics; refer to Appendix B.1) will be site-specific to each study, the process used to determine these parameters is similar between all three modelling studies.

The scenarios and outputs of each modelling study is summarised below.

Acoustic Modelling (Anchored MODU)

JASCO Applied Sciences undertook acoustic modelling to inform the impact assessment associated with underwater sound exposure from operating an anchored MODU and associated support vessels (Stroot, Koessler, and McPherson 2022). The modelling was done to help understand the potential acoustic impact on receptors including marine mammals, turtles, fish (including larvae and eggs). Estimated underwater acoustic levels are presented as sound pressure levels (SPL) or accumulated sound exposure levels (SEL_{24h}), as appropriate for different noise effect criteria.

Advice from JASCO indicates that for similar activities in similar water depths on the NWS, the predicted ranges to the noise effect criteria thresholds in previous modelling could be used to support an approximation of the effects of sound on fauna and an associated impact assessment (Koessler and McPherson 2023).

The modelling site, JULA-P, is ~40 km west-south-west of the Project Area and has a water depth of ~167 m, which is within the depth range of activities within the Project Area (~70–160 m). The modelling is based on an anchored semisubmersible MODU, which is one of the options for the Goodwyn Area Infill Development (Section 5.7.1). Given the similar activity and similar water depths, the outcomes of the JULA-P acoustic modelling are considered appropriate to inform the impact assessment for the Goodwyn Area Infill Development.

Scenario

The acoustic modelling study incorporated multiple scenarios based on various combinations of the anchored MODU in isolation, and with up to two support vessels (Table 9-3). The MODU was assumed to drill continuously while at anchor.

Table 9-3: Scenarios and broadband source levels used for anchored MODU acoustic modelling

Modelling Scenarios	Sound Source Levels (dB re 1 µPa²m²s)
• Anchored MODU drilling (24 h) • Anchored MODU drilling (24 h) + offshore supply vessel (OSV) on standby (24 h) • Anchored MODU drilling + OSV resupply under DP (2 h) • Anchored MODU drilling (24 h) + OSV resupply under DP (8 h) • Anchored MODU drilling (24 h) + OSV resupply under DP (8 h) + OSV on standby (24 h)	• Anchored MODU drilling ~175.4 • OSV stationary under DP ~187.6 • OSV on standby (slow transit) ~177.8

Source: Stroot, Koessler, and McPherson 2022

Exposure Criteria

Because different species perceive and respond to sound differently, various exposure criteria for the different types of impacts and species hearing groups were considered. These noise effect criteria, based on current best available science, were selected for use in the impact assessment:

- frequency-weighted SEL_{24h} from Southall et al. (2019) for the onset of permanent threshold shift[39] (PTS) and temporary threshold shift[40] (TTS) in marine mammals for continuous sound sources
- marine mammal behavioural threshold based on the current interim US National Oceanic and Atmospheric Administration (NOAA) (2019) criterion for marine mammals continuous sound sources
- frequency-weighted SEL_{24h} from Finneran et al. (2017) for the onset of PTS and TTS in marine turtles
- sound exposure guidelines for fish, fish eggs, and larvae from Popper et al. (2014).

Table 9-5 lists these noise effect criteria.

Commonwealth guidance has defined ‘injury to blue whales’ as both PTS and TTS hearing impairment, as well as any other form of physical harm arising from anthropogenic sources of underwater noise (DAWE and NOPSEMA 2021).

Modelling Outputs

Table 9-6 lists the horizontal maximum distances (R_{max}) from the sound source to the relevant noise effect criteria for marine mammals, turtles, and fish.

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of sound levels within a 24-hour period, based on the assumption that a receptor is consistently exposed to such sound levels at a fixed position. However, marine fauna are unlikely to remain stationary in the same location or at the same range for a 24-hour period. Therefore, a modelled exposure distance for the SEL_{24h} criteria does not mean that marine fauna travelling within this area will be impaired, but rather that they could be exposed to the sound level associated with impairment (either PTS or TTS) if they remain in that location or range for 24 hours.

Similarly, distances are given for recoverable injury or TTS effects to fish, but fish must remain within these distances for either 12 hours (TTS) or 48 hours (recoverable injury) for the effect to occur.

[39] PTS is a physical injury to an animal’s hearing organs.

[40] TTS is a temporary reduction in an animal’s hearing sensitivity due to receptor hair cells in the cochlea becoming fatigued.

Acoustic Modelling (DP MODU)

JASCO Applied Sciences undertook acoustic modelling to inform the impact assessment associated with underwater sound exposure from operating a DP MODU and associated support vessels (Wecker et al. 2022).

The modelling site, XNA02, is ~20 km west of the Project Area and has a water depth of ~180 m, which is within the depth range of activities within the Project Area (~70–160 m). The modelling is based on a MODU using thrusters for positioning during drilling operations, which is one of the options for the Goodwyn Area Infill Development (Section 5.7.1). Given the similar activity and similar water depths, the outcomes of the XNA02 acoustic modelling are considered appropriate to inform the impact assessment for the Goodwyn Area Infill Development.

Scenario

The acoustic modelling study incorporated multiple scenarios based on various combinations of the anchored MODU in isolation and with up to two support vessels (Table 9-4). The MODU was assumed to drill continuously while also using thrusters (DP) at 50% capacity.

Table 9-4: Scenarios and broadband source levels used for DP MODU acoustic modelling

Modelling Scenarios	Sound Source Levels (dB re 1 µPa^{2}m^{2}s)
• MODU under DP drilling (24 h) • MODU under DP drilling (24 h) + OSV on standby (24 h) • MODU under DP (24 h) + OSV resupply under DP (2 h) • MODU under DP (24 h) + OSV resupply under DP (8 h) • MODU under DP (24 h) + OSV resupply under DP (8 h) + OSV on standby (24 h)	• MODU under DP drilling ~187.7 • OSV stationary under DP ~187.6 • OSV on standby (slow transit) ~177.8

Source: Wecker et al. 2022

Exposure Criteria

The noise effect criteria are the same as other continuous sound modelling studies, and are listed in Table 9-5.

Modelling Outputs

Table 9-7 lists the horizontal maximum distances (R_{max}) from the sound source to the relevant noise effect criteria for marine mammals, turtles, and fish.

Acoustic Modelling (Construction Vessel)

JASCO Applied Sciences undertook acoustic modelling to inform the impact assessment associated with underwater sound exposure from operating a construction vessel (Muellenmeister, Connell, and Koessler 2023). The modelling was undertaken to help understand the potential acoustic impact on receptors including marine mammals, turtles, fish (including larvae and eggs).

Scenario

The acoustic modelling study was based on a single scenario for 24-hour operation of a construction vessel under DP. The broadband source level for the construction vessel used in the modelling was ~193.2 dB re 1 µPa^{2}m^{2}s. Given the proximity to sensitive receptors, modelling was undertaken for a nominal location in the Wilcox field, outside the Montebello Marine Park.

Exposure Criteria

The noise effect criteria are the same as other continuous sound modelling studies, and are listed in Table 9-5.

Modelling Outputs

Table 9-8 lists the horizontal maximum distances (R_{max}) from the sound source to the relevant noise effect criteria for marine mammals, turtles, and fish.

Table 9-5: Noise effect criteria for continuous sound for different types of impacts and species groups

Receptor	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 199 dB re 1 µPa²s	SEL_{24h}: 179 dB re 1 µPa²s	N/A	SPL: 120 dB re 1 µPa
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 198 dB re 1 µPa²s	SEL_{24h}: 178 dB re 1 µPa²s	N/A	SPL: 120 dB re 1 µPa
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 173 dB re 1 µPa²s	SEL_{24h}: 153 dB re 1 µPa²s	N/A	SPL: 120 dB re 1 µPa
Marine turtles	N/A	N/A	SEL_{24h}: 220 dB re 1 µPa²s	SEL_{24h}: 200 dB re 1 µPa²s	N/A	N/A
Fish (no swim bladder)[1]	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	N/A	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish (swim bladder not involved in hearing)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	N/A	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish (swim bladder involved in hearing)	(N) Low (I) Low (F) Low	SPL: 170 dB re 1 µPa for 48 hours	N/A	SPL: 158 dB re 1 µPa for 12 hours	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae[2]	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	N/A	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

1. Hearing group relevant to sharks.

2. Hearing group relevant to plankton.

Relative risk (high, moderate, low) is given for fauna at three distances from the source (near [N]—tens of metres, intermediate [I]—hundreds of metres, and far [F]—thousands of metres).

Table 9-6: Modelled maximum horizontal distances (R_{max}) from the JULA-P drilling site to reach noise effect criteria for continuous sound

Receptor	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.07 km	SEL_{24h}: 0.92 km	N/A	SPL: 8.85 km
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.05 km	SEL_{24h}: 0.15 km	N/A	SPL: 8.85 km
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.21 km	SEL_{24h}: 2.76 km	N/A	SPL: 8.85 km
Marine turtles	N/A	N/A	SEL_{24h}: 0.03 km	SEL_{24h}: 0.07 km	N/A	N/A
Fish (no swim bladder)[1]	N/A	N/A	N/A	N/A	N/A	N/A
Fish (swim bladder not involved in hearing)	N/A	N/A	N/A	N/A	N/A	N/A
Fish (swim bladder involved in hearing)	N/A	SPL: 0.02 km	N/A	SPL: 0.07 km	N/A	N/A
Fish eggs and fish larvae[2]	N/A	N/A	N/A	N/A	N/A	N/A

1. *Hearing group relevant to sharks.*
2. *Hearing group relevant to plankton.*

Table 9-7: Modelled maximum horizontal distances (R_{max}) from the XNA02 drilling site to reach noise effect criteria for continuous sound

Receptor	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.13 km	SEL_{24h}: 2.66 km	N/A	SPL: 20.7 km
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.09 km	SEL_{24h}: 0.13 km	N/A	SPL: 20.7 km
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.15 km	SEL_{24h}: 2.63 km	N/A	SPL: 20.7 km
Marine turtles	N/A	N/A	SEL_{24h}: 0.09 km	SEL_{24h}: 0.14 km	N/A	N/A
Fish (no swim bladder)[1]	N/A	N/A	N/A	N/A	N/A	N/A
Fish (swim bladder not involved in hearing)	N/A	N/A	N/A	N/A	N/A	N/A

Receptor	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Fish (swim bladder involved in hearing)	N/A	SPL: 0.05 km	N/A	SPL: 0.08 km	N/A	N/A
Fish eggs and fish larvae[2]	N/A	N/A	N/A	N/A	N/A	N/A

1. *Hearing group relevant to sharks.*
2. *Hearing group relevant to plankton.*

Table 9-8: Modelled maximum horizontal distances (R_{max}) from the construction vessel to reach noise effect criteria for continuous sound

Receptor	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.17 km	SEL_{24h}: 3.89 km	N/A	SPL: 10.4 km
High-frequency cetaceans	N/A	N/A	SEL_{24h}: –	SEL_{24h}: 0.09 km	N/A	SPL: 10.4 km
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.10 km	SEL_{24h}: 1.19 km	N/A	SPL: 10.4 km
Marine turtles	N/A	N/A	SEL_{24h}: –	SEL_{24h}: 0.13 km	N/A	N/A
Fish (no swim bladder)[1]	N/A	N/A	N/A	N/A	N/A	N/A
Fish (swim bladder not involved in hearing)	N/A	N/A	N/A	N/A	N/A	N/A
Fish (swim bladder involved in hearing)	N/A	SPL: –	N/A	SPL: 0.06 km	N/A	N/A
Fish eggs and fish larvae[2]	N/A	N/A	N/A	N/A	N/A	N/A

1. *Hearing group relevant to sharks.*
2. *Hearing group relevant to plankton.*
3. *A dash (–) indicates the noise effect criteria was not reached within the limits of the modelling resolution (20 m).*

9.1.4.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Potential changes to fauna behaviour						✓	
Potential injury or mortality to fauna						✓	
Potential changes to the functions, interests, or activities of other users							✓
Potential changes to the values and sensitivities of protected places					✓		

9.1.4.3 Consequence Evaluation

9.1.4.3.1 Potential changes to fauna behaviour

Receptor	Consequence Evaluation
Planktonic Communities	Planktonic communities (as described in Section 7.5.2) comprise both phytoplankton and zooplankton. These communities are diverse and includes organisms that complete their lifecycle as plankton as well as larval stages of other taxa such as fishes. Continuous sound sources have a moderate risk of causing behavioural changes within the near (tens of metres) and intermediate (hundreds of metres) vicinity of a sound source for plankton; this risk decreases with increasing distance from the source (Table 9-5). Any effects to plankton must be assessed in the context of natural mortality rates, which are generally considered high and variable. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Given the patchy and variable plankton communities, continuous sound emissions are not expected to result in a substantial adverse change in behaviour. Therefore, continuous sound emissions within the Project Area are not expected to have a lasting effect on planktonic communities, and thus the consequence level is ranked as F.
Fish, Sharks, and Rays	<u>Fish (without swim bladders)</u> Continuous sound sources have a moderate risk of causing behavioural changes within the near (tens of metres) and intermediate (hundreds of metres) vicinity of a sound source for fish with no swim bladders; this risk decreases with increasing distance from the source (Table 9-5). Cartilaginous fish (e.g. sharks, rays) or pelagic fish (e.g. mackerel) do not have swim bladders. As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. One BIA—a foraging BIA for whale sharks—intersects the Project Area. Whale sharks are known to aggregate at Ningaloo between March and July. Following this aggregation period, they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). The Conservation Advice for Whale Sharks (TSSC 2015f) does not identify sound emissions as a threat to the species. The Mackerel Managed Fishery is active within the Project Area (Section 7.10.1.2). A key species for the fishery is the Spanish mackerel (Table 7-33), which has a depth range up to 50 m (Newman 2020). The activities within the Project Area are in waters ~70–160 m deep; therefore, no significant behavioural impacts to this species are predicted. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there.

Receptor	Consequence Evaluation
	Cartilaginous and pelagic fish species are also highly mobile, suggesting that behavioural responses would be limited and any effects on the distribution of these species will be incidental, localised and of short duration. Therefore, continuous sound emissions within the Project Area are not expected to have a lasting effect on the behaviour of fish without swim bladders, and thus the consequence level is ranked as F. Fish (with swim bladders) For fish with swim bladders not involved in hearing, continuous sound sources are a moderate risk for causing behavioural changes within the near (tens of metres) and intermediate (hundreds of metres) vicinity of a sound source; this risk decreases with increasing distance from the source (Table 9-5). For fish with swim bladders involved in hearing, continuous sound sources are a high risk for causing behavioural changes within the near (tens of metres), and a moderate risk within the intermediate (hundreds of metres) vicinity of a sound source; this risk decreases with increasing distance from the source (Table 9-5). Fish with swim bladders include: • demersal fish species (e.g. tropical snappers, emperors) (swim bladders not used for hearing) • some reef fish and site-attached fish species (swim bladders used for hearing). The Pilbara Line and Pilbara Trap Managed Fisheries are active within the Project Area (Section 7.10.1.2), and key species for these fisheries include varieties of emperors (Table 7-33). Given the nature of demersal fish (i.e. living near the seabed), if they were present directly under a vessel or MODU (i.e. where the sound is predominantly generated at the surface), a behavioural response may occur. However, these are mobile species, which suggests that behavioural responses would be limited and any effects on distribution will be incidental, localised and of short duration. Rankin Bank occurs within the Project Area and is known to support a diverse fish assemblage (Section 7.5.3.6). Wilcox Shoal also occurs within the Project Area; given the bathymetry of this shoal and its proximity to Rankin Bank, it is expected that Wilcox Shoal would also support a site-attached fish community. Rankin Bank is ~5 km north-west of the proposed tie-in to LPA, and Wilcox Shoal is ~1 km south-east of the phased development nominal infrastructure corridor. Because the risk of behavioural changes is expected to occur up to hundreds (not thousands) of metres from the sound source, the site-attached fish assemblages at these features are not predicted to be exposed. Therefore, continuous sound emissions within the Project Area are not expected to have a lasting effect on the behaviour of fish with swim bladders, and thus the consequence level is ranked as F.
Marine Mammals	Acoustic modelling indicated that the R_{max} from the source to SPL noise effect criteria for all cetaceans was 8.85–20.7 km during drilling (Table 9-6, Table 9-7), or 10.4 km during installation activities (Table 9-8). As identified in Section 7.6.3, several marine mammal species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. The threatened and/or migratory cetaceans that may be present within the Project Area are low-frequency and high-frequency cetaceans (Section 7.6.3). Very-high-frequency cetaceans (e.g. *Kogia* spp.) were identified as species or species habitat that may occur within the Project Area but are not listed as threatened and/or migratory under the EPBC Act (Table 7-13). No BIAs for regionally significant marine mammals intersect with the Project Area; however, two migration BIAs occur nearby—the migration BIA for the humpback whale occurs ~2 km south and the other ~15 km north-west for the pygmy blue whale. Depending on the type and location of the Goodwyn Area Infill Development activities and the proximity of the migration BIAs to the Project Area, these BIAs may be within the predicted ensonified area: • the pygmy blue whale migration BIA is ~23 km (at its closest) from the phased development nominal infrastructure corridor (Section 5.1.3); exposure of this BIA to continuous sound emissions is not predicted to occur during drilling or installation activities • the humpback whale migration BIA is ~12.5 km (at its closest) from the phased development nominal infrastructure corridor:

Receptor	Consequence Evaluation
	– exposure of this BIA to continuous sound emissions may occur during drilling activities if a hybrid MODU (i.e. with DP) is used; however if a moored MODU (i.e. without DP) is used, the predicted ensonified area is not expected to extend into the humpback whale BIA – exposure of this BIA to continuous sound emissions is not predicted to occur during installation activities. All cetacean species (for all hearing groups) transit through the area; no areas of known aggregation within or around the ensonified area have been identified. Migrating pygmy blue whales are likely to occur in the Exmouth to Montebello Islands region from April to August (northern migration) and November to December (southern migration); humpback whales are typically present from June to October. The migratory patterns of fin and sei whales within Australian waters is not well defined (Sections 7.6.3.2 and 7.6.3.5). Opportunistic cetacean sighting data from Woodside's facilities on the NWS indicate that humpback whales are the most commonly observed cetacean species (Section 7.6.3). Marine mammal presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from MODUs or vessels. Because continuous sound emissions will only occur during specific activities (e.g. drilling, installation, and IMMR during operations), they are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development, and no significant change to cetacean behaviours is expected. Therefore, continuous sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.
Planktonic Communities ***Fish, Sharks, and Rays*** ***Marine Mammals***	As detailed in Section 9.1.4.1 there is the potential for concurrent MODU and vessel operations within the Project Area for the Goodwyn Area Infill Development. Concurrent MODU and support vessel operations during drilling activities has already been considered within acoustic modelling and the consequence evaluations presented above. For concurrent drilling and subsea installation not occurring within proximity of each other, multiple individual (i.e. not overlapping) ensonified areas may occur. However, given the offshore location of the Project Area (~30 km north of the Montebello Islands) and the seasonal and transitory nature of the presence of marine fauna within the Project Area, the cumulative impact of multiple ensonified areas is not expected to adversely affect the biological behaviours of marine fauna within the Project Area to an extent greater than already assessed above. Where drilling and subsea installation activities occurring within proximity of each other, a slightly larger overall ensonified area may occur for the duration of the activity. For example, if an installation vessel (rather than the MODU) was used to install the Xmas tree, these concurrent drilling and installation activities are expected to take ~2–3 days and be in close proximity of each other. Given the offshore location of the Project Area (~30 km north of the Montebello Islands) the seasonal and transitory nature of the presence of marine fauna within the Project Area, and the short duration of concurrent activities within close proximity, the cumulative impact of slightly larger ensonified areas and/or small areas of increased emissions is not expected to adversely affect the biological behaviours of marine fauna within the Project Area to an extent greater than already assessed above.

9.1.4.3.2 Potential injury or mortality to fauna

Receptor	Consequence Evaluation
Planktonic Communities	**Mortal or potential mortal injury, recoverable injury, and auditory impairment (TTS)** Continuous sound sources have a low risk of causing mortal or potential mortal injury, recoverable injury, or TTS for plankton (Table 9-5); therefore, they are not evaluated further. **Masking** Continuous sound sources have a high risk of causing masking within the near (tens of metres), and a moderate risk within intermediate (hundreds of metres) vicinity of a sound source for plankton; this risk decreases with increasing distance from the source (Table 9-5). Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable.

Receptor	Consequence Evaluation
	Given the patchy and variable plankton communities, continuous sound emissions are not expected to result in a substantial adverse change in population. Therefore, continuous sound emissions within the Project Area are not expected to have a lasting effect on planktonic communities, and thus the consequence level is ranked as F.
Fish, Sharks, and Rays	**Mortal or potential mortal injury** Fish (without swim bladders) Continuous sound sources have a low risk of causing mortal or potential mortal injury for fish with no swim bladders (Table 9-5), and therefore are not evaluated further. Fish (with swim bladders) Continuous sound sources have a low risk of causing mortal or potential mortal injury for fish with swim bladders (Table 9-5), and therefore are not evaluated further. **Recoverable injury** Fish (without swim bladders) Continuous sound sources have a low risk of causing recoverable injury for fish with no swim bladders (Table 9-5), and therefore are not evaluated further. Fish (with swim bladders) Continuous sound sources have a low risk of causing recoverable injury for fish with swim bladders not involved in hearing (Table 9-5), and therefore are not evaluated further. Acoustic modelling indicated that the R_{max} from the source to SPL noise effect criteria for fish with swim bladders involved in hearing was 0.02–0.05 km during drilling (Table 9-6, Table 9-7). This noise effect criteria for recoverable injury was not predicted to be reached during installation activities (Table 9-8). During drilling activities, for an injury effect to occur, the fish must remain within these distances (i.e. 20–50 m) for 48 hours (Table 9-5). This was not considered a credible scenario and no further evaluation was undertaken. **Auditory impairment (TTS)** Fish (without swim bladders) Continuous sound sources have a moderate risk of causing TTS within the near (tens of metres) vicinity of a sound source for fish with no swim bladders; this risk decreases with increasing distance from the source (Table 9-5). However, for a TTS effect from continuous sound to occur, the fish must remain within these distances (tens of metres) for a prolonged period. This was not considered a credible scenario and no further evaluation was undertaken. Fish (with swim bladders) Continuous sound sources have a moderate risk of causing TTS within the near (tens of metres) vicinity of a sound source for fish with swim bladders not involved in hearing; this risk decreases with increasing distance from the source (Table 9-5). However, for a TTS effect from continuous sound to occur, the fish must remain within these distances (tens of metres) for a prolonged period. This was not considered a credible scenario and no further evaluation was undertaken. Acoustic modelling indicated that the R_{max} from the source to SPL noise effect criteria for fish with swim bladders involved in hearing was 0.07–0.14 km during drilling (Table 9-6, Table 9-7), or 0.06 km during installation activities (Table 9-8). However, for an injury effect to occur, the fish must remain within these distances for 12 hours (Table 9-5). This was not considered a credible scenario and no further evaluation was undertaken. **Auditory impairment (masking)** Fish (without swim bladders) Continuous sound sources have a high risk of causing masking within the near (tens of metres) and intermediate (hundreds of metres), and a moderate risk within far (thousands of metres) vicinity of a sound source for fish with no swim bladders (Table 9-5). Sound of any level that is detectable by fishes can mask signal detection, and thus may have a pervasive effect on fish behaviour. However, the consequences of this masking and any attendant behavioural changes for the survival of fishes are unknown (Popper et al. 2014). Most fish (including sharks and rays) are expected to exhibit avoidance behaviour from a sound source if it reaches levels that may cause behavioural or physiological effects. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there. These fish species are also highly mobile, suggesting that auditory impairment would be limited, and any effects on the distribution of these species will be incidental, localised and of short duration.

Receptor	Consequence Evaluation
	Therefore, continuous sound emissions within the Project Area are not expected to have a lasting effect on fish without swim bladders, and thus the consequence level is ranked as F. Fish (with swim bladders) For fish with swim bladders not involved in hearing, continuous sound sources have a high risk of causing masking within the near (tens of metres) and intermediate (hundreds of metres) vicinity, and a moderate risk within the far (thousands of metres) vicinity of a sound source (Table 9-5). For fish with swim bladders involved in hearing, continuous sound sources have a high risk of causing masking within the near (tens of metres) and intermediate (hundreds of metres) and far (thousands of metres) vicinity of a sound source (Table 9-5). Demersal fish species are mobile, which suggests that auditory impairment would be limited and any effects on distribution will be incidental, localised and of short duration. Rankin Bank is ~5 km north-west of the proposed tie-in to LPA, and Wilcox Shoal is ~1 km south-east of the phased development nominal infrastructure corridor. Because the risk of masking may extend up to thousands of metres for the sound source, the site-attached fish assemblages at Wilcox Shoal may be exposed. The proposed works closest to this feature are associated with installing a new umbilical between the new Wilcox field and the existing LPA (Section 5.2.1.2); the sound source (i.e. the installation vessel) will not remain near Wilcox Shoal for an extended duration. Therefore, continuous sound emissions within the Project Area are not expected to have a lasting effect on fish with swim bladders, and thus the consequence level is ranked as F.
Marine Reptiles	**Auditory impairment (TTS) or injury (PTS)** Acoustic modelling indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria during drilling for marine turtles was 0.07–0.14 km and 0.03–0.09 km respectively (Table 9-6, Table 9-7). Acoustic modelling indicated that the R_{max} from the source to TTS SEL_{24h} noise effect criteria during installation for marine turtles was 0.13 km; and the PTS SEL_{24h} noise effect criteria was not reached (Table 9-8). Note: SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. Specifically for marine turtles, this requires them to remain within ~30–90 m of the MODU during drilling for at least a 24-hour period before PTS may occur, and within ~70–140 m before TTS may occur. Similarly, turtles would need to remain within 130 m of the installation vessel for at least a 24-hour period before TTS may occur. Marine turtles (if present) are expected to transit through the area; therefore, these risks are not considered credible and are not evaluated further.
Marine Mammals	Low-frequency cetaceans Acoustic modelling indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria during drilling for low-frequency cetaceans was 0.92–2.66 km and 0.07–0.13 km respectively (Table 9-6, Table 9-7). Acoustic modelling indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria during installation for low-frequency cetaceans was 3.89 km and 0.17 km respectively (Table 9-8). As identified in Section 7.6.3, several marine mammal species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. The threatened and/or migratory cetaceans that may be present within the Project Area include low-frequency cetaceans (Section 7.6.3). No BIAs for regionally significant marine mammals intersect with the Project Area, however, two migration BIAs occur nearby—humpback whale (south) and pygmy blue whale (north-west). The pygmy blue whale migration BIA is ~23 km (at its closest) from the phased development nominal infrastructure corridor (Section 5.1.3); exposure of this BIA to continuous sound emissions at levels associated with TTS or PTS is not predicted to occur during drilling or installation activities. Similarly, the humpback whale migration BIA is ~12.5 km (at its closest) from the phased development nominal infrastructure corridor; exposure of this BIA to continuous sound emissions at levels associated with TTS or PTS is not predicted to occur during drilling or installation activities. Migrating pygmy blue whales are likely to occur in the Exmouth to Montebello Islands region from April to August (northern migration) and November to December (southern migration); humpback whales are typically present from June to October. The migratory patterns of fin and sei whales within Australian waters is not well defined (Sections 7.6.3.2 and 7.6.3.5).

Receptor	Consequence Evaluation
	Opportunistic cetacean sighting data from Woodside's facilities on the NWS indicate that humpback whales are the most commonly observed cetacean species (Section 7.6.3). Marine mammal presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from MODUs or vessels. Because continuous sound emissions will only occur during specific activities (e.g. drilling, installation, and IMMR during operations), they are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development. The activities associated with the Goodwyn Area Infill Development are not expected to have a significant auditory impact on cetaceans. Therefore, continuous sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E. High-frequency cetaceans Acoustic modelling indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria during drilling for high-frequency cetaceans was 0.13–0.15 km and 0.05–0.09 km respectively (Table 9-6, Table 9-7). Acoustic modelling indicated that the R_{max} from the source to TTS SEL_{24h} noise effect criteria during installation for high-frequency cetaceans was 0.09 km respectively; and the PTS SEL_{24h} noise effect criteria was not reached (Table 9-8). Note: SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. Specifically for high-frequency cetaceans, this requires them to remain within ~50–90 m of the MODU for at least 24 hours before PTS may occur, and within ~130–150 m of the MODU or ~90 m of the installation vessel before TTS may occur. High-frequency cetaceans (if present) are expected to transit through the area; therefore, these risks are not considered credible and are not evaluated further. Very-high-frequency cetaceans Acoustic modelling indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria during drilling for very-high-frequency cetaceans was 2.63–2.76 km and 0.15–0.21 km respectively (Table 9-6, Table 9-7). Acoustic modelling indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria during installation for very-high -frequency cetaceans was 1.19 km and 0.10 km respectively (Table 9-8). Very-high-frequency cetaceans (e.g. *Kogia* spp.) were identified as species or species habitat that may occur within the Project Area but are not listed as threatened and/or migratory under the EPBC Act (Table 7-13). No BIAs for regionally significant marine mammals intersect with the Project Area, and there are none associated with very-high frequency cetaceans within the vicinity. All cetacean species are expected to transit through the area; no areas of known aggregation within or around the ensonified area have been identified. Marine mammal presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from MODUs or vessels. Because continuous sound emissions will only occur during specific activities (e.g. drilling, installation, and IMMR during operations), they are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development. The activities associated with the Goodwyn Area Infill Development are not expected to have a significant auditory impact on cetaceans. Therefore, continuous sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.
Planktonic Communities ***Fish, Sharks, and Rays*** ***Marine Reptiles*** ***Marine Mammals***	As detailed in Section 9.1.4.1 there is the potential for concurrent MODU and vessel operations within the Project Area for the Goodwyn Area Infill Development. Concurrent MODU and support vessel operations during drilling activities has already been considered within acoustic modelling and the consequence evaluations presented above. For concurrent drilling and subsea installation not occurring within proximity of each other, multiple individual (i.e. not overlapping) ensonified areas may occur. However, given the offshore location of the Project Area (~30 km north of the Montebello Islands) and the seasonal and transitory nature of the presence of marine fauna within the Project Area, the cumulative impact

Receptor	Consequence Evaluation
	of multiple ensonified areas is not expected to adversely affect the biological behaviours of marine fauna within the Project Area to an extent greater than already assessed above. Where drilling and subsea installation activities occurring within proximity of each other, a slightly larger overall ensonified area may occur for the duration of the activity. For example, if an installation vessel (rather than the MODU) was used to install the xmas tree, these concurrent drilling and installation activities are expected to take ~2–3 days and be in close proximity of each other. Given the offshore location of the Project Area (~30 km north of the Montebello Islands) the seasonal and transitory nature of the presence of marine fauna within the Project Area, and the short duration of concurrent activities within close proximity, the cumulative impact of slightly larger ensonified areas and/or small areas of increased emissions is not expected to adversely affect the biological behaviours of marine fauna within the Project Area to an extent greater than already assessed above.

9.1.4.3.3 Potential changes to the functions, interests, or activities of other users

Receptor	Consequence Evaluation
Commercial Fisheries	The Project Area intersects with 3 State-managed commercial fisheries—Mackerel Managed Fishery, Pilbara Line Fishery, and Pilbara Trap Managed Fishery. Based on recent fishing effort, these fisheries are expected to be active within the Project Area (Section 7.10.1.2). The key species associated with these fisheries include those without swim bladders (e.g. mackerel) and those with swim bladders (e.g. emperors). The potential for changes to the function, interests, or activities of commercial fisheries from continuous sound emissions within the Project Area may occur as an indirect consequence of an impact to the relevant fish species (i.e. the commercial fish stocks). However, as described in the consequence evaluations above, continuous sound emissions within the Project Area are not expected to result in a lasting effect to pelagic and demersal fish. Therefore, impacts to commercial fisheries are not considered credible and are not evaluated further.

9.1.4.3.4 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from continuous sound emissions within the Project Area may occur as an indirect consequence of an impact to the marine fauna identified as a value of the Montebello Marine Park. However, as described in the consequence evaluations for the marine fauna groups above, continuous sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population. Therefore, no significant long-term adverse impacts to the values of the Montebello Marine Park are expected to occur, and thus the consequence level is ranked as E.

9.1.4.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine Acoustic Emissions: Continuous Sound Generation, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-13**: Vessels and helicopters must comply with legislative requirements for interacting with cetaceans, including Part 8 Division 8.1 of the EPBC Regulations 2000 (Cth)
Good Industry Practice	• **CM-14**: Consider and implement appropriate acoustic mitigation and adaptive management measures during the EP process to reduce impacts to marine fauna to ALARP

9.1.4.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*
Potential changes to fauna behaviour	Planktonic communities					✓			A	F
	Fish, sharks, and rays						✓			F
	Marine mammals						✓			E
Potential injury or mortality to fauna	Planktonic communities					✓				F
	Fish, sharks, and rays						✓			F
	Marine reptiles						✓			–
	Marine mammals						✓			E
Potential changes to the functions, interests, or activities of other users	Commercial fisheries							✓		–
Potential changes to the values and sensitivities of protected places	Australian Marine Parks						✓			E

9.1.4.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine Acoustic Emissions: Continuous Sound Generation aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect, are **AL-05**, **AL-06**, **AL-07**, and **AL-08**, as defined in Table 4-3 (and shown below in Section 9.1.4.7). As described in the consequence evaluation (Section 9.1.4.3), the predicted environmental impact would be short-term behavioural disturbances or auditory effects to individuals and would not be expected to result in impacts at a population level that prevent their long-term recovery or survival. Therefore, the predicted level of impact for these receptors is better than the acceptable levels (**AL-06**, **AL-07**). Impacts to marine turtles from continuous sound emissions were not credible, and consequently displacement from habitat critical to the survival of a species or disruption to biologically important behaviours within a BIA are not predicted to occur. Similarly, the risk of injury (TTS or PTS) to a blue whale within its BIA was not predicted to occur. Therefore, the

Acceptability Criteria	Demonstration
	predicted level of impact to threatened species with a recovery plan is equal to or better than the acceptable level (**AL-08**). Further demonstration against the relevant management actions from the Marine Turtle Recovery Plan and Conservation Management Plan for Blue Whales are provided below within the 'Other Requirements' component of this demonstration of acceptability. Given the short-term impacts predicted for marine fauna, no lasting effects were predicted to occur to the Montebello Marine Park such that it would prevent the long-term protection and conservation of marine park values. Therefore, the predicted level of impact to this receptor is better than the acceptable level (**AL-05**).
Impact and Risk Classification, and Decision Type	The impacts arising from the continuous sounds emissions within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and thus are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) the legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.4.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.4) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding continuous sound generation from the offshore project – this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.4.4) • Precautionary Principle – the impact consequence rating for this aspect is slight; therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with predicted environmental impact and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.4) impact analysis – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	No specific Woodside management processes or procedures were deemed relevant for this aspect.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding continuous sound emissions arising from the offshore project.
Other Requirements	Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.

Acceptability Criteria	Demonstration	
	Requirement	***Demonstration***
	Conservation Management Plan for the Blue Whale 2015–2025 *Management action A.2.3*: Anthropogenic noise in BIAs will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area	TTS and PTS from accumulated SEL_{24h} exposures to continuous sounds is not predicted to occur within the migration BIA north of the Project Area. The Project Area does not intersect with designated foraging areas for the pygmy blue whale. The nearest foraging BIA is ~245 km south-west of the Project Area, offshore from North West Cape. A recent study has indicated areas of probable foraging along the NWS based on proxy indicators (Section 7.6.3.4); however, there is no overlap with the Project Area or predicted ensonified areas. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Conservation Management Plan for the Blue Whale (CoA 2015a).
	Conservation Advice *Balaenoptera borealis* Sei Whale No specific conservation action identified.	N/A
	Conservation Advice *Balaenoptera physalus* Fin Whale No specific conservation action identified.	N/A
	Conservation Advice *Rhincodon typus* Whale Shark No specific conservation action identified.	N/A
	Recovery Plan for Marine Turtles in Australia *Management action A1.5*: Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of marine turtles *Management action A1.6*: Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue	TTS and PTS from accumulated SEL_{24h} exposures to continuous sounds is not predicted to occur for marine turtles. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Recovery Plan for Marine Turtles in Australia (CoA 2017b).
	Conservation Advice *Dermochelys coriacea* Leatherback Turtle No specific conservation action identified.	N/A
	Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A
	North-west Marine Parks Network Management Plan 2018 No specific zone rules identified.	N/A

9.1.4.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level of the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine Acoustic Emissions: Continuous Sound Generation aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-06: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	**EPO-06**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to marine fauna from underwater sound emissions during the petroleum activity
AL-08: No adverse effect from the petroleum activity that is inconsistent with any threatened species recovery plan made or adopted under the EPBC Act	**EPO-05**: The petroleum activity will not be undertaken in a manner that is inconsistent with any threatened species or community recovery plan, or threat abatement plan, as made or adopted under the EPBC Act
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.5 Routine Acoustic Emissions: Impulsive Sound Generation

9.1.5.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in impulsive sound[41] generation are described in the following table.

Activity Group	Description
Drilling and Completions	During drilling and completion activities, impulsive sounds will be emitted from using: • acoustic positioning • VSP. As described in Section 5.3.11, a LBL array may be in place for ~1–3 months at each well location. Acoustic transmissions from the transponders are not continuous through the deployment period. Typical emitted SPLs for positional equipment range from 187 to 204 dB re 1 µPa @ 1 m (Sonardyne 2023). VSP may be undertaken as part of formation evaluation. If selected for use, VSP within a wellbore is typically completed within <24 hours (Section 5.3.7). Typical emitted SPLs from VSP are estimated as ~216–228 dB re 1 µPa @ 1 m. Matthews (2012) indicates that airguns with a 250 cui source that is discharged ~5 times at 20-second intervals, create peak sound pressure levels of ~238 dB re 1 µPa @ 1 m. Peak sound pressure levels are expected to attenuate rapidly to ~180 dB re 1µPa (PK) within 100 m (Matthews 2012).
Subsea Installation and Pre-commissioning	During subsea installation activities, impulsive sounds will be emitted from using: • acoustic positioning • geophysical survey equipment (e.g. MBES, SSS). As described in Section 5.4.2, a LBL array or an USBL transponder may be used. Various site surveys (e.g. pre-lay, post-lay) will be carried out during installation activities; these may use acoustic survey equipment in addition to visual inspections. Typical SPLs emitted by each source type were estimated by MacGillivray et al. (2014) as: • SSS: ~229 dB re 1 µPa @ 1 m • MBES: ~218 dB re 1 µPa @ 1 m.
Start-up and Operations	During operations, IMMR may use acoustic survey techniques, as described above for the subsea installation phase.

[41] Impulsive sound is a qualitative term meaning sounds that are typically transient, brief (less than 1 s), broadband, with rapid rise time and rapid decay. They can occur in repetition or as a single event. Examples of impulsive sound include explosives, seismic airguns, and impact pile drivers.

Activity Group	Description
Decommissioning	Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3). Subsea acoustic positioning and geophysical survey equipment may be used during this phase; these are the same as those described above.
Field Support Activities (MODU)	The drilling phase will be supported by MODUs. Depending on the MODU type and location, the mooring systems between the different well locations may vary (Section 5.7.1.1). If pile moorings are selected for use, installation methods may include impact piling, which creates a low-frequency impulsive sound source. Mooring design will be completed for sites during the FEED phase, but it is anticipated that up to 8–12 piles may be required at each site. The sound emanating from a pile during pile-driving is a function of its material type, its size, the force applied to it and the characteristics of the substrate into which it is driven. The frequency bandwidth for most of the energy in pile driving sounds is typically <1,000 Hz. Estimated received sound levels 10 m from impact piling activity within the Project Area was estimated as ~181–191 dB re 1 µPa^2.s (Ozanich et al. 2023).

9.1.5.1.1 Modelling and Exposure Assessment

As described above, acoustic emissions from the Goodwyn Area Infill Development include multiple sources of impulsive sound related to different activities from different phases of the offshore project. For the impact assessment, the highest source of impulsive sound (impact pile driving) was selected for modelling because this represents the greatest spatial extent of potential impacts.

Acoustic Modelling (Impact Pile Driving)

Woodside commissioned JASCO Applied Sciences to conduct acoustic modelling to inform the impact assessment associated with underwater sound exposure from pile driving (Ozanich et al. 2023) (Appendix F). The modelling was done to help understand the potential acoustic impact on receptors including marine mammals, turtles, and fish (including larvae and eggs) (Ozanich et al. 2023).

JASCO's pile driving source model (in conjunction with the GRLWEAP 2010 wave equation model) was used to predict source levels associated with impact pile driving activities. JASCO's FWRAM propagation model used the outputs of the pile driving source model, with spatial and temporal environmental factors, to predict sound field levels.

Estimated underwater acoustic levels are presented as sound pressure levels (SPL), zero-to-peak sound pressure levels (PK), and either single-strike ($SEL_{per\text{-}strike}$) or accumulated sound exposure levels (SEL_{24h}) as appropriate for different noise effect criteria (Ozanich et al. 2023).

Scenario

Two nominal piling locations were selected—Wilcox (~72.0 m water depth) and Yodel South (~112.7 m water depth). These sites represent the geographical extent of the phased development and were selected to consider the effect of local bathymetry on the acoustic propagation.

The underwater sound field was modelled for a 32 m long pile, with a 2.18 m diameter and 76 mm wall thickness. Piles were modelled as a vertical installation using a hydraulic impact hammer, to a total penetration depth of 30 m. Per-strike modelling was undertaken at 3 penetration depths (2 m, 16 m, and 30 m). Assuming a continuous installation, the total time taken to install a single pile was estimated at ~70 mins. Modelling was based on installing one pile each day.

Exposure Criteria

Different species perceive and respond to sound differently, and so various exposure criteria were considered for the different types of impacts and species hearing groups. The noise effect criteria, based on current best available science, selected for use in this impact assessment were:

- peak sound pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL_{24h}) from Southall et al. (2019) for the onset of PTS and TTS in marine mammals

- marine mammal behavioural threshold based on the current interim US NOAA (2019) unweighted SPL criterion for marine mammals for impulsive sound sources
- PK and frequency-weighted accumulated SEL_{24h} from Finneran et al. (2017) for the onset of PTS and TTS in marine turtles
- SPL associated with marine turtle behavioural response from impulsive sound, and an SPL associated with behavioural disturbance from McCauley et al. (2000)
- sound exposure guidelines for fish, fish eggs, and larvae from Popper et al. (2014).

Table 9-9 lists the noise effect criteria.

Commonwealth guidance has defined 'injury to blue whales' as both PTS and TTS hearing impairment, as well as any other form of physical harm arising from anthropogenic sources of underwater sound (DAWE and NOPSEMA 2021).

Modelling Outputs

For impact pile driving, most of the acoustic energy from the sound source is output at lower frequencies (with peak energy ~100–400 Hz). The sound produced from impact pile driving was axially symmetric, and the sound source energy was highest at the shallowest (2 m) modelled penetration depth.

The predicted acoustic propagation at Wilcox and Yodel South is also approximately axisymmetric, and typically restricted to the shallower depths on the continental shelf. The distances to per-strike isopleths are generally farthest when at shallow pile penetration (i.e. most of the pile is in the water column), and distances are shortest at the end of piling (i.e. when most of the pile is buried in the sediment).

For criteria based on SEL_{24h} metrics, modelling output needs to be considered in the context of the length and duration of operations. As described above, the time to drive a single pile to a penetration depth of 30 m was estimated at ~70 mins, with only one pile installed each day. Therefore, the accumulated sound exposure during this 70 mins becomes the equivalent of $SEL_{24h.}$

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within the driving period and assumes that an animal is consistently exposed to such noise levels at a fixed position. However, marine fauna are unlikely to remain stationary in the same location or at the same range for an extended period. Therefore, a modelled exposure distance for the SEL_{24h} criteria does not mean that marine fauna travelling within this distance will be impaired, but rather that they could be exposed to the sound level associated with impairment (either PTS or TTS) if they remained in that location or range for the duration of the pile driving.

Horizontal maximum distances (R_{max}) from the sound source to the relevant noise effect criteria for marine mammals, turtles, and fish are shown in Table 9-10 and Table 9-11 for Wilcox and Yodel South respectively.

The largest R_{max} value was applied as a buffer around each modelling site (Note: A 4 km radius buffer was initially applied to each site first, as a conservative allowance for the potential area that piling could occur) to determine the ensonified areas for the impact assessment. Figure 9-5 to Figure 9-7 shows these maximum distances in relation to adjacent BIAs.

Table 9-9: Noise effect criteria for impulsive sound for different types of impacts and species hearing groups

Receptor hearing group	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 183 dB re 1 µPa²s PK: 219 dB re 1 µPa	SEL_{24h}: 168 dB re 1 µPa²s PK: 213 dB re 1 µPa	N/A	$SPL_{per\text{-}strike}$: 160 dB re 1 µPa
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 185 dB re 1 µPa²s PK: 230 dB re 1 µPa	SEL_{24h}: 170 dB re 1 µPa²s PK: 224 dB re 1 µPa	N/A	$SPL_{per\text{-}strike}$: 160 dB re 1 µPa
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 155 dB re 1 µPa²s PK: 202 dB re 1 µPa	SEL_{24h}: 140 dB re 1 µPa²s PK: 196 dB re 1 µPa	N/A	$SPL_{per\text{-}strike}$: 160 dB re 1 µPa
Marine turtles	N/A	N/A	SEL_{24h}: 204 dB re 1 µPa²s PK: 232 dB re 1 µPa	SEL_{24h}: 189 dB re 1 µPa²s PK: 226 dB re 1 µPa	N/A	$SPL_{per\text{-}strike}$: 166 dB re 1 µPa (response) $SPL_{per\text{-}strike}$: 175 dB re 1 µPa (disturbance)
Fish (no swim bladder)[1]	SEL_{24h}: >219 dB re 1 µPa²s PK: >213 dB re 1 µPa	SEL_{24h}: >216 dB re 1 µPa²s PK: >213 dB re 1 µPa	N/A	SEL_{24h}: >>186 dB re 1 µPa²s	(N) Moderate[3] (I) Low (F) Low	(N) High[3] (I) Moderate (F) Low
Fish (swim bladder not involved in hearing)	SEL_{24h}: 210 dB re 1 µPa²s PK: >207 dB re 1 µPa	SEL_{24h}: 203 dB re 1 µPa²s PK: >207 dB re 1 µPa	N/A	SEL_{24h}: >>186 dB re 1 µPa²s	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish (swim bladder involved in hearing)	SEL_{24h}: 207 dB re 1 µPa²s PK: >207 dB re 1 µPa	SEL_{24h}: 203 dB re 1 µPa²s PK: >207 dB re 1 µPa	N/A	SEL_{24h}: 186 dB re 1 µPa²s	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae[2]	SEL_{24h}: >210 dB re 1 µPa²s PK: >207 dB re 1 µPa	(N) Moderate[3] (I) Low (F) Low	N/A	(N) Moderate[3] (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

1. *Hearing group relevant to sharks.*
2. *Hearing group relevant to plankton.*
3. *Relative risk (high, moderate, low) is given for fauna at three distances from the source (near [N]—tens of metres, intermediate [I]—hundreds of metres, and far [F]—thousands of metres).*

Table 9-10: Modelled maximum horizontal distances (R_{max}) from the nominal Wilcox piling site to reach noise effect criteria for impulsive sound

Receptor hearing group	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 2.43 km PK: –	SEL_{24h}: 16.0 km PK: 0.03 km	N/A	$SPL_{per\text{-}strike}$: 1.49–4.79 km
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.06 km PK: –	SEL_{24h}: 0.36 km PK: –	N/A	$SPL_{per\text{-}strike}$: 1.49–4.79 km
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 1.61 km PK: 0.06–0.13 km	SEL_{24h}: 8.88 km PK: 0.40–0.47 km	N/A	$SPL_{per\text{-}strike}$: 1.49–4.79 km
Marine turtles	N/A	N/A	SEL_{24h}: 0.03 km PK: –	SEL_{24h}: 0.28 km PK: –	N/A	$SPL_{per\text{-}strike}$: 0.73–2.15 km (response) $SPL_{per\text{-}strike}$: 0.39–0.58 km (disturbance)
Fish (no swim bladder)[1]	SEL_{24h}: – PK: 0.03 km	SEL_{24h}: 0.02 km PK: 0.03 km	N/A	SEL_{24h}: 2.43 km	N/A	N/A
Fish (swim bladder not involved in hearing)	SEL_{24h}: 0.05 km PK: 0.02–0.06 km	SEL_{24h}: 0.25 km PK: 0.02–0.06 km	N/A	SEL_{24h}: 2.43 km	N/A	N/A
Fish (swim bladder involved in hearing)	SEL_{24h}: 0.15 km PK: 0.02–0.06 km	SEL_{24h}: 0.25 km PK: 0.02–0.06 km	N/A	SEL_{24h}: 2.43 km	N/A	N/A
Fish eggs and fish larvae[2]	SEL_{24h}: 0.05 km PK: 0.02–0.06 km	N/A	N/A	N/A	N/A	N/A

1. *Hearing group relevant to sharks.*
2. *Hearing group relevant to plankton.*
3. *A dash (–) indicates the noise effect criteria was not reached within the limits of the modelling resolution (20 m).*
4. *The range of distances presented for SPLper-strike or PK results corresponds to a variation in maximum distances predicted for the different stages of penetration depth of the pile during installation.*

Table 9-11: Modelled maximum horizontal distances (R_{max}) from the nominal Yodel South piling site to reach noise effect criteria for impulsive sound

Receptor hearing group	Mortal or potential mortal injury	Recoverable injury	PTS	TTS	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 3.11 km PK: –	SEL_{24h}: 22.6 km PK: 0.02–0.05 km	N/A	$SPL_{per\text{-}strike}$: 4.13–5.78 km
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 0.05 km PK: –	SEL_{24h}: 0.41 km PK: –	N/A	$SPL_{per\text{-}strike}$: 4.13–5.78 km
Very-high-frequency cetaceans	N/A	N/A	SEL_{24h}: 1.87 km PK: 0.11–0.14 km	SEL_{24h}: 10.6 km PK: 0.31–0.37 km	N/A	$SPL_{per\text{-}strike}$: 4.13–5.78 km
Marine turtles	N/A	N/A	SEL_{24h}: 0.03 km PK: –	SEL_{24h}: 0.34 km PK: –	N/A	$SPL_{per\text{-}strike}$: 1.46–2.45 km (response) $SPL_{per\text{-}strike}$: 0.39–0.77 km (disturbance)
Fish (no swim bladder)[1]	SEL_{24h}: 0.03 km PK: 0.02–0.05 km	SEL_{24h}: 0.05 km PK: 0.02–0.05 km	N/A	SEL_{24h}: 3.53 km	N/A	N/A
Fish (swim bladder not involved in hearing)	SEL_{24h}: 0.09 km PK: 0.04–0.10 km	SEL_{24h}: 0.33 km PK: 0.04–0.10 km	N/A	SEL_{24h}: 3.53 km	N/A	N/A
Fish (swim bladder involved in hearing)	SEL_{24h}: 0.20 km PK: 0.04–0.10 km	SEL_{24h}: 0.33 km PK: 0.04–0.10 km	N/A	SEL_{24h}: 3.53 km	N/A	N/A
Fish eggs and fish larvae[2]	SEL_{24h}: 0.09 km PK: 0.04–0.10 km	N/A	N/A	N/A	N/A	N/A

1. *Hearing group relevant to sharks.*
2. *Hearing group relevant to plankton.*
3. *A dash (–) indicates the noise effect criteria was not reached within the limits of the modelling resolution (20 m).*
4. *The range of distances presented for SPLper-strike or PK results corresponds to a variation in maximum distances predicted for the different stages of penetration depth of the pile during installation.*

Animat Exposure Modelling for pygmy blue whales

In addition to the acoustic modelling, JASMINE was used to predict the exposure of migrating pygmy blue whales (Ozanich et al. 2023) (Appendix F).

JASMINE integrates the predicted sound field with biologically meaningful movement rules that results in an exposure history for each simulated animal (animat) in the model. Biologically meaningful movement rules include swim speed, direction, diving depths, and surface time. This approach provides a more realistic prediction of sound exposure by taking into account the movement of the simulated animal, rather than it being in a static position.

The exposure simulation was run for a representative 24-hour period to coincide with the acoustic modelling. Animal movements and exposures were modelled for both nominal pile driving locations (Wilcox and Yodel South). Scenarios were run for migrating pygmy blue whales restricted to their migration BIA, as well as unrestricted. The scenarios also accounted for two different migration directions (230° and 270° tracks). The same noise effect criteria as defined for low-frequency cetaceans in Table 9-9 were used for this pygmy blue whale exposure modelling.

The modelled 95th percentile exposure ranges ($ER_{95\%}$) from the sound source to the relevant noise effect criteria for pygmy blue whales are shown in Table 9-12. The closest distance between the migratory pygmy blue whale BIA and the nominal pile driving locations used in the modelling is ~27 km. The exposure modelling for animats restricted to the BIA did not result in any exposures above noise effect criteria, and these results are not discussed further.

The predicted exposure ranges for behavioural criteria were very similar to the static acoustic modelling ranges for both pile driving scenarios; this is as expected based on the vertical distribution of the sound field (Table 9-12). Exposure ranges for PTS and TTS criteria are typically shorter than those predicted using acoustic modelling because of the generally shorter time ('dwell time') to accumulate sound energy of the moving animats (Ozanich et al. 2023). The probability of exposure within $ER_{95\%}$ range in all cases varied between 64–87%, indicating that most, but not all, animats within the $ER_{95\%}$ range were exposed above threshold. This is because animats can move in and out of the modelling range as well as their vertical position in the water column, thus potentially limiting the length of time they are within the exposure radius (Ozanich et al. 2023).

Table 9-12: Modelled 95th percentile exposure ranges ($ER_{95\%}$) and probability of exposure, compared to modelled maximum horizontal distances (R_{max}) for pygmy blue whales

Modelling	Parameter	PTS	TTS	Behavioural
Wilcox				
Acoustic modelling	R_{max}	SEL_{24h}: 2.43 km	SEL_{24h}: 16.0 km	$SPL_{per\text{-}strike}$: 4.79 km
Animat exposure modelling	$ER_{95\%}$	SEL_{24h}: 0.53–0.59 km	SEL_{24h}: 6.29–6.36 km	$SPL_{per\text{-}strike}$: 4.04–4.10 km
	P_{exp}	68–75%	64–66%	64–67%
Yodel South				
Acoustic modelling	R_{max}	SEL_{24h}: 3.11 km	SEL_{24h}: 22.6 km	$SPL_{per\text{-}strike}$: 5.78 km
Animat exposure modelling	$ER_{95\%}$	SEL_{24h}: 0.72–0.77 km	SEL_{24h}: 8.86–8.98 km	$SPL_{per\text{-}strike}$: 4.04–4.16 km
	P_{exp}	77–81%	76–77%	86–87%

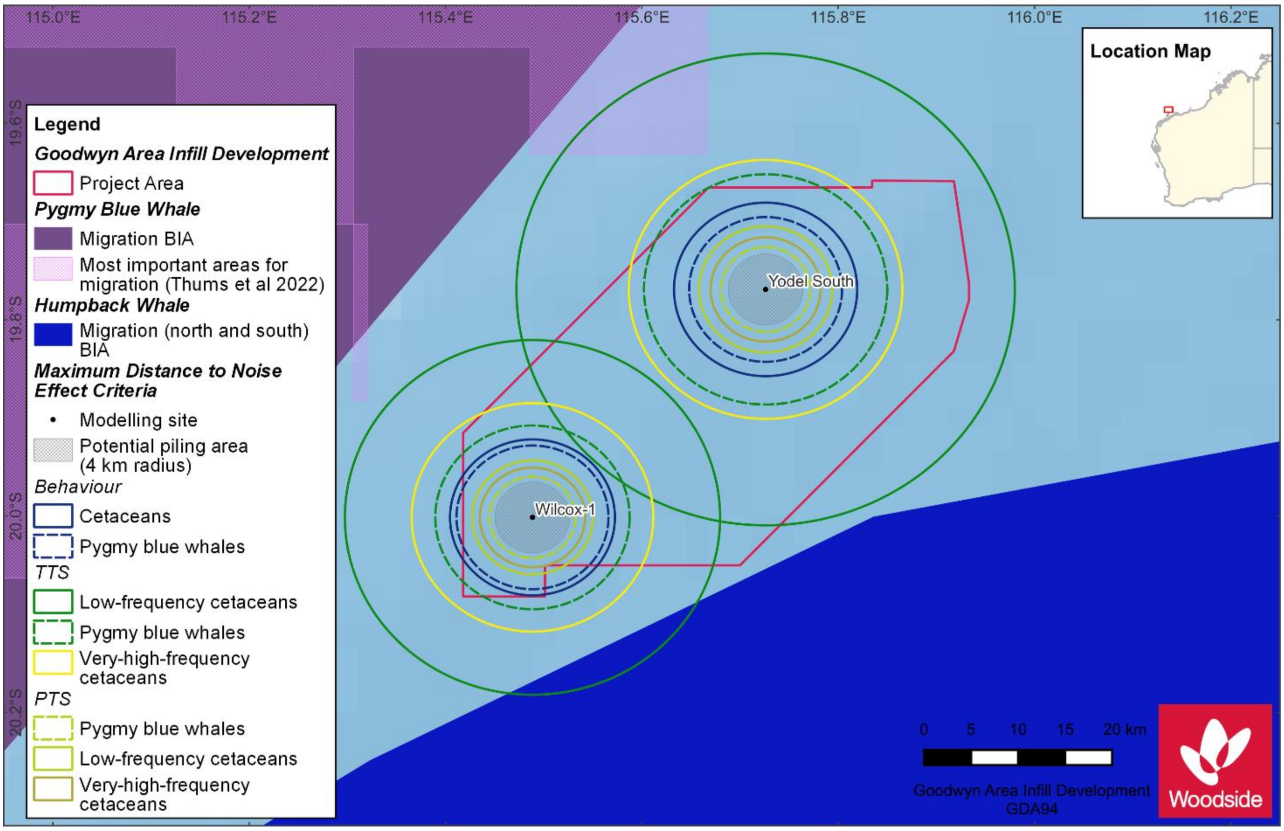


Figure 9-5: Maximum predicted distances to noise effect criteria for cetaceans from impact pile driving acoustic and animat modelling

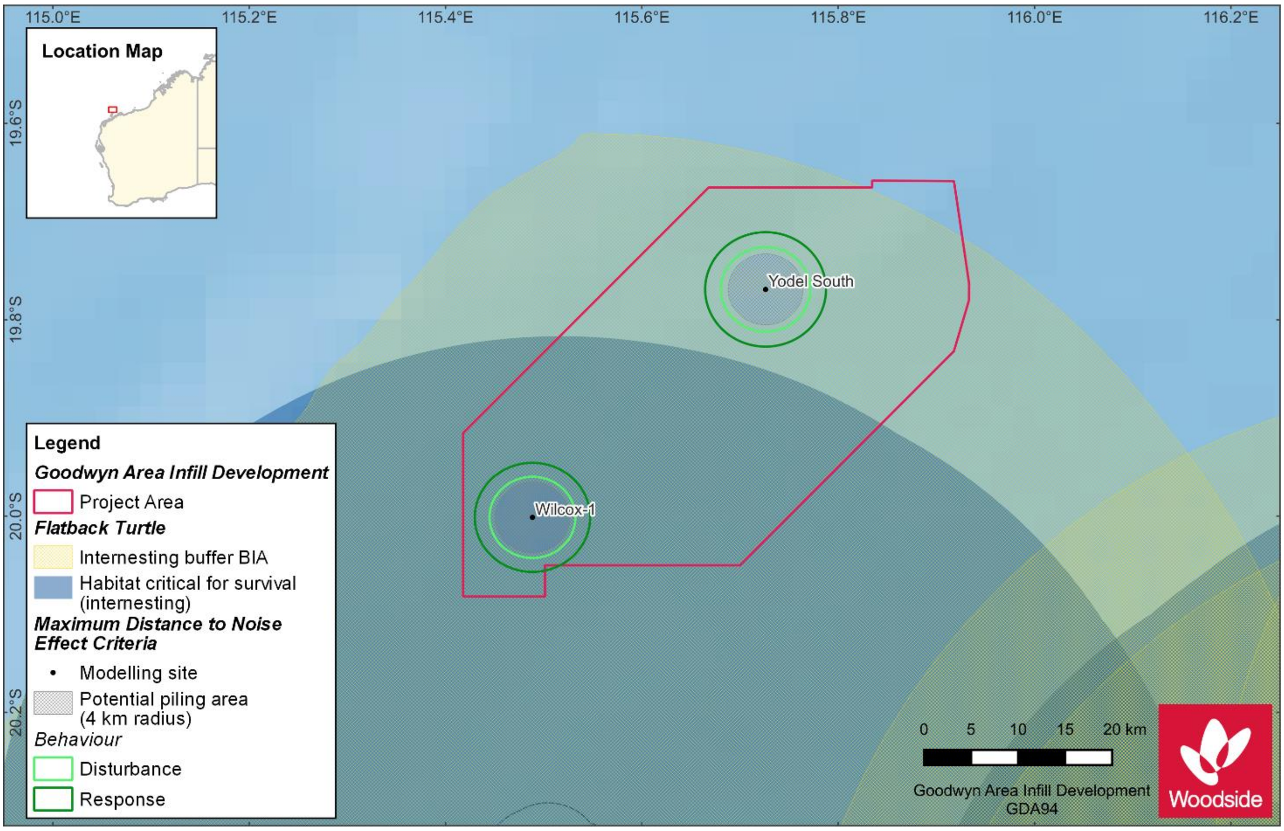


Figure 9-6: Maximum predicted distances to behavioural noise effect criteria for marine turtles from impact pile driving acoustic modelling

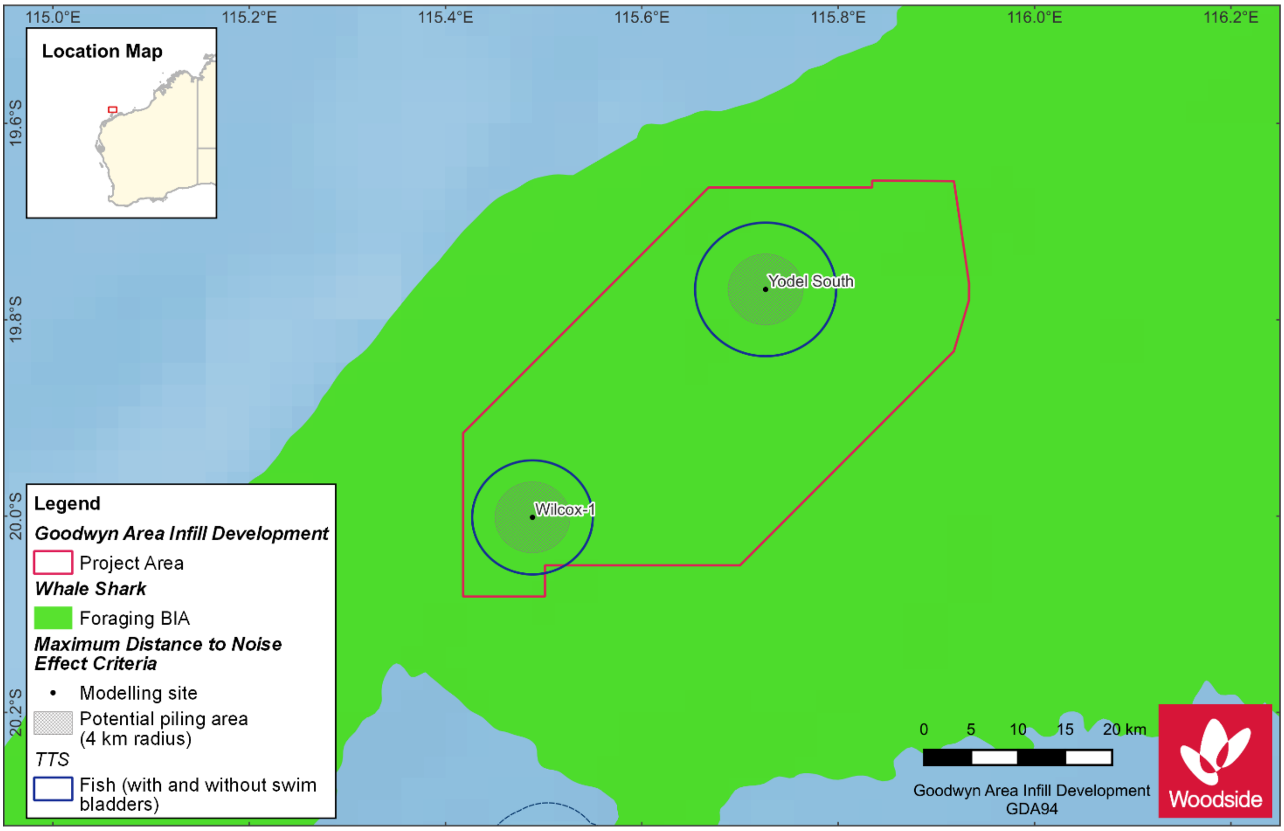


Figure 9-7: Maximum predicted distances to TTS noise effect criteria for fish from impact pile driving acoustic modelling

9.1.5.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Potential changes to fauna behaviour						✓	
Potential injury or mortality to fauna						✓	
Potential changes to the functions, interests, or activities of other users							✓
Potential changes to the values and sensitivities of protected places					✓		

9.1.5.3 Consequence Evaluation

9.1.5.3.1 Potential changes to fauna behaviour

Receptor	Consequence Evaluation
Planktonic Communities	Planktonic communities (as described in Section 7.5.2) comprise both phytoplankton and zooplankton. These communities are diverse and include organisms that complete their lifecycle as plankton as well as larval stages of other taxa such as fishes.

Receptor	Consequence Evaluation
	Impulsive sound sources have a moderate risk of causing behavioural changes within the near (tens of metres) vicinity of a sound source for plankton; this risk decreases with increasing distance from the source (Table 9-9). Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Given the patchy and variable plankton communities, impulsive sound emissions are not expected to result in a substantial adverse change in behaviour. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on planktonic communities, and thus the consequence level is ranked as F.
Fish, Sharks, and Rays	<u>Fish (without swim bladders)</u> Impulsive sound sources have a high risk of causing behavioural changes within the near (tens of metres) vicinity and a moderate risk within intermediate (hundreds of metres) vicinity of a sound source for fish with no swim bladders; this risk decreases with increasing distance from the source (Table 9-9). Cartilaginous (e.g. sharks, rays) or pelagic fish (e.g. mackerel) do not have swim bladders. The hearing system of most fishes is sensitive to sound pressures between 50–500 Hz (Ladich 2000), which overlaps the predominant frequency ranges of impact pile driving activities. Potential behavioural impacts to finfish from impulsive sounds include temporary stunning, changing positions in the water, displacing from the area and effects on breeding behaviours (Webster et al. 2018). As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. One BIA—foraging BIA for whale sharks—intersects with the Project Area. Whale sharks are known to aggregate at Ningaloo between March and July. Following this aggregation period, they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). The Conservation Advice for Whale Sharks (TSSC 2015f) does not identify sound emissions as a threat to the species. The Mackerel Managed Fishery is active within the Project Area (Section 7.10.1.2); its key species is Spanish mackerel (Table 7-33), which has a depth range up to 50 m (Newman 2020). The activities within the Project Area are in waters ~70–160 m deep; therefore, no significant behavioural impacts to this species are predicted. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there. These species are also highly mobile, suggesting that behavioural responses would be limited and any effects on distribution will be incidental, localised and of short duration. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on the behaviour of fish without swim bladders, and thus the consequence level is ranked as F. <u>Fish (with swim bladders)</u> For fish with swim bladders not involved in hearing, impulsive sound sources have a high risk of causing behavioural changes within the near (tens of metres) and a moderate risk within intermediate (hundreds of metres) vicinity of a sound source; this risk decreases with increasing distance from the source (Table 9-9). For fish with swim bladders involved in hearing, impulsive sound sources have a high risk of causing behavioural changes within the near (tens of metres) and intermediate (hundreds of metres) vicinity, and a moderate risk within the far (thousands of metres) vicinity of a sound source (Table 9-9). Fish with swim bladders include: • demersal fish species (e.g. tropical snappers, emperors) (swim bladders not used for hearing) • some reef fish and site-attached fish species (swim bladders used for hearing). Studies indicate that exposure to an impulsive source that results in behavioural response in demersal fish (e.g. startle, changes in swimming speed or direction, avoidance) are likely to be limited to durations of minutes or hours and occur within hundreds of metres of the impulsive source (McCauley et al. 2000; Pearson, Skalski, and Malme, n.d.; Fewtrell and McCauley 2012; Miller and Cripps 2013; Bruce et al. 2018). The demersal fish species likely to be present within

Receptor	Consequence Evaluation
	the Project area (e.g. snappers, emperors, rock cods) can be found across various habitats and are typically mobile, with home ranges encompassing kilometres or tens of kilometres (Newman et al. 2018; Harasti et al. 2015; NWS DPI 2014; Parsons et al. 2011). The Pilbara line and Pilbara Trap Managed Fisheries are active within the Project Area (Section 7.10.1.2), and key species for these fisheries include varieties of emperors (Table 7-33). Given the nature of demersal fish (i.e. living near the seabed), if they were present directly within the vicinity of the piling activity, a behavioural response may occur. However, these are mobile species, which suggests that behavioural responses would be limited and any effects on distribution will be incidental, localised and of short duration. Rankin Bank occurs within the Project Area and is known to support a diverse fish assemblage (Section 7.5.3.6). Wilcox Shoal also occurs within the Project Area; given the bathymetry of this shoal and its proximity to Rankin Bank, it is expected that Wilcox Shoal would also support a site-attached fish community. Rankin Bank is ~8 km west of proposed drilling at Yodel South and Rankin fields, and Wilcox Shoal is ~13 km north-east of the proposed drilling at Wilcox. Because the risk of behavioural changes is expected to occur up to thousands of metres from the sound source, the site-attached fish assemblages at these features are not predicted to be exposed. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on the behaviour of fish with swim bladders; thus the consequence level is ranked as F.
Marine Reptiles	Acoustic modelling indicated that the R_{max} from the source to $SPL_{per-strike}$ behavioural response noise effect criteria for turtles was 2.15 km at Wilcox and 2.45 km at Yodel South; the R_{max} to the behavioural disturbance noise effect criteria was 0.58 km at Wilcox and 0.77 km at Yodel South (Table 9-10, Table 9-11). As identified in Section 7.6.2, several marine reptile species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. An internesting buffer BIA for the flatback turtle and internesting habitat critical to the survival of the flatback turtle also intersect with the Project Area (Figure 9-6). The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies noise interference as a key threat to the species. The Recovery Plan (CoA 2017b) defines the habitat critical to the survival of a species for nesting for each species at a stock level. The closest nesting habitat critical to the survival of flatback turtles is the Montebello Islands—at its closest, the Project Area is ~30 km from these islands. The Recovery Plan (CoA 2017b) indicates that flatback turtles nest at the Montebello Islands from October to March, with a peak between November and January. The predicted ensonified area for behavioural response will not intersect with nearshore or coastal areas. The Recovery Plan (CoA 2017b) defines the habitat critical to the survival of a species for internesting as a distance 60 km seaward from nesting habitat critical to the survival of flatback turtles. A study by Whittock et al. (2016a) indicates that the internesting behaviour of flatback turtles on the NWS appears more spatially restricted than the Recovery Plan suggests. This study reported that during their internesting periods flatback turtles prefer habitats closer to the coast (maximum 27.8 km; mean <6.1 km) and at relatively shallow depths (maximum <44 m, mean <10 m). The preference for shallow (<40 m water depth) internesting habitat is also supported by other studies (Dobbs 2007; Guinea, Sperling, and Whiting 2006; Pendoley Environmental 2010). This suggests that although the Project Area does overlap with some internesting habitat critical to the survival of flatback turtles and an internesting buffer BIA, because it is offshore (~30 km from the Montebello Islands) and has deep waters (generally >70 m, except around banks or shoals), it is considered unlikely that flatback turtles would aggregate within the Project Area during their internesting period. If flatback turtles (or other marine turtles) are present within the Project Area, their presence are not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. Consequently any behavioural responses would be limited, and behavioural disturbance negligible, such that any effects on distribution will be incidental, localised and of short duration. Therefore, impulsive sound emissions within the Project are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.
Marine Mammals	Acoustic modelling indicated that the R_{max} from the source to $SPL_{per-strike}$ behavioural noise effect criteria for cetaceans was 4.79 km at Wilcox and 5.78 km at Yodel South (Table 9-10, Table 9-11). The 95th percentile predicted exposure range for pygmy blue whales to the behavioural noise effect criteria was similar at 4.79 km at Wilcox and 4.16 km at Yodel South (Table 9-12).

Receptor	Consequence Evaluation
	As identified in Section 7.6.3, several marine mammal species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. The threatened and/or migratory cetaceans that may be present within the Project Area are low-frequency and high-frequency cetaceans (Section 7.6.3). Very-high-frequency cetaceans (e.g. *Kogia* spp.) were identified as species or species habitat that may occur within the Project Area but are not listed as threatened and/or migratory under the EPBC Act (Table 7-13). No BIAs for regionally significant marine mammals intersect with the Project Area; however, two migration BIAs occur nearby—humpback whale (south) and pygmy blue whale (north-west). The pygmy blue whale migration BIA is ~25 km north-west of proposed drilling (Echo field) and the humpback whale migration BIA is ~16 km from proposed drilling (Wilcox field)—exposure of these BIAs to underwater sound above the behaviour thresholds is not predicted to occur during impact piling activities (Figure 9-5). All cetacean species (for all hearing groups) transit through the area; no areas of known aggregation within or around the ensonified area have been identified. Migrating pygmy blue whales are likely to occur in the Exmouth to Montebello Islands region from April to August (northern migration) and November to December (southern migration); humpback whales are typically present from June to October. The migratory patterns of fin and sei whales within Australian waters is not well defined (Sections 7.6.3.2 and 7.6.3.5). Opportunistic cetacean sighting data from Woodside's facilities on the NWS indicate that humpback whales are the most commonly observed cetacean species (Section 7.6.3). Marine mammal presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from impact piling activities. Because impulsive sound emissions will only occur for short durations (e.g. installing each pile will take ~70 mins), they are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development, and no significant change to cetacean behaviours is expected. Therefore, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.

9.1.5.3.2 Potential injury or mortality to fauna

Receptor	Consequence Evaluation
Planktonic Communities	**Mortal or potential mortal injury** Acoustic modelling indicated that the per-strike PK and SEL_{24h} effect criteria for fish eggs and larvae for mortal or potential mortal injury was 0.06 km and 0.05 km respectively at Wilcox (Table 9-10), and 0.10 km and 0.09 km respectively at Yodel South (Table 9-11). Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Given the patchy and variable plankton communities, impulsive sound emissions are not expected to result in a substantial adverse change in population or distribution. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on planktonic communities, and thus the consequence level is ranked as F. **Recoverable injury, and auditory impairment (TTS or masking)** Impulsive sound sources have a moderate risk of causing recoverable injury, TTS, or masking within the near (tens of metres) vicinity of a sound source for plankton; this risk decreases with increasing distance from the source (Table 9-9). Given the patchy and variable plankton communities, impulsive sound emissions are not expected to result in a substantial adverse change in population or distribution. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on planktonic communities, and thus the consequence level is ranked as F.
Fish, Sharks, and Rays	**Mortal or potential mortal injury** <u>Fish (without swim bladders)</u> Acoustic modelling indicated that the per-strike PK and the accumulated SEL_{24h} effect criteria for fish (without swim bladders) for mortal or potential mortal injury was 0.06 km and 0.05 km

Receptor	Consequence Evaluation
	respectively at Wilcox (Table 9-10), and 0.10 km and 0.09 km respectively at Yodel South (Table 9-11). Note: SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. Specifically for fish without swim bladders, this requires them to remain within ~50–90 m of the impact pile driving for at least a 24-hour period (or the period of active impact piling if this is <24 hours) before mortal or potential mortal injury may occur. This was not considered a credible scenario and no further evaluation was undertaken. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there. Because a fish must be within ~60–100 m of the impact pile driving sound source for a per-strike PK to result in a mortal or potential mortal injury, and impulsive sound emissions will only occur for short durations (~70 mins per pile per day), and cartilaginous and pelagic fish species are highly mobile, auditory impacts would be limited and any effects on distribution will be incidental, localised and of short duration. Studies to date have not demonstrated direct mortality of adult fish in response to impulsive sound emissions (Popper et al. 2014; DFO 2004; Boeger et al. 2006; Carroll et al. 2017). Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on fish without swim bladders, and thus the consequence level is ranked as F. <u>Fish (with swim bladders)</u> Acoustic modelling indicated that the per-strike PK and SEL_{24h} effect criteria for fish (with swim bladders) for mortal or potential mortal injury was 0.06 km and 0.15 km respectively at Wilcox (Table 9-10), and 0.10 km and 0.20 km respectively at Yodel South (Table 9-11). Note: SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. Specifically for fish with swim bladders, this requires them to remain within ~150–200 m of the impact pile driving for at least a 24-hour period before mortal or potential mortal injury may occur. This was not considered a credible scenario and no further evaluation was undertaken. Fish with swim bladders include: • demersal fish species (e.g. tropical snappers, emperors) (swim bladders not used for hearing) • some reef fish and site-attached fish species (swim bladders used for hearing). The Pilbara Line and Pilbara Trap Managed Fisheries are active within the Project Area (Section 7.10.1.2); key species for these fisheries include varieties of emperors (Table 7-33). Because a fish must be within ~60–100 m of the impact pile driving sound source for a per-strike PK to result in a mortal or potential mortal injury, and impulsive sound emissions will only occur for short durations (~70 mins per pile per day), and cartilaginous and pelagic fish species are highly mobile, auditory impacts would be limited and any effects on distribution will be incidental, localised and of short duration. Rankin Bank occurs within the Project Area and is known to support a diverse fish assemblage (Section 7.5.3.6). Wilcox Shoal also occurs within the Project Area; given the bathymetry of this shoal and its proximity to Rankin Bank, it is expected that Wilcox Shoal would also support a site-attached fish community. Rankin Bank is ~8 km west of proposed drilling (Yodel South and Rankin fields) and Wilcox Shoal is ~13 km north-east of proposed drilling (Wilcox field). Because the risk of mortal or potential mortal injury is expected to occur ~60–100 m from the sound source, the site-attached fish assemblages at these features are not predicted to be exposed. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on fish with swim bladders, and thus the consequence level is ranked as F. **Recoverable injury** <u>Fish (with no swim bladder)</u> Acoustic modelling indicated that the per-strike PK and SEL_{24h} effect criteria for fish (without swim bladders) for recoverable injury was 0.03 km and 0.02 km respectively at Wilcox (Table 9-10), and 0.05 km for both at Yodel South (Table 9-11). Given these distances (~30–50 m), exposure to SEL_{24h} was not considered a credible scenario and no further evaluation was undertaken. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there. Because a fish must be within ~30–50 m of the impact pile driving sound source for a per-strike PK to result in a mortal or potential mortal injury, and impulsive sound emissions will only occur for short

Receptor	Consequence Evaluation
	durations (~70 mins per pile per day), and cartilaginous and pelagic fish species are highly mobile, auditory impacts would be limited and any effects on distribution will be incidental, localised and of short duration. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on fish without swim bladders, and thus the consequence level is ranked as F. <u>Fish (with swim bladder)</u> Acoustic modelling indicated that the per-strike PK and SEL_{24h} effect criteria for fish (with swim bladders) for recoverable injury was 0.06 km and 0.25 km respectively at Wilcox (Table 9-10), and 0.10 km and 0.33 km respectively at Yodel South (Table 9-11). Because a fish must be within ~60–100 m of the impact pile driving sound source for a per-strike PK to result in a recoverable injury or remain within ~250–330 m for the duration of active impact pile driving (~70 mins per pile per day), and demersal fish species are highly mobile, auditory impacts would be limited and any effects on distribution will be incidental, localised and of short duration. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on fish with swim bladders, and thus the consequence level is ranked as F. **Auditory impairment (TTS)** <u>Fish (with no swim bladder)</u> Acoustic modelling indicated that the R_{max} from the source to the TTS SEL_{24h} effect criteria for fish (with and without swim bladders) was 2.43 km at Wilcox and 3.53 km at Yodel South (Table 9-10, Table 9-11). Cartilaginous (e.g. sharks, rays) and pelagic fish (e.g. mackerel) do not have swim bladders. As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. One BIA—foraging BIA for whale sharks—intersects with the Project Area. Whale sharks are known to aggregate at Ningaloo between March and July. Following this aggregation period, they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). The predicted ensonified areas for TTS represents ~0.008–0.02% of the foraging BIA and do not intersect with the full width of the BIA (Figure 9-7). The Conservation Advice for Whale Sharks (TSSC 2015f) does not identify sound emissions as a threat to the species. The Mackerel Managed Fishery is active within the Project Area (Section 7.10.1.2); its key species is Spanish mackerel (Table 7-33), which has a depth range up to 50 m (Newman 2020). The activities within the Project Area are in waters ~60–160 m deep; therefore, no significant behavioural impacts to this species are predicted. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there. Whale shark presence would also be seasonal and transitory. There are no constraints (e.g. shallow water or shorelines) that prevent fish from moving away from impact piling activities. Impulsive sound emissions will only occur for short durations (~70 mins per pile per day), and are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development. Therefore, no significant auditory impacts to fish without swim bladders are expected. Therefore, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E. <u>Fish (with swim bladders)</u> Acoustic modelling indicated that the R_{max} from the source to the TTS SEL_{24h} effect criteria for fish (with and without swim bladders) was 2.43 km at Wilcox and 3.53 km at Yodel South (Table 9-10, Table 9-11). Rankin Bank occurs within the Project Area and is known to support a diverse fish assemblage (Section 7.5.3.6). Wilcox Shoal also occurs within the Project Area; given the bathymetry of this shoal and its proximity to Rankin Bank, it is expected that Wilcox Shoal would also support a site-attached fish community. Rankin Bank is ~8 km west of proposed drilling (Yodel South and Rankin fields) and Wilcox Shoal is ~13 km north-east of proposed drilling (Wilcox field). Because the risk of behavioural changes is expected to occur up to thousands of metres from the sound source, the site-attached fish assemblages at these features are not predicted to be exposed to sound levels for the durations required for auditory impairments to occur.

Receptor	Consequence Evaluation
	The Pilbara Line and Pilbara Trap Managed Fisheries are active within the Project Area (Section 7.10.1.2); key species for these fisheries include varieties of emperors (Table 7-33). Because a fish must be within ~2.43–3.53 km of the impact pile driving sound source for a TTS effect to occur, and impulsive sound emissions will only occur for short durations (~70 mins per pile per day), and demersal fish species are highly mobile, auditory impacts would be limited and any effects on distribution will be incidental, localised and of short duration. Therefore, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E. **Auditory impairment (masking)** Fish (without swim bladders) Impulsive sound sources have a moderate risk of causing masking within the near (tens of metres) vicinity of the sound source for fish without swim bladders; this risk decreases to low with increasing distance from the source (Table 9-9). Sound of any level that is detectable by fishes can mask signal detection, and thus may have a pervasive effect on fish behaviour. However, the consequences of this masking and any attendant behavioural changes for the survival of fishes are unknown (Popper et al. 2014). Most fish (including sharks and rays) are expected to exhibit avoidance behaviour from a sound source if the sound reaches levels that may cause behavioural or physiological effects. Cartilaginous or pelagic fish presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas are known to occur there. These species are highly mobile, suggesting that auditory impairment would be limited and any effects on distribution will be incidental, localised and of short duration. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on fish without swim bladders, and thus the consequence level is ranked as F. Fish (with swim bladders) For fish with swim bladders not involved in hearing, impulsive sound sources have a moderate risk of causing masking within the near (tens of metres) vicinity of a sound source; this risk decreases to low with increasing distance from the source (Table 9-9). Demersal fish species are highly mobile, suggesting that auditory impairment would be limited and any effects on distribution will be incidental, localised and of short duration. For fish with swim bladders involved in hearing, impulsive sound sources have a high risk of causing masking within the near (tens of metres) and intermediate (hundreds of metres) vicinity, and a moderate risk within the far (thousands of metres) vicinity of a sound source (Table 9-9). Rankin Bank is ~8 km west of proposed drilling (Yodel South and Rankin fields), and Wilcox Shoal is ~13 km north-east of proposed drilling (Wilcox field). Because the risk of behavioural changes is expected to occur up to thousands of metres from the sound source, the site-attached fish assemblages at these features are not predicted to be exposed to sound levels for the durations required for auditory impairments to occur. Therefore, impulsive sound emissions within the Project Area are not expected to have a lasting effect on fish without swim bladders, and thus the consequence level is ranked as F.
Marine Reptiles	**Auditory impairment (TTS) or injury (PTS)** Acoustic modelling indicated that the per-strike PK noise effect criteria for turtles for TTS and PTS was not reached at either Wilcox or Yodel South (Table 9-10, Table 9-11). Acoustic modelling also indicated that the R_{max} from the source to the PTS SEL_{24h} noise effect criteria for turtles was 0.03 km at Wilcox and Yodel South (Table 9-10, Table 9-11). Note: SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. For a PTS effect to occur, the turtle would need to remain within a range of 30 m of the impact piling for the full duration (~70 mins) of piling activities. This was not considered a credible scenario and no further evaluation was undertaken. Acoustic modelling indicated that the R_{max} from the source to the TTS SEL_{24h} noise effect criteria for turtles was 0.28 km at Wilcox (Table 9-10) and 0.34 km at Yodel South (Table 9-11). For a TTS effect to occur, the turtle would need to remain within a range of 280–340 m of the impact piling for the full duration (~70 mins) of piling activities. As identified in Section 7.6.2, several marine reptile species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. An internesting buffer BIA for the flatback turtle and internesting habitat critical to the survival of the flatback turtle intersect with the Project Area. However, as described above previous studies on

Receptor	Consequence Evaluation
	internesting behaviour of flatback turtles (Dobbs 2007; Guinea, Sperling, and Whiting 2006; Pendoley Environmental 2010) and specifically on the internesting habitat suitability on the NWS (Whittock, Pendoley, and Hamann 2016a) suggest that the Project Area (~30 km from the Montebello Islands and with activities in waters ~70–160 m deep) is unlikely to be used by flatback turtles during their internesting period. As described above, the maximum distance from the sound source to the behavioural response noise effect criteria for turtles was 2.15 km at Wilcox and 2.45 km at Yodel South (Table 9-10, Table 9-11). Marine turtles are unlikely to remain within a range of 280–340 m of the impact piling for the full duration of piling activities, such that a TTS effect would occur. Therefore, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.
Marine Mammals	**Auditory impairment (TTS) or injury (PTS)** <u>Low-frequency cetaceans</u> Acoustic modelling indicated that the per-strike PK noise effect criteria for low-frequency cetaceans for TTS was 0.03 km at Wilcox and 0.05 km at Yodel South (Table 9-10, Table 9-11). The PK PTS effect criteria was not reached at either Wilcox or Yodel South for low-frequency cetaceans. For a per-strike TTS effect to occur, the cetacean would need to be within 30–50 m of the impact piling. This was not considered a credible scenario and no further evaluation was undertaken. Acoustic modelling also indicated that the R_{max} from the source to the TTS and PTS SEL_{24h} noise effect criteria for low-frequency cetaceans was 16.0 km and 2.43 km respectively at Wilcox (Table 9-10), and 22.6 km and 3.11 km respectively at Yodel South (Table 9-11). The animat exposure modelling for pygmy blue whales reduced the predicted distances to TTS and PTS to 6.63 km and 0.59 km respectively (Table 9-12). As identified in Section 7.6.3, several marine mammal species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. The threatened and/or migratory cetaceans that may be present within the Project Area include low-frequency cetaceans (Section 7.6.3). No BIAs for regionally significant marine mammals intersect with the Project Area; however, two migration BIAs occur nearby—humpback whale (south) and pygmy blue whale (north-west). The pygmy blue whale migration BIA is ~25 km north-west of proposed drilling (Echo field) and the humpback whale migration BIA is ~16 km from proposed drilling (Wilcox field). Exposure to these BIAs to underwater sound levels above PTS SEL_{24h} thresholds is not predicted to occur during impact piling activities (Figure 9-5). However, if piling was selected for use at Wilcox, underwater sound levels above TTS SEL_{24h} thresholds may extend into the humpback whale BIA (Figure 9-5). Based on the results of the animat modelling, exposure to underwater sound levels above TTS SEL_{24h} thresholds is not predicted to occur within the pygmy blue whale migration BIA, or the 'most important' areas for migration (Figure 9-5). Migrating pygmy blue whales are likely to occur in the Exmouth to Montebello Islands region from April to August (northern migration) and November to December (southern migration); humpback whales are typically present from June to October. The migratory patterns of fin and sei whales within Australian waters is not well defined (Sections 7.6.3.2 and 7.6.3.5). Opportunistic cetacean sighting data from Woodside's facilities on the NWS indicate that humpback whales are the most commonly observed cetacean species (Section 7.6.3). Marine mammal presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from impact piling activities. Impulsive sound emissions will only occur for short durations (~70 mins per pile per day), and they are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development. Therefore, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E. <u>High-frequency cetaceans</u> Acoustic modelling indicated that the per-strike PK noise effect criteria for high-frequency cetaceans for TTS and PTS was not reached at either Wilcox or Yodel South (Table 9-10, Table 9-11).

Receptor	Consequence Evaluation
	Acoustic modelling also indicated that the R_{max} from the source to the TTS and PTS SEL_{24h} noise effect criteria for high-frequency cetaceans was 0.36 km and 0.06 km respectively at Wilcox (Table 9-10), and 0.41 km and 0.05 km respectively at Yodel South (Table 9-11). Note: SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. For a PTS effect to occur, the cetacean would need to remain within 50–60 m of the impact piling for the full duration of piling activities (~70 mins); for a TTS effect to occur, it would need to remain within 360–410 m for the full duration. This was not considered a credible scenario and no further evaluation was undertaken. Very-high-frequency cetaceans Acoustic modelling indicated that the per-strike PK noise effect criteria for very-high-frequency cetaceans for TTS and PTS was 0.47 km and 0.13 km respectively at Wilcox (Table 9-10) and 0.37 km and 0.14 km respectively at Yodel South (Table 9-11). For a per-strike TTS effect to occur, the cetacean would need to be within 370–470 m of the impact piling (130–140 m for a PTS effect). This was not considered a credible scenario and no further evaluation was undertaken. Acoustic modelling also indicated that the R_{max} from the source to the TTS and PTS SEL_{24h} noise effect criteria for very-high-frequency cetaceans was 8.88 km and 1.61 km respectively at Wilcox (Table 9-10) and 10.6 km and 1.87 km respectively at Yodel South (Table 9-11). Very-high-frequency cetaceans (e.g. *Kogia* spp.) were identified as species or species habitat that may occur within the Project Area but are not listed as threatened and/or migratory under the EPBC Act (Table 7-13). No BIAs for regionally significant marine mammals intersect with the Project Area, and none are associated with very-high frequency cetaceans within the vicinity. All cetacean species are expected to transit through the area; no areas of known aggregation within or around the ensonified area have been identified. Marine mammal presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration.. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from impact piling activities. Impulsive sound emissions will only occur for short durations (~70 mins per pile per day), and they are not a continual or prolonged sound source for the life of the Goodwyn Area Infill Development. Therefore, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E. **Auditory impairment (masking)** There are no specific received level thresholds for reliably assessing or regulating masking responses (Gomez et al. 2016). A study undertaken by Clark et al. (2009) suggests that masking impacts from vessels (continuous sound) can be extended to non-continuous sources. This study considers the potential for masking and communication impacts is classified as high (within tens of metres), moderate (within hundreds of metres), and low (within thousands of metres) of the vessel. Some cetaceans might respond acoustically to impulsive sound in a range of ways, including by increasing the amplitude of their calls (Lombard effect), changing their spectral (frequency content) or temporal vocalisation properties, and in some cases, ceasing vocalising (McDonald, Hildebrand, and Webb 1995; Parks, Clarke, and Tyack 2008; Di Iorio and Clarke 2010; Castellote, Clarke, and Lammers 2012; Hotchkin and Parks 2013). Given the relatively small predicted ensonified area (i.e. up to hundreds of metres from the impact piling) for masking effects to occur, and the seasonal and transitory nature of cetacean presence within the Project Area, impulsive sound emissions are not expected to have a lasting effect on cetaceans, and thus the consequence level is ranked as F.

9.1.5.3.3 Potential changes to the functions, interests, or activities of other users

Receptor	Consequence Evaluation
Commercial Fisheries	The Project Area intersects with 3 State-managed commercial fisheries—Mackerel Managed Fishery, Pilbara Line Fishery, and Pilbara Trap Managed Fishery. Based on recent fishing effort, these fisheries are expected to be active within the Project Area (Section 7.10.1.2). The key species associated with these fisheries include those without swim bladders (e.g. mackerel) and those with swim bladders (e.g. emperors).

	The potential for changes to the function, interests, or activities of commercial fisheries from impulsive sound emissions within the Project Area may occur as an indirect consequence of an impact to the relevant fish species (i.e. the commercial fish stocks). However, as described in the consequence evaluations for the marine fauna groups above, impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population. Therefore, impacts to commercial fisheries are not considered credible and are not evaluated further.

9.1.5.3.4 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from impulsive sound emissions within the Project Area may occur as an indirect consequence of an impact to the marine fauna identified as a value of the Montebello Marine Park. However, as described in the consequence evaluations for the marine fauna groups above, the impulsive sound emissions within the Project Area are not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population. Therefore, no significant long-term adverse impacts to the values of the Montebello Marine Park are expected to occur, and thus the consequence level is ranked as E.

9.1.5.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine Acoustic Emissions: Impulsive Sound Generation, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	None identified
Good Industry Practice	• **CM-14**: Consider and implement appropriate acoustic mitigation and adaptive management measures during the EP process to reduce impacts to marine fauna to ALARP • **CM-15**: Implement Woodside's Vertical Seismic Profile Procedure

9.1.5.5 Impact Analysis Summary

		Environmental Value							Evaluation	
Impact	**Receptor**	***Soil and Groundwater***	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***	***Decision Type***	***Consequence***
Potential changes to fauna behaviour	Planktonic communities					✓			A	F
	Fish, sharks, and rays						✓			F
	Marine reptiles						✓			E

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence
	Marine mammals						✓			E
Potential injury or mortality to fauna	Planktonic communities					✓				F
	Fish, sharks, and rays						✓			E
	Marine reptiles						✓			E
	Marine mammals						✓			E
Potential changes to the functions, interests, or activities of other users	Commercial fisheries							✓		–
Potential changes to the values and sensitivities of protected places	Australian Marine Parks						✓			E

9.1.5.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine Acoustic Emissions: Impulsive Sound Generation aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect, are **AL-05**, **AL-06**, **AL-07**, and **AL-08**, as defined in Table 4-3 (and shown below in Section 9.1.5.7). As described in the consequence evaluation (Section 9.1.5.3), the predicted environmental impact would be short-term behavioural disturbances or auditory effects to individuals and would not be expected to result in impacts at a population level that prevent their long-term recovery or survival. Therefore, the predicted level of impact to these receptors is better than the acceptable levels (**AL-06** and **AL-07**). An injury (TTS or PTS) to a blue whale within its BIA was not predicted to occur. Modelling suggests an ensonified area for marine turtles intersects with an internesting buffer BIA and internesting habitat critical for the survival of flatback turtles, but studies suggest that the Project Area does not represent habitat likely to be used by flatback turtles during their internesting period. Therefore, the predicted level of impact to threatened species with a recovery plan is equal to or better than the acceptable level (**AL-08**). Further demonstration against the relevant management actions from the Marine Turtle Recovery Plan and Conservation Management Plan for Blue Whales are provided below within the 'Other Requirements' component of this demonstration of acceptability. Given the short-term impacts predicted for marine fauna, no lasting effects were predicted to occur to the Montebello Marine Park such that it would prevent the long-term protection and conservation of marine park values. Therefore, the predicted level of impact for this receptor is better than the acceptable level (**AL-05**).
Impact and Risk Classification, and Decision Type	The impacts arising from the impulsive sound emissions within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting legislative requirements, industry codes and standards, applicable

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.5.4).</td></tr>
<tr><td>Principles of ESD</td><td colspan="2">These principles of ESD were considered for this aspect:
• Integration Principle
– the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.5) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations
– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding impulsive sound generation from the offshore project
– this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.5.4)
• Precautionary Principle
– the impact consequence rating for this aspect is slight; therefore, no potential for serious or irreversible environmental damage is expected
– there is little scientific uncertainty associated with predicted environmental impact and the anticipated effectiveness of management measures
• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.5) impact analysis
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.</td></tr>
<tr><td>Internal Context</td><td colspan="2">This Woodside procedure was deemed relevant for this aspect:
• Vertical Seismic Profile (VSP) Procedure
Control measures related to this procedure have been described for this aspect (Section 9.1.5.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding impulsive sound emissions arising from the offshore project.</td></tr>
<tr><td rowspan="3">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Conservation Management Plan for the Blue Whale 2015–2025
Management action A.2.3: Anthropogenic noise in BIAs will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area</td><td>TTS and PTS from accumulated SEL_{24h} exposures to impulsive sounds is not predicted to occur within the migration BIA north of the Project Area.
The Project Area does not intersect with designated foraging areas for the pygmy blue whale. The nearest foraging BIA is ~245 km south-west of the Project Area, offshore from North West Cape. A recent study has indicated areas of probable foraging along the NWS based on proxy indicators</td></tr>
</table>

Acceptability Criteria	Demonstration	
		(Section 7.6.3.4); however, there is no overlap with the Project Area or predicted ensonified areas. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Conservation Management Plan for the Blue Whale (CoA 2015a).
	Conservation Advice *Balaenoptera borealis* Sei Whale No specific conservation action identified.	N/A
	Conservation Advice *Balaenoptera physalus* Fin Whale No specific conservation action identified.	N/A
	Conservation Advice *Rhincodon typus* Whale Shark No specific conservation action identified.	N/A
	Recovery Plan for Marine Turtles in Australia *Management action A1.5*: Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of marine turtles *Management action A1.5*: Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue	The predicted ensonified area for behavioural disturbance, TTS and PTS SEL_{24h} intersects with an internesting buffer BIA and internesting habitat critical for the survival of the species for flatback turtles. However, studies on internesting behaviour and internesting habitat suitability for flatback turtles suggest that the Project Area does not represent habitat likely to be used by flatback turtles during their internesting period. Given the distance to nesting areas and the control measures in place, the continued use of habitat critical to the survival of a species and BIAs by marine turtles without displacement or disruption to biologically important behaviours is expected to continue. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Recovery Plan for Marine Turtles in Australia (CoA 2017b).
	Conservation Advice *Dermochelys coriacea* Leatherback Turtle No specific conservation action identified.	N/A
	Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A
	North-west Marine Parks Network Management Plan 2018 No specific zone rules identified.	N/A

9.1.5.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine Acoustic Emissions: Impulsive Sound Generation aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-06: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	**EPO-06**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to marine fauna from underwater sound emissions during the petroleum activity
AL-08: No adverse effect from the petroleum activity that is inconsistent with any threatened species recovery plan made or adopted under the EPBC Act	**EPO-05**: The petroleum activity will not be undertaken in a manner that is inconsistent with any threatened species or community recovery plan, or threat abatement plan, as made or adopted under the EPBC Act
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.6 Routine and Non-routine Emissions: Atmospheric

9.1.6.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in atmospheric emissions[42] are described in the following table.

Activity Group	Description
Drilling and Completions	Well unloading may be undertaken during drilling operations or during commissioning, and this may occur in multiple phases for the Goodwyn Area Infill Development dependant on available options. As described in Section 5.3.10, the base case for well unloading will be to unload to host which involves the flow back of well completion fluids to the GWA platform topsides. The unload to host option does not result in flaring as a direct result of unloading the wells under the base case, and is carried out during the commissioning phase. There are two contingent scenarios that may result in flaring as a result of well unloading : • unload to the MODU—this may occur for several reasons, such as design or process safety considerations (such as the presence of sands/particulate in the unloaded materials) – flaring during well unloading will be of short duration (typically ~1–2 days per well) • nitrogen suspended flowlines—this nitrogen must be flared as excessive volume cannot be processed (refer to Operations below). Flaring at the MODU may also occur during drilling if a well-kick occurs during reservoir penetration (contingent activity). Atmospheric emissions and combustion products from flaring may include carbon monoxide (CO), water vapour, nitrogen oxides (NO_x), sulphur oxides (SO_x), particulates, and volatile organic compounds (VOCs).
Subsea Installation and Pre-commissioning	Prior to commissioning subsea infrastructure, infrastructure will be suspended with either pre-commissioning fluids or nitrogen. During commissioning, nitrogen flaring may occur (refer to Drilling and Completions above for emissions as a result of commissioning decisions).
Operations	During commissioning and start-up, nitrogen and hydrocarbons may be flared at the GWA platform (Section 5.5.1; also refer to Drilling and Completions above).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).

[42] Where atmospheric emissions refer to gas or particulate atmospheric pollutants (i.e. non-GHG emissions) which are emitted to the atmosphere and pose a recognised level of adverse effect on flora, fauna and/or human health.

Activity Group	Description
Field Support Activities (MODU, Vessels, Helicopters, ROV)	Atmospheric emissions produced during MODU, vessel, and helicopter operations will be emitted to the atmosphere during all project phases. MODUs and vessels are powered via the use of onboard engines and/or generators. Operations require the use of a marine fuel to undertake daily functions such as transport, desalination, sewage treatment, etc. A moored MODU may be used resulting in less fuel needed for station keeping, however DP or hybrid DP MODU may also be used due to the depths within the Project Area. Any equipment (e.g. ROV) used from vessels are powered by the vessel itself, and as such these don't represent an additional emission source. Atmospheric emissions and combustion products from use of marine or aviation fuels may include water vapour, NO_x, SO_x, particulates, and VOCs. SO_x and particulate matter emissions are heavily influenced by the fuel used and its relative sulphur content (e.g. MGO having a lower sulphite content than MDO).

9.1.6.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***
Change in air quality				✓			

9.1.6.3 Consequence Evaluation

9.1.6.3.1 Change in air quality

Receptor	Consequence Evaluation
Physical Environment (Air Quality)	**MODU, vessel, helicopter activities within the Project Area** Atmospheric emissions from the operation of the MODU (including flaring), vessels, or helicopters within the Project Area have the potential to result in localised and temporary reduction in air quality. These sources of routine and non-routine atmospheric emissions are not constant throughout the duration of the offshore project, and local air quality is expected to return to pre-disturbance levels once the source of emissions (e.g. vessel, MODU, helicopter) is no longer within the Project Area. During a study undertaken by BP (2013), NO_2 emissions from flaring were modelled for clean-up flaring on MODUs at a rate of 250 MMscfd for up to two days and emergency flaring on production facilities at full load for up to an hour. This model showed that short-term concentrations of NO_2 from flaring increased by up to about 60 µg/m³ (0.06 ppm) within 10 km of the source and increase of up to 20 µg/m³ (0.02 ppm) at about 40 km from the source. For emergency flaring, modelling showed that NO_x concentrations may increase by up to 10 µg/m³ (0.01 ppm) at 10 km from the source and 4 µg/m³ (0.0004 ppm) at about 40 km from the source. The results of this study are considered a conservative indicator for planned flaring during well unloading for the Goodwyn Area Infill Development as flaring rates are expected to be similar (or less). NO_2 emissions from routine MODU and production platform power generation were also modelled within the previous study undertaken by BP (2013). NO_2 is the focus of the modelling, on account of the larger predicted emission volumes compared to the other pollutants, and the potential for NO_2 to impact on human health. The model demonstrated that atmospheric emissions generated by MODU operations may increase ambient NO_2 concentrations by 1 µg/m³ (0.001 ppm) within 10 km of the source and 0.1 µg/m³ (0.0001 ppm) within 40 km of the source. This represents an increase of 2% over typical background concentrations within 40 km. The use of this study for MODU and production platform emissions is considered a conservative indicator of MODU (expected to be similar) and vessels emissions (which are likely to be less).

Receptor	Consequence Evaluation
	The National Environmental Protection (Ambient Air Quality) Measure (NEPM) recommends that hourly exposure to NO_2 is <0.12 ppm with and annual exposure of <0.03 m. Based on modelling results, exposure above NEPM standards is not expected to occur. Any potential impacts are expected to be short-term, localised air quality changes, limited to the airshed local to the emission sources. Thus, the consequence level is assessed as F. **GWA platform and KGP operations** Routine and non-routine atmospheric emissions from the GWA platform and KGP, predominantly routine fuel gas combustion (power generation) and operational flaring (from gas processing), have the potential to generate dark smoke, particulates, and ozone resulting in a localised and temporary reduction in air quality. The GWA platform is located offshore, ~90 km north-east from the Montebello Islands and ~155 km north-west from Karratha. Given the existing platform design, including the gas turbine exhausts and flares, any pollutants within the emissions are expected to rapidly disperse into the atmosphere. As such, any changes from ambient air quality conditions are expected to be limited to the airshed local to the platform. As described above, NO_2 emissions from routine MODU and production platform power generation were modelled by BP (2013), and it was demonstrated that increases in ambient NO_2 concentrations were minimal. The National Environmental Protection (Ambient Air Quality) Measure (NEPM) recommends that hourly exposure to NO_2 is <0.12 ppm with and annual exposure of <0.03 m. Based on modelling results, exposure above NEPM standards is not expected to occur. Air quality around the GWA platform is also maintained to provide a safe working environment for operational staff. Monitoring and modelling of air quality in the vicinity of the KGP is described in the North West Shelf Project Extension Environmental Review Document and was determined that there is a low risk of emissions reducing air quality to a level causing human health impacts or amenity (e.g. odour or visual) impacts (e.g. due to odour or visual) Therefore, any potential impacts are expected to be localised air quality changes, limited to the airshed local to the emission sources. Thus, the consequence level is assessed as F.

9.1.6.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine and Non-routine Emissions: Atmospheric, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-01**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth) and any subsequent marine orders • **CM-16A**: Comply with legislative requirements for emissions reporting, including National Pollutant Inventory (NPI)
Good Industry Practice	• **CM-23**: Maintain flare on GWA platform to maximise efficiency of combustion and minimise venting, incomplete combustion waste products, and smoke emissions

9.1.6.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence
Change in air quality	Physical Environment				✓				A	F

9.1.6.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine and Non-routine Emissions: Atmospheric aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable level for this aspect is **AL-04**, as defined in Table 4-3 (and shown below in Section 9.1.6.7). As described in the consequence evaluation (Section 9.1.6.3), the predicted impact was no lasting effect to air quality, and as such is not expected to substantially affect the biodiversity, ecosystem function, or integrity of the NWMR. Therefore, the predicted level of impact for these receptors is better than the acceptable level (**AL-04**).
Impact and Risk Classification, and Decision Type	The impacts arising from atmospheric emissions are considered lower-order impacts (decision type A) in accordance with Table 4-4, and thus are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.6.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.6) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding atmospheric emissions from the offshore project – this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.6.4) • Precautionary Principle – the impact consequence rating for this aspect (atmospheric emissions attributable to the Goodwyn Area Infill Development) is no lasting effect (F) – there is little scientific uncertainty associated with predicted environmental impact and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations

Acceptability Criteria	Demonstration
	– as described above, the predicted environmental impact is below the acceptable level for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.6) impact analysis – as described above, the predicted environmental impact is below the acceptable level for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	This Woodside management process or procedures was deemed relevant for this aspect: • Production Optimisation and Opportunity Management Procedure. Control measures related to this management process or procedures have been described for this aspect (Section 9.1.6.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding atmospheric emissions arising from the offshore project.
Other Requirements	Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.

Requirement	***Demonstration***
Marine Order 97 Gives effect to Annex VI of MARPOL 73/78	The requirements of Marine Order 97 are incorporated into the key control measures (Section 9.1.6.4).
National Pollutant Inventory (NPI) Reporting Annual air pollutant reporting	The requirements of annual NPI reporting are incorporated into the key control measures (Section 9.1.6.4).
Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A
North-west Marine Parks Network Management Plan No specific zone rules identified.	N/A

9.1.6.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine and Non-routine Emissions: Atmospheric aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-07**: No adverse effects greater than an F consequence (localised, no lasting effect) to air quality from atmospheric emissions during the petroleum activity

9.1.7 Routine and Non-routine Emissions: Greenhouse Gases

9.1.7.1 Aspect Source

The GHG Emissions associated with the Goodwyn Area Infill Development are described in the following table. In accordance with the GHG Protocol these are classified as indirect as they '*are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity*. The terms Direct GHG Emissions and Indirect GHG Emissions, as they apply to the Goodwyn Area Infill Development and this OPP, are defined in Table 9-13. Note: No sources of Direct GHG Emissions were identified (see Section 9.1.7.1.2).

Activity Group	Description
Drilling and Completions	Well unloading may be undertaken during drilling operations or during commissioning, and this may occur in multiple phases for the Goodwyn Area Infill Development dependant on available options. As described in Section 5.3.10, the base case for well unloading will be to unload to host which involves the flow back of well completion fluids to the GWA platform topsides. The unload to host option does not result in flaring as a direct result of unloading the wells Under the base case, and is carried out during the commissioning phase. There are two contingent scenarios that may result in flaring as a result of well unloading: • unload to the MODU—this may occur for several reasons, such as design or process safety considerations (such as the presence of sands/particulate in the unloaded materials) – flaring during well unloading will be of short duration (typically ~1–2 days per well) • nitrogen suspended flowlines—this nitrogen must be flared as excessive volume cannot be processed (refer to Operations below). Flaring at the MODU may also occur during drilling if a well-kick occurs during reservoir penetration (contingent activity). GHG emissions from flaring may include CO_2, nitrogen oxides (NO_x), and methane (CH_4).
Subsea Installation and Pre-commissioning	Prior to commissioning subsea infrastructure, infrastructure will be suspended with either pre-commissioning fluids or nitrogen. During commissioning, nitrogen flaring may occur (refer to Drilling and Completions above for emissions as a result of commissioning decisions), noting that nitrogen is not a greenhouse gas.
Operations	The following emission sources were identified during the start-up and operations phase of the Goodwyn Area Infill Development: • during commissioning and start-up, nitrogen and hydrocarbons may be flared at the GWA platform (Section 5.5.1; also refer to Drilling and Completions above) • emissions generated from the GWA platform gas turbines, operational flaring, and fugitive sources for the offshore processing of Goodwyn Area Infill Development hydrocarbons • emissions associated with onshore processing at KGP, third-party transportation, regassification and combustion by end users from Goodwyn Area Infill Development hydrocarbons. Further justification of GHG emission sources, and an estimated volume of GHG emissions to EOFL for the Goodwyn Area Infill Development is provided below.
Decommissioning	Decommissioning activities will have GHG emissions from several sources: • support vessel, MODU and subsea recovery vessels operations (see Field Support Activities below) • disposal of recovered infrastructure.
Field Support Activities (MODU, Vessels, Helicopters, ROV)	GHG emissions produced during MODU, vessel, and helicopter operations will be emitted to the atmosphere during all project phases. MODUs and vessels are powered via the use of onboard engines and/or generators. Operations require the use of a marine fuel to undertake daily functions such as transport, desalination, sewage treatment, etc. A moored MODU may be used resulting in less fuel needed for station keeping, however DP or hybrid DP MODU may also be used due to the depths within the Project Area. Any equipment (e.g. ROV) used from vessels are powered by the vessel itself, and as such these don't represent an additional emission source. GHG emissions from use of marine or aviation fuels may include CO_2, NO_x, and CH_4.

9.1.7.1.1 GHG Accounting Principles

GHG emissions are typically characterised by reference to the GHG Protocol Corporate Standard (WBCSD and WRI 2015). One of the outcomes of developing the Protocol has been the widespread recognition of a high-level emissions classification scheme that allows organisations and industries to better define key focus areas for abatement activities. This scheme has been adapted and deployed by national and local regulators, and represents a globally accepted subdivision of GHG emissions for evaluation and reporting purposes. The consideration of GHG emissions includes the concept of operational control which is consistent with *National Greenhouse and Energy Reporting Act 2007* (Cth). Consistent with the International Standard ISO 19694:2021 (Stationary Source Emissions: Determination of GHG emissions in energy-intensive industries) Woodside has included both GHG emissions from sources owned or controlled by the reporting organisation and GHG emissions that may occur as a consequence of an organisation's operations and activities, but that arise from GHG sources that are not owned or controlled by the organisation.

Examples of common emissions within an organisation's control include the combustion of fossil fuels, manufacturing processes, transportation, and intentional or unintentional GHG ('fugitive') emissions. Whereas GHG emissions that are a consequence of an organisation's operations but arise from sources not owned or controlled by the organisation are commonly associated with the use of energy in another part of the reporting organisation's value chain.

Within the context provided by the GHG Protocol and International Standard, the emissions classification scheme adopted in this OPP is summarised in Table 9-13. For the purposes of this OPP the "organisation" is the Goodwyn Area Infill Development.

Table 9-13: Classification of GHG emissions

Type	Description
Within organisation's (i.e. the Goodwyn Area Infill Development), control (Direct GHG Emissions)	GHG emissions from operations that are owned or controlled by the organisation (i.e. the Goodwyn Area Infill Development)
Outside organisation's (i.e. the Goodwyn Area Infill Development) control (Indirect GHG Emissions)	GHG emissions that occur within the Project Area that are a consequence of the organisation operations (i.e. the Goodwyn Area Infill Development), but that arise from GHG sources that are not owned or controlled by the organisation (e.g. GHG emissions from third-party owned MODU or vessels).
	GHG emissions that occur in the value chain of the organisation (i.e. the Goodwyn Area Infill Development), including both upstream and downstream emissions

9.1.7.1.2 GHG Emissions Inventory

One of the main principles of GHG accounting and reporting is relevance, of which an integral aspect is defining an appropriate GHG emissions inventory boundary (WBCSD and WRI 2015). Woodside has defined the emissions boundary for the assessment of Direct GHG Emissions to those within the Goodwyn Area Infill Development's control and resulting from planned petroleum activities within the Project Area. Any unplanned activities, including repairs, or emergency events, have been excluded from the emissions inventory.

Of the potential GHG emissions described in the aspect source table above (Section 9.1.6), no activities have been identified as sources of Direct GHG Emissions from planned activities within the Goodwyn Area Infill Development's control under this OPP. This is due to the scope of the offshore project set out in Section 5, where emissions from planned activities within the Project Area are predominantly from the use of third-party assets (e.g. MODU, vessels etc.) and therefore outside of the organisation's control.

Woodside has determined that Indirect GHG Emissions occurring within the Project Area, and which are outside of the Goodwyn Area Infill Development's control, include:

- fuel combustion by MODUs, vessels, and helicopters during drilling, installation (including pre-commissioning), operation, and decommissioning phases
- flaring from the MODU during well unloading (contingent activity)
- flaring from the MODU during a well kick event (contingent activity)

Woodside determined that Indirect GHG Emissions occurring beyond the Project Area to the petroleum activities under this OPP, include:

- flaring at the GWA platform during well unloading, commissioning, and initial start-up
- activities associated with processing of Goodwyn Area Infill Development hydrocarbons at the GWA platform and KGP
- transport and end-use of Goodwyn Area Infill Development hydrocarbons.

The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WBCSD and WRI 2011) identifies 15 categories of value chain emissions. Of these, the following categories of emissions have been included in the Indirect GHG Emissions, as identified above:

- downstream transportation and distribution
- processing of sold products
- use of sold products

While the GHG Protocol Corporate Value Chain includes other categories, including those associated with capital goods (e.g. materials required for subsea infrastructure) and business travel or commuting (e.g. transfer of personnel to/from GWA platform or KGP), the proportion of GHG emissions from these other value chain categories are considered negligible when compared to the processing, transportation, and end-use of the Goodwyn Area Infill Development hydrocarbons. Therefore, other potential sources of emissions from sources outside of the Goodwyn Area Infill Development's control have not been included in the Indirect GHG Emissions inventory.

9.1.7.1.3 Existing Environmental Approvals

GHG emissions for both the GWA platform and KGP, are described in other environmental approval documents: the NOPSEMA-accepted GWA Facility Operations EP[43] and the NWS Project Extension Environmental Review Document[44] (currently under assessment under Part IV of the EP Act) respectively.

While the proportion of hydrocarbons from the Goodwyn Area Infill Development processed at the GWA platform and KGP will vary over time, the total production and GHG emissions will remain within limits set by these other environmental approvals. For example, the production of hydrocarbons from the Goodwyn Area Infill Development to the GWA platform will not increase the estimated total possible emissions to EOFL within the NOPSEMA-accepted GWA Facility Operations EP. The GWA Facility Operations EP identifies ~417 Mt CO2-e[45] emissions to EOFL (from 2026–2040); the Indirect GHG Emissions associated with the Goodwyn Area Infill Development (the subject of this OPP) emitted at the GWA platform will form a portion of the total figure in the GWA Facility Operations EP.

9.1.7.1.4 Quantification Methods

GHG emissions quantification was performed to estimate expected GHG emissions over the life of the Goodwyn Area Infill Development, aligning with the GWA Facility Operations EP until EOFL.

[43] The currently accepted GWA Facility Operations EP is available from: https://info.nopsema.gov.au/activities/71/show_public

[44] The NWS Project Extension Environmental Review Document is available from: https://www.epa.wa.gov.au/proposals/north-west-shelf-project-extension

[45] The GWA Facility Operations EP has estimated ~27.8 Mt CO2-e / year.

Emissions assessment considers and covers GHG emissions from sources both within and out of the control of the organisation (Goodwyn Area Infill Development) as required for GHG reporting purposes and to provide transparency with available information. Table 9-13 describes these emissions.

The intent of the Goodwyn Area Infill Development is to recover hydrocarbons thereby allowing the GWA Facility to operate at design capacity for as long as practical to minimise emissions intensity. Current estimates for GHG emissions associated with the Goodwyn Area Infill are based on estimated recoverable reserves from 8 wells.

GHG Emissions estimates for this OPP have been performed using both energy and emissions factors from NGERS emissions determination guideline, and historic operations of GWA offshore platform and KGP to inform expected energy requirements for processing hydrocarbon and has been applied proportionately to the estimated recoverable reserves. Accounting methods described below have been applied to both reserves estimates and past fuel/flare performance.

Accounting Methods

To estimate the GHG emissions, the calculation method presented in the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Cth), with the most recent emission factors from the Australian National GHG Accounts Factors (DCCEEW 2023a) were used. Data was converted into the appropriate units and multiplied by the required emissions factor to determine the carbon dioxide equivalent (CO_2-e) amounts of CO_2, CH_4, and N_2O emissions. The use of CO_2-e is aligned with global best practice in GHG accounting.

GHG emissions from the combustion of fuel and flaring as part of processing at the GWA platform and onshore at KGP have been estimated based on apportioning GHG emissions associated with processing of Goodwyn Area Infill Development hydrocarbons. As detailed in Section 9.1.7.1.3, the indirect GHG emissions associated with the Goodwyn Area Infill Development are included in the total figure currently considered in the GWA Facility Operations EP.

MODU, vessels and helicopters

GHG emissions are generated by the MODU, vessels and helicopters during all project phases. MODU / Vessels are powered via the use of on-board generators (diesel-powered and/or LNG). Operations require the use of marine diesel to undertake daily activities functions such as dynamic positioning, crane movements, desalination, sewage treatment, etc. GHG emissions from MODU and vessels vary depending on vessel size and the nature of activities being undertaken; for example, travelling or “steaming” to a destination at low speed uses less fuel and generates lower atmospheric and GHG emissions than high speed steaming. Project vessels and activities are described in Section 5.7.

Using estimated MODU / vessel fuel consumption rates, internal helicopter fuel consumption data and emission factors from the National Greenhouse and Energy Reporting Scheme, GHG emissions have been estimated and are presented in Table 9-16. These figures are estimates only. The actual consumption of fuel varies based on factors such as the nature of activity being undertaken, metocean conditions etc. While Woodside may influence via contracting approaches, in-field day to day operations including fuel consumption is under the control of MODU and vessel masters.

Offshore and Onshore Processing

Processing emissions related to fuel, flare and fugitive emissions have been estimated by using emission factors appropriate to each of the likely processing facilities. These emissions factors are sourced from publicly available materials or estimated using historical emissions intensities as per Table 9-14. While these emission factors are considered adequate for the purposes of estimating indirect emissions from processing facilities (noting that processing emissions are a small portion of the overall indirect emissions estimate which includes end-user consumption), actual processing facility emissions intensity may vary from these factors. Aspects outside of GWA Infill Development control which may impact the actual emissions intensity of processing facilities include flaring, reliability performance, implementation of energy efficiency/decarbonisation initiatives and the combined throughput of those facilities.

The GHG emissions estimates are presented in Table 9-16.

Table 9-14: Emission factors used for GWA Area Infill Development processing

Processing facility	Emission Factor
GWA Platform	0.20 tCO_2e per tonne of export gas produced Note 1
Processing Emissions Downstream - KGP	0.33 tCO_2e per tonne of LNG produced Note 2, 3

1 Based on the FY2022-2023 GWA Platform GHG Emissions Intensity, with additional 25% contingency.

[2] Based on the North West Shelf Project Extension (GHG MP). Downstream reservoir CO2 emissions are estimated separately.

[3] Emissions Factor is inclusive of emissions generated in the production of other products (Domestic Gas, LPGs and Condensate).

Reservoir CO_2 Emissions Methodology and Context

An assessment of the total quantity of reservoir CO_2 likely to be emitted has been completed. The assessment assumed that all reservoir CO_2 must be removed prior to liquefaction of the gas, at the relevant onshore facility. The estimate of vented reservoir CO_2 was based on the expected worst case CO_2 composition of the reservoirs, 4.6 mol% (Table 5-4).

CO_2 content in the hydrocarbon reservoir is a naturally occurring geological phenomenon that is typically treated as a waste product during LNG liquefaction. It is not influenced by the design of the processing facilities.

The emissions associated with venting of reservoir CO_2 have been included in the onshore processing estimates in Table 9-16.

Third Party consumption

GHG emissions from third party consumption have been based on estimated recoverable reserves. Key influences impacting GHG emissions from third party consumption attributable to the Goodwyn Area Infill development, include:

- Split of saleable products – the proportion of hydrocarbons from the Goodwyn Area Infill development sold as LNG, LPG and domestic gas varies. Each product requires differing amounts of energy to process to the point of sale and varies based on reservoir composition, field contribution and commercial reasons.
- Efficiency of end user – sold product may be used in a variety of ways by the customer, with the energy efficiency of their transport and processing contributing to the GHG emissions released.

An emissions factor has been sourced from the Ecoinvent v3.5 database which considers the transport, regasification, distribution and final combustion of LNG, (Table 9-15). For the consumption of domestic gas, LPG and condensate anticipated to be produced from the Goodwyn Area Infill development, an emissions factor has been developed based on NGERs Measurement Determination (Table 9-15). For domestic gas, the emissions factor includes distribution losses (estimated as per NGERS Measurement Determination).

For each source, the estimate of CO_2-e emissions is based on the quantity of product, multiplied by the respective emissions factor. The emissions factors adopted align with emissions factors used in the NWS Project Extension ERD.

Table 9-15: Emission factors used for GWA Area Infill Development hydrocarbon transit and market emissions

Source / Fuel	Emissions Factor	Reference
LNG	3.13 kg CO_{2e}/kg LNG[Note 1]	EcoInvent v3.5 Database
LPG	60.6 kg CO_{2e}/GJ	NGER (Determination) Schedule 1
Domgas	57.35 kg CO_{2e}/GJ[Note 2]	NGER (Determination) Schedule 1 and S3.80
Condensate	61.3 kg CO_{2e}/GJ	NGER (Determination) Schedule 1

[1]: Ecoinvent v3.5 emissions factor of 3.13 kg CO2e/kg LNG represents an increase in 8.6% from the NGERs (Determination) Schedule 1 factor of 2.88 kg CO2e/kg LNG. The additional emissions account for other emission sources, including transport, regasification and distribution.

[2]: Emission factor includes end user combustion and distribution losses.

9.1.7.1.5 Summary

Based on the GHG Protocol and International Standard classification scheme (Table 9-13), the nature and origin, and the estimated total (to EOFL) Indirect GHG Emissions, associated with the Goodwyn Area Infill Development are shown in Table 9-16.

Woodside has estimated that the total (to EOFL) Indirect GHG Emissions for the Goodwyn Area Infill Development is ~102 Mt CO_2-e (Table 9-16).

Table 9-16: Estimated Indirect GHG Emissions to EOFL for the Goodwyn Area Infill Development[1 2]

Activity Group	Emission Sources	Emission Type Description	Emission Location	Jurisdiction	Direct/ Indirect	Total estimated GHG emissions (Mt CO_2-e)
Drilling and completions Subsea installation and pre-commissioning Start-up and operations Decommissioning	MODU, vessels, and helicopters (fuel combustion)	GHG emissions outside of the Goodwyn Area Infill Development's control generated from activities associated with the construction, installation, commissioning, IMMR, and decommissioning of upstream infrastructure	Project Area	Commonwealth	Indirect GHG Emissions	0.16
Drilling and completions	MODU (flaring during well unloading)					
Drilling and completions	MODU (flaring during well kick)					
Start-up and operations	Vessels and helicopters (fuel combustion)	GHG emissions outside of the Goodwyn Area Infill Development's control from combustion of hydrocarbon-based fuels required for processing and compression of hydrocarbon at the GWA platform	Downstream offshore (GWA platform)	Commonwealth	Indirect GHG Emissions	0.03
Start-up and operations	Fuel, flaring, fugitives at GWA platform					0.61
Start-up and operations	Onshore hydrocarbon processing at KGP	GHG emissions outside of the Goodwyn Area Infill Development's control from combustion of hydrocarbon-based fuels required for processing of hydrocarbon gas downstream prior to export, including the venting of reservoir CO_2 extracted from the hydrocarbons exported from the GWA platform	Downstream onshore (KGP)	State	Indirect GHG Emissions	12.4
Third-party consumption	Third party transport of products, regassification, distribution and end use	GHG emissions outside of the Goodwyn Area Infill Development's control from transportation of products to the markets into which they will be sold, including regasification and distribution of LNG in customer	Transit / Market	Subject to consumer location	Indirect GHG Emissions	89.1

Activity Group	Emission Sources	Emission Type Description	Emission Location	Jurisdiction	Direct/ Indirect	Total estimated GHG emissions (Mt CO_2-e)
		markets, and the indirect GHG emissions from combustion of products as part of power generation and other energy solutions within final market environment				
					Total	***102.3***

1. Source: Energy Institute: Statistical Review of World Energy 2023.

2. Source: EcoInvent v3.5 database and National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Cth) (as amended). EcoInvent v3.5 represents a large collection of inventory data. It has been recognised as emission factor source for the European Union Renewable Energy Direction GHG methodology and is aligned to the principles of the NGER methodology.

9.1.7.2 Relevant Environmental Values Matrix

Relevant Environmental Values						
Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural
				✓	✓	✓

9.1.7.3 Contextual Evaluation

Receptor Group	Contextual Evaluation
Habitat and Biological Communities ***Protected Species*** ***Key Ecological Features*** ***Protected Places*** ***Socioeconomic and Cultural Environment***	GHG emissions associated with the Goodwyn Area Infill Development are estimated to be ~103 Mt CO_2-e to EOFL, of which ~21.7 Mt CO_2-e may originate in Australia. For the purposes of comparison, assuming this total was split evenly across operational years (2026–2040; 15 years) the ~1.44 Mtpa CO_2-e would represent a negligible (~0.31%) portion of national Australian emissions (463.9 Mt CO_2-e during 2022) (DCCEEW 2023i). These GHG emissions are not expected to materially or substantially contribute to either Australia's GHG emissions or global GHG emissions. Climate change impacts cannot be attributed to any one project, including Goodwyn Area Infill Development, as they are instead the result of GHG emissions, minus GHG sinks, that have accumulated in the atmosphere since the industrial revolution started. Even discounting the role gas can play towards customer commitments and plans to decarbonise through the energy transition, emissions associated with the project are negligible in the context of existing and future predicted global GHG emissions The accumulation of GHG emissions in the atmosphere is, in turn, influenced by global energy demand and the composition of the global energy mix. Although the Goodwyn Area Infill Development cannot be linked to climate change impacts, the following contextual evaluation is provided. Climate science is a rapidly evolving field in which new observations continue to deepen understanding of the current and potential impacts of global warming, and the possible pathways for mitigation and adaptation (Woodside 2023a). The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change, and finalised the Sixth Assessment Report (AR6) in 2023. This consists of three Working Group contributions and a Synthesis Report. A summary of outcomes of the working group contributions comprises a range of matters, which amongst others include • The AR6 Working Group I (AR6-WG1) report stated that it is unequivocal that there is human-induced warming. It also stated that increased atmospheric carbon dioxide (CO_2) levels, generated by human activity, are the largest driver of warming over the longer term, and that there are a range of factors, including emissions of methane, which increase warming in the short-term. • The AR6-WG2 report stated that human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts and related losses and damages to nature and people, beyond natural climate variability. It stated that global warming, reaching 1.5 °C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans. The report noted that societal choices and actions implemented in the next decade will determine the extent to which medium- and long-term pathways will deliver climate resilient development. • The AR6 Working Group III (AR6-WG3) report provided an updated global assessment of climate change mitigation progress and pledges, and examined the sources of global emissions. It explained developments in emissions reduction and mitigation efforts, and assessed the impact of national climate pledges in relation to long-term emissions goals. More than 2,000 quantitative emissions pathways were submitted to the IPCC, of which 1,202 scenarios included sufficient information for assessing the associated warming. The report found that there are many pathways in the literature that likely limit global warming to 2 °C with

Receptor Group	Contextual Evaluation
	no overshoot[46], or to 1.5 °C with limited overshoot. These variations occur because, while climate science is able to calculate a 'carbon budget' of net emissions before any particular temperature outcome is reached, the allocation of this budget between different human activities requires additional judgements about for example technology, economics, consumer preferences and policy choices. For further information related to Woodside's approach to climate change, please see Section 5.3 'Managing Physical Risk' and Section 6.3 'A Just Transition' of Woodside's Climate Transition Action Plan and 2023 Progress Report. The AR6 Working Group I (AR6-WGI) report states "[c]limate change is a global phenomenon, but manifests differently in different regions" (IPCC 2021). IPCC projections for climate change in Australia from the AR6 Working Group II (AR6-WGII) report include: • further climate change is inevitable, with the rate and magnitude largely dependent on the emission pathway (*very high confidence*)[47] • ongoing warming is projected, with more hot days and fewer cold days (*very high confidence*) • further sea level rise, ocean warming, and ocean acidification are projected (*very high confidence*) • less winter and spring rainfall is projected in southern Australia, with more winter rainfall in Tasmania, less autumn rainfall in southwestern Victoria and less summer rainfall in western Tasmania (*medium confidence*), with uncertain rainfall changes in northern Australia. • more extreme fire weather is projected in southern and eastern Australia (*high confidence*) • increased drought frequency is projected for southern and eastern Australia (*medium confidence*) • increased heavy rainfall intensity is projected, with fewer tropical cyclones and a greater proportion of severe cyclones (*medium confidence*) (Lawrence et al. 2022). The AR6-WGII report identified nine key climate risks for the Australasian region: • loss and degradation of coral reefs and associated biodiversity and ecosystem service values in Australia due to ocean warming and marine heatwaves (*very high confidence*) • loss of alpine biodiversity in Australia due to less snow (*high confidence*) • transition or collapse of alpine ash, snowgum woodland, pencil pine and northern jarrah forests in southern Australia due to hotter and drier conditions with more fires (*high confidence*) • loss of kelp forests in southern Australia due to ocean warming, marine heatwaves, and overgrazing by climate-driven range extensions of herbivore fish and urchins (*high confidence*) • loss of natural and human systems in low-lying coastal areas due to sea level rise (*high confidence*) • disruption and decline in agricultural production and increased stress in rural communities in south-western, southern and eastern mainland Australia due to hotter and drier conditions (*high confidence*) • increase in heat-related mortality and morbidity for people and wildlife in Australia due to heatwaves (*high confidence*) • cascading, compounding and aggregate impacts on cities, settlements, infrastructure, supply-chains and services due to wildfires, floods, droughts, heatwaves, storms and sea level rise (*high confidence*) • inability of institutions and governance systems to manage climate risks (*high confidence*) (Lawrence et al. 2022). An earlier report by Australia's Biodiversity and Climate Change Advisory Group summarised the potential impacts of climate change to marine and terrestrial species, habitats and ecosystems across Australia (Steffen et al. 2009). The 2009 report identified examples of observed changes in Australia's biota that were considered consistent with the emerging climate change 'signal', as genetic constitution, geographic ranges, life cycles, populations, ecotonal boundaries, ecosystems, and disturbance regimes (Steffen et al. 2009). The report also stated:

[46] Overshoot means the temporary exceedance of a specified level of global warming, such as 1.5 °C. Overshoot implies a peak followed by a decline in global warming, achieved through anthropogenic removal of CO_2 exceeding remaining CO_2 emissions globally.

[47] A level of confidence is expressed using five qualifiers: very low, low, medium, high, and very high. For a given evidence and agreement statement, different confidence levels can be assigned, but increasing levels of evidence and degrees of agreement are correlated with increasing confidence (Lawrence et al. 2022).

Receptor Group	Contextual Evaluation
	• "Biodiversity is one of the most vulnerable sectors to climate change" • "Australia's biodiversity is not distributed evenly over the continent but is clustered in a small number of hotspots with exceptionally rich biodiversity", and that these "include the Great Barrier Reef, south-west Western Australia, the Australian Alps, the Queensland Wet Tropics and the Kakadu wetlands" Further, it was stated that "many of the most important impacts of climate change on biodiversity will be the indirect ones at the community and ecosystem levels, together with the interactive effects with existing stressors (Steffen et al. 2009). Future climate change (e.g. increased temperature and decreased, but more variable, rainfall) has the potential to have a range of impacts on ecological factors and threaten biodiversity in the Australian mediterranean ecosystem (CSIRO 2017). Extensive modelling and monitoring studies over the last twenty years provide considerable evidence that global climate change is already affecting and will continue to affect species (Hoegh-Guldberg et al. 2018) however these impacts are likely to be highly species-dependent and spatially variable. The most frequently observed and cited ecological responses to climate change include species distributions shifting towards the poles, upwards in elevation and shifts in phenology (earlier and later autumn life-history events) (Dunlop et al. 2012). Climate change may not only change species distribution patterns but also life-history traits such as migration patterns, reproductive seasonality and sex ratios (Steffen et al. 2009). Impacts of climate change such as altering temperature, rainfall patterns and fire regimes, are likely to lead to changes in vegetation structure across all terrestrial ecosystems within Australia (Dunlop et al. 2012; Steffen et al. 2009). Increases in fire regimes will impact Australian ecosystems altering composition structure, habitat heterogeneity and ecosystem processes. Changes in climate variability, as well as averages, could also be important drivers of altered species interactions, both endemic and invasive species (Dunlop et al. 2012). Climate change could result in significant ecosystem shifts, as well as alterations to species ranges and abundances within those ecosystems (Hoegh-Guldberg et al. 2018). The 'loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' has been listed as a key threatening process under the EPBC Act (DCCEEW 2021d). The threatening process consists of reductions in the bioclimatic range within which a given species or ecological community exists due to emissions induced by human activities of GHGs (DCCEEW 2021d). The process is considered to have a continental distribution, including both terrestrial and marine areas. Ecosystems in which the process occurs include: alpine habitats, coral reefs, wetlands and coastal ecosystems, polar communities, tropical forests, temperate forests, and arid and semi-arid environments (DCCEEW 2021d). Coral reefs were recognised by both IPCC and the Australian Government as being at risk of climate change (Lawrence et al. 2022; DCCEEW 2021d). Protected coral reef areas in Australia include those within World Heritage listed sites, such as Ningaloo Coast, Shark Bay, or the Great Barrier Reef. Climate change has been identified as a threat for each of these World Heritage areas, with potential risks to coral reef as well as other environmental values (such as marine fauna) within these ecosystems (IUCN 2020b; 2020c; 2020a). Climate variability and change has been identified as a threat to some EPBC Act protected species, including marine turtles, whales, seabirds and migratory shorebirds: • the Recovery Plan for Marine Turtles in Australia (CoA 2017b) states that "[c]limate change is of particular concern to marine turtles because it is likely to have impacts across their entire range and at all life stages. Climate change is expected to cause changes in dispersal patterns, food webs, species range, primary sex ratios, habitat availability, reproductive success and survivorship". • the Conservation Management Plan for the Blue Whale (CoA 2015a) states: [c]limate change is expected to cause changes in migratory timing and destinations, population range, breeding schedule, reproductive success and survival of baleen whales, including blue whale species and subspecies" • the Wildlife Conservation Plan for Seabirds (CoA 2022c) states that "[c]onsequences to seabirds could include negative impacts from an increase in extreme weather events, reduced or changed prey abundance and distribution, and decrease in nesting habitat" • the Wildlife Conservation Plan for Migratory Shorebirds (CoA 2015c) states that '[s]uch changes have the potential to affect migratory shorebirds and their habitats by reducing the extent of coastal and inland wetlands or through a poleward shift in the range of many species".

Receptor Group	Contextual Evaluation
	The North-west Marine Parks Network Management Plan 2018 (DNP 2018a) identifies climate change as a pressure that may impact marine park values. The management plan states that "[t]he impacts of climate change on the marine environment are complex and may include changes in sea temperature, sea level, ocean acidification, sea currents, increased storm frequency and intensity, species range extensions or local extinctions, all of which have the potential to impact on marine park values" (DNP 2018a). Within the Marine Bioregional Plan for the NWMR (DSEWPaC 2012b), pressures related to climate change are assessed as 'of potential concern' for species of marine turtle, inshore dolphins, sawfish, sea snakes, whale shark, dugong, and seabird and shorebird, as well as the KEFs and shipwrecks known to occur in the NWMR. GHG emissions associated with the Goodwyn Area Infill Development are not predicted to materially or substantially contribute to Australia's total GHG emissions, and there is no link between Indirect GHG Emissions associated with the Goodwyn Area Infill Development and climate change impacts upon Australian receptors.

9.1.7.4 Key Control Measures

While Indirect GHG Emissions associated with Goodwyn Area Infill Development cannot be linked to climate change or the impacts of climate change, key control measures are included in this OPP that commit Woodside to adaptive management to enable the Goodwyn Area Infill Development continues to manage GHG emissions to an acceptable level.

Type	Key Control Measures[1]
Legislation, Codes and Standards	• **CM-01**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth) and any subsequent marine orders • **CM-16B**: Comply with legislative requirements for emissions reporting, including National Greenhouse and Energy Reporting (NGER) scheme • **CM-17**: Comply with emissions intensity requirements for reservoir carbon dioxide from new gas fields as described under Division 11, section 35A in Part 19 of Schedule 1 of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth) • **CM-18**: Apply for and manage NWS Project GHG emissions to within the relevant baseline under the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth)
Good Industry Practice	• **CM-19**: Contracting strategy and evaluation for hire of vessels includes consideration of vessel emissions parameters and low carbon/alternate fuels • **CM-20**: Maintain a program to monitor market developments related to the contribution of hydrocarbons in the energy transition • **CM-21**: Forecast, measure, monitor and/or estimate facility GHG emissions (in accordance with NGER/NPI) to inform optimisation management practices and minimise environmental impact of indirect GWA platform GHG emissions • **CM-22**: Implement relevant methane management measures at GWA platform • **CM-23**: Maintain flare on GWA platform to maximise efficiency of combustion and minimise venting, incomplete combustion waste products, and smoke emissions

1. The following key control measures for the Goodwyn Area Infill Development (CM-01, CM-16B, CM-18, CM-17, CM-20, CM-21, CM-22, CM-23,) are consistent with the intent of existing controls within the GWA Facility Operations EP (C 7.1, C 7.2, C 7.3, C 7.7, C 8.1, C 7.4, C 7.5, C 7.6 respectively).

9.1.7.5 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that Routine and Non-routine Emissions: Greenhouse Gases can be managed to an acceptable level.

<table>
<tr><th>Acceptability Criteria</th><th>Demonstration</th></tr>
<tr><td>Comparison with Acceptable Level</td><td>Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3).

The acceptable level for this aspect is AL-09, as defined in Table 4-3 (and shown below in Section 9.1.7.6).

The Woodside Climate Policy is applicable to all activities under Woodside’s operational control, including the Goodwyn Area Infill Development. As such, the offshore project has been designed and will be managed (including via key control measures identified in Section 9.1.7.4) to align with the objective and principles defined in the policy.

Australia is a signatory to the Paris Agreement and is currently committed to a Nationally Determine Contribution (NDC) of reducing GHG emissions by 43% below 2005 levels by 2030 and achieving net zero by 2050. These targets are also both legislated in the Climate Change Act 2022 (Cth).

The estimated Indirect GHG Emissions associated with the Goodwyn Area Infill Development are considered de minimis and as such, below the acceptable levels, and will not materially or substantially contribute to Australia's GHG emissions or global GHG emissions levels.</td></tr>
<tr><td>Impact and Risk Classification, and Decision Type</td><td>Indirect GHG Emissions associated with the Goodwyn Area Infill Development are managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.7.4).

While no objections or claims were raised regarding GHG emissions during preliminary consultation (Section 8.4.1), Woodside acknowledges that there is known stakeholder interest in GHG emissions and climate change, and as such this aspect has been determined as a decision type B. In accordance with Section 4.8.2, evaluation and justification for acceptability is evaluated via the other acceptability criteria (see below discussions).</td></tr>
<tr><td>Principles of ESD</td><td>These principles of ESD were considered for this aspect:
• Integration Principle
– the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.7) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations
– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding GHG emissions associated with the offshore project
– Indirect GHG Emissions associated with the Goodwyn Area Infill Development can be managed to an acceptable level by implementing the key control measures (Section 9.1.7.4)
• Precautionary Principle
– there is some scientific uncertainty associated with the projection of climate change trends, the predicted and observed environmental effects of climate change, and the changing regulatory and social requirements and/or expectations
– while Indirect GHG Emissions associated with Goodwyn Area Infill Development cannot be linked to climate change or the impacts of climate change, key control measures (Section 9.1.7.4) are included in this OPP that commit Woodside to adaptive management to ensure that the Goodwyn Area Infill Development continues to manage GHG emissions to an acceptable level
• Intergenerational Principle
– The Goodwyn Area Infill Development has the potential to:
▪ provide a reliable energy source (i.e. natural gas) noting:
▪ natural gas is considered to have a critical role in energy supply and security during the transition to lower carbon energy sources (AEMO 2022; IEA 2022)</td></tr>
</table>

Acceptability Criteria	Demonstration
	▪ gas has the potential to contribute to an incremental reduction in global GHG emissions by displacing more carbon intensive power generation (e.g. coal), firming[48] up renewables, or in hard-to-abate sectors. – continue to provide LNG as a source of fuel for global markets and pursue the development of lower carbon energy sources with reference to the UN Sustainable Development Goal 7, Affordable and Clean Energy. – the Parties to the Paris Agreement acknowledge that climate change is a common concern of humankind and the Parties should consider their respective obligations, including intergenerational equity ▪ as described above, GHG emissions from the Goodwyn Area Infill Development are not predicted to materially or substantially contribute to Australia's GHG emissions ▪ the Goodwyn Area Infill Development will be managed such that all regulatory requirements on GHG emissions (e.g. emission intensity for reservoir carbon for new gas fields as required under the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 [Cth]) are met ▪ committing to implementing mitigation measures for GHG emissions that are controlled or influenced by Woodside and connected to the operations of the GWA Facility or KGP, in accordance with legislative and approval requirements – the estimated Indirect GHG Emissions associated with the Goodwyn Area Infill Development are not predicted to materially or substantially contribute to Australia's GHG emissions or global GHG emissions, cannot be linked to climate change impacts, and as such, the Goodwyn Area Infill Development is not considered to have the potential to materially or substantially affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within the contextual evaluation (Section 9.1.7.3) – as described above, the estimated GHG emissions associated with the Goodwyn Area Infill Development are not predicted to materially or substantially contribute to Australia's GHG emissions, and cannot be linked to climate change impacts – it is acknowledged that climate change is a threat for many environmental values, including MNES; however it is not possible to link GHG emissions associated with the Goodwyn Area Infill Development with climate change or any particular climate related impacts (given it is a global scale phenomenon).
Internal Context	These Woodside policies and procedures were deemed relevant for this aspect: • Climate Policy (Appendix A) • GHG Emissions and Energy Management Procedure • Production Optimisation and Opportunity Management Procedure Control measures related to these policies and procedures have been described for this aspect (Section 9.1.7.4). Therefore, management of GHG emissions associated with the Goodwyn Area Infill Development is consistent with company policy, culture, and standards.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding GHG emissions arising from the offshore project. GHG emissions are a global concern, and as such Woodside has undertaken a contextual evaluation of GHG emissions associated with the Goodwyn Area Infill Development and identified key control measures to enable GHG emissions be managed to an acceptable level. According to Wood Mackenzie Energy Research Consultancy, LNG from Woodside operated facilities is amongst the lowest carbon intensity in the world delivered into North Asia[49]. The global consensus on climate change led to the implementation of the Paris Agreement. The aim of the Paris Agreement, as stated in the Article 2.1(a), is to hold the increase in global average temperature to well below 2 °C above pre-industrial levels. The Paris Agreement also

[48] Firming means to support intermittent renewable generation by quickly ramping up or down to support stable supply (Wood and James 2021)

[49] Export from the Wood Mackenzie LNG Carbon Emissions Tool available from: https://www.woodside.com/docs/default-source/our-business---documents-and-files/pluto---documents-and-files/wood-mackenzie-lng-carbon-emissions-tool.pdf

Acceptability Criteria	Demonstration
	aims to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change. An extract of Article 2.1(a) of the Paris Agreement is shown below: "This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;".[50] This was reaffirmed in December 2023 in the 28th Conference of the Parties of the United Nations Framework Convention on Climate Change (COP28) decision text on the First global stocktake.[51] The decision text further recognised that the transition away from fossil fuels in energy systems is to be done "in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science".[52] The COP28 decision also "recognises that transitional fuels can play a role in facilitating the energy transition while ensuring energy security".[53] The Paris Agreement establishes a framework where countries make NDCs to manage and reduce their own emissions. Australia has ratified the Paris Agreement and has set an NDC to reduce emissions by 43% below 2005 levels by 2030, and to reach net zero emissions by 2050 (DISER 2022a). Australia's emissions projections demonstrate that it is on track to reduce emissions by up to 43% below 2005 levels by 2030 (DCCEEW 2022b; DISER 2022a). Climate science has drawn a link between cumulative emissions of greenhouse gases and global temperature levels. The link between cumulative emissions and temperature levels allows a carbon budget to be calculated. This is the remaining amount of net emissions (i.e. all global sources of emissions minus all global sinks of emissions) that can occur before today's concentration of greenhouse gases increases to the concentration associated with potential temperature outcomes. However, the distribution of this carbon budget across different human activities requires additional judgements about a wider range of social, economic and technological factors and consumer and policy choices. Strategies to achieve emissions reductions include transitioning from fossil fuels without CCS to very low-or zero-carbon energy sources, such as renewables or fossil fuels with CCS, demand side measures and improving efficiency, reducing non-CO2 emissions, and deploying carbon dioxide removal (CDR) methods to counterbalance residual greenhouse gas emissions. Pathways to limit warming therefore show different combinations of sectoral mitigation strategies consistent with a given warming level. As a result the demand for oil and gas in climate-related scenarios that could limit global warming to 1.5°C or 2°C is uncertain. For example in the AR6-WG3 report, the IPCC stated that in pathways that limit warming to 1.5°C (with a greater than 50% probability and with no or limited overshoot) the potential global use of gas in 2050 ranges from 30% above 2019 levels to 85% below them with a median 45% decline (Woodside 2023a). The Goodwyn Area Infill Development will provide an incremental volume of hydrocarbons to Australian and international markets during its estimated field life (2026–2040). Woodside considers that this development is aligned with their goals for supporting the energy transition and is compatible with the Paris Agreement goal to limit global warming to below 2 °C. Further, field life of the reservoirs comprising the Goodwyn Area Infill Development shall not extend beyond 2040 which contributes to global emissions reductions from beyond this point in time. Woodside is a signatory to several global initiatives which are complementary to our corporate approach to methane emissions management, which include OGMP (2024), Oil and Gas Climate Initiative Aiming for Zero Methane Emissions (OGCI Near-Zero) and the Methane Guiding Principles (MGP, 2022), which are voluntary, international multi-stakeholder partnerships between industry and non-industry organisations. Woodside will implement relevant methane

[50] Paris Agreement available from: https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf

[51] FCCC/PA/CMA/2023L.17 First global stocktake (Draft decision distributed 13 December 2023), Section I, Clause 3; available from: https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf

[52] FCCC/PA/CMA/2023L.17 First global stocktake (Draft decision distributed 13 December 2023), Section II, Subsection A, Clause 28(d); available from: https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf

[53] FCCC/PA/CMA/2023L.17 First global stocktake (Draft decision distributed 13 December 2023), Section II, Subsection A, Clause 29; available from: https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf

Acceptability Criteria	Demonstration	
	management measures at the GWA platform (CM-22) (refer to Internal Context above, and key control measures in Section 9.1.7.4).	
Other Requirements	Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below. GHG emissions from existing operations at the GWA platform are managed under the NOPSEMA-accepted GWA Facility Operations EP. Any emissions from GWA platform that are associated with the Goodwyn Area Infill Development will be managed via a revision to this EP. Note: the Goodwyn Area Infill Development will not increase the estimated total possible GHG emissions to EOFL within the current version of the EP. GHG emissions from onshore processing at KGP are managed under Ministerial Statement 536. As part of the North West Shelf Project Extension approvals (currently under assessment; Section 1.4.2.1) a draft Greenhouse Gas Management Plan has been submitted to the EPA that includes management actions including emissions reduction targets. Any emissions from KGP that are associated the Goodwyn Area Infill Development will be regulated and compliance monitored via the EP Act regulatory requirements.	
	Requirement	***Demonstration***
	Marine Order 97 Gives effect to Annex VI of MARPOL 73/78	The requirements of Marine Order 97 are incorporated into the key control measures (Section 9.1.6.4).
	National Greenhouse and Energy Reporting (NGER) scheme Annual GHG reporting for facilities	The requirements of NGER reporting scheme are incorporated into the key control measures (Section 9.1.6.4).
	National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 Emission intensity for reservoir carbon from new gas fields	The requirements of NGER Safeguard Mechanism are incorporated into the key control measures (Section 9.1.6.4).
	National Pollutant Inventory (NPI) Reporting Annual air pollutant reporting	The requirements of annual NPI reporting are incorporated into the key control measures (Section 9.1.6.4).
	Conservation Management Plan for the Blue Whale 2015–2025 *Management action A3.1*: Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica	As described in Section 9.1.6.3, the estimated Indirect GHG Emissions associated with the Goodwyn Area Infill Development are considered *de minimis,* with no link to climate change impacts upon Australian receptors. Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the Conservation Management Plan for the Blue Whale 2015–2025 (CoA 2015a), Conservation Advice for Sei Whale (TSSC 2015a), Conservation Advice for Fin Whale (TSSC 2015b), Conservation Management Plan for the Southern Right Whale (DSEWPaC 2012a), or the Recovery Plan for Marine Turtles in Australia (CoA 2017b).
	Conservation Advice *Balaenoptera borealis* Sei Whale *Conservation action*: Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica	
	Conservation Advice *Balaenoptera physalus* Fin Whale *Conservation action*: Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica	
	Conservation Management Plan for the Southern Right Whale 2011-2021 *Management action A4.1*: Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica	

Acceptability Criteria	Demonstration	
	Recovery Plan for Marine Turtles in Australia *Management action A2.1*: Continue to meet Australia's international commitments to address the causes of climate change	
	Conservation Advice *Rhincodon typus* Whale Shark No specific strategies or actions identified.	N/A
	Recovery Plan for the White Shark (*Carcharodon carcharias*) No specific strategies or actions identified.	N/A
	Wildlife Conservation Plan for Seabirds No specific strategies or actions identified.	N/A
	Wildlife Conservation Plan for Migratory Shorebirds No specific strategies or actions identified.	N/A
	Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A
	North-west Marine Parks Network Management Plan No specific zone rules identified.	N/A

9.1.7.6 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine and Non-routine Emissions: Greenhouse Gases aspect are shown in the below table. For reference, the relevant acceptable level have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-09: Meet the objectives and principles of Woodside's Climate Policy	**EPO-08**: Indirect GHG Emissions associated with the Goodwyn Area Infill Development and that are directly within operator influence, shall assist in NWS Project achieving GHG reductions under reformed Safe Guard Mechanism (inclusive of legislated net zero emissions by 2050). **EPO-09**: Woodside to support customers and suppliers to reduce their GHG emissions by Woodside complying with relevant Corporate Woodside policies, including those designed to monitor market developments related to hydrocarbons in the energy transition.

9.1.8 Routine and Non-routine Discharges: Hydrocarbons and Chemicals

9.1.8.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development, that will result in the discharge of hydrocarbons and chemicals, are described in the following table.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (routine and non-routine discharges from drilling operations are included in Sections 9.1.10 and 9.1.11).
Subsea Installation and Pre-commissioning	Planned (routine and non-routine) hydrocarbon and chemical discharges may occur during a range of subsea installation and pre-commissioning activities, including: • connection of new and/or existing subsea infrastructure • pressure and leak testing to check system integrity • hydrotest of rigid flowlines • barrier testing and tie-in to existing GWF infrastructure. Types of discharges may include preservation fluids, control fluids, MEG, hydrocarbon, or other chemicals. It should be noted that the discharges during the subsea installation and pre-commissioning phase are typically small volumes and are intermittent. The exception is hydrotest fluids from flowlines, as depending on the length of flowline and location of discharge, these may be higher volumes. Hydrotest fluids may comprise biocide, corrosion inhibitor, oxygen scavenger, scale inhibitor, MEG, and fluorescein dye. Any hydrotest fluids will typically be discharged to the GWA platform, and these discharges will be managed in accordance with the NOPSEMA-accepted GWA Facility Operations EP; this does not form part of this impact assessment (refer to indirect PW emissions in Section 9.1.12). However, due to distance to GWA platform, hydrotest discharge from the Wilcox flowline may need to be discharged in situ. This discharge may occur at either the Wilcox or LPA end of the flowline, and has been estimated to be ~2,000 m^3.
Start-up and Operations	Planned (routine and non-routine) hydrocarbon and chemical discharges may occur during a range of subsea system operation and IMMR activities, including: • commissioning and start-up – as described in Section 5.5.1, where practicable flowlines will be dewatered to the GWA platform (host), and discharged via the PW system (refer to Section 9.1.12 for PW impact and risk assessment) – where dewater to host is not feasible, flowlines will be discharged in situ – the subsea discharge of preservation fluids from flowlines in situ are typically treated seawater that may contain chemicals such as a biocide, corrosion inhibitor, MEG, or fluorescein dye • operational activities – subsea discharge of control fluid during valve operations – potential non-routine hydraulic fluid discharge associated with EHU system losses or weeps – discharge of minor fugitive hydrocarbon from wells and subsea equipment (e.g. weeps, seeps, or bubbles) – discharge of MEG from subsea intensifiers (at well locations where they are required) • IMMR activities – discharge of residual hydrocarbons in subsea lines and equipment and small gas releases associated with isolation testing and breaking containment – discharge of residual chemicals in subsea lines and equipment,; small quantities of chemicals may remain in the flushed infrastructure, which may be released to the environment after disconnection – marine growth removal (which may require acid soaking or washing). It should be noted that the discharges during the start-up and operations phase are small volumes and are intermittent. Discharge volumes will vary based on activity scope, but typical estimates include: • during flowline dewatering the discharge is ~50% chemically treated water and ~50% MEG mixture (discharge volume will vary with the dimensions of the flowline) – the largest volume of dewatering in situ has been estimated at ~600 m^3 (i.e. ~300 m^3 of MEG) – chemical treatment is typically injected at ~600 ppm, and includes biocide (~1–2%), corrosion inhibitor and fluorescein dye

Activity Group	Description
	• up to an estimated total ~1,000 L of corrosion inhibitor, and ~1,000 L of fluorescein dye up to ~6 L of control fluid per valve actuation during subsea operations • up to ~1,500 L (1.5 m^3) of MEG per test/event from subsea intensifiers (Note: the discharge would be a ~2,250 L water/MEG mixture, based on a 1.5:1 intensifier ratio) • up to ~10 L chemical dye or control fluid, ~40 L of hydraulic fluid, ~50 L of hydrocarbon or MEG, and ~80 L of acid during subsea IMMR activities. r
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. During cessation of operations, any fluids within subsea infrastructure is typically displaced with inhibited seawater. Small quantities of hydrocarbons or chemicals may remain in the flushed infrastructure. As the infrastructure is recovered to the surface, the contents may be discharged to the marine environment. Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities	N/A – aspect not associated with this activity group (routine and non-routine discharges from vessel and MODU operations are included in Section 9.1.9).

9.1.8.1.1 Modelling and Exposure Assessment

As described above, potential planned (routine and non-routine) hydrocarbon and chemical discharges from the Goodwyn Area Infill Development include sources related to different activities during different phases of the offshore project. For the impact assessment, the largest volume of a routine discharge was selected for modelling because this represents the greatest spatial extent of potential impacts.

Hydrotest Modelling

Woodside commissioned RPS to undertake a marine dispersion modelling study for a hydrotest discharge (RPS 2023b) (Appendix G). The principal aim of the study was to predict the extent of the near-field and far-field mixing zones, based on the required dilution levels for biocide in the hydrotest discharge.

The modelling involve two main steps: first, assessing the near-field mixing zone, then using those outcomes to determine the starting state of simulations for assessing the far-field mixing zone. The near-field mixing and dispersion was simulated using CORMIX[54], a three-dimensional flow model. The far-field modelling (undertaken using CHEMMAP[55]) expanded on the near-field modelling by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume.

Scenario

Given the proximity to sensitive receptors, modelling was undertaken for a nominal well location in the Wilcox field, outside the Montebello Marine Park. Table 9-17 lists the key inputs used in the dispersion modelling.

Table 9-17: Key inputs to dispersion modelling for hydrotest discharge at Wilcox

Parameter	Nominal Wilcox well
Location	19°59'53.8" S 115°29'38.4" E
Hydrotest discharge flow rate	130 m^3/h

[54] CORMIX is a widely used and validated mixing zone model and decision support system for environmental impact assessment (RPS 2023b).

[55] CHEMMAP predicts the movement and fate of a wide variety of chemical products, including floating, sinking, soluble/insoluble chemicals and product mixtures (RPS 2023b).

Parameter	Nominal Wilcox well
Total volume of hydrotest discharged	2,000 m^3
Discharge duration	15 hours
Discharge depth	73 m
Discharge pipe orientation	Horizontal
Total water depth	74 m
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August)
Number of simulations	50 per season (150 total)

Exposure Criteria

Based on previously undertaken whole effluent toxicity (WET) testing of a hydrotest fluid (which contained the biocide Hydrosure 0-3670R) (CAPL 2015), the exposure criteria adopted for this study is that the median concentration of fluid is not to exceed 0.06 mg/L over a 48-hour period.

The WET testing was conducted on five species (from four different taxonomic groups) relevant to the NWS. The no observed effect concentration (NOEC) for the single species WET test results were used to develop species sensitivity distributions and subsequent environmental criteria. The 0.06 mg/L corresponds to a 99% species protection value, and the 48-hour duration is based on the lowest duration used during WET testing (test duration ranged between 48–96 hours).

Based on an expected dose concentration of hydrotest fluid (containing biocide), the required dilution factor to meet the above exposure criteria is 10,000.

Modelling Outputs

Table 9-18 show the outcomes of the far-field modelling and analysis. Results are presented as 95th and 99th percentiles, which represent the more extreme values (and therefore a conservative approach to impact assessment). The 95th percentile values would not be exceeded more than 5% of the time, while the 99th percentile values would not be exceeded more than 1% of the time.

The hydrotest discharge marine dispersion modelling study (RPS 2023b) showed that 48-hour median the exposure criteria was not predicted to be exceeded at any distance from the discharge location, during any season.

Table 9-18: Modelled instantaneous and 48-hour exposure required to meet 10,000 dilutions of hydrotest fluid

Season	Instantaneous Exposure		48-hour Median Exposure
	Maximum Distance	Total Area	
95th percentile			
Summer	0.22 km	0.03 km^2	–
Transitional	0.36 km	0.03 km^2	–
Winter	0.49 km	0.07 km^2	–
99th percentile			
Summer	2.58 km	2.51 km^2	–
Transitional	3.02 km	2.67 km^2	–
Winter	2.80 km	2.74 km^2	–

A dash (–) indicates the criteria was not reached.

9.1.8.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural
Change to water quality			✓				
Change to sediment quality		✓					
Potential changes to habitats and biological communities					✓		
Potential changes to the values and sensitivities of protected places					✓		

9.1.8.3 Consequence Evaluation

9.1.8.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Subsea planned (routine and non-routine) discharges of hydrocarbons and chemicals will result in localised and temporary changes to water quality. Changes in water quality will depend on the discharge volume, rate and chemical composition. During operations, the subsea discharges are intermittent and small volumes, which are expected to rapidly mix and disperse in the open ocean. The small quantities of hydrocarbons (liquid and gas) that may be released will be buoyant and float upwards towards the surface. However, given the water depth, pressure, and the small volumes released, these hydrocarbons are not expected to reach the sea surface. Rather, the release will disperse and dissolve within the water column. A typical acid–water mix discharge may would be expected to quickly dilute and neutralise as it reacts with the calcareous material being removed from the subsea infrastructure. The aquatic toxicity of MEG is very low, it is listed as an 'E' category fluid under the Offshore Chemical Notification Scheme (OCNS), and is on the OSPAR list of substances that are considered to pose little or no risk to the environment once released (PLONOR). MEG is biodegradable and water soluble and dilutes rapidly in the marine environment to low concentrations. Given the relatively small volumes, intermittent discharges, and rapid mixing expected to occur within an open ocean environment, only localised and temporary changes in water quality are predicted. During commissioning and start-up, larger volumes of MEG (e.g. up to ~300 m^3) may be discharged to the marine environment. Previous modelling undertaken for the dewatering of a Lambert Deep flowline indicated an average of 4,998, 8,607, and >20,000 dilutions were achieved within 200 m of the discharge location during summer, transitional and winter periods respectively (Woodside 2020a). Direct toxicity testing of MEG (100% concentration), on eight mainly tropical species, representing seven taxonomic groups, established the lowest no observable effect concentration (NOEC) is for sea urchin fertilisation at 130 mg/L (Woodside 2019b). Based on the modelling for the Lambert Deep flowline (which had a total release of~830 m^3 of MEG) the plume would dilute to below 130 mg/L within 600 m of the discharge location. The largest potential discharge of MEG for flowline dewatering for the Goodwyn Area Infill Development has been estimated at ~300 m3 (i.e. less than half of that modelled for Lambert Deep), and as such the spatial extent of any discharge plume is not expected to be larger than that predicted for Lambert Deep. Further, as described above, MEG has a low aquatic toxicity and long-term changes to water quality are not anticipated. Hydrotest fluid discharge is likely to be the largest routine discharge during Goodwyn Area Infill Development activities, and will occur during the subsea installation and pre-commissioning phase. Hydrotest fluids may comprise biocide, corrosion inhibitor, oxygen scavenger, scale inhibitor, MEG, and fluorescein dye. Modelling of hydrotest discharge indicate that dilution is expected rapidly upon release, with an average of between 896–1,214 dilutions occurring within ~282 m of the discharge location (RPS 2023b). The modelling also indicated that the distance to

	reach an instantaneous concentration of 0.06 ppm of they hydrotest fluid was estimated to be up to ~3 km from the discharge location (Table 9-18); however this instantaneous exposure is not associated with any predicted ecotoxicological affects. Therefore, the routine and non-routine discharge of hydrocarbons and chemicals within the Project Area is expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.1.8.3.2 Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	Accumulation of contaminants in sediments depends primarily on the volume and concentration of particulates in discharges or constituents that adsorb onto seawater particulates, the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths), and the resuspension, bioturbation, and microbial decay of those particulates in the water column and on the seabed. However, given the subsea discharges are expected to rapidly mix in the water column and become diluted, accumulation in sediments at a measurable level is not expected to occur. Thus, any potential change to sediment quality has not evaluated further.

9.1.8.3.3 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Planktonic Communities	A change in water quality as a result of routine and non-routine hydrocarbon and chemical discharges has the potential to change planktonic communities within the water column through toxicity effects. Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). As described in the consequence evaluation above, the discharge of hydrocarbons and chemicals within the Project Area is not expected to result in a lasting effect to water quality. Given the patchy and variable plankton communities, these discharges are not expected to cause a change in planktonic communities at a measurable level and will not change the viability of the population or ecosystem. Therefore, potential changes to planktonic communities are not evaluated further.
Offshore Habitats and Biological Communities ***Key Ecological Features***	A change in water quality as a result of routine and non-routine hydrocarbon and chemical discharges has the potential to change benthic habitats and communities through toxicity effects. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). Rankin Bank and Wilcox Shoal both occur within the Project Area (Section 7.5.3.6). Wilcox Shoal is ~1 km south-east of a phased development nominal infrastructure corridor, and Rankin Bank is ~5 km north-west of the proposed tie-in at LPA. There is also a smaller shoal feature (~3.5 km north-east of nominal Wilcox wells; Figure 5-2) that is within the phased development nominal infrastructure corridor. Given the distances to installation and operational activities, neither Rankin Bank, Wilcox Shoal, or the smaller shoal feature are expected to be exposed to discharges of hydrocarbons or chemicals from the petroleum activities. The Project Area also partially overlaps the ancient coastline at 125 m depth contour KEF. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). As described in the consequence evaluation above, the discharge of hydrocarbons and chemicals within the Project Area is not expected to result in a lasting effect to water quality, and no change in sediment quality is predicted. Given the predominantly soft sediment habitats within

Receptor	Consequence Evaluation
	the Project Area, these discharges are unlikely to cause a change in habitats or communities at a measurable level and will not change the viability of the population or ecosystem. Therefore, potential changes to offshore habitats and biological communities and KEFs are not evaluated further.

9.1.8.3.4 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include ecosystems representative of the Northwest Shelf Province, including areas of ancient coastline. Benthic habitat surveys within the northern section of the marine park indicate that it has a relatively flat and sandy seabed with variable coverage of benthic epifauna (e.g. sponges, corals) (Section 7.5.3.7; (Advisian 2019)). This is not dissimilar to the benthic habitats and communities expected to occur throughout most of the Project Area, which are broadly represented throughout the NWMR (Section 7.5.3.1). The potential for changes to the values of the marine park from discharging hydrocarbons or chemicals within the Project Area may occur as an indirect consequence of an impact to the benthic habitat identified as a value of the Montebello Marine Park. However, as described in the consequence evaluation above, the discharge of hydrocarbons and chemicals within the Project Area is not expected to result in a lasting effect to water quality, and no change in sediment quality is predicted. Given the predominantly soft sediment habitats within the northern extent of the Montebello Marine Park, these discharges are unlikely to cause a change in habitats or communities at a measurable level and will not change the viability of the population or ecosystem. Therefore, the routine and non-routine discharge of hydrocarbons and chemicals within the Project Area is expected to have no lasting effect on the values of the Montebello Marine Park, and thus the consequence level is ranked as F.

9.1.8.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine and Non-routine Discharges: Hydrocarbons and Chemicals, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	No controls were identified.
Good Industry Practice	• **CM-24**: Implement Woodside’s Engineering Standard Pipelines Flooding, Cleaning, Gauging and Hydrotesting • **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline • **CM-26**: Implement Woodside's Engineering Operating Standard (Subsea Isolation) Procedure

9.1.8.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence
Change to water quality	Physical environment			✓					A	F
Change to sediment quality	Physical environment		✓							–
Potential changes to habitats and biological communities	Planktonic Communities					✓				–
	Offshore Habitats and Biological Communities					✓				–
	Key Ecological Features					✓				–
Potential changes to the values and sensitivities of protected places	Australian Marine Parks					✓				F

9.1.8.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine and Non-routine Discharges: Hydrocarbons and Chemicals aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect is **AL-04** and **AL-05**, as defined in Table 4-3 (and shown below in Section 9.1.8.7). As described in the consequence evaluation (Section 9.1.8.3), the predicted environmental impacts will be localised and temporary, with no lasting effect to water quality, and as such are not expected to substantially affect the biodiversity, ecosystem function, integrity of the marine area. Therefore, the predicted level of impact for these receptors is better then the acceptable level (**AL-04**). Given the localised and temporary impacts predicted for water quality, no lasting effects were predicted to occur to the Montebello Marine Park such that it would prevent the long-term protection and conservation of marine park values. Therefore, the predicted level of impact for this receptor is better than the acceptable level (**AL-05**).
Impact and Risk Classification, and Decision Type	The impacts arising from hydrocarbon and chemical discharges within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.8.4)
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">
included within this (Section 9.1.7) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social
– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with marine fauna arising from the offshore project
– this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.8.4)
• Precautionary Principle
– the highest impact consequence rating for this aspect is no lasting effect (F), therefore, no potential for serious or irreversible environmental damage is expected
– there is little scientific uncertainty associated with predicted environmental impact and the anticipated effectiveness of management measures
• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.8.3) impact analysis
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
</td></tr>
<tr><td>Internal Context</td><td colspan="2">
These Woodside management processes or procedures were deemed relevant for this aspect:
• Engineering Standard Pipelines Flooding, Cleaning, Gauging and Hydrotesting
• Chemical Selection and Assessment Environment Guideline
• Engineering Operating Standard (Subsea Isolation) Procedure
Control measures related to these management processes or procedures have been described for this aspect (Section 9.1.8.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.
</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding routine and non-routine discharges arising from the offshore project.</td></tr>
<tr><td rowspan="4">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
</table>

9.1.8.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine and Non-routine Discharges: Hydrocarbons and Chemicals aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-10**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality from routine and non-routine hydrocarbon and chemical discharges during the petroleum activity
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.9 Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine

9.1.9.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in the discharge of sewage, putrescible waste, greywater, bilge water, drain water, cooling water, and brine are described in the following table.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (for MODU operations, refer Field Support Activities below).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. The number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). During operations, the MODU and vessels routinely discharge various wastewater streams to the marine environment, including sewage, putrescible waste, bilge water, drain water, cooling water, and brine (Sections 5.7.1.2 and 5.7.2). Ablution, laundry, and galley facilities used by MODU and vessel crews will generate sewage, putrescible waste, and greywater; these are typically discharged to the marine environment. Depending on the number of POB, vessels and MODUs typically generate ~5–15 m^3/day of sewage and greywater (NERA 2017). The volume of putrescible waste discharged overboard is estimated at ~1–2 kg per person per day (NERA 2017). Typically, MODUs and vessels have open and closed drainage systems—non contaminated streams are sent directly to open drains for discharge, with potentially contaminated streams (e.g. resulting from chemical or hydrocarbon leaks or spills to the deck) diverted to bilge tanks (typically for treatment before being discharged). MODUs and vessels routinely generate and discharge relatively small volumes of bilge water. Bilge tanks receive fluids from many parts of the MODU/vessel, including machinery spaces, and this bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids, or chemicals. MODUs and vessels may also discharge drainage water from decks directly overboard or via deck drainage systems; deck drainage may also contain traces of chemicals. Water sources could include rainfall and/or deck activities such as cleaning/wash-down of equipment/decks.

Activity Group	Description
	MODU and vessels typically use seawater to produce potable water, and small volumes of reject brine are discharged to the marine environment. Reject brine is hypersaline water, typically 20–50% higher in salinity than the intake seawater (depending on the desalination process used) and may contain low concentrations of scale inhibitors and biocides, which are used to prevent pipework fouling (Woodside 2014). To maintain performance and reduce energy loss from heat, the machinery on the MODU and vessels may need to use a cooling media, which will be circulated through a central cooling system. Once the cooling media has completed its cycle, it is discharged into the marine environment. The heat exchange medium most used is seawater; however, in some instances, a different fluid may be used within a closed circuit and further cooled by seawater within a separate seawater cooler (hence this is known as cooling water). The discharge stream will be warmer than the ambient ocean temperature and will contain a range of chemicals including biocides and scale inhibitors. Biocides and oxygen scavengers are generally used in low dosages to prevent pipework fouling and are usually consumed during the inhibition process, resulting in very low concentrations being discharged. MODUs are stationary during drilling operations, so these waste streams are discharged from a stationary point; vessels will typically discharge waste while in transit.

9.1.9.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Change to water quality			✓				
Potential changes to fauna behaviour						✓	
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places						✓	

9.1.9.3 Consequence Evaluation

9.1.9.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	The planned (routine and non-routine) discharge of sewage, putrescible waste, greywater, bilge water, drain water, cooling water or brine will result in a localised and temporary change in water quantity, depending on the volume and composition of the discharge. The composition of sewage, putrescible wastes, and greywater includes nutrients (e.g. ammonia, nitrate, nitrite, and orthophosphate); therefore, these wastewater stream discharges may lead to eutrophication. Open marine waters are influenced by regional wind and large-scale ocean current patterns resulting in the rapid mixing of surface and near-surface waters, which is where MODU and vessel discharges would occur (NERA 2017). Therefore, any nutrients from sewage, putrescible waste, and greywater discharges from MODUs or vessels are not expected to accumulate or lead to eutrophication due to the highly dispersive environment (NERA 2017). Monitoring of sewage discharges from another offshore petroleum activity (drilling rig at the Torosa field) demonstrated that a 10 m^3 sewage discharge reduced to ~1% of its original concentration within 50 m of the discharge location (SKM and ERM 2008). Monitoring at distances 50, 100 and 200 m downstream of the drilling rig and at 5 different water depths confirmed that discharges were rapidly diluted and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels (Woodside 2014). In addition, water quality monitoring around the GWA

Receptor	Consequence Evaluation
	platform, which would have higher routine discharges, indicated no detectable change in oxygen saturation, oxygen demand, or nutrients above background levels within the vicinity of the GWA platform (BMT Oceanica 2015). A vessel's bilge system is designed to safely collect, contain, and dispose of oily water so that hydrocarbon discharges to the marine environment are minimised or avoided. Bilge water is processed via an oil-water separator before being discharged to sea. Discharge is intermittent and occurs at or near surface waters, where oily bilge discharges are expected to readily dilute and disperse under the action of waves and currents. Once exposed to air, any volatile components of the oil will readily evaporate. Drain water from the MODU and vessels may contain small quantities of chemicals such as detergents. The planned release of water-foaming agents used in aqueous firefighting foam is restricted to testing activities that ensure safe and effective operation of the system in an emergency. If used, these foams will be discharged via the drain water system. Potentially contaminated streams will go to a bilge/slops tank for initial treatment. Drain water discharge is intermittent and occurs at or near surface waters, where it is also expected to readily dilute and disperse. Typically, discharged cooling water is warmer than the receiving marine water, and consequently is relatively buoyant, forming a plume in near-surface waters down current from the discharge point. Because it is a surface plume, discharged cooling water is expected to be rapidly mixed by sea surface waves and wind. Water quality monitoring around the GWA platform, which would have higher routine discharges than the Goodwyn Area Infill Development, indicated that water temperatures are consistent with background levels (BMT Oceanica 2015). Typically, discharged brine is denser than the receiving marine water, and consequently will initially tend to sink (until a neutral buoyancy is achieved). This initial sinking contributes to turbulent mixing in the near-field; additional mixing and dispersion also occurs in surface waters caused by currents and waves. Monitoring of desalination brine of continuous wastewater discharges (including cooling water) undertaken for the Torosa South-1 drilling program in the Scott Reef complex found that discharge water temperature decreases quickly as it mixes with the receiving waters, with the discharge water temperature being <1 °C above ambient within 100 m (horizontally) of the discharge point, and 10 m vertically (Woodside 2014). Impacts from RO brine discharge will have no lasting effects on the environment and are highly localised to the discharge location. Given the relatively small volumes, intermittent discharges, and rapid mixing expected to occur within the surface waters of an open ocean environment, only localised and temporary changes in water quality are predicted. Therefore, the routine and non-routine discharge of sewage, putrescible waste, greywater, bilge water, drain water, cooling water or brine within the Project Area is expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.1.9.3.2 Potential changes to fauna behaviour

Receptor	Consequence Evaluation
Fish, Sharks and Rays ***Seabirds and Migratory Shorebirds***	Discharges of organic matter, such as those present in sewage, putrescible waste or greywater can increase scavenging behaviour in fauna. Discharges will be intermittent, and any effect is expected to be localised and temporary because the discharge will be quickly broken down by microbial action and dispersed by wave action and local ocean currents. Therefore, no effects on environmental receptors along the food chain (e.g. fish, birds) are expected, beyond the effects in the immediate vicinity of the discharge (NERA 2017). Any behavioural changes (e.g. avoidance, attraction) by fish due to an elevated temperature within a cooling water discharge plume is expected to be localised, temporary, and intermittent. As described in the consequence evaluation above, the discharge of sewage, putrescible waste, greywater, and cooling water within the Project Area is not expected to result in a lasting effect to water quality. Therefore, these discharges are unlikely to cause a change in behaviour of marine fauna at a measurable level and will not result in a change in the viability of the population or ecosystem. Thus, potential changes to fauna behaviour are not evaluated further.

9.1.9.3.3 Potential injury or mortality to fauna

Receptor	Consequence Evaluation
Planktonic Communities	Bilge water, drain water, or cooling water may be toxic to plankton, depending on the type and volume of contaminants, and changes in temperature or salinity from cooling water or brine discharges may injure or kill plankton. Discharges will be intermittent, and any effect is expected to be localised and temporary as the discharges will be rapidly dispersed by wave action and ocean currents. Plankton communities have patchy distributions and naturally high mortality rates, primarily through predation (ITOPF 2011). However, in favourable conditions (e.g. nutrient supply), plankton populations can increase rapidly. If the favourable conditions cease, plankton populations will collapse and/or return to their previous state. Plankton populations have evolved to respond to environmental changes by high production within short generation times (ITOPF 2011). Any potential change in phytoplankton or zooplankton abundance and composition is expected to be localised, typically returning to background conditions within tens to a few hundred metres of the discharge location (Abdellatif et al. 1993; Axelrad et al. 1981; Parnell 2003). Larval plankton stages are more susceptible to the impacts of increased salinity than most other marine life (Neuparth, Costa, and Costa 2002). Discharged brine sinks through the water column where its rapidly mixed with receiving waters and dispersed by ocean currents. Studies indicate effects from increased salinity on planktonic communities in areas of high mixing and dispersion are generally limited to the point of discharge only (Azis et al. 2003). The impact to plankton species from a change in temperature also varies from species to species. Vijverberg (1980) showed that changes in temperature (due to discharges from a desalination plant) on plankton lead to a positive effect on reproduction biology and the growth rate of several species of plankton. However, thermal stress was also the major source of copepod mortality reported by Choi et al. (2012), with mortality caused by a temperature difference of ~5° C. Given the patchy and variable plankton communities, planned (routine and non-routine) discharges from the MODU and vessels are not expected to cause a change in planktonic communities at a measurable level and will not change the viability of the population or ecosystem. Therefore, MODU and vessel wastewater discharges within the Project Area are not expected to have a lasting effect on planktonic communities, and thus the consequence level is ranked as F.
Fish, Sharks and Rays ***Marine Reptiles*** ***Marine Mammals***	Bilge water, drain water, or cooling water may be toxic to marine fauna, depending on the type and volume of contaminants. Discharges will be intermittent, and any effect is expected to be localised and temporary as these discharges will be rapidly dispersed by wave action and ocean currents. Studies indicate that impacts from discharges are only expected from prolonged exposure in waters with poor mixing (McKinley and Johnston 2010). Biocides (e.g. sodium hypochlorite) and other chemicals are generally used in low dosages within cooling water systems, resulting in very low concentrations being discharged to the marine environment. Once released, these chemicals are expected to readily dissociate and disperse within the surface waters. Water quality monitoring around the GWA platform, which would have higher routine discharges, indicated pH is consistent with background levels (BMT Oceanica 2015). Sodium hypochlorite is alkaline (e.g. a solution of 5% sodium hypochlorite has a pH of ~11), and as such monitoring suggests its concentrations diminish rapidly after discharge to ambient conditions. Aqueous firefighting foam in its diluted form (as applied during a fire or for testing) is generally considered to have a relatively low toxicity to aquatic species (Schaefer 2013; IFSEC Global 2008). As described in the consequence evaluation above, the discharge of bilge, drain, or cooling waters within the Project Area is not expected to result in a lasting effect to water quality. Therefore, these discharges are unlikely injure or kill marine fauna at a measurable level and will not result in a change in the viability of the population or ecosystem. Thus, potential changes to fauna behaviour are not evaluated further.

9.1.9.3.4 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from discharging sewage, putrescible waste, greywater, bilge water, drain water, cooling water or brine within the Project Area may occur as an indirect consequence of an impact to the marine fauna identified as a value of the Montebello Marine Park. Although the Project Area intersects with the Montebello Marine Park, only intermittent and low levels of vessel activity are expected to occur within the park's boundaries. The proposed development of the Wilcox reservoir has all top-hole drilling locations (and therefore the MODU) outside the marine park boundary. As described in the consequence evaluations for the marine fauna groups above, discharging sewage, putrescible waste, greywater, bilge water, drain water, cooling water and/or brine within the Project Area is not expected to result in a lasting effect to marine fauna. Therefore, the routine and non-routine vessel discharges within the Project Area is expected to have no lasting effect on the values of the Montebello Marine Park, and thus the consequence level is ranked as F.

9.1.9.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-27**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth), *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth), and any subsequent marine orders
Good Industry Practice	• **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline

9.1.9.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***	***Decision Type***	***Consequence***
Change to water quality	Physical environment			✓						F
Potential changes to fauna behaviour	Fish, sharks and rays						✓			–
	Seabirds and migratory shorebirds						✓		A	–
Potential injury or mortality to fauna	Planktonic communities					✓				F
	Fish, sharks and rays						✓			–

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence
	Marine reptiles						✓			–
	Marine mammals						✓			–
	Seabirds and migratory shorebirds						✓			–
Potential changes to the values and sensitivities of protected places	Australian Marine Parks					✓	✓			F

9.1.9.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable level for this aspect is **AL-04**, and **AL-05**, as defined in Table 4-3 (and shown below in Section 9.1.9.6). As described in the consequence evaluation (Section 9.1.9.3), the predicted environmental impacts will be localised and temporary, with no lasting effect to water quality or planktonic communities, and as such are not expected to substantially affect the biodiversity, ecosystem function, integrity of the area. Therefore, the predicted level of impact for these receptors is better than the acceptable level (**AL-04**). Given the localised and temporary impacts predicted for water quality, no lasting effects were predicted to occur to the Montebello Marine Park such that it would prevent the long-term protection and conservation of marine park values. Therefore, the predicted level of impact is better than the acceptable level (**AL-05**).
Impact and Risk Classification, and Decision Type	The impacts arising from discharging sewage, putrescible waste, greywater, bilge water, drain water, cooling water and brine within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered ‘broadly acceptable’. These impacts are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.9.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.9) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations

Acceptability Criteria	Demonstration
	– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding the discharge of sewage, putrescible waste, greywater, bilge water, drain water, cooling water and brine from the offshore project – this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.9.4) • Precautionary Principle – the highest impact consequence rating for this aspect is no lasting effect (F), therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with predicted environmental impact (and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.9) impact analysis – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	These Woodside management processes or procedures were deemed relevant for this aspect: • Chemical Selection and Assessment Environment Guideline. Control measures related to these management processes or procedures have been described for this aspect (Section 9.1.9.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding routine and non-routine discharges arising from the offshore project.
Other Requirements	Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.

Requirement	***Demonstration***
Marine Order 91 Gives effect to Annex IV of MARPOL 73/78	Requirements from relevant marine orders are incorporated into the key control measures (Section 9.1.9.4).
Marine Order 95 Gives effect to Annex V of MARPOL 73/78	Requirements from relevant marine orders are incorporated into the key control measures (Section 9.1.9.4).
Marine Order 96 Gives effect to Annex I of MARPOL 73/78	Requirements from relevant marine orders are incorporated into the key control measures (Section 9.1.9.4).
North-west Marine Parks Network Management Plan 2018 The Plan requires that 'waste from normal operations of vessels must be compliant with requirements under the International Convention for the Prevention of Pollution from Ships (MARPOL), the International Maritime Organization (IMO) convention covering prevention of pollution of the marine	The MARPOL requirements are incorporated into the key control measures (Section 9.1.9.4). Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the North-west Marine Parks Network Management Plan (DNP 2018a).

Acceptability Criteria	Demonstration	
	environment by ships from operational or accidental causes'.	

9.1.9.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine aspect are shown in the below table. For reference, the relevant acceptable level have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-09**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality and biological communities from routine and non-routine MODU/vessel discharges during the petroleum activity
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.10 Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids

9.1.10.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that will result in the discharge of drill cuttings and drilling fluids are described in the following table.

Activity Group	Description
Drilling and Completions	Types of routine drilling discharges include drill cuttings, drilling fluids retained on cuttings, and bulk discharge of drilling fluids from mud pits. These may also be discharged as non-routine discharges associated with contingency activities (e.g. re-spud, sidetracking). Up to 8 wells (Table 5-1) may be drilled within the Project Area as part of the Goodwyn Area Infill Development. Each production well is anticipated to take ~1–3 months from the start of drilling to completions. For top-hole sections, drill cuttings and drilling fluids are discharged at the seabed (Section 5.3.3). For bottom-hole sections, cuttings and fluids are circulated back to the MODU via the riser, where the cuttings are separated from the drilling fluids by the SCE (Section 5.3.5). The cuttings (with adhered residual fluids) are discharged at or below the water surface. The mud pits form part of the drilling fluid circulating system and may be discharged at the end of specific well sections if the drilling fluid system needs to be changed or the drilling fluid cannot be re-used (e.g. due to deterioration/contamination). Drilling generates cuttings as solid material from within the borehole breaks up. The cuttings are rock particles of various shapes and sizes (typically ranging from very fine to very coarse). The volume of cuttings discharged for each production well will vary depending on the well's geometry and total depth. Estimated volumes of drill cuttings discharged from a typical well are in the order of ~108 m^3 at the seabed, and ~474 m^3 from the surface (RPS 2023a). Drilling fluids (drilling muds) comprise a base fluid, weighting agents, and chemical additives. As described in Section 5.3.6, all wells will be drilled using WBM for the top-hole sections and either WBMs or NWBMs for the lower sections (the selection of fluid types will not be finalised until detailed well design is complete). WBM mainly comprises water (salt or fresh) with the addition of some additives (e.g. bentonite, guar gum). NWBMs compromise a synthetic base fluid, which may contain a hydrocarbon. Estimated volumes of fluids (and solids) discharged from a typical well are in the order of ~7,057 bbl (~89.7 m^3 solids) at the seabed, and ~30,461 bbl (~387.5 m^3 solids) from the surface (RPS 2023a).

Activity Group	Description
	For drilling or well related discharges that are not drill cuttings or drilling fluids (e.g. cement), refer to Section 9.1.11.
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group.
Start-up and Operations	During operations well parts may require maintenance, repair, or replacement. If well intervention or workover is required as part of subsea IMMR activities during operations, well annular fluids (which may contain WBM used during riserless top-hole drilling) may be exposed to the marine environment. Only small volumes of fluid exchange between the annular spaces and the marine environment will occur. The exchange will not be instantaneous as the annular spaces are small and the fluids are typically heavier than seawater. The gradual release of the well annular fluids is expected to result in rapid dilution within metres of the release location. For drilling or well related discharges that are not drill cuttings or drilling fluids (e.g. cement), refer to Section 9.1.11.
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. During decommissioning, wells will be plugged for abandoned (Section 5.6.1). During well plugging, well annular fluids (which may contain WBM used during riserless top-hole drilling) may be exposed to the marine environment when the wellhead is removed during well abandonment. Upon wellhead removal, small volumes (~1 m^3) of fluid exchange between the annular spaces and the marine environment may occur. The exchange will not be instantaneous as the annular spaces are small and the fluids are typically heavier than seawater. The gradual release of the well annular fluids is expected to result in rapid dilution within metres of the release location. For well related discharges that are not drill cuttings or drilling fluids, refer to Section 9.1.11. Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities	N/A – aspect not associated with this activity group.

9.1.10.1.1 Modelling and Exposure Assessment

As described above, drill cuttings and drilling fluids will predominantly be discharged during the drilling and completions phase of the Goodwyn Area Infill Development. Therefore, for the impact assessment, drilling operations was selected for modelling as it represents the greatest spatial extent of potential impacts.

Drill Cuttings Discharge and Dispersion Modelling

Woodside commissioned RPS to undertake a sediment dispersion modelling study that considered discharges of drill cuttings and drilling fluids to the marine environment during drilling activities (RPS 2023a) (Appendix H). Based on the modelled fate of discharged drill cuttings and drilling fluids, predictions of the levels of suspended sediments within the water column and bottom deposition (thickness and accumulated load) were quantified.

The modelling involve two main steps: first, assessing the near-field discharge mixing and dispersion, then using those outcomes to determine the starting state of simulations for assessing the far-field mixing and dispersion.

The near-field mixing and dispersion was simulated using CORMIX[56], a three-dimensional flow model. The far-field modelling (using MUDMAP[57]) expanded on the near-field modelling by allowing the varying nature of currents to be included, with the potential for localised build-up when current speeds are low (e.g. at slack tide) or recirculation of the plume.

Scenario

Given the proximity to sensitive receptors, modelling was undertaken for a nominal well location in the Wilcox field, outside the Montebello Marine Park.

The modelling takes into account these discharge sources:

- continuous discharge of drill cuttings and retained fluids as drilling proceeds
- bulk discharge of drilling fluids at the end of each hole section
- routine (approximately daily) discharge of a single mud pit.

The drill cuttings and drilling fluids generated during top-hole drilling are discharged to the seabed; all other discharges occur within surface waters. Table 9-19 lists the key inputs used in the dispersion modelling. Although actual volumes, discharge rates and scheduling of drilling activities are yet to be confirmed, modelling assumptions provided for a conservative assessment of potential impacts from drill cuttings disposal.

The particle size distributions of drill cuttings, and the solids within the drilling fluids that were used in the modelling were based on samples collected by Woodside as part of the GWF-2 study (Jones and Miller 2019; Jones et al. 2021). Particle size distribution for drill cuttings and drilling fluids are included in Appendix H.

Table 9-19: Key inputs to dispersion modelling during drilling activities at Wilcox

Parameter	Nominal Wilcox well
Location	19°59'53.8" S 115°29'38.4" E
Volume of drill cuttings discharged	582 m^3
Volume of solids in drilling fluids discharged	477.2 m^3
Depth of discharges for bottom-hole sections	20 m
Discharge pipe orientation	Vertical
Water column depth	70 m
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August)
Number of simulations	50 per season

Exposure Criteria

RPS used the criteria listed in Table 9-20 to help assess the environmental impact of drill cuttings and drilling fluid discharges.

The ecological impact thresholds were based on previous studies by IOGP (2016) that indicated ecological impacts to benthic biota are predicted when sediment deposition is ≥6.5 mm (in

[56] CORMIX is a widely used and validated mixing zone model and decision support system for environmental impact assessment (RPS 2023a).

[57] MUDMAP is a widely used and validated three-dimensional plume model used to help assess the potential environmental effects from operational discharges such as drilling cuttings, drilling fluids (RPS 2023a). The model predicts the dynamics of the discharge material and resulting seabed concentrations and bottom thicknesses over the far-field.

thickness), and Nelson et al. (2016) which identified <10 mg/L as no effect or sub lethal minimal effect concentration for TSS.

Table 9-20: Exposure criteria for suspended sediment and sediment deposition

Component	Parameter	Threshold
Seabed	Thickness (mm)	Lowest reportable deposition: 0.1 mm Ecological impact: 6.5 mm
Water column	Total suspended solids (TSS; mg/L)	TSS area of influence: 1–3 mg/L Ecological impact: 10 mg/L

Modelling Outputs

Table 9-21 and Table 9-22 show the outcomes of the far-field modelling and analysis. Results are presented as 95th and 99th percentiles, which represent the more extreme values (and therefore a conservative approach to impact assessment). The 95th percentile values would not be exceeded more than 5% of the time, while the 99th percentile values would not be exceeded more than 1% of the time. Annualised results summarise the worst-case scenario from among the stochastic modelling for seasonal effects.

Stochastic modelling from the RPS (2023a) drill cuttings and drilling fluids dispersion modelling showed:

- local sedimentation will occur as a mound around the well site, with the major contribution by larger sediments (fine sand and larger), while finer, slower-sinking particles would disperse more widely with the prevailing current
- the thickness of the deposits generated by particles settling decreased exponentially with distance from the drilling location
- most of the sediment released by continuous discharges will settle out over an elliptical area with a long axis aligned with the tidal currents (typically west-north-west to east-south-east)
- the potential for thin (0.1 mm) deposits of sediment to settle out at distances >1 km is very low (<1%) for all seasons (Table 9-21)
- TSS distribution calculations indicate that concentrations >10 mg/L may extend up to ~100–150 m from the source up to 5% of the time, and up to ~2,000 m from the source up to 1% of the time (Table 9-22)
- TSS concentrations >1 mg/L were calculated to extend ~10–12 km from the source up to 1% of the time (Table 9-22).

Examples of visual representation of modelling outcomes are shown in Figure 9-8 and Figure 9-9 for sediment thickness and TSS respectively. The figures illustrate the elliptical area of exposure, with the west-north-west to east-south-east axis aligned with tidal currents.

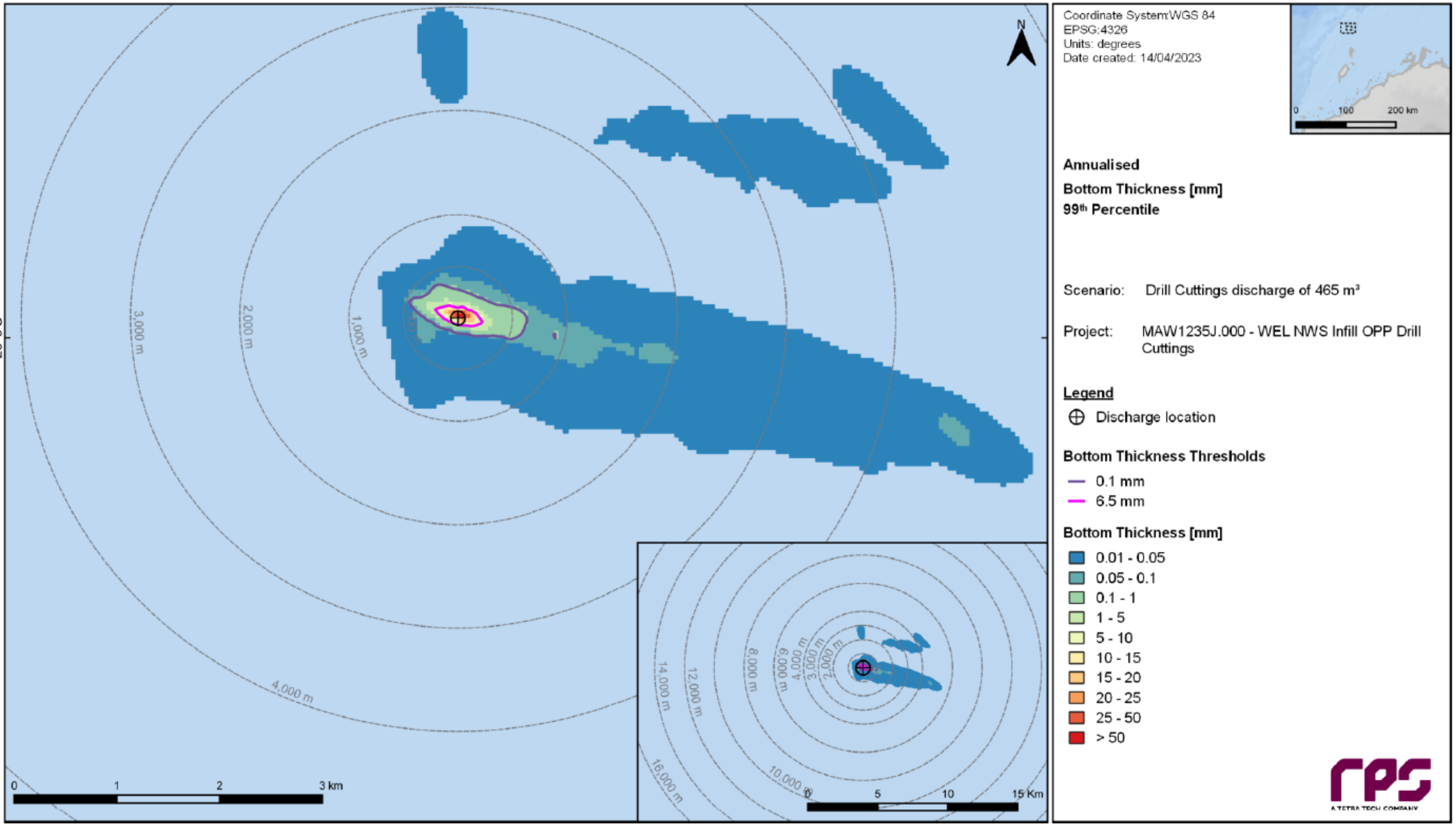
Table 9-21: Modelled maximum bottom thickness, area of coverage, and distance from the discharge location for sedimentation exposure criteria

Season	Maximum bottom thickness (mm)	Total area of coverage (km^2) above threshold		Maximum distance (m) from well to threshold	
		Lowest reportable deposition	Ecological impact	Lowest reportable deposition	Ecological impact
		0.1 mm	(6.5 mm)	0.1 mm	6.5 mm
Highest 95th percentile value					
Summer	67.3	0.26	0.05	923.2	192.7
Winter	69.7	0.29	0.04	599.3	221.5

Season	Maximum bottom thickness (mm)	Total area of coverage (km^2) above threshold		Maximum distance (m) from well to threshold	
		Lowest reportable deposition	Ecological impact	Lowest reportable deposition	Ecological impact
		0.1 mm	(6.5 mm)	0.1 mm	6.5 mm
Transitional	66.8	0.27	0.04	627.6	181.3
Highest 99th percentile value					
Summer	71.2	0.27	0.05	923.2	192.7
Winter	72.6	0.29	0.04	599.3	221.5
Transitional	68.7	0.27	0.04	627.6	181.3

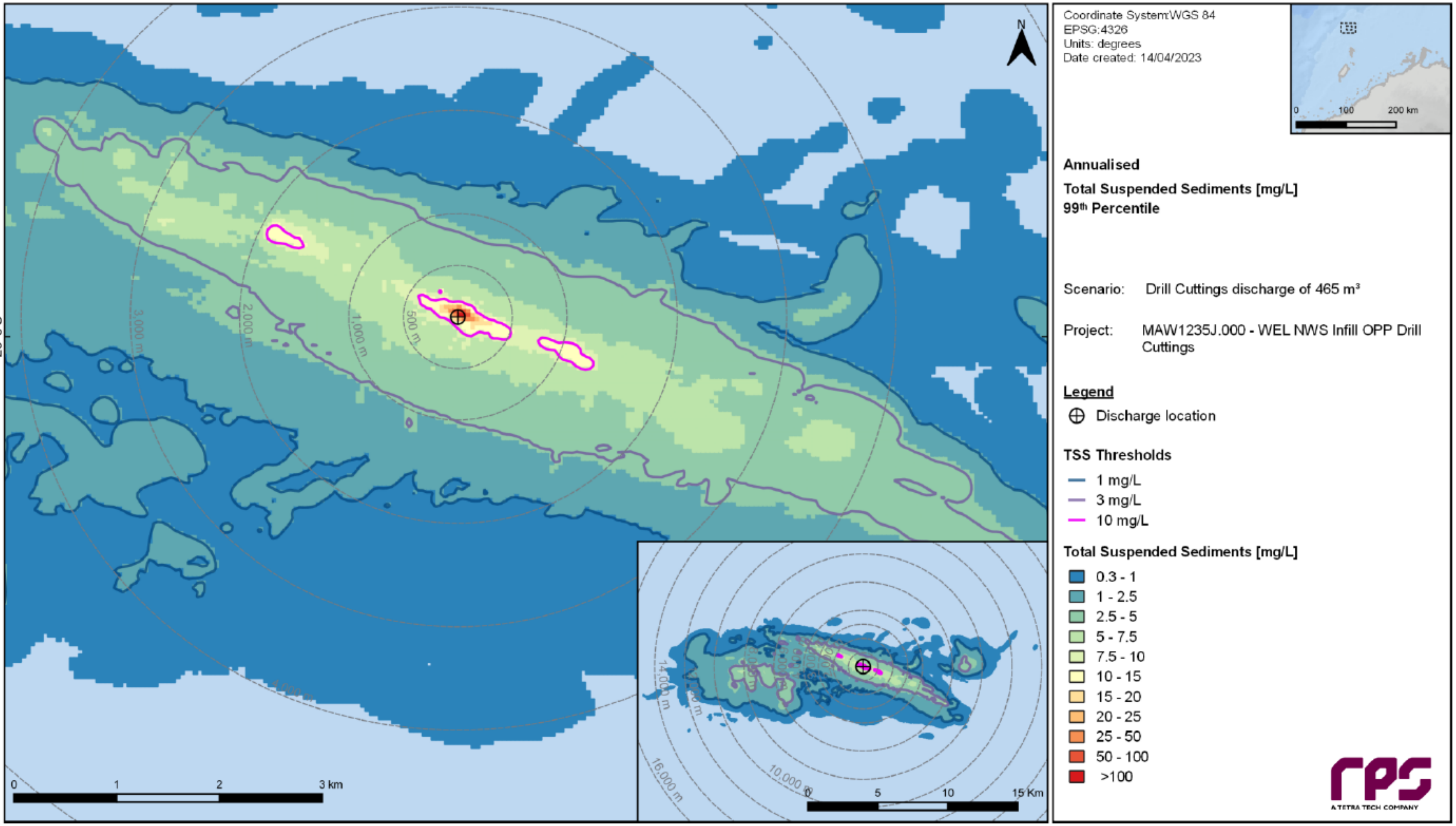
Table 9-22: Modelled maximum water column concentration, area of coverage, and distance from the discharge location for TSS exposure criteria

Season	Maximum water column concentration (m)	Total area of coverage (km^2) above threshold			Maximum distance (m) from well to threshold		
		Area of influence		Ecological impact	Area of influence		Ecological impact
		1 mg/L	3 mg/L	10 mg/L	1 mg/L	3 mg/L	10 mg/L
Highest 95th percentile value							
Summer	69.5	12.00	2.40	0.02	5,209.7	2,926.7	103.2
Winter	69.1	13.06	1.62	0.01	8,150.0	1,938.2	103.2
Transitional	84.4	17.93	2.20	0.02	8,186.2	2,569.2	142.6
Highest 99th percentile value							
Summer	196.8	49.72	11.02	0.11	12,056.9	8,937.1	393.9
Winter	178.1	49.25	10.60	0.08	11,957.2	7,301.6	1,310.5
Transitional	197.0	46.65	11.53	0.22	10,305.0	8,133.2	1,920.4



Source: (RPS 2023a)

Figure 9-8: Predicted 99th percentile sediment thickness under annualised environmental conditions



Source: (RPS 2023a)

Figure 9-9: Predicted 99th percentile water column TSS concentrations under annualised environmental conditions

9.1.10.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural
Change to water quality			✓				
Change to sediment quality		✓					
Potential changes to habitats and biological communities					✓		
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places					✓		

9.1.10.3 Consequence Evaluation

9.1.10.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Surface and subsea discharges of drill cuttings and drilling fluids will result in temporary changes to water quality. A reduction in water quality may occur via a change in suspended sediment within the water column, or from a change to the chemical content in the water column. The discharge of cuttings and drilling fluids at the surface (associated with bottom-hole drilling), is expected to result in a larger spatial change to water quality because there is a greater possibility for wider dispersal (e.g. dur to surface currents and waves) than discharging at the seabed (associated with top-hole drilling). Hinwood et al. (1994) explain that when cuttings are discharged to the ocean from the surface, the larger particles (which represent ~90% of the mass of the solids) form a plume that settles quickly to the seabed close to the release point. A similar finding was observed by Jones et al. (2021) over 95% of the cuttings were greater than 1 mm (and >35% >2 mm) and the settling time to the seabed was minutes to tens of minutes. The remaining solids form a plume in the upper water column that drifts with prevailing currents away from the platform and is diluted rapidly in the receiving waters (Neff 2005; 2010). Neff (2005) state that in well-mixed oceanic waters, the drilling cuttings and fluid plume from a surface discharge is diluted by more than 100-fold within 10 m of the discharge. Marine dispersion modelling for the Goodwyn Area Infill Development indicated that the area of influence of TSS (1–3 mg/L) ranges between ~1.9–8.2 km and ~7.3–12.0 km for 95th and 99th percentile exposures respectively (Table 9-22). Modelling also indicated that the distance to ecological impact threshold (10 mg/L) is up to ~0.1 km and ~1.9 km for 95th and 99th percentile exposures respectively (Table 9-22). Note that these results represent distances that would only be reached 5% and 1% of the time respectively, and are based on instantaneous predictions for TSS. Monitoring and modelling undertaken by Jones et al. (2021) of a drilling campaign at LPA, indicated that TSS concentrations up to 10 mg/L were possible ~1 km away from the discharge point, but these concentrations only remained for periods of minutes due to the intermittent nature of drilling discharges from the MODU. As context, Jones et al. (2021) also noted that transient peaks in TSS levels of tens or hundreds of mg/L for a few hours are common during cyclones and storms in tropical shallow water reef environments. Drilling fluid discharges are mixtures of crushed rock (drill cuttings) and drilling fluid particles; these particles contain adsorbed organic components from the WBM or NWBM. When discharged, they form a plum in the water column. Dissolved components of the plume (particularly salts and water soluble drilling fluid additives) dilute rapidly by mixing in the water column (IOGP 2016).

Receptor	Consequence Evaluation
	Fluid components of WBM currently in use are ‘non-toxic’ or ‘almost non-toxic’ (Hinwood et al. 1994). Additives to WBMs are either completely inert in the marine environment, naturally occurring benign materials, or rapidly biodegradable organic polymers. Bentonite and guar gum are listed as ‘E’ category fluids under the OCNS and are included on the Oslo Paris (OSPAR) Commission PLONOR list (chemicals that ‘pose little or no risk to the environment’) (OSPAR Commission 2009). Given their inert nature, adverse impacts to water quality from additives to WBMs are not predicted to occur. NWBM use a non-aqueous base fluid, with water and chemical additives. The environmental effects of NWBM are determined by the base fluid used; however the additives typically adsorb to particles in the cuttings (IOGP 2016). NWBM cuttings are hydrophobic and do not disperse or dissolve in the water column (IOGP 2016). As such, they are not expected to dissolve into the water column. Due to the intermittent nature of drill cuttings and drilling fluid discharges, the short (~50 days per well) drilling campaign, and that peaks in TSS are expected to only remain for periods of minutes following a discharge, the routine and non-routine discharge of drill cuttings and drilling fluids within the Project Area is expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.1.10.3.2 Change to sediment quality

Receptor	Description
Physical Environment (Marine Sediments)	Surface and subsea discharges of drill cuttings and drilling fluids could result in particles accumulating on the seabed, which may result in a localised and temporary change in sediment quality (e.g. physicochemical or composition), depending on the volume and type of contaminants. Marine dispersion modelling for the Goodwyn Area Infill Development predicted that local sedimentation would occur as a mound around the well site, and that the thickness of the deposits generated by the particles settling on the seabed decreases exponentially with distance from the drilling location (RPS 2023a). Modelling indicated that the distance to ecological impact threshold (6.5 mm) is up to ~0.2 km for 95th and 99th percentile exposures (Table 9-21). The modelling also indicated that there is no potential for thin (0.1 mm) deposits of sediment to settle out at distances >1 km (Table 9-21). Monitoring and modelling undertaken by Jones et al. (2021) of a drilling campaign at LPA, indicated that an area up to ~50 m from the drilling site showed a build-up of cuttings and muds. Beyond this distance, the build-up decreased and gradually thinned to a veneer of fine sediments. All Goodwyn Area Infill Development wells will be drilled using WBM for the top-hole sections (Section 5.3.6). As described above, additives to WBMs are either completely inert in the marine environment, naturally occurring benign materials, or rapidly biodegradable organic polymers. Most of the metals detected in drilling muds are primarily trace impurities in barite, bentonite clay, or the sedimentary rocks (drill cuttings) in the formations penetrated by the drill bit (Neff 2008). Barite and bentonite have been referred to as practically inert from a toxicological perspective (Neff 1987; Smit et al. 2008). The metals of environmental concern (because of their potential toxicity and persistence) that may be present in some drilling mud barites include cadmium, chromium, copper, mercury, lead, and zinc, which are primarily insoluble mineralised sulfide salts in the barite (Neff 2008) and have limited environmental mobility. Laboratory testing on industrial barite samples indicates that mercury and other trace metals are not released in significant quantities into seawater or the pore water of marine sediment (Crecelius et al. 2007). Given the low concentrations of trace metals within the stock barite that would be within WBM, the overall volumes of heavy metals within the drilling fluid discharges are minimal. IOGP (2016) summarised several field studies of cuttings and associated WBMs from top-hole drilling—they found that cuttings could be detected visually or as elevated barium concentrations in benthic sediments within 10–150 m of the discharge, with a greater spread down-current. This is consistent with measurements of barium in the sediment taken during a drilling campaign which showed elevated concentrations at 50 m from the drilling site, but decreased with increasing distance away (Jones et al. 2021). Jones et al. (2021) also detected some chromium around the wells, however this well below ANZG sediment quality guidelines. As such, a change in sediment quality from top-hole drilling discharges is expected to be localised to within hundreds of metres of the drilling site, and limited to inert minerals (e.g. barite) and trace amounts of mineralised metal sulfides.

Receptor	Description
	Bottom-hole drilling may be undertaken using either WBM or NWBM depending on the technical requirements for the well (Section 5.3.6). NWBM remain as non-dispersible clumps of particles if the amount of NWBM on the cuttings is high (IOGP 2016). These clumps tend to settle rapidly and accumulate on the seafloor over a small area near the discharge location (Neff 2010; IOGP 2016). NWBM discharges in water depths of <400 m are usually deposited within ~100–200 m of the discharge (IOGP 2016). WBM discharged at the surface from a drilling rig tend to disperse more widely and settle more slowly than NWBM; estimated distances for deposition range from ~100 m to >1 km (IOGP 2016). Jones et al. (2021) detected slightly elevated barium levels >2 km from the drilling site. This is consistent with other monitoring that referenced elevated sediment barium concentrations in sediment samples up to 1000 m and 3000 m from the platforms before decreasing to background levels (Jones et al. 2021). Due to the localised area of effect for sedimentation, and trace amounts of constituents of concern in drilling fluids, the routine and non-routine discharge of drill cuttings and drilling fluids within the Project Area is expected to have no lasting effect on sediment quality, and thus the consequence level is ranked as F.

9.1.10.3.3 Potential changes to habitats and biological communities

Receptor	Description
Planktonic Communities	Physicochemical changes in water quality as a result of routine and non-routine drill cuttings and drilling fluid discharges has the potential to change planktonic communities within the water column. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. As described above, predicted changes to water quality are a localised and temporary increase in suspended sediments. Adverse changes to the chemical water quality parameters are not expected to occur due to the inert nature of additives to WBMs. Therefore this evaluation is focussed on potential suspended sediment impacts to planktonic communities. Impacts to zooplankton from turbidity are associated with variations in predator–prey dynamics, which favour planktonic feeders over visual feeders (Gophen 2015). Smit et al. (2008) also suggests that impacts to zooplankton occur due to physical effects to filter-feeding and respiration organs. Impacts to phytoplankton occur with decreases in available light, which reduces productivity (Dokulil 1994). Concentrations at which impacts to phytoplankton may occur are highly localised and unlikely to occur >25 m from the discharge point (IOGP 2016; Smith, Brandsma, and Nedwed 2004). Jenkins and McKinnon (2006) reported that levels of suspended sediments greater than 500 mg/L are likely to produce a measurable impact upon larvae of most fish species, and that levels of 100 mg/L will affect the larvae of some species if exposed for >96 hours. Jenkins and McKinnon (2006) also indicated that levels of 100 mg/L may affect the larvae of several marine invertebrate species, and that fish eggs and larvae are more vulnerable to suspended sediments than older life stages. Note: Any impact to fish larvae is expected to be limited due to high natural mortality rates (McGurk 1986), intermittent exposure, and the dispersive characteristics of the open water near the wells. Previous dilution estimates (Hinwood et al. 1994; Neff 2005) suggest suspended sediment concentrations caused by the discharge of drill cuttings will be well below the levels required to cause an effect on fish or invertebrate larvae (i.e. predicted levels are well below a 96-hour exposure at 100 mg/L, or instantaneous 500 mg/L exposure). Modelling for the Goodwyn Area Infill Development indicated a maximum TSS concentration in the water column of 84.4 mg/L and 197 mg/L for 95th and 99th percentile exposures respectively (RPS 2023a). Note that these results represent distances that would only be reached 5% and 1% of the time respectively, and are based on instantaneous predictions for TSS. Further, the modelling indicated that the distance to ecological impact threshold for TSS (10 mg/L) is up to ~0.1 km and ~1.9 km for 95th and 99th percentile exposures respectively (Table 9-22). As described in the consequence evaluation above, the discharge of drill cuttings and drilling fluids within the Project Area is not expected to result in a lasting effect to water quality. Given the patchy and variable plankton communities, these discharges are unlikely to cause a change in planktonic communities at a measurable level and will not change the viability of the

Receptor	Description
	population or ecosystem. Therefore, potential changes to planktonic communities are not evaluated further
Offshore Habitats and Biological Communities	Sedimentation, and physicochemical changes sediment or water quality resulting from routine and non-routine drill cuttings and drilling fluid discharges has the potential to change benthic habitats and communities. The main environmental disturbance from discharging drill cuttings and drilling fluids is associated with smothering and burying sessile benthic and epibenthic fauna (Hinwood et al. 1994; Jones et al. 2021). Elevated TSS levels are also a well-known hazard for filter feeder communities (Jones et al. 2021). Modelling for the Goodwyn Area Infill Development indicated that the distance to ecological impact threshold for sediment (6.5 mm) is up to ~0.2 km for 95th and 99th percentile exposures respectively (Table 9-21). The largest area predicted to be exposed above this ecological threshold was ~0.05 km^2 (Table 9-21). Further, the modelling indicated a maximum bottom thickness of 69.7 mm and 72.6 mm for 95th and 99th percentile exposures respectively (RPS 2023a). This is supported by monitoring and modelling undertaken by Jones et al. (2021) of a drilling campaign at LPA, which indicated: • a zone of high impact surrounding the drilling site up to 50–75 m • an area of medium impact up to the ends of the 200 m transect lines. The zone of high impact is due to a combination of riserless top-hole sections that discharged straight to the seabed, as well as surface discharges from the MODU (Jones et al. 2021). Effects to the sparse benthic filter feeder communities close to the wells were observed, but no effects were seen on the epibenthic or demersal fish assemblages across the nearby mesophotic reef (Jones et al. 2021). Although chemicals can usually be detected within the sediment surrounding the discharge site, impacts to benthic flora and fauna are generally subtle (Cranmer 1988; Neff et al. 1989; Hyland et al. 1994; Daan and Mulder 1996; Currie and Isaacs 2005; OSPAR Commission 2009; Bakke, Klungsøyr, and Sanni 2013). An increase in NWBM in sediments may deplete oxygen in surface layers; development of hypoxia in surface layers, accompanied by increased concentrations of ammonia and sulfide, often leads to a decrease in benthic community diversity (IOGP 2016). Terrens et al. (1998) found that NWBM was not detectable in sediments after 11 months. Although some components of WBM or NWBM are potentially bioaccumulative, organisms can oxidise and expel aromatics—i.e. aromatic hydrocarbons may be bioavailable but they are not expected to bioconcentrate (Melton et al. 2000). Mobile benthic fauna (e.g. crabs, shrimps, demersal fish) tend to avoid affected areas; therefore, no impacts to these fauna are expected (IOGP 2016). Most of the metals detected in drilling muds are primarily trace impurities in barite, bentonite clay, or the sedimentary rocks (drill cuttings) in the formations penetrated by the drill bit (Neff 2008). Barite and bentonite have been referred to as practically inert from a toxicological perspective (Neff 1987; Smit et al. 2008). Trace metals within barite are primarily insoluble mineralised sulfide salts (Neff 2008). Laboratory testing on industrial barite samples indicates that mercury and other trace metals are not released in significant quantities into seawater or the pore water of marine sediment (Crecelius et al. 2007). As barite releases little of these metals to seawater or sediment pore-water, it is not likely that barite will cause environmental effects to organisms living on or near the seafloor. A study on the impacts of drilling in Bass Strait by Terrens et al. (1998) observed biological effects within 100 m of the drilling site shortly after drilling; recovery of seabed communities across the area were reported within 4 months. Neff (2010) found that recolonisation of NWBM cuttings piles in cold-water marine environments began within one to two years of ceasing discharges, after the hydrocarbon component of the cutting piles had biodegraded. Both Balcom et al. (2012) and IOGP (2016) indicate that impacts to benthic communities as a result of drill cuttings and drilling fluids discharges are minimal, resulting in highly localised impacts; benthic environments recover after drilling ceases. The studies reviewed in IOGP (2016) reported varying recovery times, but substantial recovery within one year post-drilling was common. Although recovery time may differ, species present in soft sediment are well adapted to changes in substrate, especially burrowing species (Kjeilen-Eilertsen et al. 2004), and they recover quickly. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on

Receptor	Description
	areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). Rankin Bank and Wilcox Shoal both occur within the Project Area (Section 7.5.3.6). Rankin Bank is ~8 km west of proposed drilling at the Yodel South and Rankin fields, and Wilcox Shoal is ~13 km north-east of the proposed drilling at the Wilcox field. No sedimentation (at either the ecological threshold or as a low-level veneer) is predicted to occur at any of these shallow bathymetric features because of drill cuttings or drilling fluid discharges during the Goodwyn Area Infill Development. Given the temporary and intermittent nature of the discharge, the predicted spatial extent of exposure, the predominantly soft sediment habitats within the Project Area, and that habitats and communities are expected to recover, the routine and non-routine discharge of drill cuttings and drilling fluids is not expected to result in a consequence greater than minor short-term disturbance to localised areas but not affect ecosystem function; therefore, the consequence level is ranked as D.
KEFs	Sedimentation, and physicochemical changes sediment or water quality resulting from routine and non-routine drill cuttings and drilling fluid discharges has the potential to change benthic habitats and communities. The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF (Section 7.7). Any interaction with the KEF is restricted to the northern part of the Project Area, associated with project activities within WA-5-L, WA-6-L, WA-23-L, and WA-24-L. The phased development nominal infrastructure corridor intersects with ~133 km^2 of the 16,190 km^2 KEF (i.e. ~0.0.82% of the KEF). Note: Not all of the nominal infrastructure corridor would be subject to disturbance from drill cutting and drilling fluid discharges. The largest area predicted to be exposed above this ecological threshold for sedimentation (6.5 mm) was ~0.05 km^2 (Table 9-21). Depending on the number of wells that intersect with the KEF, this will still represent a very small proportion of the overall KEF. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). Physical habitat modification is listed as a pressure within the Marine Bioregional Plan for the NWMR, but has not been identified a pressure of concern for this KEF (DSEWPaC 2012b). The potential impacts to benthic habitats and communities from drill cuttings and drilling fluid discharges are described above. Given the temporary and intermittent nature of the discharge, the predicted spatial extent of exposure, and the variable benthic habitat (sand interspersed with areas of rubble or pavement) within the KEF, the routine and non-routine discharge of drill cuttings and drilling fluids is not expected to result in a consequence greater than minor short-term disturbance to localised areas but not affect ecosystem function; therefore, the consequence level is ranked as D

9.1.10.3.4 Potential injury or mortality to fauna

Receptor	Description
Fish, Sharks and Rays ***Marine Reptiles*** ***Marine Mammals***	Physicochemical changes in water quality as a result of routine and non-routine drill cuttings and drilling fluid discharges has the potential to cause toxic effects to marine fauna within the water column. IOGP (2016) indicates that in general marine fauna are at low risk of harm from drilling discharges due primarily to the rapid rate of dilution an dispersion in the water column following discharge (IOGP 2016). WBM have been shown to have little or no toxicity to marine organisms (Jones, Hood, and Moiseychenko 1998), and that lack of toxicity and low bioaccumulation potential of the drilling fluids means that the effects of the discharges are highly localised and are not expected to spread through the food web (Neff 2010). Several metal bioaccumulation bioassays of WBM cuttings found that metal concentrations in the tissues of exposed animals were very similar to those in the tissues of unexposed animals (IOGP 2016).

Receptor	Description
	However, as described above, predicted changes to water quality are a localised and temporary increase in suspended sediments. Adverse changes to the chemical water quality parameters are not expected to occur due. Therefore, while transient marine fauna, which includes fish, marine reptiles and marine mammals, would have the potential to be exposed to these discharges, the concentration of bioavailable contaminants within the drilling fluids would be below toxicity thresholds. As such the potential for injury or death to marine fauna is not considered credible and is not evaluated further.

9.1.10.3.5 Potential changes to the values and sensitivities of protected places

Receptor	Description
Australian Marine Park	The potential for changes to the values of the Montebello Marine Park may occur from sedimentation or a change in suspended solids within the marine park resulting from the routine or non-routine discharge of drill cuttings or drilling fluids from drilling activities adjacent to the marine park associated with the Wilcox reservoir. No top holes for production wells will occur within the boundary of the marine park (Section 5.3.1). Modelling indicated that the distance to ecological impact threshold for sedimentation (6.5 mm) is up to ~0.2 km for 95th and 99th percentile exposures respectively (Table 9-21). The modelling also indicated that there is no potential for thin (0.1 mm) deposits of sediment to settle out at distances >1 km (Table 9-21). Therefore, depending on the exact location of the drilling activity, no exposure above ecological sedimentation thresholds is expected to occur within the marine park; however, some deposition (<6.5 mm thick) may occur. Modelling indicated that the distance to ecological impact threshold for TSS (10 mg/L) is up to ~0.1 km and ~1.9 km for 95th and 99th percentile exposures respectively (Table 9-21). Modelling also indicated that the area of influence of TSS (1–3 mg/L) ranges between ~1.9–8.2 km and ~7.3–12.0 km for 95th and 99th percentile exposures respectively (Table 9-22). As such, changes in suspended sediment loads are expected to occur within the marine park boundary, with concentrations depending on the exact location of the drilling activity. The values of the Montebello Marine Park (as described in Table 7-24) include ecosystems representative of the Northwest Shelf Province, including areas of ancient coastline. Benthic habitat surveys within the northern section of the marine park indicate that it is a relatively flat and sandy seabed with variable coverage of benthic epifauna (e.g. sponges, corals) (Section 7.5.3.7; (Advisian 2019)), which is similar to the benthic habitats and communities expected to occur throughout most of the Project Area, and which is broadly represented throughout the NWMR (Section 7.5.3.1). However, as described above, predicted changes to water quality are a localised and temporary increase in suspended sediments. Adverse changes to the chemical water quality parameters are not expected to occur due. Potential impacts to benthic habitats and communities are also highly localised (e.g. up to ~200 m) from a drilling location, and as such no or negligible change to benthic habitats and communities within the Montebello Marine Park is expected. Therefore, the routine and non-routine discharge of drill cuttings and drilling fluids adjacent to the Montebello Marine Park is not expected to result in a consequence greater than slight short-term disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as E.

9.1.10.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	No controls identified.
Good Industry Practice	• **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline • **CM-28**: Implement Woodside's Drilling Fluid Best Practice guidelines • **CM-29**: Implement Woodside's Reservoir, Drilling and Completions Fluids Guideline • **CM-30**: Where NWBM are selected for use, implement overburden Drilling Fluids Environmental Requirements process • **CM-31**: SCE used to treat drill cuttings returned to the MODU prior to discharge • **CM-32**: Discharge drill cuttings from the MODU below the waterline • **CM-33**: Maintain average oil on cuttings (OOC) at <6.9% by weight on wet cuttings (for sections drilled with NWBM) • **CM-34**: Prohibit bulk overboard discharge of NWBM • **CM-36**: Limit stock barite to a maximum of 1 mg/kg dry weight of mercury, and a maximum 3 mg/kg dry weight of cadmium
Professional Judgement	• **CM-07**: Consider and implement appropriate adaptive management measures during the EP process to reduce impacts on banks and shoals to ALARP • **CM-35**: No top-hole locations within the Montebello Marine Park

9.1.10.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*
Change to water quality	Physical environment			✓					A	F
Change to sediment quality	Physical environment		✓							F
Potential changes to habitats and biological communities	Planktonic communities					✓				–
	Offshore habitats and biological communities					✓				D
	KEF					✓				D
Potential injury or mortality to fauna	Fish, sharks and rays						✓			–
	Marine reptiles						✓			–
	Marine mammals						✓			–
Potential changes to the values and sensitivities of protected places	Australian Marine Park		✓	✓		✓				E

9.1.10.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-04**, and **AL-05**, as defined in Table 4-3 (and shown below in Section 9.1.10.6). As described in the consequence evaluation (Section 9.1.10.3), the predicted impacts range from no lasting effect on water and sediment quality to localised and short-term impacts to habitats, and as such are not expected to substantially affect the biodiversity, ecosystem function, integrity of the area, or values (natural, cultural, heritage, or socioeconomic) based on these attributes. Therefore, the predicted level of impact for these receptors is better than the acceptable levels (**AL-04**, **AL-05**).
Impact and Risk Classification, and Decision Type	The impacts arising from discharging drill cuttings and drilling fluids within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.10.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.10) impact analysis; therefore the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding drill cutting and drilling fluid discharges from the offshore project – this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.10.4) • Precautionary Principle – the impact consequence rating for this aspect is Minor (D), therefore, potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with predicted environmental impact and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.10) impact analysis – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	These Woodside management processes or procedures were deemed relevant for this aspect: • Chemical Selection and Assessment Environment Guideline • Drilling Fluids Management Procedure • Reservoir, Drilling and Completions Fluids Guideline • Drilling Fluids Environmental Requirements Process.

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">Control measures related to each management process or procedure have been described for this aspect (Section 9.1.10.4). As such, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding routine and non-routine discharges arising from the offshore project.</td></tr>
<tr><td rowspan="4">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
</table>

9.1.10.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids aspect are shown in the below table. For reference, the relevant acceptable level have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-12**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality from routine and non-routine drill cuttings and drilling fluid discharges during the petroleum activity **EPO-13**: No adverse effects greater than a D consequence (minor, not affecting ecosystem function) to benthic habitats and communities from routine and non-routine drill cuttings and drilling fluid discharges during the petroleum activity
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity

9.1.11 Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product

9.1.11.1 Aspect Source

The petroleum activities associated with the Goodwyn Area Infill Development that may result in cement, cementing fluids, subsea well fluids, PW, and unused bulk product discharges are described in the following table.

Activity Group	Description
Drilling and Completions	Up to 8 wells (Table 5-1) may be drilled within the Project Area as part of the Goodwyn Area Infill Development. Each production well is anticipated to take ~1–3 months from the start of

Activity Group	Description
	drilling to completions. Various products will be discharged during the drilling activities, such as cement, cementing fluids, subsea well fluids, PW, and unused bulk product. Routine discharges of cement and cementing fluids include when securing casings at the end of top-hole section drilling (discharged at seabed), flushing cement lines, and testing cement units (both discharged at surface). Some dry bulk is also released during routine cementing operations. Routine discharges are typically small (e.g. ~1 m^3 for a line flushing, ~10 m^3 for cement unit testing, or ~80 m^3 during top-hole drilling). Routine discharges of subsea fluids include control fluids during BOP testing, completion fluids during well clean-ups, completions, and unloading. Subsea control fluids are generally water-based with a glycol-based detergent or equivalent water-based anticorrosive additive; and discharges are typically small (e.g. ~10–30 L). Completion fluids are usually brines (i.e. a mixture of seawater or formation water) with additives (e.g. chlorides, bromides, hydrate inhibitor [MEG], and biocide). As described in Section 5.3.10, the wells will be flowed to back to host (i.e. the GWA platform) or flowed back to facility (i.e. the MODU). PW discharges from the MODU are considered a direct discharge under this OPP; any PW discharges from the GWA platform are an indirect discharge and these are incorporated into the assessment in Section 9.1.12. PW discharge during well unloading will be of short duration (typically occurs for ~1–2 days per well). Fluids that cannot be treated or flared will be sent onshore in tanks for disposal (Section 5.3.10). Non-routine discharges include excess dry bulk, contaminated cement, or those associated with contingency activities (e.g. re-spud, sidetracking). Unused bulk product (e.g. cement, barite, bentonite) may be discharged in bulk during or at the end of the activity if they cannot be re-used or taken back to shore. Dry bulk discharges may be in the form of dry bulk or as a slurry.
Subsea Installation and Pre-commissioning	Routine discharges of subsea fluids include control fluids when installing and testing the Xmas trees. Discharges are typically small (e.g. ~10–30 L).
Start-up and Operations	During operations well parts may require maintenance, repair, or replacement. If a well intervention or workover is required as part of subsea IMMR activities during operations, non-routine discharges may include subsea control fluids, completion fluids, and well annular fluids.
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. During decommissioning, wells will be plugged and abandoned (Section 5.6.1). During well abandonment, non-routine discharges may include subsea control fluids, well annular fluids, and cement. Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities	N/A – aspect not associated with this activity group.

9.1.11.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Change to water quality			✓				
Change to sediment quality		✓					

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural
Potential changes to habitats and biological communities					✓		
Potential changes to the values and sensitivities of protected places					✓		

9.1.11.3 Consequence Evaluation

9.1.11.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Surface and/or subsea discharges of cement, cementing fluids, subsea fluids, PW, or bulk product may result in temporary changes to water quality. A reduction in water quality may occur via a change in suspended sediment within the water column, or from a change to the chemical content in the water column. Cement-related discharges may occur at the seafloor or at the surface. Cement discharges increase the volume of suspended material in the water column, which can temporarily reduce water quality in a localised area. A surface discharge is expected to result in a larger spatial change to water quality because there is a greater possibility for wider dispersal (e.g. due to surface currents and waves) than discharging at the seabed. Modelling of cement wash out discharges for another offshore project (BP Azerbaijan 2013) was used as it provides a comparison of the potential extent of exposure from cementing activities during drilling. Two hours after the start of discharge, plume TSS concentrations were determined to be 5–50 mg/L, and the horizontal and vertical extents of the plume were ~150 m and 10 m, respectively. Four hours after ceasing the discharge, modelling indicates that the plume had dispersed to concentrations <5 mg/L (BP Azerbaijan 2013). Based on this modelling, it is conservatively estimated that changes to water quality from cement discharges will be limited to within hundreds of metres of the discharge source. Cement mixtures have the potential for toxicity due to the chemical additives that may be added. Discharge of cement mixtures is limited to the subsea release of cement (i.e. not discharge of dry cement or slurry). However, once the cement has hardened, chemical additives are locked into the cement (Terrens, Gwyther, and Keough 1998) and not are expected to pose any toxicological risk to the marine environment. Therefore adverse impacts to water quality from additives to cement mixtures are not predicted to occur. Completion fluids are generally brine with additives that can may be toxic (e.g. biocides, oxygen scavengers). PW may contain metals, hydrocarbons, glycols, phenols, organic acids, naturally occurring radioactive materials, and residual process chemicals. Changes to water quality are expected to be localised as these fluids will rapidly disperse within the Project Area. As these are intermittent discharges, any change in water quality will also be temporary and short term, due to rapid dilution from ocean currents. Control fluids are typically biodegradable and are expected to readily disperse after discharge to the marine environment. Modelling by BP (2013) indicates that a release of control fluids during BOP function testing is expected to reach a dilution of 3,000 times within a maximum displacement plume of 98 m. As the discharge of control fluids are intermittent small volumes, the subsequent changes to water quality are expected to highly localised and temporary. Therefore, routine and non-routine discharges of cement, cementing fluids, subsea fluids, PW, and bulk product within the Project Area are expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.1.11.3.2 Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	Surface and/or subsea discharges of cement, cementing fluids, or bulk product could result in particles accumulating on the seabed, which may result in a localised and temporary change in sediment quality (e.g. physicochemical or composition), depending on the volume and type of contaminants. Most cement discharges that will occur during the drilling activities will be at the seabed during cementing of the casing. Cement discharged at the seabed is not expected to disperse—it is designed to set in a marine environment and thus will set in situ, limiting its impact to the area directly around the well. BP (2013) modelled a 200 T subsurface cement discharge and determined that impacts would be limited to a radius of ~10–20 m (depending on the height of the discharge) from the well. Once overspill from cementing activities hardens, the physical sediment properties of the area directly adjacent to the well (10–50 m) will be permanently altered (Terrens, Gwyther, and Keough 1998). As described above, once cement has hardened, any chemical additives (and potential source of toxicity) is locked into the cement (Terrens, Gwyther, and Keough 1998) and is not expected to pose any toxicological risk to the marine environment. This estimated area for benthic habitat disturbance from cement discharges falls within the predicted exposure area for drill cuttings and drilling fluid discharges (Section 9.1.10). The highly localised (e.g. up to ~50 m) physical footprint at the well site is not expected to affect the overall sediment quality of the Project Area. Additional products such as barite and bentonite may be discharged in bulk during or at the end of the activity if they cannot be reused or taken back to shore. An overboard bulk discharge is expected to disperse over a wide area. Barite and bentonite have been referred to as practically inert from a toxicological perspective (Neff 1987; Smit et al. 2008). The metals of environmental concern (because of their potential toxicity and persistence) that may be present in some drilling mud barites include cadmium, chromium, copper, mercury, lead, and zinc, which are primarily insoluble mineralised sulfide salts in the barite (Neff 2008) and have limited environmental mobility. Laboratory testing on industrial barite samples indicates that mercury and other trace metals are not released in significant quantities into seawater or the pore water of marine sediment (Crecelius et al. 2007).Therefore, the routine and non-routine discharge of cement, cementing fluids, subsea fluids, PW, and bulk product within the Project Area is expected to have no lasting effect on sediment quality, and thus the consequence level is ranked as F.

9.1.11.3.3 Potential changes to habitats and biological communities

Receptor	Description
Planktonic Communities	Physicochemical changes in water quality as a result of routine and non-routine discharges of cement, cementing fluids, subsea fluids, PW, or bulk product has the potential to change planktonic communities within the water column. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. As described in the consequence evaluation above, the discharge of cement, cementing fluids, subsea fluids, PW, and bulk product within the Project Area is not expected to result in a lasting effect to water quality. Given the patchy and variable plankton communities, these discharges are unlikely to change planktonic communities at a measurable level and will not change the viability of the population or ecosystem. Therefore, potential changes to planktonic communities are not evaluated further.
Offshore Habitats and Biological Communities	Sedimentation, and physicochemical changes sediment or water quality resulting from routine and non-routine cement, cementing fluids, subsea fluids, PW, or bulk product has the potential to change benthic habitats and communities. As described in the consequence evaluation above, the discharge of cement, cementing fluids, subsea fluids, PW, and bulk product within the Project Area is not expected to result in a lasting effect to water or sediment is predicted to occur. The area of sedimentation—and therefore potential smothering or burial of benthic habitats and communities—was predicted to be highly localised (up to ~50 m) around a well site. This estimated area for benthic habitat disturbance from cement discharges falls within the predicted exposure area for drill cuttings and drilling fluid discharges (Section 9.1.10).

Receptor	Description
	An overboard bulk discharge of unused barite or bentonite is expected to disperse over a wide area. Barite and bentonite have been referred to as practically inert from a toxicological perspective (Neff 1987; Smit et al. 2008). Trace metals within barite are primarily insoluble mineralised sulfide salts (Neff 2008). Laboratory testing on industrial barite samples indicates that mercury and other trace metals are not released in significant quantities into seawater or the pore water of marine sediment (Crecelius et al. 2007). As barite releases little of these metals to seawater or sediment pore-water, it is not likely that barite will cause environmental effects to organisms living on or near the seafloor. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). The highly localised (i.e. up to ~50 m) physical footprint at the well site is not expected to affect the overall diversity or ecosystem function of the benthic communities of the Project Area. Given the temporary and intermittent nature of the discharge, the predicted spatial extent of exposure, and the predominantly soft sediment habitats within the Project Area, the routine and non-routine discharge of cement, cementing fluids, subsea fluids, PW, or bulk product is not expected to result in a consequence greater than slight short-term disturbance to localised areas but not affect ecosystem function; therefore, the consequence level is ranked as E.
KEF	Sedimentation, and physicochemical changes sediment or water quality resulting from routine and non-routine cement, cementing fluids, subsea fluids, PW, or bulk product has the potential to change benthic habitats and communities. The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF (Section 7.7). Any interaction with the KEF is restricted to the northern part of the Project Area, associated with project activities within WA-5-L, WA-6-L, WA-23-L, and WA-24-L. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). Physical habitat modification is listed as a pressure within the Marine Bioregional Plan for the NWMR, but has not been identified a pressure of concern for this KEF (DSEWPaC 2012b). The potential impacts to benthic habitats and communities are described above. Given the temporary and intermittent nature of the discharge, the predicted spatial extent of exposure, and the variable benthic habitat (sand interspersed with areas of rubble or pavement) within the KEF, the routine and non-routine discharge of drill cuttings and drilling fluids is not expected to result in a consequence greater than slight short-term disturbance to localised areas but not affect ecosystem function; therefore, the consequence level is ranked as E.

9.1.11.3.4 Potential changes to the values and sensitivities of protected places

Activity Group	Description
Australian Marine Parks	The potential for changes to the values of the Montebello Marine Park may occur from sedimentation or a change in suspended solids within the marine park resulting from the routine or non-routine discharge of cement, cementing fluids, subsea fluids, PW, or bulk product from drilling activities adjacent to the marine park associated with the Wilcox reservoir. No top holes for production wells will occur within the boundary of the marine park (Section 5.3.1). As described in the consequence evaluations above, the discharge of cement, cementing fluids, subsea fluids, PW, and bulk product within the Project Area is not expected to result in a lasting effect to water or sediment is predicted to occur. The area of sedimentation—and therefore potential smothering or burial of benthic habitats and communities—was predicted to be highly localised (up to ~50 m) around a well site. Given the highly localised (i.e. up to ~50 m) physical footprint at the well site, exposure to the Montebello Marine Park from the routine or non-routine discharge of cement, cementing fluids,

Activity Group	Description
	subsea fluids, PW, or bulk product is not predicted to occur. Therefore, potential changes to values of the Montebello Marine Park are not evaluated further.

9.1.11.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	No controls were identified.
Good Industry Practice	• **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline • **CM-28**: Implement Woodside's Drilling Fluid Best Practice guidelines • **CM-29**: Implement Woodside's Reservoir, Drilling and Completions Fluids Guideline • **CM-36**: Limit stock barite to a maximum of 1 mg/kg dry weight of mercury, and a maximum 3 mg/kg dry weight of cadmium • **CM-37**: Consider options for using excess bulk cement, bentonite, or barite, and implement as appropriate during the EP process • **CM-38**: During well unloading and completion activities (to MODU), process any produced water through the well test water filtration treatment package before discharging to the environment
Professional Judgement	• **CM-35**: No top-hole locations within the Montebello Marine Park

9.1.11.5 Impact Analysis Summary

Impact	Receptor	Environmental Value							Evaluation	
		Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***	***Decision Type***	***Consequence***
Change to water quality	Physical environment			✓					A	F
Change to sediment quality	Physical environment		✓							F
Potential changes to habitats and biological communities	Planktonic communities					✓				–
	Offshore habitats and biological communities					✓				E
	KEF					✓				E
Potential changes to the values and sensitivities of protected places	Australian Marine Park					✓				–

9.1.11.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable level for this aspect is **AL-04**, as defined in Table 4-3 (and shown below in Section 9.1.11.7). As described in the consequence evaluation (Section 9.1.11.3), the predicted impacts range from no lasting effect on water and sediment quality to localised impacts to benthic habitats, and as such are not expected to substantially affect the biodiversity, ecosystem function, integrity of the area. Therefore, the predicted level of impact for these receptors is better than the acceptable level (**AL-04**).
Impact and Risk Classification, and Decision Type	The impacts arising from discharging cement, cementing fluids, subsea fluids, PW, and bulk product within the Project Area are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.11.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.10) impact analysis; therefore the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding discharges from cement, cementing fluids, subsea fluids, PW, and bulk product from the offshore project – this impact has been identified as a lower-order impact that can be managed to an acceptable level by implementing the key control measures (Section 9.1.11.4). • Precautionary Principle – the highest impact consequence rating for this aspect is slight (E), therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with the predicted environmental impact and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.11) impact analysis – as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td>Internal Context</td><td colspan="2">These Woodside management processes or procedures were deemed relevant for this aspect:
• Chemical Selection and Assessment Environment Guideline
• Drilling Fluids Management Procedure
• Reservoir, Drilling and Completions Fluids Guideline
Control measures related to these management processes or procedures have been described for this aspect (Section 9.1.11.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding routine and non-routine discharges arising from the offshore project.</td></tr>
<tr><td rowspan="4">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
</table>

9.1.11.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPOs relevant to the Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product aspect are shown in the below table. For reference, the relevant acceptable level have also been shown against the relevant EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-14**: No adverse effects greater than an F consequence (localised, no lasting effect) to water or sediment quality from routine and non-routine cement and other drilling related discharges during the petroleum activity **EPO-15**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to benthic habitats and communities from routine and non-routine cement and other drilling related discharges during the petroleum activity

9.1.12 Downstream Discharges: Produced Water Stream

9.1.12.1 Aspect Source

While the operation of the GWA platform is out of scope of this OPP (Section 1.4.2), Woodside considers that the discharge of the PW stream is a downstream discharge of the Goodwyn Area Infill Development. As such the petroleum activities associated with the Goodwyn Area Infill Development, that will result in downstream PW stream discharges, are described in the following table. The PW stream is predominantly recovered PW, but also includes other types of fluids that are discharged via the PW system on the GWA platform.

Activity Group	Description
Drilling and Completions	As described in Section 5.3.10, the wells will be flowed to back to host (i.e. the GWA platform) or flowed back to facility (i.e. the MODU). PW discharges from the GWA platform area considered an downstream discharge under this OPP; any PW discharges from the MODU are a direct discharge and these are incorporated into the assessment in Section 9.1.11. PW discharge during well unloading will be of short duration (typically occurs for ~1–2 days per well). The discharge during well unloading will primarily be condensed water.
Subsea Installation and Pre-commissioning	If rigid flowlines are selected for use, hydrotest fluids may be produced back to the GWA platform (Section 5.4.4.3); these fluids will be treated and discharged via the PW system. Hydrotest fluids may comprise biocide, corrosion inhibitor, oxygen scavenger, scale inhibitor, MEG, and fluorescein dye.
Start-up and Operations	During commissioning and start-up, the flowlines will be dewatered. The intent for the Goodwyn Area Infill Development is for the flowline preservation fluids to dewater to host (GWA platform); these fluids will be treated and discharged via the existing PW system (Section 5.5.1). Preservation fluids are typically treated seawater that can contains chemicals such as a biocide, corrosion inhibitor, MEG, and fluorescein dye. These discharges are not continuous—they will occur once during the pre-commissioning of each flowline. The dewatering volumes will vary depending on the volume of the flowlines. During initial start-up of the production wells, any preservation fluids, residual well completion fluids, and condensed water are produced to the GWA platform. The well completion fluids and condensed water potentially contain fines coated in condensate. During steady-state operations, PW discharges will also occur from the GWA platform associated with the processing of hydrocarbons associated with the Goodwyn Area Infill Development. PW is condensed water (water vapour present within gas/condensate that condenses when brought to the surface) or formation water (derived from a water reservoir below the hydrocarbon formation), or a combination of both. Separation of water from reservoir fluids is not 100% effective and therefore, PW often contains small amounts of naturally occurring contaminants including dispersed oil, dissolved organic compounds (e.g. aliphatic and aromatic hydrocarbons, organic acids, phenols), inorganic compounds (e.g. soluble inorganic chemicals, dissolved metals) and residual process chemicals (including MEG on a non-routine basis). The composition of formation water associated with the reservoir is different to that condensed from the gas—condensed water typically has low levels of dissolved salts while formation water from the reservoir contains high levels of salts. Potential higher OIW concentrations may occur during initial start-up compared to steady-state production. Upon start-up, the production process requires heating to temperatures which promote effective OIW separation. It is expected that following the successful commissioning of each reservoir zone, the process will allow for effective OIW separation with OIW concentrations reflective of steady-state conditions. Given the phased approach, and nature of the reservoirs being targeted as part of the Goodwyn Area Infill Development, the rate of PW discharged during start-up and operations will vary, but will have an upper limit of 1,700 m^3/day. Exact PW characterisations for Goodwyn Area Infill Development are not yet available, however refer to additional information below regarding constituent analysis for Woodside's existing NWS facilities. At the start of field life for each of the wells, the PW is expected to predominantly be condensed water. When formation water does breakthrough, this is only expected to occur for a relatively short duration. The mechanism for formation water breakthrough timing and duration of water production is related to aquifer strength, where duration and breakthrough timing are expected to be inversely proportionate (i.e. early breakthrough results in short duration, and late breakthrough results in longer duration of water production). The peak water rate is expected to remain the same. Further description of the management for the PW discharges from the GWA platform is provided below.
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. During cessation of operations, any fluids within subsea infrastructure is typically displaced with inhibited seawater. The intent is that displaced fluids will be produced to the GWA platform, and discharged via the PW system.

Activity Group	Description
	Decommissioning planning for the Goodwyn Area Infill Development will align with Woodside's processes (Figure 5-3).
Field Support Activities	N/A – aspect not associated with this activity group.

9.1.12.1.1 Produced Water Stream Discharge at GWA Platform

Discharge Rates

PW is brought to the surface from the reservoir, separated out from hydrocarbons during the production process and discharged to the marine environment via the closed drains caisson (~51 m below sea level) on the GWA platform. The PW stream is predominantly this recovered PW, but also includes other types of fluids that are discharged via the PW system on the GWA platform.

The existing GWA PW system has been designed to process a maximum of 7,500 m^3/day.

Actual discharge rates are typically lower; for example, in 2020 PW stream discharge from the GWA platform from existing fields ranged from 339–2,155 m^3/day, with the higher discharge rate reflective of high water cut well production. It is acknowledged in the GWA Operations EP that PW rates may change in the future as high water cut wells are unloaded, cycled, and produced. Overall, it is expected that PW rates will increase as the existing fields age or as new fields are tied in.

The inclusion of PW stream attributable to the Goodwyn Area Infill Development, with a maximum daily upper limit of 1,700 m^3/day, will not exceed the process capacity and currently approved (within the NOPSEMA-accepted GWA Facility Operations EP) PW discharge limit of 7,500 m^3/day from the GWA platform.

Approved Mixing Zone

The PW stream discharge from the GWA platform caisson forms positively buoyant jets which rise towards the surface. As mixing increases and buoyancy of the plume erodes, and the rise towards the surface slows. On reaching the surface the plume collapses and spreads horizontally whilst mixing vertically downwards.

An Approved Mixing Zone for the PW stream from the GWA platform has been developed using PW discharge modelling and predicted no-effect concentration (PNEC) values based on WET testing results. The PW discharge model was also validated by field dye dispersion studies.

In accordance with the NOPSEMA-approved GWA Facility Operations EP, the Approved Mixing Zone is defined as 1,200 m. This mixing zone reflects 99% species protection safe dilutions at the maximum expected discharge 7,500 m^3/day.

Monitoring and Management Framework

Woodside has developed a monitoring and management framework for PW stream discharges that is currently being implemented at the GWA platform. A description of this framework (extracted from the GWA Facility Operations EP) has been provided in Appendix I.

9.1.12.1.2 Produced Water Stream Characterisation

As the reservoirs are not currently producing, exact PW characterisations for Goodwyn Area Infill Development are not yet available. However, to support the impact assessment Table 9-23 provides the highest concentrations or most toxic chemicals measured from Woodside's three NWS gas/condensate facilities (Angel, North Rankin Complex [NRC] and GWA) over the five year period 2016–2020. The samples were collected at the point of discharge (end of pipe), and dilutions to reach ANZG (2018) 99% species protection guideline values are provided where applicable.

The composition of PW is complex and may consist of components such as volatile aromatic compounds benzene, toluene, ethylbenzene, xylenes (BTEX) and polycyclic aromatic hydrocarbons

(PAHs), concentrations of which vary throughout the field life. Of the NWS facilities the greatest dilution required to meet the 99% guideline values was 680 for PAH anthracene (Table 9-23).

Table 9-23: Worst-case contaminant concentrations from the PW stream discharge from GWA, NRC, and Angel facilities between 2016 and 2020

Contaminant	99% Trigger Value (µg/L) [1]	95% Trigger Value (µg/L) [1]	Source Concentration (µg/L)	Facility and Year of PW Result	Dilution Required to Meet 99% Species Protection
Total petroleum hydrocarbon (TPH)	–	70 [2]	30,000	30 mg/L limit is a legacy of the former regulations 29 and 29A repealed in 2014	428
Benzene	500 (moderate)	700 (moderate)	9,800	NRC 2018	20
Toluene	110 (unknown)	180 (unknown)	12,000	NRC 2018	109
Ethylbenzene	50 (unknown)	80 (unknown)	650	NRC 2016	13
Phenol	270 (moderate)	400 (moderate)	9,900	NRC 2019	37
Naphthalene	50 (moderate)	70 (moderate)	180	NRC 2019	4
Phenanthrene	0.6 (unknown)	2.0 (unknown)	18	Angel 2018	30
Anthracene	0.01 (unknown)	0.4 (unknown)	6.8	Angel 2016	680
Aluminium (Al)	2.1 [3]	24 [3]	53	Angel 2018	26
Copper (Cu)	0.3 (very high)	1.3 (very high)	2	NRC 2020	7
Chromium (Cr VI)	0.14 (very high)	4.4 (very high)	5.2 (total)	Angel 2018	38
Mercury (Hg)	0.1 (very high)	0.4 (very high)	1.5	GWA 2019	15
Ammonia	500 (moderate)	910 (moderate)	29,000	Angel 2019	58

1. *ANZG (2018) guideline for 95 and 99% species protection in marine water; reliability rankings of unknown, very low, low, moderate, high and very high reliability are shown in parenthesis.*
2. *Guideline value for dispersed oil as per OSPAR (OSPAR Agreement: 2012-7)*
3. *Golding et al. (2015) and draft submission paper to the Council of Australian Government's Standing Council on Environment and Water.*

9.1.12.1.3 Produced Water Stream WET Testing

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

The results are combined by plotting a species sensitivity distribution to derive safe dilutions (50% confidence), that are calculated from the species protection triggers following the Warne et al. (2018) revised method for deriving ANZG guideline values for toxicants, to obtain estimates of safe dilution.

As the reservoirs are not currently producing, the contaminants and their concentrations in condensed or formation waters for the Goodwyn Area Infill Development are not yet available. However, to support the impact assessment Table 9-24 provides the results of WET testing from Woodside's three NWS gas/condensate facilities (Angel, NRC, and GWA) from 2017 and 2020.

Table 9-24: Actual 99% species protection safe dilutions for the PW stream at GWA, NRC, and Angel facilities

Facility	Year of Testing	Salinity (‰)	PNEC dilution (PC99)
GWA	2020	15	1 in 667
	2017	20	1 in 2000
NRC	2020	13	1 in 667
	2017	0.6	1 in 3130
Angel	2020	24	1 in 1,111
	2017	29	1 in 1900

9.1.12.1.4 Residual Process Chemicals

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

9.1.12.2 Impact Identification and Environmental Value Screening

Impact	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Change to water quality			✓				
Change to sediment quality		✓					
Potential changes to habitats and biological communities					✓		
Potential injury or mortality to fauna						✓	

9.1.12.3 Consequence Evaluation

9.1.12.3.1 Change in water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Discharge of the PW stream from the GWA platform will result in localised changes to water quality. Changes in water quality will depend on the discharge volume, rate, and chemical composition. As described above, the PW stream discharge from the GWA platform forms a positively buoyant plume. On reaching the surface the plume collapses and spreads horizontally whilst mixing vertically downwards. Based on the available worst-case PW stream compositions from Woodside's existing NWS facilities, the highest dilution required before meeting ANZG 99% species protection guidelines was 680 (Table 9-23). Modelling for the PW stream discharge at GWA (RPC 2021) predicted

Receptor	Consequence Evaluation
	7,000 and 2,040 dilutions would be achieved within 200 m from the discharge point at the 2020 maximum discharge rate (2,155 m^3/day) and maximum design discharge rate (7,500 m^3/day) respectively. Based on these dilution rates, all 99% species protection guideline values are expected to be met within 200 m of the discharge location. This is well within the 1,200 m Approved Mixing Zone for the PW stream from the GWA platform. In addition, during 2015 in situ water quality monitoring was conducted to coincide with routine end of pipe sampling for the existing PW stream discharge from the GWA platform, with results indicating the physical influence of the PW stream discharge could not be detected in the water column (to 50 m water depth) at ≥25 m from the discharge location (BMT Oceanica 2015). Given the highly localised area of exposure the discharge of PW stream attributable to Goodwyn Area Infill Development is expected to have a slight effect on water quality, and thus the consequence level is ranked as E.

9.1.12.3.2 Change in sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	Discharge of the PW stream from the GWA platform could result in particles accumulating on the seabed, which may result in a localised changes in sediment quality (e.g. physicochemical or composition). Accumulation of PW stream contaminants in sediments depends primarily on the volume/concentration of particulates in PW stream discharges or constituents that adsorb onto seawater particulates, the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths), and the re-suspension, bioturbation and microbial decay of those particulates in the water column and on the seabed. The PW stream plume is buoyant, due to lower salinity and/or higher temperature than surrounding sea water. Therefore, potential contaminants in the PW stream discharge may be introduced into sediments around the GWA platform through precipitation of soluble contaminants and flocculation and sedimentation of the particles in the PW stream plume. Studies into potential sediment accumulation from PW stream discharge have been undertaken by Woodside, including analysis of a sample of PW stream from GWA (Jacobs 2016; BMT 2021). The Jacobs (2016) study found that the PW stream at GWA had very small amounts of solid material, with very little potential of settling out due to small particle sizes (100% particles <40 µm), and that it was unlikely to flocculate. The BMT (2021) study found that 95% of particles were <72 µm, with some settling and precipitation associated with bioavailable iron. Concentration of iron in raw PW stream in 2021 was consistent with previous years (BMT 2021) and 2015 sediment sampling indicated iron concentration in sediments in close proximity to the platform (i.e. within 100 m) were consistent with concentration found in sediments 5 km from the platform (i.e. background levels), indicating no impacts to sediment from iron concentrations in PW stream (BMT Oceanica 2015). Dr Graeme Hubbert categorised particulate behaviour based on oceanographic experience and mathematical calculations using settling rates and resuspension velocities for various particle sizes. He determined that particles of a size 1–5µm would never permanently settle out of the water column, and that particles 5–40 µm would not permanently settle out of the water column, unless they were in very deep water (>5,000 m) or in areas where hydrodynamic conditions were very weak and did not continuously resuspend the particles (SKM 2013). In 2015 sediment sampling was conducted at GWA to verify impacts to sediment were not observed from PW stream discharges (BMT Oceanica 2015). Sediment samples were collected both inside and outside the Approved Mixing Zone (1,200 m) to a maximum distance of 5 km from the GWA platform. Beyond 400 m from the GWA platform, metals and hydrocarbon concentrations were consistent with background concentrations and well below ANZG Interim Sediment Quality Guideline (ISQG) trigger values, indicating no impacts to sediment due to PW stream discharges. Given the expected behaviour of particles in the PW stream discharge (i.e. that they predominantly won’t settle), the discharge of PW stream attributable to Goodwyn Area Infill Development is expected to have a slight and localised effect on sediment quality, and thus the consequence level is ranked as E.

9.1.12.3.3 Potential changes to habitats and biological communities

Activity Group	Description
Planktonic Communities	Physicochemical changes in water quality as a result of routine and non-routine drill cuttings and drilling fluid discharges has the potential to change planktonic communities within the water column. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. As described above, monitoring and modelling of the PW stream discharge plume indicates that it remains within surface waters, with 99% species protection guidelines for contaminants typically met within 200 m of the discharge location. Given the highly localised area of exposure to reduced water quality, and the patchy and variable plankton communities, the discharge of PW stream attributable to Goodwyn Area Infill Development is expected to have short-term localised effect on planktonic communities, and thus the consequence level is ranked as E.
Offshore Habitats and Biological Communities ***KEFs***	Sedimentation, and/or physicochemical changes sediment or water quality resulting from PW stream discharge from the GWA platform has the potential to change benthic habitats and communities. The GWA platform is located on the ancient coastline at 125 m depth contour KEF. However, hard substrates are not known to occur within the vicinity of the GWA platform. Sampling indicates the presence of fine sands, very find sands, and silt (BMT Oceanica 2015). As described above, sedimentation from particulates within the PW stream discharge from the GWA platform is predominantly not expected to occur, and monitoring and modelling of the PW stream discharge plume indicates that it remains within surface waters. Where changes in metals or hydrocarbon concentrations were recorded, these were within 400 m of the GWA platform (BMT Oceanica 2015). Based on the limited exposure (i.e. low to no sedimentation over a small spatial area), exposure to benthic habitats and communities that would result in an observable effect is not expected to occur and has not been evaluated further.

9.1.12.3.4 Potential injury or mortality to fauna

Activity Group	Description
Fish, Sharks and Rays ***Marine Reptiles*** ***Marine Mammals***	Physicochemical changes in water quality as a result of PW stream discharge from the GWA platform has the potential to cause toxic effects to marine fauna within the water column. Most treated PW has low to moderate toxicity (Neff, Lee, and DeBlois 2011), with actual toxicity of discharge dependant on the chemical constituents of the PW and any added process chemicals, the level of treatment and dilution with PW prior to release, and the dilution of the discharge as it mixes with sea water. Most hydrocarbons in PW are considered non-specific narcotic toxins with additive toxicities; therefore, the toxicity of a PW does, in part, depend on the total concentration and range of bioavailable hydrocarbons (Neff 2002). Based on the available WET testing results from PW stream discharges from Woodside's existing NWS facilities, the highest dilution required before meeting PNEC for 99% species protection was 2,000 (Table 9-24). Modelling for the PW stream discharge at GWA (RPC 2021) predicted 7,000 and 2,040 dilutions would be achieved within 200 m from the discharge point at the 2020 maximum discharge rate (2,155 m^3/day) and maximum design discharge rate (7,500 m^3/day) respectively. Based on these dilution rates, the 99% species protection PNEC for PW are expected to be met within 200 m of the discharge location. This is well within the 1,200 m Approved Mixing Zone for PW stream from the GWA platform. As identified in Section 7.6, several protected species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. One BIA—a foraging BIA for whale sharks—also intersects with the Project Area. Whale sharks are known to aggregate at Ningaloo between March and July. Following this aggregation period, they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). Whale shark presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas are known to occur there. Whale shark presence would also be seasonal and transitory.

Activity Group	Description
	The potential for constituents in PW to bioaccumulate in marine invertebrates and fish was investigated by Neff, Lee and DeBlois (2011). The study results indicated no bioconcentration of monocyclic aromatic hydrocarbons or phenols; and that the concentration of PAHs present in tissue samples were well below concentrations that might be harmful to the marine fauna or to humans who might collect them for food. Therefore the potential risk of bioaccumulation of PW constituents in the water column is considered to be very low. This monitoring completed in 2015 around the GWA platform (BMT Oceanica 2015) validates this conclusion: "'the potential environmental impact associated with bioaccumulation of PW constituents in the water column and in the sediments, is considered to be very low and limited to a potential localised effect on a small number of non-threated species in waters immediately surrounding each facility". Therefore, while transient marine fauna, which includes fish, marine reptiles, and marine mammals, would have the potential to be exposed to PW stream discharges from the GWA platform, the concentration of contaminants above toxicity thresholds are only predicted to occur within a highly localised area. As such consequence level is ranked as E.

9.1.12.4 Decision Type and Key Control Measure

Based on the decision support framework (Section 4.5.1) and the predicted consequences of potential impacts from Downstream Discharges: Produced Water, these have been determined as lower-order impacts (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	None identified.
Good Industry Practice	• **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline • **CM-39**: Implement Woodside's Offshore Marine Discharges Adaptive Management Plan • **CM-40**: Non-routine (potential high OIW) PW discharge activities will not occur concurrently • **CM-41**: Temporary OIW skid used during commissioning (initial start -up)

9.1.12.5 Impact Analysis Summary

		Environmental Value							Evaluation	
Impact	Receptor	*Soil and Groundwater*	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*
Change in water quality	Physical environment			✓					A	E
Change in sediment quality	Physical environment		✓							E
Potential changes to habitats and biological communities	Planktonic communities					✓				E
	Offshore habitats and communities					✓				–
	KEFs					✓				–
	Fish, sharks and rays						✓			E

Impact	Receptor	Environmental Value: Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Evaluation: Decision Type	Consequence
Potential injury or mortality to fauna	Marine reptiles						✓			E
	Marine mammals						✓			E

9.1.12.6 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts associated with the Downstream Discharges: Produced Water aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-04**, **AL-06** and **AL-07**, as defined in Table 4-3 (and shown below in Section 9.1.12.7). As described in the consequence evaluation (Section 9.1.12.3), the predicted impacts are highly localised effects on water quality, sediment quality, and planktonic communities, and as such are not expected to substantially affect the biodiversity, ecosystem function, or integrity of the area. Therefore the predicted level of impact for these receptors is better than the acceptable level (**AL-04**). The predicted impact (slight) to water quality would not cause lasting effects to marine fauna and would not be expected to result in impacts at a population level that prevent their long-term recovery or survival. Therefore, the predicted level of impact for these receptors is better than the acceptable levels (**AL-06**, **AL-07**).
Impact and Risk Classification, and Decision Type	The impacts arising from the downstream discharge of the PW stream from the GWA platform are considered lower-order impacts (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.1.12.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.1.12.3) impact analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding downstream PW stream discharge from the offshore project – this impact has been identified as a higher-order impact; however the impacts can be managed to an acceptable level by implementing the key control measures (Section 9.1.12.4) • Precautionary Principle – the impact consequence rating for this aspect is slight (E), therefore, potential for serious or irreversible environmental damage is expected

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">– although serious or irreversible environmental damage is not predicted to occur, there is some scientific uncertainty associated with the chemical characterisation of PW that will be produced from the Goodwyn Area Infill Development wells
• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.1.12) impact analysis
– as described above, the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.</td></tr>
<tr><td>Internal Context</td><td colspan="2">These Woodside management processes or procedures were deemed relevant for this aspect:
• Chemical Selection and Assessment Environment Guideline
• Offshore Marine Discharges Adaptive Management Plan.
Control measures related to each management process or procedure have been described for this aspect (Section 9.1.12.4). As such, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding downstream PW stream discharges arising from the offshore project.</td></tr>
<tr><td rowspan="4">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Technical Guidance: Protecting the Quality of Western Australia’s Marine Environment</td><td rowspan="2">The adopted key control measures (Section 9.1.12.4) has considered relevant regulatory guidance, in particular WA EPA (2016) Technical Guidance: Protecting the Quality of Western Australia’s Marine Environment and the ANZG (2018) guidelines. Both sources of regulatory guidance state that environmental values should be identified, and levels of ecological protection should then be set. To ensure ecosystem health is maintained overall, the cumulative size of the areas where lower levels of ecological protection apply should be proportionally small compared to the areas designated high and maximum. The ANZG (2018) guidelines similarly provide guidance that levels of protection should be identified, based on the environmental values to be protected.
The Monitoring and Management Framework (Appendix I) aligns to the levels of protection described by both WA EPA (2016) Technical Guidance and the ANZG (2018) guidelines through the acceptable limit of change. A maximum level of protection is required for most categories of Marine Park however a high level of protection may be appropriate for non-conservation areas as stated in the EPA</td></tr>
<tr><td>ANZG National Water Quality Guidelines</td></tr>
</table>

Acceptability Criteria	Demonstration	
		(2016) guidance. By monitoring the PW stream discharge within the Approved Mixing Zone in accordance with Woodside's Offshore Marine Discharges Adaptive Management Plan (OMDAMP) there can be high confidence that any potential for impacts can be detected and managed.

9.1.12.7 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, and equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted environmental impact (Section 4.9).

The EPO relevant to the Downstream Discharges: Produced Water aspect is shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPO. By limiting environmental change from PW stream discharges to within the Approved Mixing Zone boundary, the habitats and species within the broader NWMR are considered to be protected.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area **AL-06**: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	**EPO-16**: No impact to ecosystem integrity from PW stream outside of the Approved Mixing Zone boundary

9.2 Unplanned Events (Accidents, Incidents, Emergency Situations)

9.2.1 Physical Presence: Interaction with Marine Fauna

9.2.1.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in interactions with marine fauna are described in the following table.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (for MODU and vessel operations, refer to Field Support Activities below).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Their presence within the Project Area is temporary (e.g. a MODU and support vessels would be present for ~1–3 months per well when drilling; Section 5.3.1). The number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). During active drilling operations, the MODU would remain stationary; transit would only occur for mobilisation/demobilisation and between drill sites during the same campaign. Similarly, during active operations (e.g. installation) project vessels typically travel at relatively slow speeds (e.g. <8 knots) or are holding station.

9.2.1.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places						✓	

9.2.1.3 Consequence Evaluation

9.2.1.3.1 Potential injury or mortality to fauna

Receptor Group	Consequence Evaluation
Fish, Sharks, and Rays	The potential for unplanned interactions with marine fauna may occur from the physical presence and transit of the MODUs and vessels within the Project Area. Any potential interaction with the MODU or vessels is limited to the surface waters where these activities occur. Vessel or MODU movements can result in a vessel strike, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement, reproduction), or death.

Receptor Group	Consequence Evaluation
	Impacts resulting from vessel strike are highly influenced by vessel speed—the greater the speed at impact, the greater the risk of death (Jensen and Silber 2004; Laist et al. 2001). The fish species most vulnerable to unplanned interactions with moving MODUs or vessels include large sharks; because these species frequent the upper portions of the water column, they are the focus of this consequence evaluation. As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. One BIA—foraging BIA for whale sharks—intersects with the Project Area. The Conservation Advice for Whale Sharks (TSSC 2015f) identifies boat strike from large vessels as a threat to the species in Australia. Similarly, the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (CoA 2017a) identifies whale sharks as a species at risk. Whale sharks are known to aggregate at Ningaloo between March and July. Following this aggregation period, they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). The species is generally encountered close to or at the surface. Whale sharks tagged off WA spend ~25% of their time <2 m from the surface, and >40% of their time in the upper 15 m of the water column (Wilson et al. 2006; Gleiss et al. 2013). Whale shark presence within the Project Area would not comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent whale sharks from moving away from a moving MODU or vessels. If a vessel strike did occur, no significant impacts to populations are expected. Therefore, the physical presence of the MODU and vessels within the Project Area is not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.
Marine Reptiles	The potential for unplanned interactions with marine fauna may occur from the physical presence and transit of the MODUs and vessels within the Project Area. Any potential interaction with the MODU or vessels is limited to the surface waters where these activities occur. Marine reptile species most vulnerable to unplanned interactions with moving MODUs or vessels include marine turtles that frequent the upper portions of the water column while surfacing to rest or breathe; these are the focus of this consequence evaluation. However, it has been reported that turtles spend comparatively limited time (3–6%) at the surface, with dives generally lasting between 15 and 60 minutes (Milton and Lutz 2003). The typical response from turtles on the surface to the presence of vessels is to dive (a potential ‘startle’ response) (Hazel et al. 2007). As identified in Section 7.6.2, several marine reptile species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. An internesting buffer BIA for the flatback turtle and internesting habitat critical to the survival of the flatback turtle, intersect with the Project Area. The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies vessel disturbance as a key threat to the species. However, it also notes that this is particularly an issue in shallow coastal foraging habitats. The Project Area is in waters generally >70 , deep, except around banks and shoals; and at its closest is ~30 km from a coast (Montebello Islands). An internesting BIA and habitat critical for the survival of flatback turtles overlap the Project Area; these internesting buffers are associated with the Montebello Islands (Section 7.6.2.7). The Recovery Plan (CoA 2017b) defines the habitat critical to the survival of a species for internesting as a distance 60 km seaward from nesting habitat critical to the survival of flatback turtles. A study by Whittock et al. (2016a) indicates that the internesting behaviour of flatback turtles on the NWS appears more spatially restricted than the Recovery Plan suggests. This study reported that during their internesting periods flatback turtles prefer habitats closer to the coast (maximum 27.8 km; mean <6.1 km) and at relatively shallow depths (maximum <44 m, mean <10 m). The preference for shallow (<40 m water depth) internesting habitat is also supported by other studies (Dobbs 2007; Guinea, Sperling, and Whiting 2006; Pendoley Environmental 2010). This suggests that although the Project Area does overlap with some internesting habitat critical to the survival of flatback turtles and an internesting buffer BIA, because it is offshore (~30 km from the Montebello Islands) and has deep waters (generally >70 m, except around banks or shoals), it is considered unlikely that flatback turtles would aggregate within the Project Area during their internesting period.

Receptor Group	Consequence Evaluation
	If flatback turtles (or other marine turtles) are present within the Project Area, their presence would not comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. If a vessel strike did occur, no significant impacts to populations are expected. Therefore, the physical presence of the MODU and vessels within the Project Area is not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.
Marine Mammals	e potential for unplanned interactions with marine fauna may occur from the physical presence and transit of the MODUs and vessels within the Project Area. Any potential interaction with the MODU or vessels is limited to the surface waters where these activities occur. Whales react in various ways to the approach of a vessel—some species remain motionless when near a vessel, while others are curious and often approach vessels that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster-moving vessels (Richardson et al. 1995). Impacts resulting from vessel strikes are highly influenced by vessel speed—the greater the speed at impact, the greater the risk of death (Jensen and Silber 2004; Laist et al. 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from 10% at a speed of 4 knots, to 20% at 8.6 knots, and to 80% at 15 knots. Vessel–whale strikes at this speed are uncommon and, based on reported data contained in the US NOAA database (Jensen and Silber 2004), only two known instances of collisions have occurred when the vessel was travelling <6 knots—both were from whale-watching vessels that were deliberately placed amongst whales. As described above, project vessels typically travel at relatively slow speeds (e.g. <8 knots) or are holding station. As identified in Section 7.6.3, several marine mammal species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. No BIAs for regionally significant marine mammals intersect with the Project Area; however, two migration BIAs occur nearby—humpback whale (~2 km south) and pygmy blue whale (~15 km north-west). The Conservation Management Plan for the Blue Whale (CoA 2015a) identifies vessel disturbance as a threat to this species. Vessel strike is also identified as a threat to fin and sei whales (TSSC 2015b; 2015a). Migrating pygmy blue whales are likely to occur in the Exmouth to Montebello Islands region from April to August (northern migration) and November to December (southern migration); humpback whales are typically present from June to October. The migratory patterns of fin and sei whales within Australian waters is not well defined (Sections 7.6.3.2 and 7.6.3.5). Opportunistic cetacean sighting data from Woodside's facilities on the NWS indicate that humpback whales are the most commonly observed cetacean species (Section 7.6.3). Marine mammal presence within the Project Area are not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. There are no constraints (e.g. shallow water or shorelines) that prevent marine mammals from moving away from MODUs or vessels. If a vessel strike did occur, no significant impacts to populations are expected. Therefore, the physical presence of the MODU and vessels within the Project Area is not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population, and thus the consequence level is ranked as E.

9.2.1.3.2 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from the physical presence of the MODUs and vessels within the Project Area may occur as an indirect consequence of an impact to the marine megafauna identified as a value of the Montebello Marine Park. However, as described in the consequence evaluations for the marine fauna groups above, the physical presence of the MODU and vessels within the Project Area is not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the

	population. Therefore, no significant long-term adverse impacts to the values of the Montebello Marine Park are expected to occur, and thus the consequence level is ranked as E.

9.2.1.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequence levels and residual risk rating from Physical Presence: Interaction with Marine Fauna, these have been determined as lower-order risks (Table 4-4); therefore , decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-13**: Vessels and helicopters must comply with legislative requirements for interacting with cetaceans, including Part 8 Division 8.1 of the EPBC Regulations 2000 (Cth)
Good Industry Practice	None identified.

9.2.1.5 Likelihood Evaluation

Due to the nature and scale of MODU and vessel activities within the scope of the Goodwyn Area Infill Development, the slow-moving nature of vessels within the Project Area, and the limited area of operation, the likelihood of a vessel strike with marine fauna is considered Highly Unlikely (1).

9.2.1.6 Risk Analysis Summary

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*	*Likelihood*	*Risk Rating*
Potential injury or mortality to fauna	Fish, sharks, and rays						✓		A	E	1	Low
	Marine reptiles						✓			E	1	Low
	Marine mammals						✓			E	1	Low
Potential changes to the values and sensitivities of protected places	Australian Marine Parks						✓			E	1	Low

9.2.1.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Physical Presence: Interaction with Marine Fauna aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-05**, **AL-06**, and **AL-07**, as defined in Table 4-3 (and shown below in Section 9.2.1.8). As described in the consequence evaluation (Section 9.2.1.3), if this risk is realised, the predicted environmental impact would be injury or death to individuals and would not be expected to result in impacts at a population level that prevent their long-term recovery or survival, or any values (natural, cultural, heritage, or socioeconomic) based on these attributes. As such, the predicted level of impact to these receptors is better than the acceptable levels (**AL-05**, **AL-06**, **AL-07**).
Impact and Risk Classification, and Decision Type	The risks arising from the physical presence of moving MODUs or vessels within the Project Area are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered ‘broadly acceptable’. These risks are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.1.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.2.1) risk analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with marine fauna arising from the project – this risk has been identified as a lower-order risk that can be managed to an acceptable level by implementing the key control measures (Section 9.2.1.4) • Precautionary Principle – the residual risk rating for this aspect is low; therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with predicted environmental impact (should be risk be realised) and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.1) risk analysis – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	No specific Woodside management processes or procedures were deemed relevant for this aspect.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with marine fauna arising from the project
Other Requirements	Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.

Acceptability Criteria	Demonstration	
	Requirement	***Demonstration***
	EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans Caution and no approach zones for interacting with cetaceans from vessels	The requirements of regulations 8.05 and 8.06 for vessels interacting with cetaceans are incorporated into the key control measures (Section 9.2.1.4). The requirements of regulation 8.07 for aircraft interacting with cetaceans are incorporated into the key control measures (Section 9.2.1.49.2.1.4).
	Conservation Management Plan for the Blue Whale 2015–2025 *Management action A.4.2*: Ensure all vessel strike incidents are reported in the National Ship Strike Database *Management action A.4.3*: Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented	Requirements to report vessel strike incidents are included in Section 11.7. This section (Section 9.2.1) provides a risk evaluation for vessel strikes on blue whales, and identifies control measures. Therefore, the offshore project is not considered to be inconsistent with the Conservation Management Plan for the Blue Whale (CoA 2015a).
	Conservation Advice *Balaenoptera borealis* Sei Whale *Conservation action*: Ensure all vessel strike incidents are reported in the National Vessel Strike Database	Requirements to report vessel strike incidents are included in Section 11.7. Therefore, the offshore project is not considered to be inconsistent with the Conservation Advice *Balaenoptera borealis* Sei Whale (TSSC 2015a).
	Conservation Advice *Balaenoptera physalus* Fin Whale *Conservation action*: Ensure all vessel strike incidents are reported in the National Vessel Strike Database	Requirements to report vessel strike incidents are included in Section 11.7. Therefore, the offshore project is not considered to be inconsistent with the Conservation Advice *Balaenoptera physalus* Fin Whale (TSSC 2015b).
	Conservation Advice *Rhincodon typus* Whale Shark *Conservation action*: Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea) and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath	The Goodwyn Area Infill Development is not located in areas of whale shark aggregations (i.e. Ningaloo Reef, Christmas Island, or Coral Sea). The Project Area intersects with the 200 m isobath northward migration route (i.e. the foraging BIA) for whale sharks. However, vessel presence and movement within the Project Area will be restricted to campaign activities. Consideration of adaptive management for marine fauna interaction is incorporated into the key control measures (Section 9.2.1.4). Therefore, the offshore project is not considered to be inconsistent with the Conservation Advice for Whale Sharks (TSSC 2015f).
	Recovery Plan for Marine Turtles in Australia No specific management action identified.	N/A
	Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle)	N/A

Acceptability Criteria	Demonstration	
	No specific conservation action identified.	
	North-west Marine Parks Network Management Plan 2018 No specific zone rules identified.	N/A
	North-west Marine Parks Network Management Plan 2018 No specific zone rules identified.	N/A

9.2.1.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9).

The EPO relevant to the Physical Presence: Interaction with Marine Fauna aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park **AL-06**: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	**EPO-17**: No vessel strikes on EPBC Act listed cetaceans or other marine megafauna during the petroleum activity

9.2.2 Physical Presence: Introduction of Invasive Marine Species

9.2.2.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in the introduction of invasive marine species are described in the following table.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (for MODU and vessel operations, refer to Field Support Activities below).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Field Support Activities	Non-endemic marine species are those that have been introduced into a region beyond their natural biogeographic range and have the ability to survive, reproduce and establish founder populations. Not all non-endemic marine species introduced into an area will thrive or cause demonstrable impacts—most are relatively benign, and few have spread widely beyond sheltered ports and harbours. Only a subset of non-endemic marine species that become established, and affect the environmental, social, cultural, human health, or economic values of Australia's marine environment are considered invasive marine species (IMS).

Activity Group	Description
	The discharge of ballast water, or the presence of marine fouling on MODU and vessels, have been identified as potential pathways to introduce IMS. All MODUs and vessels experience some level of marine fouling, which occurs when organisms attach to external surfaces. Marine fouling particularly occurs on surfaces and in areas where organisms can easily attach and take hold (e.g. seams, strainers, unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests). Organisms can also be drawn into ballast tanks during when ballast water is taken in as cargo is loaded or to balance vessels under load. All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Their presence within the Project Area is temporary (e.g. a MODU and support vessels would be present for ~1–3 months per well when drilling; Section 5.3.1). The number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling, installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). MODUs and vessels may be sourced locally within Australia or from international locations, depending on the type of vessel required and availability. Any vessel arriving from an international location will need the *Biosecurity Act 2015* (Cth) requirements.

9.2.2.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Potential changes to ecosystems					✓		
Potential changes to the functions, interests, or activities of other users							✓

9.2.2.3 Consequence Evaluation

9.2.2.3.1 Potential changes to ecosystems

Receptor	Consequence Evaluation
Offshore Habitats and Biological Communities ***Key Ecological Features***	IMS are considered a significant threat to Australia's marine environment and industries (Knight et al. 2007). Introducing IMS into the local marine environment may alter the ecosystem, as IMS have characteristics that make them superior (in a survival and/or reproductive sense) to non-endemic species. They may prey on local species (which had previously not been subject to this kind of predation and therefore not have evolved protective measures against the attack), they may outcompete non-endemic species for food, space or light, and can also interbreed with local species, creating hybrids such that the endemic species is lost. Other resulting impacts from changing ecosystems include altering local nutrient cycles, increasing predation pressure, or changing the community structure/dynamics. Impacts can be temporary or permanent, depending on the receiving environment and the number of individuals introduced. Benthic habitats are most at risk from the introduction of an IMS. Establishment of IMS may change habitat composition, which leads to the creation of new habitats or fragmentation of existing habitats. A new habitat type may allow other endemic species to increase their distribution or range, thus influencing population processes of existing species. In species with limited dispersal, habitat fragmentation can isolate subpopulations, with secondary impacts to population genetics, population dynamics, species distribution, ecosystem processes, resource consumption and nutrient cycling processes.

Receptor	Consequence Evaluation
	Once established, some IMS can be difficult to eradicate; therefore, there is the potential for a long-term change in habitat structure (DAWE 2018). IMS can spread outside the area where they were introduced, potentially having widespread impacts. IMS typically require hard substrate in the photic zone; therefore, requiring shallow waters to become established. Ecosystems that are particularly susceptible to IMS colonisation are highly disturbed shallow water and coastal marine environments (Dafforn, Glasby, and Johnston 2009; Dafforn, Johnston, and Glasby 2009). Whereas IMS are generally unable to successfully establish in deep water ecosystems (Geiling 2014). The Australian Government's Bureau of Resource Sciences estimates that the median risk of establishment[58]at 3 nm, 12 nm and 24 nm is ~40%, ~28%, and ~9% respectively (Knight et al. 2007), which indicates that offshore waters are less susceptible to impacts associated with introducing an IMS. At its closest, the Project Area is ~140 km (~75 nm) north-west of Karratha, and within waters typically >70 m deep, except around banks and shoals. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (e.g. subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). Two main shallow bathymetric features are known to occur within the Project Area (Section 7.5.3.6)—Wilcox Shoal (~1 km south-east of the phased development nominal infrastructure corridor) and Rankin Bank (~5 km north-west of the proposed tie-in at LPA). Rankin Bank is considered to represent habitats that likely play an important role in the productivity of the Pilbara region—it has diverse reef and algae habitats, which support a diverse fish assemblage (AIMS 2014a; Abdul Wahab et al. 2018). The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF (Figure 9-1). The values of this KEF include providing areas of hard substrate that may provide higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). Activities for the Goodwyn Area Infill Development will occur in an open ocean offshore location more than 12 nm from the mainland, in waters >70 m deep. Despite the potential high consequence if an IMS does establish, the deep offshore open waters are not conducive to the settlement and establishment of IMS, because these is a lack of light and/or suitable habitat to sustain growth or survival. Therefore, the introduction of an IMS within the Project Area is not expected to result in a consequence greater than a slight disturbance to benthic habitats but not affecting ecosystem functions, and thus the consequence level is ranked as E.

9.2.2.3.2 Potential changes to the functions, interests, or activities of other uses

Receptor	Consequence Evaluation
Commercial Fisheries	The potential for changes to the functions, interest or activities of commercial fisheries within the Project Area may occur as an indirect consequence of an impact to the benthic habitats and communities of the marine environment if IMS became established. The establishment of IMS may cause changes to targeted species' prey abundance, distribution, or behaviour, thus impacting commercial fishery activities. IMS can also change fisheries' stock levels and locations as a result of changes in the dynamics of in the surrounding ecosystem. As identified in Section 7.10.1.1, 3 State-managed commercial fisheries may be active within the Project Area—Pilbara Trap Managed Fishery, Pilbara Line Fishery, and Mackerel Managed Fishery. Fishing effort is typically low; during the 5-year (2017–18 to 2021–22) period, the Pilbara Line Fishery recorded between <3 to 5 vessels, and the Pilbara Trap Fishery recorded <3 vessels as present within the within the 60 nm fishery grid blocks that intersect with the Project Area, while the Mackerel Managed Fishery recorded ≤3 vessels present within the 10 nm fishery grid blocks that intersect with the Project Area. As described in the consequence evaluation above, the introduction of an IMS within the Project Area is only expected to result in slight disturbance to localised areas of benthic habitat. Given

[58] In this context, establishment refers to an organism being able to find suitable habitat and survive.

Receptor	Consequence Evaluation
	the low level of fishing effort within the Project Area, and the unsuitability of the benthic habitats to support widespread IMS establishment, any impacts to commercial fisheries are not considered credible and are not evaluated further.
Tourism and Recreation	The potential for changes to the functions, interest or activities of tourism and recreational users within the Project Area may occur as an indirect consequence of an impact to the benthic habitats and communities of the marine environment if IMS became established. Due to the water depths (typically >70 m except around banks or shoals) and distance offshore, tourism and recreational activities are expected to be limited in the Project Area. Some fishing tour operators may be active within the Project Area, but recent effort is low (typically <3 active licences; Section 7.10.3). Where it does occur, charter fishing is active in the southern part of the Project Area (in the vicinity of the Montebello Marine Park) and within grid blocks known to contain shallow bathymetric features (such as banks and shoals). As described in the consequence evaluation above, the introduction of an IMS within the Project Area is only expected to result in slight disturbance to localised areas of benthic habitat. Given the low level of tourism and recreation occurring within the Project Area, and the unsuitability of the benthic habitats to support widespread IMS establishment, any impacts to tourism and recreational users are not considered credible and are not evaluated further.

9.2.2.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequence levels and residual risk rating from Physical Presence: Introduction of Invasive Marine Species, these have been determined as lower-order risks (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-42**: Vessels must comply with legislative requirements, including *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* (Cth), *Biosecurity Act 2015* (Cth), any subsequent marine orders, and any national best practice guidance
Good Industry Practice	• **CM-43**: Implement Woodside's Invasive Marine Species Management Plan

9.2.2.5 Likelihood Evaluation

MODU and vessel activities occur in deeper Commonwealth waters (not in shallow coastal areas), and with well-known and implemented IMS control measures in place, it is considered Highly Unlikely (1) that an IMS would be introduced that resulted in impacts to the ecological functions of benthic habitats and communities within the Project Area.

9.2.2.6 Risk Analysis Summary

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*	*Likelihood*	*Risk Rating*
Potential changes to ecosystems	Offshore habitats and biological communities					✓			A	E	1	Low

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence	Likelihood	Risk Rating
	Key Ecological Features					✓				E	1	Low
Potential changes to the functions, interests, or activities of other uses	Commercial fisheries							✓		–	–	–
	Tourism and recreation							✓		–	–	–

9.2.2.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Physical Presence: Introduction of Invasive Marine Species aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable level for this aspect is **AL-04**, as defined in Table 4-3 (and shown below in Section 9.2.2.8). As described in the consequence evaluation (Section 9.2.2.3), if this risk is realised the predicted environmental impact would be slight disturbance to localised areas of benthic habitat, and as such are not expected to substantially affect the biodiversity, ecosystem function, or integrity of the NWMR. Therefore, the predicted level of impact is better than the acceptable level (**AL-04**).
Impact and Risk Classification, and Decision Type	The risks arising from the introduction of an IMS within the Project Area are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These risks are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.2.4).
Principles of ESD	The principles of ESD have been considered for this aspect as follows: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.2.2) risk analysis; therefore the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding the introduction of an IMS arising from the project – this risk has been identified as a higher-order risk; however, the risks can be managed to an acceptable level by implementing the key control measures (Section 9.2.2.4) • Precautionary Principle – the highest residual risk rating for this aspect is Low, and as such the potential for serious or irreversible environmental damage is not expected to occur

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">– there is little scientific uncertainty associated with predicted environmental impact (should be risk be realised) and the anticipated effectiveness of management measures
• Intergenerational Principle
– the acceptable levels have been developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, the risks can be managed to an acceptable level for this aspect, and thus are not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined within regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.2) risk analysis
as described above, the risks can be managed to an acceptable level for this aspect, and thus are not considered to have the potential to affect biological diversity or ecological integrity.</td></tr>
<tr><td>Internal Context</td><td colspan="2">This Woodside management process or procedure was deemed relevant for this aspect:
• Invasive Marine Species Management Plan.
Control measures related to this management process or procedure have been described for this aspect (Section 9.2.2.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding the introduction of IMS arising from the project</td></tr>
<tr><td rowspan="7">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Protection of the Sea (Harmful Anti-fouling Systems) Act 2006
Gives effect to Marine Order 98</td><td>The requirements of this Act are incorporated into the key control measures (Section 9.2.2.4).</td></tr>
<tr><td>Biosecurity Act 2015
Pre-arrival reporting before arrival in Australian territory</td><td>The requirements of this Act are incorporated into the key control measures (Section 9.2.2.4).</td></tr>
<tr><td>Australian Ballast Water Management Requirements
Best practice guidance for managing ballast water within Australian seas, including legislative obligations under Biosecurity Act 2015</td><td>These requirements are incorporated into the key control measures (Section 9.2.2.4).</td></tr>
<tr><td>Australian Biofouling Management Requirements
Best practice guidance for managing biofouling within Australian seas, including legislative obligations under Biosecurity Act 2015</td><td>These requirements are incorporated into the key control measures (Section 9.2.2.4).</td></tr>
<tr><td>North-west Marine Parks Network Management Plan
The Plan requires that ‘[b]allast water discharge and exchange must be compliant with Australian ballast water management requirements administered by the Australian Maritime Safety Authority’.</td><td>Montebello Marine Park is a multiple use zone (IUCN VI). The key control measures identified for managing ballast water (Section 9.2.2.4) are in accordance with Australian requirements, and therefore also in accordance with the requirements of the multiple use zone of an Australian Marine Park.</td></tr>
</table>

Acceptability Criteria	Demonstration	
	Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A

9.2.2.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9).

The EPO relevant to the Physical Presence: Introduction of Invasive Marine Species aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-18**: No introduction and establishment of an IMS into the Project Area as a result of the petroleum activity

9.2.3 Physical Presence: Unplanned Seabed Disturbance

9.2.3.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in unplanned seabed disturbance are described in the following table.

Activity Group	Description
Drilling and Completions	Although not intentional, dropped objects may occur during drilling and completion activities, including: • geotechnical sampling—survey equipment, small tools • drilling—casings, small tools, equipment Operator error, bad weather events, or failure of equipment may lead to an object being lost overboard. A typical footprint associated with these types of dropped objects is expected to be up to ~15 m^2.
Subsea Installation and Pre-commissioning	Subsea infrastructure (e.g. manifolds, UTA) may be dropped from the vessels during subsea installation activities. A typical footprint associated with these types of dropped objects is expected to be ~150 m^2.
Start-up and Operations	During operations, objects (e.g. small tools, equipment) may be dropped during subsea IMMR activities. A typical footprint associated with these types of dropped objects is expected to be up to ~15 m^2.
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. Subsea infrastructure may be dropped from vessels during decommissioning activities (similar to the installation activity group described above).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. If a moored or hybrid MODU is used, unplanned seabed disturbance may occur because of mooring drag. High-energy weather events (e.g. cyclones) that occur while the MODU is on station, can place excessive loads on mooring lines, resulting in failure (e.g. anchors dragging, mooring lines parting). A failure of mooring integrity may drag the mooring lines and anchors attached to the MODU across the seabed.

Activity Group	Description
	Vessels will use DP, therefore anchoring is not expected to occur (Section 5.7.2). However, anchor may be required in an emergency. Unplanned seabed disturbance may occur because of vessel anchor drag. The extent of seabed disturbance will depend on the total drift or movement of the anchor/mooring and chain.

9.2.3.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural
Change to water quality			✓				
Potential changes to habitats and biological communities					✓		
Potential changes to the values and sensitivities of protected places					✓		

9.2.3.3 Consequence Evaluation

9.2.3.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Unplanned seabed disturbance has the potential to result in a localised and temporary decline in water quality due to an increase in suspended sediment. After a period, the suspended sediments settle and the turbidity in the water column returns to pre-disturbance levels. Displacing naturally occurring sediments during project activities will likely result in low levels of highly localised (within tens of metres of the disturbance area) increases in turbidity levels at the seabed; these will quickly disperse in the oceanic marine environment due to prevailing hydrodynamic conditions. Any reduction in water quality will be temporary and will be limited to the waters close to the seabed immediately surrounding the disturbance area. Low levels of sediment deposition will likely be naturally reworked into surface sediment layers through bioturbation. Sediment loads are not expected to be significant due to the relatively small footprint for each activity. Each activity near the seabed is likely to cause a single brief disturbance resulting in a transient plume of suspended sediment, within an area of predominantly soft sand habitat. Therefore, unplanned seabed disturbance associated with activities within the Project Area is expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.2.3.3.2 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Offshore Habitats and Biological Communities	Unplanned seabed disturbance has the potential to change benthic habitats and communities within the Project Area. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). The infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b).

Receptor	Consequence Evaluation
	Unplanned seabed disturbance footprints will typically range from ~15 m^2 (from tools or equipment) to ~150 m^2 (infrastructure). Note: Unplanned seabed disturbance from a mooring or anchor drag will vary, depending on the extent of the drag. This estimated extent of seabed disturbance is considered very small in relation to the extent of the soft sediment habitats, which are broadly represented within the Project Area and the wider NWMR. Physical disturbance in soft sediment habitats can disrupt the sediment structure and lead to the death or emigration of resident biota (Dernie et al. 2003). Experiments on the effects of physical disturbance to the habitat and fauna of a sheltered sandflat showed that benthic recovery occurred within ~64 days and ~208 days post-disturbance for a lower and higher intensity disturbance, respectively (Dernie et al. 2003). Rankin Bank and Wilcox Shoal both occur within the Project Area (Section 7.5.3.6) but are unlikely to be within a direct unplanned seabed disturbance footprint for the Goodwyn Area Infill Development. Wilcox Shoal is ~1 km south-east of the phased development nominal infrastructure corridor, and Rankin Bank is ~5 km north-west of the proposed tie-in at LPA. Given the distances from installation activities, and that any resuspended sediment is expected to remain localised, neither Rankin Bank or Wilcox Shoal are expected to be exposed to suspended sediments from project activities. There is a smaller shoal feature (~3.5km north-east of nominal Wilcox wells; Figure 5-2) that is within the phased development nominal infrastructure corridor and consequently could be at risk from unplanned seabed disturbance from dropped objects or mooring/anchor drag depending on the specific location and nature of any project activities. Therefore, unplanned seabed disturbance within the Project Area is not expected to result in a consequence greater than short-term disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as E.
Key Ecological Features	Unplanned seabed disturbance has the potential to result in changes to a KEF. The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF (Figure 9-1). Any interaction with the KEF is restricted to the northern part of the Project Area, associated with project activities within WA-5-L, WA-6-L, WA-23-L, and WA-24-L. Unplanned seabed disturbance footprints will typically range from ~15 m^2 (from tools or equipment) to ~150 m^2 (infrastructure). Note: Unplanned seabed disturbance from a mooring or anchor drag will vary, depending on the extent of the drag. This unplanned seabed disturbance represents a very small proportion of the 16,190 km^2 area of the KEF. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). Physical habitat modification is listed as a pressure within the Marine Bioregional Plan for the NWMR, but has not been identified a pressure of concern for this KEF (DSEWPaC 2012b). Therefore, seabed disturbance within the KEF is not expected to result in a consequence greater than slight short-term disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as E.

9.2.3.3.3 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The potential for changes to the Montebello Marine Park may occur from an unplanned seabed disturbance within the marine park boundary. No top-hole locations for production wells or other subsea infrastructure will occur within the boundary of the marine park, but it is possible the MODU mooring system may extend within the marine park boundary, depending on the type of MODU selected for activities at Wilcox reservoir. The values of the Montebello Marine Park (as described in Table 7-24) include ecosystems representative of the Northwest Shelf Province, including areas of ancient coastline. Benthic habitat surveys within the northern section of the marine park indicate that it has a relatively flat and sandy seabed with variable coverage of benthic epifauna (e.g. sponges, corals) (Section 7.5.3.7; (Advisian 2019)). This is not dissimilar to the benthic habitats and communities expected to occur throughout most of the Project Area, which are broadly represented throughout the NWMR (Section 7.5.3.1).

Receptor	Consequence Evaluation
	As described above, recovery of benthic habitats after physical disturbance are expected to occur up to ~64 days and ~208 days (for a lower and higher intensity disturbance, respectively) (Dernie et al. 2003). Therefore, seabed disturbance within the Montebello Marine Park is not expected to result in a consequence greater than slight short-term disturbance to habitats or biological communities, or affect ecosystem function, and thus the consequence level is ranked as E.

9.2.3.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequence levels and residual risk rating from Physical Presence: Unplanned Seabed Disturbance, these have been determined as lower-order risks (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	None identified.
Good Industry Practice	• **CM-05**: Undertake project-specific Mooring Design Analysis • **CM-42**: Station-keeping systems and mooring system testing implemented as per project-specific Mooring Design Analysis

9.2.3.5 Likelihood Evaluation

Industry statistics from the North Sea show that the most common failure mechanism for MODUs is single mooring line failure (33×10^{-4} per line per year), followed by double mooring line failure (11×10^{-4} per line per year) (PSA 2014). Note: Typically, single and double mooring line failures do not result in the loss of station keeping. If partial or complete mooring failures are sufficient to result in a loss of station keeping, industry experience indicates that MODUs may drift considerable distances from their initial position (Sharples, Smith, and Bea 2004). Partial mooring failures leading to a loss of station keeping resulted in smaller MODU displacements, due to the remaining anchors dragging along the seabed when compared to complete mooring failures, which resulted in a freely drifting MODU (Sharples, Smith, and Bea 2004).

As such, the likelihood of the worst-case environmental consequence occurring as described above was considered Highly Unlikely (1).

9.2.3.6 Risk Analysis Summary

		Environmental Value							Evaluation			
Risk	Receptor	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence	Likelihood	Risk Rating
Change to water quality	Physical environment			✓					A	F	1	Low
Potential changes to habitats and	Offshore habitats and biological communities					✓				E	1	Low

Risk	Receptor	Environmental Value: Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Evaluation: Decision Type	Consequence	Likelihood	Risk Rating
biological communities	Key Ecological Features					✓				E	1	Low
Potential changes to the values and sensitivities of protected places	Australian Marine Parks					✓				E	1	Low

9.2.3.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Physical Presence: Unplanned Seabed Disturbance aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-04** and **AL-05**, as defined in Table 4-3 (and shown below in Section 9.2.3.8). As described in the consequence evaluation (Section 9.2.3.3), if this risk is realised the predicted impacts range from no lasting effect on water quality to minor short-term (recoverable) effects to benthic habitat and communities; and therefore is not expected to substantially affect the biodiversity, ecosystem function, or integrity of the area, or the values (natural, cultural, heritage, or socioeconomic) based on these attributes. Therefore, the predicted level of impact to these receptors is better than the acceptable levels (**AL-04**, **AL-05**).
Impact and Risk Classification, and Decision Type	The risks arising from unplanned seabed disturbance within the Project Area are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered ‘broadly acceptable’. These risks are considered to be managed to an acceptable level by meeting legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.3.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.2.3) risk analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding unplanned seabed disturbance arising from the project – this risk has been identified as a lower-order risk that can be managed to an acceptable level by implementing the key control measures (Section 9.2.3.4) • Precautionary Principle – the highest residual risk rating for this aspect is moderate; therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with the predicted environmental impact and the anticipated effectiveness of management measures

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations
– as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.3) risk analysis
– as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.</td></tr>
<tr><td>Internal Context</td><td colspan="2">No specific Woodside management processes or procedures were deemed relevant for this aspect.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with marine users arising from the project</td></tr>
<tr><td rowspan="4">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>North-west Marine Parks Network Management Plan 2018
No specific zone rules identified.</td><td>N/A</td></tr>
<tr><td>Marine bioregional plan for the North-west Marine Region
No specific strategies or actions identified.</td><td>N/A</td></tr>
</table>

9.2.3.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9).

The EPOs relevant to the Physical Presence: Unplanned Seabed Disturbance aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area **AL-05**: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-19**: No unplanned seabed disturbance within the Project Area resulting in greater than a D consequence (minor, not affecting ecosystem function) during the petroleum activity

9.2.4 Unplanned Release: Hazardous and Non-hazardous Solid Wastes

9.2.4.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in the release of hazardous and non-hazardous solid wastes are described in the following table.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (for MODU and vessel operations, refer to Field Support Activities below).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Normal operations on the MODU and vessels generate various hazardous and non-hazardous wastes. All solid waste materials that are generated on the MODU or vessels, including hazardous wastes, are transported to the WA mainland for disposal or recycling. Non-hazardous solid wastes may include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard, scrap steel. Hazardous wastes may include oil-contaminated materials (e.g. sorbents, filters, rags), or batteries. Non-hazardous and hazardous solid wastes may be accidentally released to the marine environment because of human error, incorrect or inappropriate waste storage, or inadequate waste management.

9.2.4.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***
Change to water quality			✓				
Change to sediment quality		✓					
Potential changes to habitats and biological communities					✓		
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places						✓	

9.2.4.3 Consequence Evaluation

9.2.4.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	An unplanned release of hazardous or non-hazardous solid wastes has the potential to result in a localised and temporary change in water quality, depending on the volume and type of waste. For example, hazardous solid wastes (e.g. paint cans, oily rags) may release chemicals, which can contaminate the water in the immediate vicinity of the release. The magnitude of the water quality change will depend on the nature of the discharge. Solid waste items such as oily rags and residue from paint cans lost overboard have relatively low levels of contamination. As a comparison, modelling of small volumes of liquid hydrocarbons (Shell 2010) indicate rapid dilution in the offshore marine environment, with impacts limited to the immediate vicinity of the source. Given the relatively small volumes, and infrequent releases, only localised and temporary changes in water quality are predicted to occur. Therefore, the unplanned release of solid waste within the Project Area is expected to have no lasting effect on water quality, and thus the consequence level is ranked as F.

9.2.4.3.2 Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	An unplanned release of hazardous or non-hazardous solid wastes has the potential to result in a localised and temporary change in sediment quality, depending on the volume and type of waste. For example, if a hazardous solid waste (e.g. paint cans, oily rags) settles to the seabed, it may release chemicals that can contaminate sediments in the immediate vicinity. Solid waste dispersion varies and depends on the buoyancy of the material—metal waste is likely to sink to the seafloor near the release site, whereas plastic items may float and be transported greater distances away from the source and never settle. The magnitude of the sediment quality change will depend on the nature of the discharge. Solid waste items such as oily rags and residue from paint cans lost overboard have relatively low levels of contamination. Given the relatively small volumes, infrequent releases, and need for the solid waste to settle to the seabed, only localised and temporary changes in sediment quality are predicted to occur. Therefore, the unplanned release of solid waste within the Project Area is expected to have no lasting effect on sediment quality, and thus the consequence level is ranked as F.

9.2.4.3.3 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Offshore Habitats and Biological Communities	An unplanned release of hazardous or non-hazardous solid wastes has the potential to result in a change to water or sediment quality that subsequently leads to a change in habitats and biological communities. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna—habitat that is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). Rankin Bank (~5 km north-west of the proposed tie-in at LPA) and Wilcox Shoal (~1 km south-east of the phased development nominal infrastructure corridor) both occur within the Project Area (Section 7.5.3.6). There is also a smaller shoal feature (~3.5 km north-east of nominal Wilcox wells; Figure 5-2) that is within the phased development nominal infrastructure corridor. However, at these distances, neither Rankin Bank, Wilcox Shoal, or the smaller shoal feature are expected to be exposed to unplanned releases of solid waste from Goodwyn Area Infill Development activities. As described in the consequence evaluations above, the unplanned release of solid wastes within the Project Area is not expected to result in a lasting effect to water or sediment quality. Therefore, these releases are unlikely to cause a change in local benthic habitats and communities at a

Receptor	Consequence Evaluation
	measurable level and will not change the viability of the ecosystem. Thus, potential changes to habitats and biological communities are not evaluated further.
Key Ecological Features	An unplanned release of hazardous or non-hazardous solid wastes has the potential to result in a change to water or sediment quality that subsequently leads to a change in benthic habitats associated with KEFs. The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF. The phased development nominal infrastructure corridor intersects with ~133 km^2 of the 16,190 km^2 KEF (i.e. ~0.82% of the KEF). Any interaction with the KEF is restricted to the northern part of the Project Area, associated with project activities within WA-5-L, WA-6-L, WA-23-L, and WA-24-L. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). As described in the consequence evaluations above, the unplanned release of solid wastes within the Project Area is not expected to result in a lasting effect to water or sediment quality. Therefore, these releases are unlikely to cause a change in benthic habitats associated with KEFs at a measurable level and will not change the viability of the ecosystem. Thus, potential changes to habitats and biological communities are not evaluated further.

9.2.4.3.4 Potential injury or mortality to fauna

Receptor	Consequence Evaluation
Fish, Sharks, and Rays ***Marine Reptiles*** ***Marine Mammals*** ***Seabirds and Migratory Shorebirds***	An unplanned release of hazardous or non-hazardous solid wastes has the potential to impact marine fauna via ingestion or entanglement. Marine fauna that ingest or become entangled in solid waste may be subject to physical harm, which may limit other biologically import behaviours potentially resulting in death. Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris was listed as a key threatening process under the EPBC Act in August 2003. One harmful marine debris source identified was "vessel-sourced, solid, non-biodegradable floating materials" (CoA 2018). As identified in Section 7.6, several marine faun species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. The following BIAs intersect with the Project Area: • foraging BIA for whale sharks • internesting buffer BIA and internesting habitat critical to the survival of the flatback turtle • breeding BIA for wedge-tailed shearwater. No BIAs for regionally significant marine mammals intersect with the Project Area; however, two migration BIAs occur nearby—humpback whale (~2 km south) and pygmy blue whale (~15 km north-west). The Conservation Advice for Whale Sharks (TSSC 2015f) identifies marine debris as a threat to the species. The Threat Abatement Plan for the Impacts of Marine Debris, also identifies the grey nurse shark as a species adversely impacted by marine debris (CoA 2018). Whale shark or grey nurse shark presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there. Whale shark presence would also be seasonal and transitory. The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies marine debris as a threat to the species. The Threat Abatement Plan for the Impacts of Marine Debris, identifies the flatback, green, hawksbill, leatherback, loggerhead and olive ridley turtles, and the elegant seasnake, as marine reptile species adversely impacted by marine debris (CoA 2018). All these species (except olive ridley turtle) have a possible presence within the Project Area (Section 7.6.2). Entanglement in marine debris can lead to restricted mobility, starvation, infection, amputation, and drowning of marine turtles (CoA 2017b). Ingestion of non-organic material can cause internal wounds, suffocation, prevent feeding, or cause intestinal blockages that increase buoyance and prevent a turtle from diving (CoA 2017b). Studies suggest that up to 52% of marine turtles may have ingested marine debris (Schuyler et al. 2016; CoA 2018). The stock level risk from ingestion is unknown (CoA 2017b). Marine reptile presence within the Project Area is not expected to comprise

Receptor	Consequence Evaluation
	significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. The Conservation Management Plan for the Blue Whale (CoA 2015a) identifies marine debris as a threat to the species. The Threat Abatement Plan for the Impacts of Marine Debris, identifies multiple cetacean species as adversely impacted by marine debris (CoA 2018). Those that have also been identified as having a possible presence within the Project Area (Section 7.6.3) include various whales (blue, Bryde's, fin, humpback, sei, Blainville's beaked, Cuvier's beaked), and dolphins (Indian Ocean bottlenose and rough-toothed dolphins, killer whale). Marine mammal presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. The Wildlife Conservation Plan for Seabirds (CoA 2022c) identifies marine debris as a threat. The Threat Abatement Plan for the Impacts of Marine Debris (CoA 2018) identifies multiple seabird and migratory shorebird species as adversely impacted by marine debris. Those that have also been identified as having a possible presence within the Project Area (Section 7.6.4) include the southern giant petrel and wedge-tailed shearwater. Many species ingest considerable quantities of plastic and other marine debris, which has a wide range of lethal or sublethal effects (CoA 2022c). This debris can cause physical damage to the body, or perforate, block or impair the digestive system, resulting in starvation (CoA 2022c). Seabird and shorebird presence within the Project Area is not expected to comprise significant numbers because no known aggregation areas occur there, and their presence would be seasonal, transitory, and of a short duration. Therefore, an unplanned release of hazardous or non-hazardous solid wastes within the Project Area is not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of a marine fauna population, and thus the consequence level is ranked as E

9.2.4.3.5 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from the unplanned release of hazardous or non-hazardous solid wastes within the Project Area may occur as an indirect consequence of an impact to the marine fauna identified as a value of the Montebello Marine Park. However, as described in the consequence evaluations for the marine fauna groups above, the unplanned release of hazardous or non-hazardous solid wastes within the Project Area is not expected to result in a consequence greater than slight short-term disruption to individuals or a small proportion of the population. Therefore, no significant long-term adverse impacts to the values of the Montebello Marine Park are expected to occur, and thus the consequence level is ranked as E.

9.2.4.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequence levels and residual risk rating from Unplanned Release: Hazardous and Non-hazardous Solid Wastes, these have been determined as lower-order risks (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-01**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth) and any subsequent marine orders

Good Industry Practice	• **CM-45**: Implement waste management procedures which provide for safe handling and transportation, segregation and storage, and appropriate classification of all waste generated

9.2.4.5 Likelihood Evaluation

Marine pollution arising from offshore operations has occurred previously in the industry. Therefore, based on Woodside's likelihood descriptions in Table 4-2, the likelihood of the worst-case environmental consequence occurring (as described above) from an unplanned release of hazardous and non-hazardous solid waste is considered Unlikely (2).

9.2.4.6 Risk Analysis Summary

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*	*Likelihood*	*Risk Rating*
Change to water quality	Physical environment			✓						F	2	Low
Change to sediment quality	Physical environment		✓							F	2	Low
Potential changes to habitats and biological communities	Offshore habitats and biological communities					✓				–		–
	Key Ecological Features					✓				–		–
Potential injury or mortality to fauna	Fish, sharks, and rays						✓		A	E	2	Moderate
	Marine reptiles						✓			E	2	Moderate
	Marine mammals						✓			E	2	Moderate
	Seabirds and migratory shorebirds						✓			E	2	Moderate
Potential changes to the values and sensitivities of protected places	Australian Marine Parks					✓	✓			E	2	Moderate

9.2.4.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Unplanned Release: Hazardous and Non-hazardous Solid Wastes aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-04**, **AL-05**, **AL-06,** and **AL-07** as defined in Table 4-3 (and shown below in Section 9.2.4.8).

Acceptability Criteria	Demonstration
	As described in the consequence evaluation (Section 9.2.4.3), if this risk is realised the predicted environmental impact would be no lasting effect to water and sediment quality, and as such are not expected to substantially affect the biodiversity, ecosystem function, or integrity of the NWMR, or any values (natural, cultural, heritage, or socioeconomic) based on these attributes. The predicted environmental impact for marine fauna would be injury or death to individuals and would not be expected to result in impacts at a population level that prevent their long-term recovery or survival. Therefore, the predicted level of impact to these receptors is better than the acceptable levels (**AL-04**, **AL-05**, **AL-06**, **AL-07**).
Impact and Risk Classification, and Decision Type	The risks arising from unplanned releases of hazardous and non-hazardous solid wastes within the Project Area are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These risks are considered to be managed to an acceptable level by meeting legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.4.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.2.4) risk analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding unplanned releases of hazardous and non-hazardous solid wastes arising from the project – this risk has been identified as a lower-order risk that can be managed to an acceptable level by implementing the key control measures (Section 9.2.4.4) • Precautionary Principle – the residual risk rating for this aspect is moderate; therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with predicted environmental impact (should be risk be realised) and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.4) risk analysis – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	This Woodside management process or procedure was deemed relevant for this aspect: • Waste Management Plan for Offshore Facilities Control measures related to this management process or procedure have been described for this aspect (Section 9.2.4.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding unplanned releases of hazardous and non-hazardous solid wastes arising from the project
Other Requirements	Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.

Acceptability Criteria	Demonstration	
	Requirement	***Demonstration***
	Marine Order 95 Gives effect to Annex V of MARPOL 73/78	These requirements are incorporated into the key control measures (Section 9.2.4.4).
	Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans No specific action identified.	N/A
	Conservation Advice *Rhincodon typus* Whale Shark No specific conservation action identified	N/A
	Recovery Plan for Marine Turtles in Australia No specific management action identified.	N/A
	Conservation Management Plan for the Blue Whale No specific management action identified.	N/A
	National Recovery Plan for Threatened Albatrosses and Giant Petrels No specific action identified.	N/A
	Wildlife Conservation Plan for Seabirds No specific action identified.	N/A
	North-west Marine Parks Network Management Plan 2018 The Plan requires that 'waste from normal operations of vessels must be compliant with requirements under the International Convention for the Prevention of Pollution from Ships (MARPOL), the International Maritime Organization (IMO) convention covering prevention of pollution of the marine environment by ships from operational or accidental causes'.	Montebello Marine Park is a multiple use zone (IUCN VI). The key control measures identified for managing unplanned releases (Section 9.2.4.4) are in accordance with MARPOL requirements, and therefore also in accordance with the requirements of the multiple use zone of an Australian Marine Park.
	Marine bioregional plan for the North-west Marine Region No specific strategies or actions identified.	N/A

9.2.4.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9).

The EPOs relevant to the Unplanned Release: Hazardous and Non-hazardous Solid Wastes aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area	**EPO-20**: No unplanned release of hazardous or non-hazardous solid waste within the Project Area resulting in greater than an E consequence (slight, not affecting ecosystem function) during the petroleum activity

AL-05: No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park **AL-06**: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	

9.2.5 Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment)

9.2.5.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in an unplanned minor loss of containment (LOC) of hydrocarbon and chemicals are described in the following table.

Activity Group	Description
Drilling and Completions	An unplanned minor LOC of hydrocarbon or chemicals may occur during several drilling activities, include failure of the slip joint packer. The slip joint packer enables compensation for the dynamic movement of the MODU in relation to the static location of the BOP. A partial or total failure of the slip joint packer could result in a loss of drilling fluids to the marine environment. Catastrophic sequential failure of both slip joint packers (pneumatic and hydraulic) would trigger the alarm and result in a loss of the volume of fluid above the slip joint (conservatively 1.5 m^3) plus the volume of fluid lost in the one minute (maximum) taken to shut down the pumps. At a flow rate of ~3,700 litres per minute this volume would equate to an additional 3.8 m^3. In total, it is expected that this catastrophic failure would result in a loss of ~5.3 m^3.
Subsea Installation and Pre-commissioning	An unplanned minor LOC of chemicals may occur during subsea installation and pre-commissioning due to wet buckle event on a rigid flowline. During a wet buckle event, the full volume of a flowline is not discharged; flowline fluids are released until pressure equilibrium is reached. Section 9.1.7 (for planned (routine and non-routine) discharges of hydrocarbons or chemicals) has evaluated the impacts associated with the release of the full volume of the Wilcox flowline during hydrotesting.
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below.
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below.
Field Support Activities (MODU, Vessels, ROVs)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. An unplanned minor LOC of hydrocarbons or chemicals may occur during several activities, including: • chemical use, transfer and storage • hydraulic line failure from equipment • marine diesel bunkering (refuelling) • bulk chemical transfers between MODU and vessels. Hydrocarbons and chemicals that may be used and accidentally released include non-process chemicals (e.g. those used for maintenance or cleaning), and non-process hydrocarbons (e.g. hydraulic fluids used in equipment or machinery, fuel). A range of hydrocarbons and other chemicals are expected to be present on the vessels and/or MODU while within the Project Area; however, the maximum credible volume associated with a single-point failure was estimated to be ~1 m^3 based on the loss of an entire intermediate bulk container due to rupture while handling. A hydraulic line failure on equipment is expected to result in a small volume only (i.e. <1 m^3).

Activity Group	Description
	AMSA (2015) suggests the maximum credible spill volume from a refuelling incident with continuous supervision is approximately the transfer rate × 15 minutes. Assuming failure of dry-break couplings and an assumed 200 m^3/h transfer rate, this equates to an instantaneous released volume of ~50 m^3. For the bulk transfers of any bulk liquid (such as NWBM) between vessels and MODU, it is estimated that the worst-case credible spill could result in up to ~8 m^3 being discharged. This scenario represents a complete failure of the bulk transfer hose combined with a failure to follow procedures requiring transfer activities to be monitored, coupled with a failure to immediately shut off pumps (e.g. mud pumped through a failed transfer hose for a period of about five minutes). Woodside's operational experience demonstrates that spills are most likely to originate from hydraulic hoses and have been less than 100 L, with an average volume <10 L (0.01 m^3).

9.2.5.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***
Change to water quality			✓				
Change to sediment quality		✓					
Potential changes to habitats and biological communities					✓		
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places						✓	

9.2.5.3 Consequence Evaluation

9.2.5.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	An unplanned minor LOC of hydrocarbons and chemicals will result in localised and temporary changes to water quality. Changes in water quality will depend on the discharge volume, rate, and chemical composition. Minor LOC releases would be infrequent and are typically small volumes (e.g. ~0.01 m^3 of hydraulic fluid, ~5 m^3 of drilling fluids), which are expected to rapidly mix and disperse in the open ocean. The largest unplanned subsea release that may occur is flowline discharge during a wet buckle event. However, modelling for the full volume of Wilcox flowline being discharged during hydrotesting (refer to Section 9.1.7) indicated that rapid dilution is expected upon release, with an average of between 896–1,214 dilutions occurring within ~282 m of the discharge location (RPS 2023b). The largest unplanned surface release that may occur is during vessel bunkering (estimated at ~50 m^3). A spill of marine fuel may have an acute impact on the water column within the immediate vicinity of the release. However, considering the hydrocarbon type, dispersion and weathering is expected to be rapid, and any effects on water quality would be localised and short term. Given the surface release, a sheen is expected to occur, however given the highly volatile nature of marine fuels, the hydrocarbon is expected to rapidly evaporate within days of release.

	Therefore, an unplanned minor LOC of hydrocarbons or chemicals within the Project Area is expected to have a slight, short-term effect on water quality, and thus the consequence level is ranked as E.

9.2.5.3.2 Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	Accumulation of contaminants in sediments depends primarily on the volume and concentration of particulates in discharges or constituents that adsorb onto seawater particulates, the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths), and the resuspension, bioturbation, and microbial decay of those particulates in the water column and on the seabed. However, given the subsea discharges are expected to rapidly mix in the water column and become diluted, accumulation in sediments at a measurable level is not expected to occur. Thus, any potential change to sediment quality has not evaluated further.

9.2.5.3.3 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Planktonic Communities	Physicochemical changes in water quality resulting from an unplanned minor LOC of hydrocarbons or chemicals has the potential to change planktonic communities within the water column. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. As described in the consequence evaluation above, an unplanned minor LOC of hydrocarbons or chemicals within the Project Area may result in slight, short-term changes to water quality. Given the patchy and variable plankton communities, these discharges are unlikely to cause a change in planktonic communities at a measurable level and will not change the viability of the population or ecosystem. Therefore, potential changes to planktonic communities from a minor LOC event are also expected to be slight, and thus the consequence level is ranked as E.
Offshore Habitats and Biological Communities ***Key Ecological Features***	Physicochemical changes sediment or water quality resulting from an unplanned minor LOC of hydrocarbons or chemicals has the potential to change benthic habitats and communities. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). Rankin Bank and Wilcox Shoal both occur within the Project Area (Section 7.5.3.6). Wilcox Shoal is ~1 km south-east of the phased development nominal infrastructure corridor, and Rankin Bank is ~5 km north-west of the proposed tie-in at LPA. Given the distances to installation and operational activities, neither Rankin Bank or Wilcox Shoal are expected to be exposed to an unplanned minor LOC of hydrocarbons or chemicals from the Goodwyn Area Infill Development. There is a smaller shoal feature (~3.5km north-east of nominal Wilcox wells; Figure 5-2) that is within the phased development nominal infrastructure corridor and consequently could be at risk from unplanned minor LOC of hydrocarbons or chemicals depending on the specific location and nature of any project activities. The Project Area also partially overlaps the ancient coastline at 125 m depth contour KEF. As described in Table 7-18, the values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). As described in the consequence evaluations above, an unplanned minor LOC of hydrocarbons or chemicals within the Project Area is not expected to result in a lasting effect to water quality, and no change in sediment quality is predicted. Given the predominantly soft sediment habitats within the Project Area, these discharges are unlikely to cause a change in habitats or communities at a measurable level and will not change the viability of the population or

Receptor	Consequence Evaluation
	ecosystem. Therefore, potential changes to offshore habitats and biological communities and KEFs are not evaluated further.

9.2.5.3.4 Potential injury or mortality to fauna

Receptor	Consequence Evaluation
Fish, Sharks, and Rays ***Marine Reptiles*** ***Marine Mammals***	Physicochemical changes in water quality resulting from an unplanned minor LOC of hydrocarbons or chemicals has the potential to cause toxic effects to marine fauna within the water column. As identified in Section 7.6, several marine fauna species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the Project Area. The following BIAs intersect with the Project Area: • foraging BIA for whale sharks • internesting buffer BIA and internesting habitat critical to the survival of the flatback turtle. No BIAs for regionally significant marine mammals intersect with the Project Area; however, two migration BIAs occur nearby—humpback whale (~2 km south) and pygmy blue whale (~15 km north-west). Acute discharges are identified as threats within the Conservation Management Plan for the Blue Whale (CoA 2015a) and the Recovery Plan for Marine Turtles in Australia (CoA 2017b). As described in the consequence evaluations above, an unplanned minor LOC of hydrocarbons or chemicals within the Project Area is not expected to result in a lasting effect to water quality. If marine fauna did come into direct contact with a release some minor fouling, ingestion, tissue irritation, or inhalation may occur. However, sublethal or lethal effects from toxicity are considered unlikely given the typically small volume of an unplanned minor LOC release, and the rapid dilution and dispersion of the discharge once entering the marine environment. Therefore, while transient marine fauna, which includes fish, marine reptiles and marine mammals, would have the potential to be exposed to these unplanned releases, the concentration and duration of exposure is expected to be below the levels required to cause toxicity effects. Therefore, an unplanned minor LOC of hydrocarbons or chemicals within the Project Area is expected to have slight, short-term effects on marine fauna, and thus the consequence level is ranked as E.

9.2.5.3.5 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park). The values of the Montebello Marine Park (as described in Table 7-24) include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The potential for changes to the values of the marine park from an unplanned minor LOC of hydrocarbons or chemicals within the Project Area may occur as an indirect consequence of an impact to the marine fauna identified as a value of the Montebello Marine Park. However, as described in the consequence evaluations for the marine fauna groups above, an unplanned minor LOC of hydrocarbons or chemicals within the Project Area is may result in slight short-term effects to marine fauna. Thus the consequence level for marine park values is also ranked as E.

9.2.5.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences levels and residual risk rating from Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment), these have been determined as lower-order risks (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-27**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth), *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth), and any subsequent marine orders
Good Industry Practice	• **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline • **CM-46**: Implement Woodside's Marine Offshore Vessel Assurance Procedure • **CM-47**: Consider options for the storage, handling, and transfer of hydrocarbons and chemicals, and implement as appropriate during the EP process

9.2.5.5 Likelihood Evaluation

Marine pollution arising from offshore operations has occurred previously in the industry. Therefore, based on Woodside's likelihood descriptions in Table 4-2, the likelihood of the worst-case environmental consequence occurring (as described above) from an unplanned minor LOC of hydrocarbons or chemicals is considered Unlikely (2).

9.2.5.6 Risk Analysis Summary

		Environmental Value							Evaluation			
Risk	**Receptor**	***Soil and Groundwater***	***Marine Sediment***	***Water Quality***	***Air Quality (including Odour)***	***Ecosystems or Habitats***	***Species***	***Socioeconomic and cultural***	***Decision Type***	***Consequence***	***Likelihood***	***Risk Rating***
Change to water quality	Physical Environment			✓						E	2	Moderate
Change to sediment quality	Physical Environment		✓							–	–	–
Potential changes to habitats and biological communities	Planktonic Communities									E	2	Moderate
	Offshore Habitats and Biological Communities					✓				–	–	–
	Key Ecological Features					✓			A	–	–	–
Potential injury or mortality to fauna	Fish, Sharks, and Rays						✓			E	2	Moderate
	Marine Reptiles						✓			E	2	Moderate
	Marine Mammals						✓			E	2	Moderate
Potential changes to the values and sensitivities of protected places	Australian Marine Parks						✓			E	2	Moderate

9.2.5.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment) aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-04**, **AL-05**, **AL-06** and **AL-07,** as defined in Table 4-3 (and shown below in Section 9.2.5.8). As described in the consequence evaluation (Section 9.2.5.3), if this risk is realised the predicted environmental impact would be no lasting effect to water quality, and as such is not expected to substantially affect the biodiversity, ecosystem function, or integrity of the NWMR, or any values (natural, cultural, heritage, or socioeconomic) based on these attributes. The predicted impact would also cause no lasting effects to marine fauna and therefore and would not be expected to result in impacts at a population level that would prevent their long-term recovery or survival. Therefore, the predicted level of impact to these receptors is better than the acceptable levels (**AL-04**, **AL-05**, **AL-06**, **AL-07**).
Impact and Risk Classification, and Decision Type	The risks arising from an unplanned minor LOC of hydrocarbons or chemicals within the Project Area are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These risks are considered to be managed to an acceptable level by meeting legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.5.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.2.5) risk analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding interaction with marine fauna arising from the project – this risk has been identified as a lower-order risk that can be managed to an acceptable level by implementing the key control measures (Section 9.2.5.4) • Precautionary Principle – the residual risk rating for this aspect is low; therefore, no potential for serious or irreversible environmental damage is expected – there is little scientific uncertainty associated with predicted environmental impact (should be risk be realised) and the anticipated effectiveness of management measures • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.5) risk analysis – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td>Internal Context</td><td colspan="2">These Woodside management processes or procedures were deemed relevant for this aspect:
• Chemical Selection and Assessment Environment Guideline
• Marine Offshore Vessel Assurance Procedure.
Control measures related to these management processes or procedures have been described for this aspect (Section 9.2.5.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding an unplanned minor LOC of hydrocarbons or chemicals arising from the project</td></tr>
<tr><td rowspan="6">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Marine Order 91
Gives effect to Annex I of MARPOL 73/78</td><td>These requirements are incorporated into the key control measures (Section 9.2.5.4).</td></tr>
<tr><td>Recovery Plan for Marine Turtles in Australia
No specific management action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Management Plan for the Blue Whale
No specific management action identified.</td><td>N/A</td></tr>
<tr><td>North-west Marine Parks Network Management Plan
The Plan requires that “[a]ctions required to respond to oil pollution incidents, including environmental monitoring and remediation, in connection with mining operations authorised under the OPGGS Act may be conducted in all zones. The Director should be notified in the event of an oil pollution incident that occurs within, or may impact upon, an Australian Marine Park and, so far as reasonably practicable, prior to a response action being taken within a marine park.”</td><td>The Montebello Marine Park is a multiple use zone (IUCN VI). Requirements to report oil pollution incidents are included in Section 11.7.
Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the North-west Marine Parks Network Management Plan.</td></tr>
</table>

9.2.5.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9).

The EPOs relevant to the Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment) aspect are shown in the below table. For reference, the relevant acceptable levels have also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-04: No adverse effect on biodiversity, ecosystem function, or integrity of the NWMR such that it prevents the long-term management and protection of the Commonwealth marine area **AL-05:** No adverse effect on Australian Marine Parks such that it prevents the long-term protection and conservation of the identified values or natural resources of the marine park	**EPO-21**: No minor unplanned release of hydrocarbons or chemicals within the Project Area resulting in greater than an E consequence (slight, not affecting ecosystem function) during the petroleum activity

AL-06: No adverse effect on EPBC Act listed threatened species, or species habitat, such that it prevents their long-term recovery **AL-07**: No adverse effect on EPBC Act listed migratory species, or species habitat, such that it prevents their long-term survival	

9.2.6 Unplanned Hydrocarbon Release: Gas and Condensate

9.2.6.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in an unplanned release of gas and condensate are described in the following table.

Activity Group	Description
Drilling and Completions	Up to 8 wells (Table 5-1) may be drilled within the Project Area as part of the Goodwyn Area Infill Development. During drilling, well control techniques are used to ensure that pressure is maintained in the wellbore to prevent the flow of reservoir fluids into the wellbore. An unplanned release of reservoir fluids (gas and condensate) could occur due to a loss of well containment event. A loss of well containment event could occur for various reasons, including: • dropped objects • intersection with shallow gas • material, design, and other defects • overpressure • extreme weather • MODU anchor drag • human/management error. Loss of well containment events can range from minor leaks to blowout scenarios. Woodside has identified a well blowout during drilling as the worst-case credible scenario for this aspect (see below for further information).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group.
Start-up and Operations	During operations, hydrocarbons extracted from the reservoir will flow from the wellhead via the Xmas tree and manifolds through the flowlines to the GWA platform. An unplanned release of reservoir fluids (gas and condensate) could occur due to a flowline loss of containment event. The longest flowline, between the Wilcox reservoir and tie-in at LPA, has an estimated capacity of ~2,000 m^3. Note: A full bore rupture of a pipeline may not release the full volume of a flowline; flowline fluids will release until pressure equilibrium is reached. If a well intervention or workover is required as part of subsea IMMR activities during operations phase, an unplanned release of reservoir fluids (gas and condensate) could occur due to a loss of well containment event. A loss of well containment event could occur for various reasons, including: • loss of well integrity • premature detonation of explosives during perforation • loss of structural integrity • human/management error.
Decommissioning	Planning for decommissioning for the Goodwyn Area Infill Development is based on subsea infrastructure above the mudline being removed from the Project Area (Section 5.6.2); and this is the activity carried through the impact and risk assessment in the OPP. During decommissioning, wells will be plugged and abandoned. These activities include installing permanent reservoir barriers and removing surface equipment (Section 5.6.1). An incorrect design or application of plug and abandonment procedures could result in a loss of well containment event.

Activity Group	Description
Field Support Activities	N/A – aspect not associated with this activity group.

9.2.6.1.1 Modelling and Exposure Assessment

Credible Scenario

A well blowout event within the Project Area is considered a credible (but unlikely) unplanned event. A release of ~745,012 m^3 of condensate over a 77-day period from a well in the Wilcox reservoir was selected as the worst-case credible spill scenario for the Goodwyn Area Infill Development. This scenario is considered appropriate to inform the risk assessment because:

- The volume has been estimated based on a loss of well integrity resulting in a full well blowout. The estimate carries the worst-case assumption that blow out occurs once the well has been drilled to total depth and an unconstrained blow out occurs.
- The 77 days duration is based on Woodside's operational experience on the NWS and previous response time modelling for relief well drilling. Time frames have been informed based on vessel mobilisation, well intercept and kill estimations, and times to drill to total depth for a relief well. Redundancy has been included in this estimation for multiple attempts to kill the well.
- Pyxis (PYA-01) condensate was selected as the most appropriate analogue based on reservoir depth, properties, and location.

Spill Modelling

Quantitative hydrocarbon spill modelling was undertaken by RPS (RPS 2023c) (Appendix J) on behalf of Woodside. Two models were used:

- OILMAP-DEEP—used to simulate the nearfield multiphase plume rise dynamics from the subsea release
- SIMAP—a 3D hydrocarbon spill trajectory and weathering model designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces.

The model settings are summarised in Table 9-25.

A stochastic modelling scheme was followed in this study, whereby SIMAP was applied to repeatedly simulate the defined credible spill scenario using different samples of current and wind data. These data samples were selected randomly from an historic time-series of wind and current data representative of the study area. Results of the replicate simulations were then statistically analysed and mapped to define contours of percentage probability of contact at identified thresholds around the hydrocarbon release point. Refer to Section 9.2.7.1 for additional information on SIMAP modelling.

Table 9-25: Well loss of containment scenario model settings

Parameter	Details
Release location	19˚59'53.8" S 115˚29'38.44"E (nominal Wilcox well location)
Water depth	~80 m
Oil type	PYA-01 Condensate
Spill type	5 days surface release followed by 72 days subsurface release
Spill volume	745,012 m^3
Spill duration	77 days

Parameter	Details
Number of simulations	100 spill trajectories (25 per quarter), varying the start time (and hence prevailing wind and current conditions)

Exposure Criteria

A conservative approach to selecting thresholds was taken by adopting the NOPSEMA guideline thresholds (NOPSEMA 2019) for surface, entrained, dissolved, and accumulated shoreline hydrocarbons (Table 7-1).

The stochastic spill modelling outputs cover a larger area than that likely to be affected during any single spill event, as the model was run for a variety of weather and metocean conditions; the stochastic outputs represent the total extent of all locations where hydrocarbon thresholds could be exceeded from all modelling runs.

Hydrocarbon Characteristics

PYA-01 condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi-volatile components (Table 9-26). In favourable evaporation conditions, ~48% by mass should evaporate within the first 12 hours; up to a further ~19% should evaporate within the first 24 hours; and a further ~30% should evaporate over several days. Around 3% of the hydrocarbon is shown to be persistent (Table 9-26).

The whole condensate has a low asphaltene content (<0.5%), indicating a low propensity for the mixture to take up water to form water-in-oil emulsion over the weathering cycle (RPS 2023c).

Soluble, aromatic hydrocarbons contribute ~21.1% by mass of the whole oil (RPS 2023c). Around 10.1% by mass is highly soluble and highly volatile. A further 4% by mass has semi-to-low volatility. These compounds dissolve more slowly but tend to persist in soluble form for longer. Discharge onto the water surface will favour the evaporation process over dissolution under calm sea conditions, but increased entrainment of oil and dissolution of soluble compounds can be expected under breaking wave conditions (RPS 2023c).

Table 9-26: Physical properties and boiling point ranges for PYA-01 condensate

Characteristic	Value			
Density	0.801 g/m^3 (at 15 °C)			
Viscosity	1.39 cP (at 20 °C)			
Boiling Point	Volatile <180 °C	Semi-volatile 180–265 °C	Low volatility 265–380 °C	Residual >380 °C
	48%	19%	30%	3%

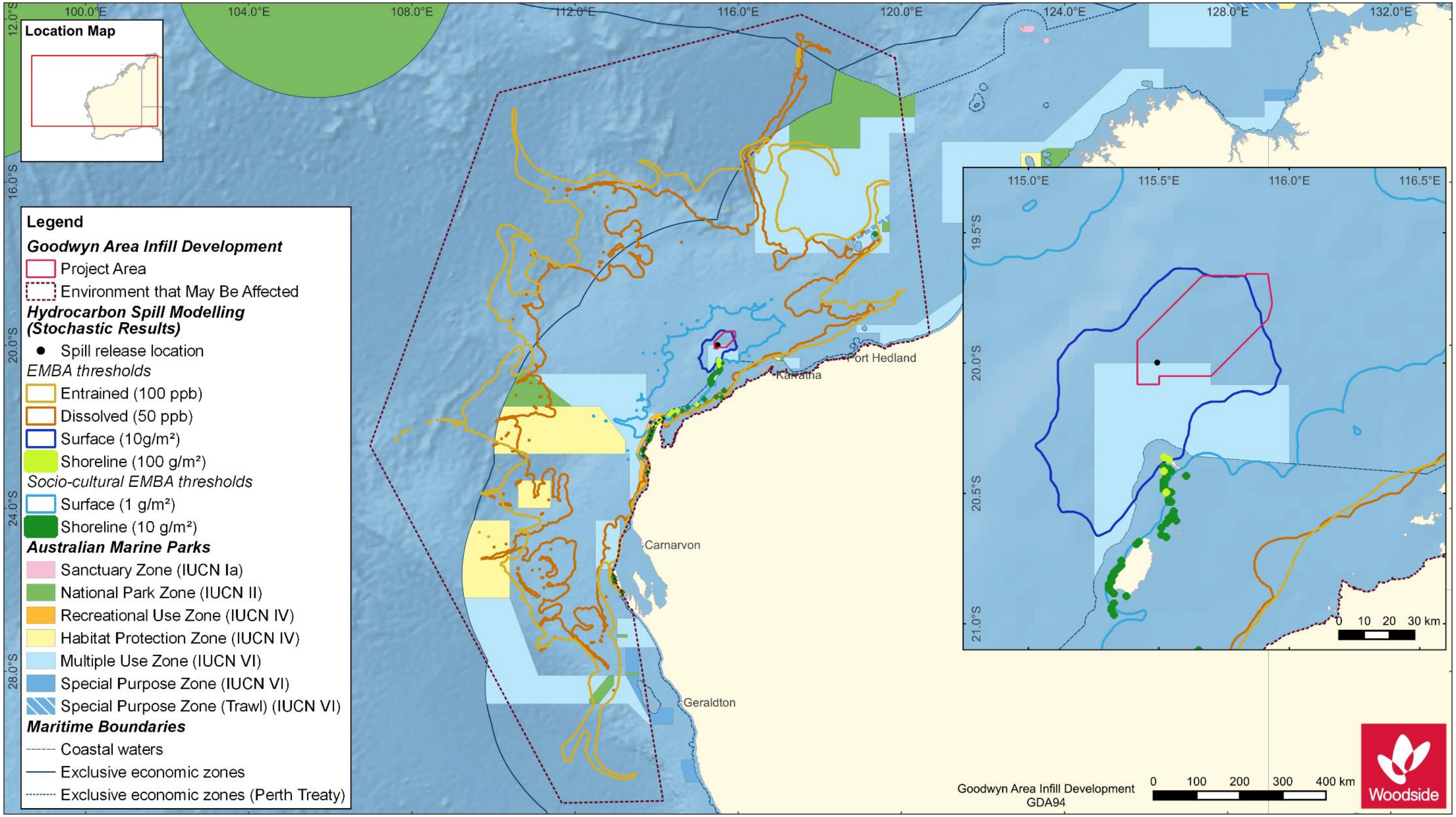
Modelling Outputs

The outputs of the quantitative hydrocarbon spill modelling were used to assess the environmental consequence by delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding selected hydrocarbon threshold concentrations if a credible hydrocarbon spill scenario occurred.

For the 745,012 m^3 MDO release within the Montebello Marine Park, stochastic modelling indicates:

- the results of the OILMAP simulation predict that the discharge will generate a cone of rising gas that will entrain the oil droplets and ambient sea water to the sea surface
- the properties of the condensate and the release conditions are expected to favour the entrainment of condensate released under the spill scenario:
  - subsurface release of ~90% of the spill volume would result in condensate releasing and rising as entrained oil, and then dispersing in the surface layer as entrained droplets

  - condensate that does form surface slicks during the initial surface release, or through floating to the surface from the subsea release phase, will more frequently entrain into the surface layer
  - entrained plumes will be subject to transport by prevailing currents, with reduced influence of the prevailing wind (compared to surface oil)
  - reduced weathering rates are also calculated for entrained oil, and consequently the entrained oil may travel larger distances than surface oil before dispersion reduces the concentration of droplets below the exposure thresholds
- the maximum distance from the release location to the ≥100 ppb impact threshold for entrained oil was ~1,206 km south
- cross-sectional transects of maximum entrained oil concentrations indicated that ≥100 ppb concentrations could extend to ~55 m below the water surface
- the maximum distance from the release location to the ≥50 ppb impact threshold for dissolved oil was ~975 km south
- cross-sectional transects of maximum dissolved oil concentrations indicated that ≥50 ppb concentrations could extend through the water to ~150 m below the water surface
- the maximum distance from the release location to the ≥1 g/m^2 visible surface threshold and the ≥10 g/m^2 surface impact threshold was ~385 km and ~271 km south-west respectively
- shoreline accumulation above the ≥100 g/m^2 impact threshold was predicted to occur on some offshore islands (Montebello, Thevenard, Peak, and Muiron islands) and parts of the western coast of North West Cape Peninsula (Figure 9-10).



Note: Stochastic outputs represent the total extent of all the locations where hydrocarbon thresholds could be exceeded from all 100 modelling runs (i.e. they are not representative of a single spill event).

Figure 9-10: Stochastic modelling contours—Surface and subsurface release of 745,012 m³ of condensate

9.2.6.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Change to water quality			✓				
Change to sediment quality		✓					
Change to air quality				✓			
Potential changes to habitats and biological communities					✓		
Potential changes to fauna behaviour						✓	
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places					✓	✓	✓
Potential changes to the functions, interests, or activities of other users							✓

9.2.6.3 Consequence Evaluation

9.2.6.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	A hydrocarbon release during a loss of well containment will result in a change to water quality within the EMBA due to hydrocarbon contamination from entrained, dissolved, or surface hydrocarbon. Condensate is a light persistent hydrocarbon, with a high proportion (~67%) of volatile and semi-volatile components. Therefore, most will evaporate within days once exposed to air on the water surface. However, during a subsurface release, entrainment is expected to occur—both during the rise through the water column, but also from wave action entraining surface droplets. Entrained hydrocarbons can persist for extended periods as it is exposed to reduced weathering rates; and will typically also disperse further under the action of prevailing currents (compared to surface hydrocarbons). Due to the weathering processes of the hydrocarbons, impacts to water quality are anticipated to be minor and long-term and/or significant and short-term as a result of hydrocarbon contamination above background levels. As such, the consequence of a release of hydrocarbons on water quality has been assessed as D.

9.2.6.3.2 Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	A hydrocarbon release during a loss of well containment may result in a change to sediment quality within the EMBA due to hydrocarbon contamination from entrained, dissolved or shoreline accumulated hydrocarbons. Studies of hydrocarbon concentrations in deep-sea sediments in the vicinity of a major well blowout indicate hydrocarbon from the blowouts can be incorporated into marine sediments; the proposed mechanism for this contamination include sedimentation of hydrocarbons and direct contact between submerged plumes and the seabed (Romero et al. 2015). If a major hydrocarbon release occurred at the seabed, modelling indicates that a pressurised release of condensate would atomise into droplets that would be transported into the water

Receptor	Consequence Evaluation
	column and to the surface. As a result, the extent of potential impacts to the seabed area at and surrounding the release site would be confined to a localised footprint. Marine sediment quality would be reduced as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term. Entrained and dissolved hydrocarbons (at or above the defined impact thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coasts (see Figure 9-10 and Appendix J). Shoreline hydrocarbons (at or above the defined impact thresholds) are also predicted to accumulate on some islands and mainland coasts. Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition shores or seabed habitat. Impacts to sediment quality are anticipated to be minor and long-term and/or significant and short-term as a result of hydrocarbon contamination above background levels. As such, the consequence of a release of hydrocarbons on water quality has been assessed as D.

9.2.6.3.3 Change to air quality

Receptor	Consequence Evaluation
Physical Environment (Air Quality)	A hydrocarbon release during a loss of well containment has the potential to result in localised, temporary reduction in air quality and contribution of GHG to the global concentration of these gases in the atmosphere. Potential impacts from reduced air quality are expected to be minor, short-term, and predominantly localised. There is potential for human health effects for workers in the immediate vicinity of atmospheric emissions. The ambient concentrations of methane and VOCs released from diffuse sources is difficult to quantify accurately, although the behaviour and fate is predictable in open offshore environments as these gases are dispersed rapidly by meteorological factors such as wind and temperature. Methane and VOC emissions from a hydrocarbon release in such environments are rapidly degraded in the atmosphere by reaction with photochemically produced hydroxyl radicals. Due to the temporary nature of any methane or VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a loss of well containment), the predicted behaviour and fate of methane and VOCs in open offshore environments, and the distance from the Project Area to the mainland sensitive air shed (e.g. Karratha is ~140 km away), an unplanned hydrocarbon release is expected to have no lasting effect on air quality, and thus the consequence level is ranked as F.

9.2.6.3.4 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Plankton Communities	Physicochemical changes in water quality because of a hydrocarbon release during a loss of well containment has the potential to change planktonic communities within the water column. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b). Plankton can occur throughout the water column, but typically they are more abundant in the surface layers. Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Primary production by plankton (supported by sporadic upwelling events in the offshore waters of the NWS) is an important component of the primary marine food web. Planktonic communities are generally mixed, including phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton, such as crustaceans (e.g. copepods), and the eggs and larvae of fish and invertebrates (meroplankton). Phytoplankton are typically not sensitive to the impacts of oil, though they do accumulate it rapidly (Hook et al. 2016). Hydrocarbons can affect the rate of photosynthesis and inhibit growth in phytoplankton, depending on the concentration range. Photosynthesis is stimulated by low concentrations of fresh oil in the water column between 10–30 ppb but becomes progressively inhibited at concentrations >50 ppb. For weathered oil, photosynthesis can be stimulated at concentrations of <100 ppb (Swan, Neff, and Young 2004). Zooplankton are vulnerable to hydrocarbons (Hook et al. 2016). Water column organisms may be affected by oil via exposure through ingestion, inhalation and dermal contact (NRDA 2012), which can cause immediate deaths or declines in reproduction (Hook et al. 2016). However, reproduction by survivors or migration from unaffected areas is likely to rapidly replenish losses

Receptor	Consequence Evaluation
	(Swan, Neff, and Young 2004). Entrained oil droplets are frequently in the food size spectra for zooplankton (Almeda et al. 2013). Lethal and sublethal effects, including narcosis, alterations in feeding, development, and reproduction have been observed in copepods exposed to petroleum hydrocarbons (Almeda et al. 2013). However, the effects on zooplankton can vary widely depending on intrinsic (e.g. species, life stage, size) and extrinsic (e.g. exposure value and duration) factors (Almeda et al. 2013). Plankton exposure to hydrocarbons in the water column can result in changes in species composition with declines or increases in one or more species or taxonomic groups (Batten, Allen, and Wotton 1998). Once background water quality conditions have re-established, the plankton community may take weeks to months to recover (ITOPF 2011), allowing for seasonal influences on the assemblage characteristics. This is due to high population turnover with copious production within short generation times that also buffers the potential for long-term (i.e. years) population decline (ITOPF 2011). Therefore, any impacts to exposed planktonic communities present within the EMBA are anticipated to be short-term, and thus the consequence level is ranked as E.
Offshore Habitats and Biological Communities	Physicochemical changes in water or sediment quality because of a hydrocarbon release during a loss of well containment has the potential to change offshore habitats and biological communities within the EMBA. The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). As described above, the extent of potential impacts to sediment quality at and surrounding the release site would be confined to a localised footprint; and consequently a similar localised footprint of impact would exist for the soft sediment habitats and communities present. Impacts to benthic communities within the Project Area would subsequently be limited to the immediate area around the release site and may include lethal or sublethal toxicity effects. **Banks and shoals** Within the offshore waters of the EMBA, impacts to benthic habitats and communities are typically not anticipated because hydrocarbons are not expected to gravitate toward the seafloor. However, geomorphic features located within the water column, such as banks and shoals, may be impacted by dissolved or entrained hydrocarbons. Rankin Bank, Glomar Shoal, and Wilcox Shoal occur within the EMBA. Rankin Bank is ~8 km west of proposed drilling at the Yodel South and Rankin fields, and Wilcox Shoal is ~13 km north-east of the proposed drilling at the Wilcox field. Glomar Shoal is located further away, ~70 km east of the Project Area. Both Rankin Bank and Glomar Shoal are considered regionally significant habitats, and it is considered that Wilcox Shoal may also show similar biodiversity (Section 7.5.3.6). Types of benthic habitats and communities known to be present at Rankin Bank and Glomar Shoal include coral reef, macroalgae, and sponges. Stochastic modelling indicated that dissolved and entrained hydrocarbons may occur within the water column (up to ~50 m for entrained and ~150 m for dissolved) (RPS 2023c). The probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved was 76% and 79% respectively for Rankin Bank, and <1% and 10% for Glomar Shoal (RPS 2023c). Given the distance (and therefore time to exposure) from a potential spill location to Rankin Bank (or Wilcox Shoal) would be much shorter compared to the distance to Glomar Shoal, hydrocarbons reaching the closer banks and shoals present a higher toxicity risk to benthic habitats because the hydrocarbon would not have undergone as much weathering. However, banks and shoals would be expected to recover over time—these habitats are subject to high levels of natural variability (AIMS 2013), suggesting that they can adapt and recover to external factors. Therefore, impacts to benthic habitats communities associated with banks and shoals within the EMBA are anticipated to be minor and long-term and/or significant and short-term as a result of hydrocarbon contamination above background levels, and associated toxicity effects. As such, the consequence of a release of hydrocarbons on offshore benthic habitats and communities has been assessed as B.

Receptor	Consequence Evaluation
Nearshore and Coastal Habitats and Biological Communities	Physicochemical changes in water or sediment quality because of a hydrocarbon release during a loss of well containment has the potential to change nearshore or coastal habitats and biological communities within the EMBA. Entrained and dissolved hydrocarbons (at or above the defined impact thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coasts (see Figure 9-10 and Appendix J). Shoreline hydrocarbons (at or above the defined impact thresholds) are also predicted to accumulate on some islands and mainland coasts. **Coral reefs** Nearshore coral reef habitats are present within the EMBA, including Montebello Islands, Barrow Island, Muiron Islands, and Ningaloo Reef (Section 7.5.4). Stochastic modelling (RPS 2023c) predicted that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved hydrocarbons was: • 97% and 92% respectively for Montebello Islands Marine Park • 98% and 96% respectively for Barrow Islands Marine Park • 99% and 98% respectively for Barrow Islands Marine Management Area • 79% and 72% respectively for Muiron Islands Marine Management Area • 76% and 70% respectively for Ningaloo Reef Marine Park • 72% and 57% respectively for Ningaloo Reef. With reference to Ningaloo Reef, wave-induced water circulation flushes the lagoon and may promote the removal of entrained and dissolved hydrocarbons from this particular reef habitat. Under typical conditions, breaking waves on the reef crest induce a rise in water level in the lagoon creating a pressure gradient that drives water in a strong outward flow through channels. Exposure to entrained (≥100 ppb) or dissolved (≥50 ppb) hydrocarbons has the potential to result in lethal or sublethal toxic effects to corals. Shallow coral habitats (i.e. nearshore and intertidal waters) are most vulnerable to hydrocarbons through coating by direct contact with surface slicks during periods when corals are exposed at spring low tides. Direct contact can cause smothering, resulting in a decline in metabolic rate, and may cause varying degrees of tissue decomposition and death. A range of impacts may also result from toxicity, including partial mortality of colonies, reduced growth rates, bleaching, and reduced photosynthesis (Shigenaka 2001; Negri and Heyward 2000). Water-soluble hydrocarbon fractions associated with surface slicks are known to cause high coral mortality (Shigenaka 2001) via direct physical contact of hydrocarbon droplets to sensitive coral species (such as the branching coral species). Sublethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward 2000). In the unlikely event of a spill occurring at the time of coral spawning at potentially affected coral locations or in the general peak period of biological productivity, there is the potential for a significant reduction in successful fertilisation and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons (Negri and Heyward 2000). Such impacts are likely to result in the failure of recruitment and settlement of new population cohorts. In addition, some non-coral species may be affected via direct contact with entrained and dissolved aromatic hydrocarbons, resulting in sublethal impacts and in some cases death. This is with particular reference to the early life-stages of coral reef animals (reef-attached fishes and reef invertebrates), which can be relatively sensitive to hydrocarbon exposure. Coral reef fish are site attached, have small home ranges and, as reef residents, they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities (which may include fringing reefs of the offshore islands and/or the Ningaloo reef system) will depend on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. Coral community live cover, structure and composition may reduce in hydrocarbon-impacted areas, manifested by loss of corals and associated sessile biota. Recovery of impacted reef areas from a range of stressors typically relies on coral larvae from neighbouring coral communities that have either not been affected or only partially affected. For example, there is evidence that Ningaloo Reef corals and fish are partly self-seeding (Underwood 2009) with the supply of larvae from locations within Ningaloo Reef of critical importance to the healthy maintenance of the coral communities. Recovery at other coral reef areas may not be aided by a large supply of larvae from other reefs, with levels of recruits after a

Receptor	Consequence Evaluation
	disturbance event only returning to previous levels after the numbers of reproductive corals had also recovered (Gilmour et al. 2013). A hydrocarbon spill may result in large-scale impacts to coral reefs within the EMBA, including around Ningaloo Reef, Montebello and Barrow Islands, with long-term effects (recovery >10 years) likely. **Seagrass and macroalgae** Nearshore seagrass and macroalgae habitats are present within the EMBA, including at Montebello Islands, Barrow Island, Muiron Islands, and Ningaloo Reef (Section 7.5.4). As described above, stochastic modelling (RPS 2023c) predicted exposure to these areas above ≥100 ppb for entrained and ≥50 ppb for dissolved impact thresholds. Macroalgae within the intertidal and shallow subtidal zone may be susceptible to impacts from hydrocarbons, ranging from potentially sublethal to lethal impacts. The toxicity of macroalgae to hydrocarbons varies for the different macroalgal life stages—gametes, larva and zygote stages are more sensitive and responsive to oil exposure than adult stages (Thursby and Steele 1984; Lewis and Pryor 2013). In macroalgae, oil can act as a physical barrier for diffusing CO_2 across cell walls (O'Brien and Dixon 1976). However, the effect of hydrocarbons largely depends on the degree of direct exposure and how much of the hydrocarbon adheres to algae, which will vary depending on the oil's physical state and relative 'stickiness'. Where impact occurs, recovery is expected. Recovery of algae is attributed to new growth being produced from near the base of the plant while the distal parts (which would be exposed to the oil contamination) are continually lost. Other studies have indicated that oiled kelp beds had a 90% recovery within 3–4 years of impact; however, full recovery to pre-spill diversity may not occur for long periods after the spill (French-McCay 2009). Seagrass in the subtidal and intertidal zones have different degrees of tolerance to exposure of hydrocarbons. Subtidal seagrass is generally considered much less vulnerable to hydrocarbon spills than intertidal seagrass, primarily because freshly spilled hydrocarbons, including crude oil, float under most circumstances. Dean et al. (1998) found that hydrocarbons mainly affect flowering; therefore, species that can spread through apical meristem growth are not as affected (e.g. *Zostera*, *Halodule* and *Halophila* species). Physical contact with entrained hydrocarbon droplets could cause sublethal stress to seagrasses, causing reduced growth rates and reduced tolerance to other stress factors (Zieman et al. 1984). Toxicity effects can occur if dissolved hydrocarbons are absorbed into tissues (Runcie, Macinnis-Ng, and Ralph 2010); the extent of toxicity impact depends on the concentration and duration of exposure. Reported toxic responses to oils have included various physiological changes to enzyme systems, photosynthesis, respiration, and nucleic acid synthesis (Lewis and Pryor 2013). Given the distance to nearshore habitats, the potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should lower the content of soluble aromatic components before contact occurs. **Mangroves** Mangrove habitat is present within the EMBA, including at Montebello Islands, Barrow Island (north-east and southern coasts), and some bays on the west coast of North West Cape peninsula (e.g. Mangrove Bay) (Section 7.5.4). Stochastic modelling (RPS 2023c) predicted that the probability of exposure above ≥100 g/m^2 for shoreline accumulation was: • 3% for Montebello Islands • 3% for Ningaloo Coast World Heritage Area. Stochastic modelling (RPS 2023c) predicted that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved hydrocarbons was: • 97% and 92% respectively for Montebello Islands Marine Park • 76% and 70% respectively for Ningaloo Reef Marine Park • 72% and 57% respectively for Ningaloo Reef. Mangroves are considered highly sensitive to hydrocarbon exposure. Mangroves can take up hydrocarbons from contact with leaves, roots or sediments, and it is suspected that this uptake causes defoliation through leaf damage and tree death (Wardrop, Butler, and Johnson 1987). Hydrocarbon coating of the prop roots of mangroves can occur when entrained hydrocarbons are deposited on the aerial roots, which can block the pores used to breathe or interfere with the trees' salt balance, resulting in sublethal and potential lethal effects. Mangroves can also be affected by entrained or dissolved hydrocarbons that may adhere to the sediment particles. In

Receptor	Consequence Evaluation
	low-energy environments, such as mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (NOAA 2014). Acute impacts to mangroves can be observed within weeks of exposure, whereas chronic impacts may take months or years to detect (NOAA 2014). Snedaker et al. (1997) suggest that at least some mangroves species can tolerate or accommodate exposure to moderate amounts of oil on breathing roots. Given the distance to coastal habitats, the potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should lower the content of soluble aromatic components before contact occurs. **Biota** Entrained or dissolved hydrocarbon impacts may include sublethal stress and death to certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be indirectly impacted due to the loss of habitats and/or lethal and sublethal in-water toxic effects. This may result in death or impair growth, survival and reproduction (Heintz et al. 2000). There is also the potential for secondary impacts on shorebirds, fish, sea turtles, rays, and crustaceans that use these intertidal habitat areas for breeding, feeding and nursery habitat. **Summary** As described, a hydrocarbon release during a loss of well containment may result in large-scale impacts to nearshore or coastal habitats and communities within the EMBA, including around Ningaloo Reef, Montebello and Barrow Islands. Recovery is expected to occur over time. Thus the consequence has been ranked as B.
KEFs	Physicochemical changes in water or sediment quality because of a hydrocarbon release during a loss of well containment has the potential to impact habitats and biological communities associated with KEFs. As identified in Section 7.7, several KEFs occur within the EMBA. Those that occur within 200 km of the Project Area include: ancient coastline at 125 m depth contour (overlaps with the Project Area), continental slope demersal fish communities (~15 km north-west), and Glomar Shoal (~70 km east), Exmouth Plateau (~110 km north-west), and canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (~170 km south-west). These KEFs are primarily defined by seabed geomorphological features and have been classified as KEFs in recognition of the potential for increased biological productivity and, therefore, ecological significance. Potential impacts to these KEFs include contamination of marine sediments, direct and indirect impacts to benthic habitats and communities, and associated impacts to demersal fish populations. Given the distance to most KEFs, the potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should lower the content of soluble aromatic components before contact occurs. The Glomar Shoal KEF (which is essentially a buffer extending around Glomar Shoal, and which has been discussed in 'offshore habitats and biological communities' above) features marine primary producer habitat and site-attached fishes, and provides foraging habitat for a number of species. Similarly, the Commonwealth waters adjacent to Ningaloo Reef are also important habitat for these animal groups. Hydrocarbon contamination of marine sediments or impacted water quality from entrained and dissolved hydrocarbons may cause flow-on effects within these ecosystems. These KEFs cover extensive areas (Section 7.7) and if impacts to receptors within the KEFs (e.g. marine sediment, benthic communities) occur, these would be anticipated to be short lived, with no permanent impacts to the KEF. Thus the consequence of a hydrocarbon release during a loss of well containment on the values of KEFs has been ranked as D.

9.2.6.3.5 Potential changes to fauna behaviour, and/or potential injury or mortality to fauna

Receptor	Consequence Evaluation
Fish, Sharks and Rays	A hydrocarbon release during a loss of well containment may cause disturbance, injury, or death to fish, sharks, and rays due to contamination from entrained or dissolved hydrocarbons in the water column, or surface hydrocarbons. **Presence of protected species** As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Of the BIAs identified within

Receptor	Consequence Evaluation
	the EMBA (Table 7-9), the foraging BIAs for whale sharks are within the area predicted to be exposed to hydrocarbons from a loss of well containment (Figure 9-10). Whale sharks are known to aggregate at Ningaloo between March and July, after which they migrate. Three potential migration routes have been identified, including one passing through the NWS along the shelf break and continental slope (Meekan and Radford 2010). This route corresponds to the foraging BIA and an expected seasonal presence during spring (DCCEEW 2016). Other listed threatened species identified in the PMST report as potentially occurring within the EMBA include the grey nurse shark, white shark, dwarf sawfish, freshwater sawfish, and green sawfish (Table 7-8). No known areas of aggregation for these species in the offshore waters of the EMBA are predicted to be exposed to hydrocarbons from a loss of well containment. **Pelagic and demersal fish communities** Demersal and pelagic fish species are associated with these offshore features within the EMBA: • ancient coastline at the 125 m depth contour KEF • continental slope demersal fish communities KEF • Glomar Shoal KEF (and Glomar Shoal) • Rankin Bank. These KEFs and geomorphic features may host relatively diverse or abundant fish assemblages compared to the otherwise relatively featureless continental shelf habitats of the NWMR. **Potential impacts** Impacts to sharks and rays may occur through direct contact with hydrocarbons, which may contaminate tissues and internal organs either through direct contact or via the food chain (i.e. consumption of prey). Potential effects include damage to the liver, stomach lining and intestine, and toxic effects on embryos (Lee et al. 2011). As gill-breathing organisms, sharks and rays may be vulnerable to toxic effects of dissolved hydrocarbons (entering the body via the gills) and entrained hydrocarbons (coating the gills and thus inhibiting gas exchange). Very few studies have demonstrated increased fish mortality as a result of oil spills (Fodrie et al. 2014; IPIECA 1999; Hjermann et al. 2007). This has generally been attributed to the possibility that pelagic fish can detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from spill-affected areas. Fish exposed to dissolved hydrocarbons can eliminate the toxicants once placed in clean water; hence, individuals exposed to a spill are likely to recover (King et al. 1996). Where fish death have been recorded historically, the spills (resulting from the groundings of the tankers *Amoco Cadiz* in 1978 and the *Florida* in 1969) have occurred in sheltered bays. Pelagic free-swimming fish and sharks are unlikely to suffer long-term damage from oil spill exposure because dissolved/entrained hydrocarbons are typically insufficient to cause harm (ITOPF 2014). Laboratory studies have shown that adult fish can detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after hydrocarbon spills (Hjermann et al. 2007). This suggests that juvenile and adult fish are capable of avoiding water contaminated with high concentrations of hydrocarbons. However, sublethal impacts to adult and juvenile fish may be possible, given long-term exposure (days to weeks) to PAH concentrations (Hjermann et al. 2007). Although loss of well containment modelling indicates the potential EMBA for dissolved hydrocarbons is relatively extensive, no time-integrated exposure metrics were modelled; however, given the oceanographic environment within the EMBA, PAH exposures over weeks for pelagic fish are not considered credible. The effects of exposure to oil on the metabolism of fish appears to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water and to a lesser extent affects fish consuming contaminated food (Cohen, Gagnon, and Nugegoda 2005). The liver, a major detoxification organ, appears to be where anaerobic activity is most impacted, probably increasing anaerobic activity to help eliminate ingested oil from the fish (Cohen, Gagnon, and Nugegoda 2005). Fish in their early life stages (particularly egg and planktonic larval stages) are perhaps most susceptible to the effects of spilled oil and can become entrained in it. Contact with oil droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and Heck 2011). More subtle, chronic effects on the life history of fish as a result of exposure of early life stages to hydrocarbons include

Receptor	Consequence Evaluation
	disruption to complex behaviours such as predator avoidance, reproductive and social behaviour (Hjermann et al. 2007). Prolonged exposure of eggs and larvae to weathered concentrations of hydrocarbons in water has also been shown to cause immunosuppression, allowing viral diseases (Hjermann et al. 2007). PAHs have also been linked to increased mortality and stunted growth rates of early life history (pre-settlement) of reef fishes, as well as behavioural impacts that may increase predation of post-settlement larvae (Johansen et al. 2017). However, the effect of a hydrocarbon spill on a population of fish in an area with fish larvae and/or eggs, and the extent to which any of the adverse impacts may occur, depends greatly on prevailing oceanographic and ecological conditions at the time of the spill and the any contact with fish eggs or larvae. *Whale Sharks* Whale sharks and manta rays (reef manta ray and giant manta ray) are known to frequent Ningaloo Reef (forming feeding aggregations March through July) and the nearshore waters of the Muiron Islands. Whale sharks and manta rays, which have similar modes of feeding, generally transit along the nearshore coast in these areas and are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spills. Whale sharks are versatile feeders, filtering large amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive subsurface ram-feeding and active surface feeding (Taylor 2007). Passive feeding involves swimming slowly at the surface with the mouth wide open. During active feeding, sharks swim high in the water with the upper part of the body above the surface with the mouth partially open (Taylor 2007). These feeding methods would result in the potential for individuals that are present in worse-affected spill areas to ingest potentially toxic amounts of entrained or dissolved aromatic hydrocarbons into their body. Large amounts of ingested hydrocarbons may affect their endocrine and immune systems in the longer term. The presence of hydrocarbons may also displace whale sharks from important feeding and resting areas at Ningaloo Reef, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks are planktonic organisms—these are abundant in the coastal waters of Ningaloo Reef in late summer/autumn and drive the annual arrival and aggregation of whale sharks in this area. If a worse-case spill event were to occur during the spawning season, this important food supply (in worse spill-affected areas of the reef) may be diminished or contaminated. The contamination of their food supply and the subsequent ingestion of this prey by whale sharks may also result in long-term impacts to individuals as a result of bioaccumulation. A spill reaching the Ningaloo coast during key aggregation periods and impacting important whale shark foraging areas may have severe impacts to the local whale shark population, including possible death of individuals and impacts to life cycle habitats such as migration patterns. However, most species of shark and ray (including whale sharks) are expected to move away from spill-affected areas, and thus experience minimal impact. **Summary** Sublethal effects may impact populations located near the release location for the worst-case hydrocarbon release from a loss of well containment, with lethal impacts not considered likely in this offshore environment. Sublethal impacts may also occur within the predicted exposure area (Figure 9-10) for entrained or dissolved aromatic hydrocarbons. Based on an assessment of the predicted exposure to hydrocarbons from an unplanned loss of well containment, impacts from unplanned hydrocarbon release to fish, sharks and rays have been ranked as C.
Marine Reptiles	A hydrocarbon release during a loss of well containment may cause disturbance, injury, or death to marine reptiles due to contamination from entrained or dissolved hydrocarbons in the water column, or surface or shoreline hydrocarbons. **Presence of protected species** As identified in Section 7.6.2, several marine reptile species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Multiple BIAs for flatback, green, hawksbill, and loggerhead turtles (Table 7-11) and habitat critical to their survival (Table 7-12) occur within the area predicted to be exposed to hydrocarbons from a loss of well containment (Figure 9-10). Nesting season for marine turtles in the Pilbara is over summer—the various species are typically expected to be present between October and March (and to May for loggerhead turtles)

Receptor	Consequence Evaluation
	(Table 7-12). Flatback, green, and hawksbill turtles are known to nest on Barrow and Montebello islands; loggerhead turtles tend to nest further south around Exmouth and Ningaloo. Other listed threatened species identified in the PMST report as potentially occurring within the EMBA include the short-nosed seasnake, leaf-scaled seasnake, leatherback turtle, and olive ridley turtle (Table 7-10). No known areas of aggregation for these species occur in the offshore waters of the EMBA that are predicted to be exposed to hydrocarbons from a loss of well containment. **Potential impacts** *Marine turtles* Marine reptiles can be exposed to oil externally (e.g. swimming through surface slick) or internally (e.g. swallowing the oil, consuming oil-affected prey, or inhaling volatile oil-related compounds) (NOAA 2021). Marine turtles are vulnerable to the effects of oil at all life stages: eggs, hatchlings, juveniles, and adults. Several aspects of turtle biology and behaviour place them at risk, including a lack of avoidance behaviour, indiscriminate feeding in convergence zones, and large pre-dive inhalations (AMSA n.d.; NOAA 2021). Contact with surface slicks or entrained hydrocarbons can result in hydrocarbon adherence to body surfaces (Gagnon and Rawson 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (NOAA 2021). Oiling can also irritate and injure skin, which is most evident on pliable areas such as the neck and flippers (Lutcavage et al. 1995). A stress response associated with this exposure pathway includes an increase in white blood cell production and even a short exposure to hydrocarbons may affect the functioning of their salt glands (Lutcavage et al. 1995). Hydrocarbons in surface waters may also impact turtles when they surface to breathe and inhale toxic vapours. Their breathing pattern, involving large ‘tidal’ volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours, which are the most toxic component of the hydrocarbon spill (Milton and Lutz 2003). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (NOAA 2021). Contact with gravid adult females or with hatchlings may occur on nesting beaches (accumulated hydrocarbons) or in nearshore waters (entrained hydrocarbons) where hydrocarbons are predicted to make shoreline contact. Eggs may also be exposed during incubation, potentially resulting in increased egg mortality and detrimental effects on hatchlings. Hatchlings may be particularly vulnerable to toxicity and smothering as they emerge from the nests and make their way over the intertidal area to the water (NOAA 2021). Marine turtles aggregating near nesting beaches during mating and nesting seasons are most vulnerable to hydrocarbons, due to greater turtle densities and the possible disruption to important life cycle behaviours. Potential impacts may occur at the population level due to the presence of a high number of breeding individuals and hatchlings (during hatchling dispersal) and may impact on overall population viability of marine turtle species. However, given the volatile nature of the hydrocarbons and low levels of shoreline accumulation above impact thresholds predicted, population level impacts are not anticipated to occur. *Seasnakes* Impacts to seasnakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (ITOPF 2011). Seasnakes may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. In general, seasnakes frequent the waters of the continental shelf area around offshore islands and potentially submerged shoals (water depths <100 m). Although seasnakes may be present in offshore waters, their abundance is not expected to be high. Exclusions may apply to the yellow-bellied seasnake, which is known to be pelagic. Seasnake species in Australia generally show strong habitat preferences (Heatwole and Cogger 1993); species that have preferred habitats associated with submerged shoals and oceanic atolls may be disproportionately affected by a hydrocarbon spill affecting such habitat. However, population level impacts are not anticipated. **Summary** A hydrocarbon release from an unplanned loss of well containment has the potential to result in moderate, medium-term impacts to marine reptile species, particularly to those that forage and/or nest near to the source of the release. The consequence severity depends on the actual timing, duration and extent of an unplanned release in relation to species’ movements and distributions.

Receptor	Consequence Evaluation
	Therefore, a hydrocarbon spill may disrupt a portion of marine reptile populations; however, this is not considered to be a threat to overall population or stock viability. Based on an assessment of the predicted exposure to hydrocarbons from an unplanned loss of well containment, impacts to marine reptiles have been ranked as B.
Marine Mammals	A hydrocarbon release during a loss of well containment may cause disturbance, injury, or death to marine mammals due to contamination from entrained or dissolved hydrocarbons in the water column, or surface hydrocarbons. **Presence of protected species** As identified in Section 7.6.3, several marine mammals species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Of the BIAs identified within the EMBA (Table 7-14), those associated with pygmy blue, humpback, and southern right whales and dugongs occur within the area predicted to be exposed to hydrocarbons from a loss of well containment (Figure 9-10). The seasonal presence of these marine mammal species varies and is associated with different biologically important behaviours (e.g. migration, foraging) (Table 7-17). Other listed threatened species identified in the PMST report as potentially occurring within the EMBA include sei and fin whales (Table 7-13). No known areas of aggregation for these species occur in the offshore waters of the EMBA predicted to be exposed to hydrocarbons from a loss of well containment. **Potential impacts** Marine mammals can be exposed to oil externally (e.g. swimming through surface slick) or internally (e.g. swallowing the oil, consuming oil-affected prey, or inhaling of volatile oil related compounds) (AMSA n.d.; IPIECA 1995). *Cetaceans* Cetaceans that have direct physical contact with hydrocarbons may suffer surface fouling, ingest hydrocarbons (including from prey, water and sediments), aspirate oily water or droplets and inhale toxic vapours (DHOSNRTC 2016). For the short period that they persist, vapours from the hydrocarbon release are a significant risk to mammal health, with the potential to damage mucous membranes of the airways and the eyes, which will reduce the health and potential survivability of an animal. Inhaled volatile hydrocarbons transfer rapidly to the bloodstream and may also accumulate in tissues (Geraci and St. Aubin 1988). Direct contact with hydrocarbons may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, increased susceptibility to infection (Geraci and St. Aubin 1988); irritation of digestive and respiratory tracts and organs, neurological damage (Helm et al. 2015), reproductive failure, adverse health effects (e.g. lung disease, poor body condition) and, potentially, death (DHOSNRTC 2016). However, direct contact with surface oil is considered to have little deleterious effect on whales, possibly due to the skin's effectiveness as a barrier (cetaceans have thick skin and blubber). Furthermore, the effect of oil on cetacean skin is probably minor and temporary (Geraci and St. Aubin 1988). French-McCay (2009) identifies that a ≥10 g/m^2 surface hydrocarbon threshold has the potential to impart a lethal dose to the species; however, the study also estimates a probability of 0.1% mortality to cetaceans if they encounter these surface hydrocarbon thresholds based on the proportion of the time spent at surface. Entrained hydrocarbons may be ingested, particularly by baleen whales, which feed by filtering large volumes of water. Toothed whales and dolphins may also be susceptible to ingestion as they gulp feed at depth. Fresh hydrocarbons (i.e. typically in the vicinity of the release location) may have a higher potential to cause toxic effects when ingested, while weathered hydrocarbons are considered less likely to result in toxic effects. Although modelling of the loss of well containment indicates the potential EMBA for dissolved and entrained hydrocarbons is relatively extensive, no time-integrated exposure metrics were modelled; however, given the oceanographic environment within the EMBA, and the transient nature of marine mammal species through most of the EMBA, extended exposures to hydrocarbons in the water column for durations that would lead to chronic effects is considered unlikely. In a review of the impacts of large-scale hydrocarbon spills on cetaceans, it was found that exposure to oil from the Deepwater Horizon spill resulted in increased mortality to cetaceans in the Gulf of Mexico (DHOSNRTC 2016), and long-term population level impacts to killer whales were linked to the *Exxon Valdez* tanker spill (Matkin et al. 2008). Given the nature of condensate

Receptor	Consequence Evaluation
	(compared with the crude oil from these two spills), such exposure impacts to cetaceans may not eventuate. Geraci (1988) has identified behavioural disturbance (i.e. avoiding spilled hydrocarbons) in some instances for several species of cetacean, suggesting that they can detect and avoid surface slicks. However, observations during spills have also recorded larger whales (both mysticetes and odontocetes) and smaller delphinids traveling through and feeding in oil slicks. During the Deepwater Horizon spill, cetaceans were routinely seen swimming in offshore and nearshore surface slicks (Aichinger Dias et al. 2017). Pygmy blue whales and humpback whales are known to migrate seasonally through the EMBA. A major spill event between June and November would coincide with the humpback whale migration through the waters off the Pilbara, North West Cape and Shark Bay. A major spill in April to July or October to January would coincide with pygmy blue whale migration. Both pygmy blue and humpback whales are baleen whales and therefore are most likely to be significantly impacted by toxic effects when feeding. However, feeding during migrations is typically low level and opportunistic, with most feeding for both species occurring in the Southern Ocean. Subsequently the risk of ingesting hydrocarbons through feeding is considered low. Migrations of both pygmy blue whales and humpback whales are protracted through time and space (i.e. the whole population will not be within the EMBA at any one time), and as such, a hydrocarbon release from a loss of well containment is not considered likely to affect an entire population. Exmouth Gulf, which is a humpback whale resting area and southern right whale reproduction area, is just within the area predicted to be exposed to entrained and dissolved hydrocarbons above impact thresholds. However, Exmouth Gulf is ~230 km from the Project Area. The likelihood of impacts occurring within this BIA are considered low. In addition, given the distance from a potential release location to Exmouth Gulf, these hydrocarbons would have undergone weathering and thus would present less of a toxicity risk compared to fresh hydrocarbons closer to the source. Suitable habitat for oceanic toothed whales (e.g. sperm whales) and dolphins (e.g. long-snouted spinner dolphin) is broadly distributed throughout the NWMR and, therefore, although these species may be present within the EMBA, impacts from a hydrocarbon release are unlikely to affect an entire population. No known aggregation areas or BIAs for dolphins or toothed whales occur within the EMBA. *Dugongs* Dugongs have smooth skin and therefore are less likely to be affected by oil adhering to their skin. If surfacing in a slick, dugongs may foul their sensory hairs (around their mouths) or their eyes, potentially leading to inflammation/infections that then affect their ability to feed or breed (AMSA n.d.). Dugongs may also ingest oil (directly, or indirectly via oil-affected seagrass), and, depending on the amount and type of oil, the effects could be short-term to long-term/chronic (e.g. organ damage). However, reports on oil pollution damage to dugongs are rare (ITOPF 2014). Nearshore populations of dugongs are known to exhibit site fidelity and are often resident populations. The dugong BIAs (foraging, breeding, calving, nursing) in Exmouth Gulf and Ningaloo area occur within the area predicted to be exposed to entrained and dissolved hydrocarbons above impact thresholds. Given the distance from a potential release location to Exmouth Gulf, these hydrocarbons would have undergone weathering, and would present less of a toxicity risk compared to fresh hydrocarbons closer to the source. Geraci (1988) also observed relatively little impacts beyond behavioural disturbance. Therefore, the likelihood of impacts occurring within this BIA is considered low. **Summary** A hydrocarbon release from an unplanned loss of well containment has the potential to result in moderate, medium-term impacts to offshore marine mammal species, with consequence severity depending on the timing, duration and extent of a spill in relation to species' migratory movements and distributions. A hydrocarbon release from an unplanned loss of well containment may impact coastal marine mammals through site displacement and damage to food sources; however, due to its non-persistent nature, condensate is not predicted to result in impacts on overall population viability of either dugongs or coastal cetaceans. Thus, the consequence has been ranked as a C.
Seabirds and Migratory Shorebirds	A hydrocarbon release during a loss of well containment may cause disturbance, injury, or death to seabirds or migratory shorebirds due to contamination from entrained or dissolved hydrocarbons in the water column, or surface or shoreline hydrocarbons.

	Presence of protected species As identified in Section 7.6.4, several seabird and/or migratory shorebird species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Of the BIAs identified within the EMBA (Table 7-16), these are within the area predicted to be exposed to hydrocarbons from a loss of well containment (Figure 9-10): • foraging (bridled tern, little shearwater, sooty tern, wedge-tailed shearwater, white-faced storm petrel) • breeding (brown booby, lesser crested tern, lesser frigatebird, roseate tern, wedge-tailed shearwater, white-tailed tropicbird) • resting (little tern). Several other listed threatened species were identified in the PMST report as potentially occurring within the EMBA (Table 7-15). **Impacts** Birds may be exposed to hydrocarbons from an oil spill at the water surface (e.g. foraging, resting) or on the shoreline (e.g. roosting, nesting). Birds that rest at the water's surface (e.g. shearwaters) or surface-plunging birds (e.g. terns, boobies) are particularly vulnerable to surface hydrocarbons (Clark 1984; AMSA n.d.). Direct contact with hydrocarbons may cause feathers to mat, which may lead to hypothermia from loss of insulation (Hassan and Javed 2011). Acute and chronic toxic effects may result where the product is ingested as the bird attempts to preen its feathers (Peakall, Wells, and Mackay 1987), or ingests contaminated prey (IPIECA 2004). Whether the toxicity of ingested hydrocarbons is lethal or sublethal will depend on the weathering stage and its inherent toxicity. Damage to external tissues, including skin and eyes, can occur, along with internal tissue irritation in lungs and stomachs (Peakall, Wells, and Mackay 1987). Migratory shorebirds are considered unlikely to interact with surface hydrocarbons as they are not expected to stop over within the offshore waters surrounding the Project Area during their migrations between mainland/island areas. However, stochastic modelling shows that the surface exposure above 10 g/m^2 does extend into nearshore areas around the northern Montebello Islands (Figure 9-10). Many seabirds and migratory shorebirds forage over extensive areas (some hundreds of kilometres out to sea) so individuals may be present. Seabirds that plunge dive to feed on prey may also contact entrained or dissolved hydrocarbons, most likely by ingesting contaminated prey. Impacts to prey abundance as a result of hydrocarbons may also indirectly impact individuals. The seabird foraging BIAs identified above all occur in the southern extent to the EMBA (south of Carnarvon), but are within the predicted exposure area for dissolved and/or entrained hydrocarbons above impact thresholds. However, given the distance from a potential release location (>650 km), these hydrocarbons would have undergone extensive weathering, and would present less of a toxicity risk compared to fresh hydrocarbons closer to the source. Similarly, the resting BIA for little terns is located ~400 km north-west of the Project Area (associated with Mermaid Reef area). Although this area is within the predicted exposure area for entrained hydrocarbons above impact thresholds, weathering of the hydrocarbon would have occurred before reaching this area. Several breeding BIAs for seabirds (e.g. wedge-tailed shearwater) overlap with the predicted exposure area for surface, entrained, and/or dissolved hydrocarbons above impact thresholds. These BIAs are buffers around islands or coastal areas where these birds nest. Typically, seabirds nest above the high water mark—these nesting areas would not be expected to be directly impacted. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in nearshore waters near their breeding colony, resulting in intensive feeding by higher seabird densities in these areas during the breeding season and making these areas particularly sensitive to a spill. Therefore, it is likely that individual birds may be exposed, depending on the timing of the hydrocarbon release and the seasonal presence and nesting location (e.g. islands closer to the source of a hydrocarbon release would have greater probability of exposure) of each species. Migratory shorebirds may be exposed to stranded hydrocarbon when foraging or resting in intertidal habitats; however, direct oiling is typically restricted to a relatively small portion of birds, and such oiling is typically restricted to the birds' feet. Unlike seabirds, shorebird mortality due to hypothermia from matted feathers is relatively uncommon (Henkel, Sigel, and Taylor 2012). Indirect impacts, such as reduced prey availability, may occur (Henkel, Sigel, and Taylor 2012).

Receptor	Consequence Evaluation
	Summary A hydrocarbon release from an unplanned loss of well containment has the potential to result in moderate, medium-term impacts to seabird and migratory shorebird species, particularly to those that forage and/or breed closer to the source of the release. The consequence severity depends on the actual timing, duration and extent of an unplanned release in relation to species' movements and distributions. However, due to its non-persistent nature, condensate is not predicted to result in impacts on overall population viability. Thus, the consequence has been ranked as a C.

9.2.6.3.6 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks ***State Marine Protected Areas***	Physicochemical changes in water or sediment quality because of a hydrocarbon release during a loss of well containment has the potential to change the values associated with marine protected areas within the EMBA. **Australian Marine Parks** Stochastic modelling (RPS 2023c) predicted that the probability of exposure was: • 100%, 80% and 78% for ≥50 ppb for dissolved hydrocarbons at Montebello, Gascoyne, and Ningaloo Marine Parks respectively • probabilities of exposure to other AMPs were low—4% at Shark Bay, 3% at Argo-Rowley Terrace, and 1% at Abrolhos and Carnarvon Canyon • 100%, 88% and 80% for ≥100 ppb for entrained hydrocarbons at Montebello, Gascoyne, and Ningaloo Marine Parks respectively • probabilities of exposure to other AMPs were low—16% at Shark Bay, 7% at Argo-Rowley Terrace, 4% at Carnarvon Canyon and 3% at Abrolhos • 100% for surface hydrocarbons ≥10 g/m^2 at Montebello Marine Park; and no exposure above surface impact thresholds at other AMPs • 100%, 10%, and 5% for surface hydrocarbons above the visible ≥1 g/m^2 at Montebello, Ningaloo, and Gascoyne Marine Park; and no exposure above visible surface thresholds at other AMPs. **State marine protected areas** Stochastic modelling (RPS 2023c) predicted that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved hydrocarbons was: • 97% and 92% respectively for Montebello Islands Marine Park • 98% and 96% respectively for Barrow Islands Marine Park • 99% and 98% respectively for Barrow Islands Marine Management Area • 79% and 72% respectively for Muiron Islands Marine Management Area • 76% and 70% respectively for Ningaloo Reef Marine Park. Probabilities of exposure for other State marine protected areas (e.g. Rowley Shoals Marine Park) to entrained and dissolved hydrocarbons were low. Stochastic modelling also predicted a 4% probability of surface hydrocarbons ≥10 g/m^2 at Montebello Islands Marine Park, and 1% at Barrow Islands Marine Management Area. Probabilities of exposure above the visible ≥1 g/m^2 surface hydrocarbon threshold were 12% at Montebello Islands Marine Park, 9% at Ningaloo Marine Park and Muiron Islands Marine Management Area, 7% at Barrow Island Marine Management Area, and 2% at Barrow Islands Marine Park. **Impacts** As the Montebello Marine Park is at the highest risk of exposure, the impact assessment (below) focuses on the values associated with this protected area. The Montebello Marine Park comprises an area of ~3,413 km^2, all of which is zoned as a Multiple Use Zone (IUCN VI). This AMP ranges in depth from <15–150 m. Its values (as described in Table 7-24) include ecosystems representative of the Northwest Shelf Province (including areas of ancient coastline), species listed as threatened, migratory, marine, or cetacean under the EPBC Act, and any identified BIAs for regionally significant marine fauna. The Montebello Marine Park connects the deeper waters of the shelf and slope and the

Receptor	Consequence Evaluation
	adjacent Barrow Island and Montebello Islands State Marine Parks. A prominent seafloor feature in this AMP is Trial Rocks—two close coral reefs that emerge at low tide. The potential impacts to the values of the Montebello Marine Park are provided below. *Natural values* The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline that is thought to be an important seafloor feature and migratory pathway for humpback whales. A KEF of this Marine Park is the ancient coastline at the 125 m depth contour where rocky escarpments are thought to provide biologically important habitat in areas otherwise dominated by soft sediments. The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include breeding habitat for seabirds; internesting, foraging, mating, and nesting habitat for marine turtles; a migratory pathway for humpback whales; and foraging habitat for whale sharks. The potential impacts to each of the natural values are discussed in consequence evaluations above for the particular receptors. *Cultural values* There is limited information about the cultural significance of this Marine Park; however, it is noted that Sea Country is valued for First Nations cultural identity, health and wellbeing. Across Australia, First Nations people have been sustainably using and managing their Sea Country for tens of thousands of years. Potential impacts to cultural values of the Marine Park will closely tie in with the impacts to the natural values of the Marine Park. *Heritage values* There are no World, Commonwealth or National heritage listings that apply to the Marine Park. Two historic shipwrecks are located within the Marine Park. Shipwrecks occurring in the subtidal zone may be exposed to entrained/dissolved hydrocarbons, and marine life that shelters and takes refuge in and around these wrecks may be affected by in-water toxicity of dispersed hydrocarbons. Potential impacts to each of these natural values are discussed throughout the consequence evaluations above. *Social and economic values* Tourism, commercial fishing, mining and recreation are important activities in the Marine Park that contribute to the wellbeing of regional communities and the prosperity of the nation. A hydrocarbon release that results in visible surface slicks in coastal waters and on shorelines will disrupt recreational activities, particularly tourism, recreation and supporting services. In the event of a well blowout, surface hydrocarbons are predicted to reach the Montebello Marine Park. There is the potential for stakeholder perception that this environment would be contaminated over a large area and for the longer term, resulting in a prolonged period of tourism decline. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in impacts ranging from moderate and medium-term to major, long-term impacts to social and economic values within the Marine Park—the consequence severity will depend on the timing, duration and extent of a spill. **Summary** A hydrocarbon release from an unplanned loss of well containment has the potential to result in moderate medium-term impacts to major long-term impacts to the values of marine protected areas. The consequence severity will depend on the timing, duration and extent of an unplanned release. The consequence for marine protected areas has been ranked as a B.
Wetlands of International Importance	Stochastic modelling did not predict entrained, dissolved, or shoreline hydrocarbon exposure to wetlands of international importance (Ramsar). Therefore, shoreline exposure to wetlands is not discussed further.

9.2.6.3.7 Potential changes to the functions, interests, or activities of other users

Receptor	Consequence Evaluation
Commercial Fisheries and Aquaculture	Several commercial fisheries have management areas and recent fishing effort recorded within the EMBA (Sections 7.10.1). Direct impacts to fish are discussed in a consequence evaluation above. Sublethal effects to populations may occur in the direct vicinity of the release location. Given the relatively low fishing effort by a small number of fisheries within the Project Area, a worst-case hydrocarbon release from a loss of well containment is not considered likely to cause significant direct impacts on the target species of these commercial fisheries.

Receptor	Consequence Evaluation
	Hydrocarbon releases also have the potential to impact commercial fisheries through indirect impacts associated with tainting, which is a change in the characteristic smell or flavour, and renders the catch unfit for human consumption or sale due to public perception. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Tainting may not be a permanent condition but will persist if the organisms are continuously exposed; when exposure is terminated, depuration will occur quickly (Clark, Cole, and Clark 1982). Depuration removes hydrocarbons from tissues by metabolic processes, although its efficacy depends on the magnitude of the hydrocarbon contamination. Fish have a high capacity to metabolise these hydrocarbons, whereas crustaceans (such as prawns) have a comparably reduced ability (Yender, Michel, and Lord 2002). Regardless of the small potential for tainting, customer perception that tainting has occurred may cause a larger impact than the direct impact itself. Seafood safety is a major concern associated with hydrocarbon release incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishers and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender, Michel, and Lord 2002). A major hydrocarbon release would result in an exclusion zone being established around the affected area. There would also be a temporary prohibition on fishing activities for a period of time. Subsequently, there is potential for economic impacts to the affected commercial fishing operators. Additionally, hydrocarbons can foul fishing equipment such as traps and trawl nets, requiring them to be cleaned or replaced. The impact to fishers would depend on the extent of the spill and resulting exclusion zone and may cause economic impacts as a result of fishing bans, damaged equipment and/or consumer perception of seafood safety. These impacts would not be expected to be long term or affect the viability of the fishery. Thus, the consequence has been ranked as D.
Traditional Fisheries	Although no designated traditional fisheries have been identified within the EMBA (Section 7.10.2), it is recognised that First Nations communities fish in the shallow coastal and nearshore waters. Nearshore mainland areas around Ningaloo Reef were predicted to be exposed if a worst-case hydrocarbon release from a loss of well containment occurred. Impacts would be similar to those identified for commercial fishing—i.e. a potential fishing exclusion zone and possible contamination/tainting of fish stocks. Thus, the consequence has been ranked as D.
Tourism and Recreation	Recreational fishers predominantly target tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish. Recreational angling activities include shore-based fishing, private boat and charter boat fishing, with peak activity between April and October (Smallwood et al. 2011). Limited recreational fishing takes place in the offshore waters of the Project Area due to its distance from the mainland; however, some fishing may take place at Rankin Bank (Section 7.10.3). Direct impacts to fish are discussed in a consequence evaluation above. Sublethal effects to populations may occur within direct vicinity of the release location. Given the relatively low fishing effort within the Project Area, a worst-case hydrocarbon release from a loss of well containment, is not considered likely to cause significant direct impacts on the target species of these recreational fisheries. The main marine nature-based tourist activities within the EMBA are concentrated around and within the Ningaloo Coast World Heritage Property (Section 7.10.3). These activities include fishing, swimming, snorkelling and other water-based activities, and the usage of beaches and surrounds have a recreational value for local residents and visitors (regional, national and international). As described above, stochastic modelling indicates that the Ningaloo Coast may be exposed due to a worst-case hydrocarbon release from a loss of well containment event. In the event of a major hydrocarbon release, tourists and recreational users may avoid areas due to perceived impacts, including after the hydrocarbon has dispersed. There is also the potential for stakeholder perception that this environment will be contaminated over a larger area and for the longer term resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of hydrocarbon spill-related tourism impacts and found that, on average, it took 12–28 months to return to baseline visitor spending. Significant impacts are likely—to the tourism industry, wider service industry (hotels, restaurants, and their supply chain) and local communities in terms of economic loss as a result of spill impacts to tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of the spill clean-up and change in any public misconceptions regarding the spill (Oxford Economics 2010).

Receptor	Consequence Evaluation
	Thus, the consequence to tourism and recreation from an unplanned hydrocarbon release from a loss of well containment has been ranked as D, with short-term impacts, but recovery expected to occur.
Petroleum Industry	An unplanned hydrocarbon release may impact functions, interests or activities of other petroleum titleholders within the affected area. Surface hydrocarbons from a worst-case hydrocarbon release may affect production from existing offshore petroleum facilities (e.g. platforms, FPSOs). For example, facility water intakes for cooling and fire hydrants could be shut off, which could result in the temporary cessation of production activities. Spill exclusion zones established to manage the spill could also prohibit activity support vessel access as well as tankers approaching facilities on the NWS. The impact on ongoing operations of regional production facilities would be determined by the nature and scale of the spill and the metocean conditions at the time. Furthermore, decisions about operating production facilities in the event of a spill would be based primarily on health and safety considerations. The closest oil and gas facility to the Project Area are the GWA and Pluto platforms (operated by Woodside) and the Wheatstone platform (operated by Chevron Australia). Operation of these facilities is likely to be affected in the event of a worst-case loss of well containment. Based on an assessment of the predicted magnitude and duration of surface oil, it is expected that no lasting effects would occur to oil and gas infrastructure. Therefore, impacts from unplanned hydrocarbon release have been assessed as F.

9.2.6.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequences levels and residual risk rating from Unplanned Hydrocarbon Release: Gas and Condensate, these have been determined as lower-order risks (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-48**: In accordance with the Resource Management and Administration Regulations, a NOPSEMA-accepted Well Operations Management Plan must be in place before commencing the petroleum activity • **CM-49**: In accordance with the Safety Regulations, a NOPSEMA-accepted Safety Case for NWS pipelines must be in place before commencing the petroleum activity • **CM-50**: In accordance with the Environment Regulations, a NOPSEMA-accepted Oil Pollution Emergency Plan must be in place before commencing the petroleum activity
Good Industry Practice	• **CM-51**: A project-specific Source Control Emergency Response Plan must be in place before commencing the petroleum activity • **CM-52**: A baseline environmental survey of Wilcox Shoal must be in place before commencing the petroleum activity

9.2.6.5 Likelihood Evaluation

Review of industry statistics indicates that the probability of a loss of well containment for production wells is low (10.6% of blowouts) relative to other activities in other hydrocarbon provinces (Gulf of Mexico and the North Sea), such as exploration drilling (31.5% of blowouts), development drilling (23.6% of blowouts) and well workovers (20.5% of blowouts) (SINTEF 2017).

The blowout frequencies data from the International Association of Oil and Gas Producers (IOGP) (2019b) was used to evaluate the likelihood of a well blowout of an appraisal well. Scenarios vary from 1.4×10^{-4} to 9.3×10^{-4} per drilled well depending on water depth and well characteristics.

The riser and pipeline release frequencies data from IOGP (2019a) was used to evaluate the likelihood of a flowline release (based on North Sea data). Scenarios vary from 5.3×10^{-5} to 7.5×10^{-3} per km/year depending on diameter and type of pipeline.

In addition, when considering likelihood of the environmental consequence of the blowout event, historic blowouts that have had major, long-term impact to the environment have not occurred many times in the industry.

Due to the low probability of a major unplanned release of gas and condensate event, and the control measures in place, the likelihood of the worst-case environmental consequence occurring as described above was assessed as Highly Unlikely (1).

9.2.6.6 Risk Analysis Summary

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*	*Likelihood*	*Risk Rating*
Change to water quality	Physical environment			✓					A	D	1	Moderate
Change to sediment quality	Physical environment		✓							D	1	Moderate
Change to air quality	Physical environment				✓					F	1	Low
Potential changes to habitats and biological communities	Plankton communities					✓				E	1	Low
	Offshore Habitats and Biological communities					✓				B	1	Moderate
	Nearshore and coastal habitats and biological communities					✓				B	1	Moderate
	KEFs					✓				D	1	Moderate
Potential changes to fauna behaviour Potential injury or mortality to fauna	Fish, sharks and rays						✓			C	1	Moderate
	Marine reptiles						✓			B	1	Moderate
	Marine mammals						✓			C	1	Moderate
	Seabirds and migratory shorebirds						✓			C	1	Moderate
Potential changes to the values	AMPs					✓				B	1	Moderate
	State marine protected areas					✓				B	1	Moderate

Risk	Receptor	Environmental Value: Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Evaluation: Decision Type	Consequence	Likelihood	Risk Rating
and sensitivities of protected places	Wetlands of international importance					✓				–	–	–
Potential changes to the functions, interests, or activities of other users	Commercial fisheries and aquaculture							✓		D	1	Moderate
	Traditional fisheries							✓		D	1	Moderate
	Tourism and recreation							✓		D	1	Moderate
	Petroleum industry							✓		F	1	Low

9.2.6.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Unplanned Hydrocarbon Release: Gas and Condensate aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable level for this aspect is **AL-10** as defined in Table 4-3 (and shown below in Section 9.2.6.8). The highest residual risk rating for this aspect is moderate (Section 9.2.6.6), which is better than the acceptable level (**AL-10**). In addition, as described in the consequence evaluation (Section9.2.6.3), if this risk is realised the predicted environmental impacts associated with a worst-case hydrocarbon release from a loss of well containment may result in up to moderate medium-term, or major long-term effects to species, habitats, or communities, and the values (natural, cultural, heritage, or socioeconomic) and/or natural resources (fisheries) associated with these attributes. However, recovery is expected to occur, and as such these impacts are not expected to substantially affect the biodiversity, ecosystem function, or integrity of the NWMR over the long-term. With the implementation of the key control measures it is highly unlikely that such an event would occur.
Impact and Risk Classification, and Decision Type	The risks arising from an unplanned release of hydrocarbon from a loss of well containment are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These risks are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.6.4).
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td></td><td colspan="2">
included within this (Section 9.2.6) risk analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations
– during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding an unplanned hydrocarbon release from the offshore project
– this risk has been identified as a lower-order risk that can be managed to an acceptable level by implementing the key control measures (Section 9.2.6.4)
• Precautionary Principle
– The highest residual risk rating for this aspect is moderate; therefore, no potential for serious or irreversible environmental damage is expected
– although serious or irreversible environmental damage is not predicted to occur, there is some scientific uncertainty associated with determining a worst-case hydrocarbon spill and the associated effects on the receiving environment
– Woodside undertook analyses to determine a conservative worst-case spill volume
– modelling of this conservative spill scenario has been used to inform the risk assessment and potential areas of exposure and receptors at risk
– modelling was undertaken for a nominal Wilcox reservoir well, which is closest to sensitive receptors
– Woodside has previously established several research projects to understand the marine environments in which it operates, notably in the Exmouth and Kimberley regions, and also Rankin Bank, Glomar Shoal, Enfield Canyon and Scott Reef
– where scientific data do not exist, Woodside assumes that a pristine natural environment exists and therefore implements all practicable steps to prevent damage
• Intergenerational Principle
– the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forgo the health, diversity, or productivity of the environment for future generations
– as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity
• Biodiversity Principle
– the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.6) risk analysis
– as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
</td></tr>
<tr><td>Internal Context</td><td colspan="2">No specific Woodside management processes or procedures were deemed relevant for this aspect.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding an unplanned hydrocarbon release from the offshore project.</td></tr>
<tr><td rowspan="3">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>North-west Marine Parks Network Management Plan
South-west Marine Parks Network Management Plan
The Plans requires that ‘[a]ctions required to respond to oil pollution incidents, including environmental monitoring and remediation, in connection with mining operations authorised under the OPGGS Act may be conducted in all zones. The Director should be notified in</td><td>The key control measures (Section 9.2.6.4) provide for managing an unplanned release, and the response to, and environmental monitoring and remediation of, an oil pollution incident.
Requirements to report oil pollution incidents are included in Section 11.7.
Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the North-west Marine Parks</td></tr>
</table>

Acceptability Criteria	Demonstration	
	the event of an oil pollution incident that occurs within, or may impact upon, an Australian Marine Park and, so far as reasonably practicable, prior to a response action being taken within a marine park.'	Network Management Plan (DNP 2018a) or South-west Marine Parks Network Management Plan (DNP 2018b).
	Conservation Management Plan for the Blue Whale 2015–2025 No specific management action identified.	N/A
	Conservation Advice *Balaenoptera borealis* Sei Whale No specific conservation action identified.	N/A
	Conservation Advice *Balaenoptera physalus* Fin Whale No specific conservation action identified.	N/A
	Conservation Advice *Rhincodon typus* Whale Shark No specific conservation action identified.	N/A
	Recovery Plan for Marine Turtles in Australia *Management action A1.5*: Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of marine turtles *Management action A1.5*: Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue *Management action A4.2*: Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs	This section (Section 9.2.6) provides an impact assessment based on stochastic modelling of the worst-case hydrocarbon release from a loss of well containment. As described above, while some disruption of biologically important behaviours or displacement from habitat critical to survival of marine turtles may occur if an unplanned hydrocarbon release occurred during turtle nesting season (i.e. when turtle presence is expected on the NWS), this is not anticipated to be an ongoing or long-term impact to these areas. Once the nature and weathering of the hydrocarbon (condensate) is below impact thresholds, use of BIAs and habitat critical to survival is anticipated to return. Assessment of spill risk strategies is within scope of the Oil Pollution Emergency Plan. The requirement to have a NOPSEMA-accepted Oil Pollution Emergency Plan has been incorporated into the key control measures (Section 9.2.6.4). Therefore, the Goodwyn Area Infill Development is considered to be consistent with the Recovery Plan for Marine Turtles in Australia.
	Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) No specific conservation action identified.	N/A
	Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area No specific management actions identified.	N/A
	Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves No specific management actions identified.	N/A

9.2.6.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9). A risk-based EPO aligns with Woodside's risk management processes so that risk is maintained within a level that has been evaluated as being appropriate to the nature and scale of the risk. The WMS and relevant key control measures are used to identify and treat potential step-outs (that may result in an increased likelihood) from expected controls performance or integrity envelopes as such the risk-based EPO is set at a level above (i.e. high) that assessed (i.e. moderate; Section 9.2.6.6). By focussing on prevention of the event occurring, and that any unplanned hydrocarbon release event has a low probability of occurrence, the principles of ESD are considered to be met (i.e. by preventing an unplanned event, no environmental change that would alter biodiversity or intergenerational equity would occur).

The EPO relevant to the Unplanned Hydrocarbon Release: Gas and Condensate aspect is shown in the below table. For reference, the relevant acceptable level has also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-10: The risk rating for environmental receptors from major unplanned hydrocarbon releases is less than or equal to high[59]	**EPO-22**: Woodside will manage its activities to prevent a significant loss of containment. During the petroleum activity a risk of well loss of containment to the environment will be limited to high[59].

9.2.7 Unplanned Hydrocarbon Release: Marine Fuel

9.2.7.1 Aspect Source

The unplanned events associated with the Goodwyn Area Infill Development that may result in an unplanned hydrocarbon release of marine fuel are described in the following table.

Activity Group	Description
Drilling and Completions	N/A – aspect not associated with this activity group (for MODU and vessel operations, refer to Field Support Activities below).
Subsea Installation and Pre-commissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Start-up and Operations	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Decommissioning	N/A – aspect not associated with this activity group (for vessel operations, refer to Field Support Activities below).
Field Support Activities (MODU, Vessels)	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Their presence within the Project Area is temporary (e.g. a MODU would be present for ~1–3 months per well during drilling; Section 5.3.1). The number of vessels in the Project Area will vary depending on activity, but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). A 500 m safety exclusion zone will be requested around the MODU and the installation vessel/s during their respective activities. The potential sources of an unplanned release of marine fuel that could occur during vessel and MODU operations are: • bunkering failure • rupture of a MODU fuel tank • rupture of vessel fuel tank.

[59] Refer to Section 4.5.2.2.3 for risk ratings.

Activity Group	Description
	Unplanned releases due to bunkering are considered a minor LOC, and have been included in Section 9.2.5; and as such are not discussed further here. The total marine fuel capacity on a MODU will vary (depending on MODU type) and may range between ~1,000–4,000 m^3. This total capacity is stored in several isolated storage tanks (e.g. an individual fuel tank may have a capacity of ~250 m^3). MODU fuel storage tanks are typically located on the inner sides of the MODU pontoons and can be over 10 m below the waterline. Given their location, it is not considered a credible scenario that a fuel storage tank on a MODU would be damaged from an unplanned collision event. An unplanned release of marine fuel could occur if the fuel tank of any vessel is ruptured. This could eventuate from a collision between project vessels (e.g. support vessel with a MODU or installation vessel) or between a project vessel and a third-party vessel such as commercial fishing or shipping vessels. A typical project vessel (e.g. an installation or subsea support vessel) is likely to have multiple isolated fuel storage tanks distributed throughout the hull of the vessel. The largest volume of a single tank for these types of vessels is in the order of ~250 m^3 (for survey vessels, support vessels) to 2,000 m^3 (for a refuelling vessel). As described in Section 5.7.2, vessels will not use HFO within the Project Area; they will use a lighter marine fuel such as MDO or MGO. For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align: • vessel interaction must result in a collision • collision must have enough force to penetrate the vessel hull • collision must be in the exact location of the fuel tank • fuel tank must be full, or at least have a volume higher than the point of penetration.

9.2.7.1.1 Modelling and Exposure Assessment

Credible Scenario

A vessel collision event within the Project Area is considered a credible (but unlikely) unplanned event. A major marine spill because of vessel collision is only likely to occur under exceptional circumstances (e.g. loss of DP, navigational error, inclement weather conditions). Given the location, water depths, and lack of shallow submerged features within most of the Project Area, grounding is not considered credible, and is not considered further.

Based upon national guidelines (AMSA 2015), the types of vessels expected to be used during the offshore project, size of largest fuel tanks and fuel type to be utilised for the activities, Woodside was able to identify the credible worst-case scenario as being a surface release of ~2,000 m^3 of MDO resulting from a vessel collision event.

While a vessel collision event may occur at any location within the Project Area, previous spill modelling based on a release location within the Montebello Marine Park was selected. This is considered an appropriate and conservative approach to inform the risk assessment given this area comprises the highest sensitivities and thus is expected to provide an indication of the highest potential impacts associated with a marine fuel release within the Project Area.

Spill Modelling

Quantitative hydrocarbon spill modelling was undertaken by RPS (RPS 2021; 2019), on behalf of Woodside, using a three-dimensional (3D) hydrocarbon spill trajectory and weathering model, Spill Impact Mapping and Analysis Program (SIMAP), which is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces. The model settings are summarised in Table 9-27.

Table 9-27: Vessel collision spill scenario model settings

Parameter	Details
Release Location	20°03'1.4" S, 115°31'35.0" E (within Montebello Marine Park)
Water Depth	~74 m
Oil Type	MDO
Spill Type	Surface
Spill Volume	2,000 m^3
Spill Duration	Instantaneous
Number of Simulations	100 annualised spill trajectories, varying the start time (and hence prevailing wind and current conditions)

A stochastic modelling scheme was followed in this study, whereby SIMAP was applied to repeatedly simulate the defined credible spill scenarios using different samples of current and wind data. These data samples were selected randomly from an historic time-series of wind and current data representative of the study area. Results of the replicate simulations were then statistically analysed and mapped to define contours of percentage probability of contact at identified thresholds around the hydrocarbon release point.

The model simulates surface releases and uses the unique physical and chemical properties of a hydrocarbon type to calculate rates of evaporation and viscosity change, including the tendency to form oil in water (OIW) emulsions. Moreover, the unique transport and dispersion of surface slicks and in-water components (entrained and dissolved) are modelled separately. Thus, the model can be used to understand the wider potential consequences of a spill, including direct contact of hydrocarbons due to surface slicks (floating hydrocarbon) and exposure of organisms to entrained and dissolved aromatic hydrocarbons in the water column.

During each simulation, the SIMAP model records the location (by latitude, longitude, and depth) of each of the particles (representing a given mass of hydrocarbons) on or in the water column, at regular time steps. For any particles that contact a shoreline, the model records the accumulation of hydrocarbon mass that arrives on each section of shoreline over time, less any mass that is lost to evaporation and/or subsequent removal by current and wind forces.

The collective records from all simulations are then analysed by dividing the study region into a 3D grid. For surface hydrocarbons (floating oil), the sum of the mass in all hydrocarbon particles located within a grid cell, divided by the area of the cell, provides hydrocarbon concentration estimates in that grid cell at each model output time interval. For entrained and dissolved aromatic hydrocarbon particles, concentrations are calculated at each time step by summing the mass of particles within a grid cell and dividing by the volume of the grid cell. The process is also subject to the application of spreading filters that represent the expected mass distribution of each distinct particle. The concentrations of hydrocarbons calculated for each grid cell, at each time step, are then analysed to determine whether concentration estimates exceed defined threshold concentrations.

All hydrocarbon spill modelling assessments undertaken by RPS undergo initial sensitivity modelling to determine appropriate time to add to the simulation after the cessation of the spill. The amount of time following the spill is based on the time required for the modelled concentrations to practically drop below threshold concentrations anywhere in the model domain in the test cases. This assessment is done by post-processing the sensitivity test results and analysing time-series of median and maximum concentrations in the water and on the surface.

Hydrocarbon Exposure Thresholds

A conservative approach to selecting thresholds was taken by adopting the NOPSEMA guideline thresholds (NOPSEMA 2019) for surface, entrained, dissolved, and accumulated shoreline hydrocarbons (Table 7-1).

The stochastic spill modelling outputs cover a larger area than the area that is likely to be affected during any single spill event, as the model was run for a variety of weather and metocean conditions, and the stochastic outputs represents the total extent of all the locations where hydrocarbon thresholds could be exceeded from all modelling runs.

Hydrocarbon Characteristics

MDO is a light persistent fuel oil used in the maritime industry. MDO is a mixture of volatile and persistent hydrocarbons with low proportions of highly volatile and residual components (Table 9-28). In general, ~6% of the oil mass should evaporate within the first 12 hours (boiling point <180 °C); a further ~35% should evaporate within the first 24 hours (180 °C < boiling point < 265 °C); and a further ~54% should evaporate over several days (265 °C < boiling point < 380 °C). About 5% of the oil is shown to be persistent. The aromatic content of the oil is ~3% (RPS 2019). The low viscosity (4 cP; Table 9-28) indicates that this oil will spread quickly when released and will form a thin film on the sea surface, increasing the evaporation rate.

Table 9-28: Physical properties and boiling point ranges for MDO

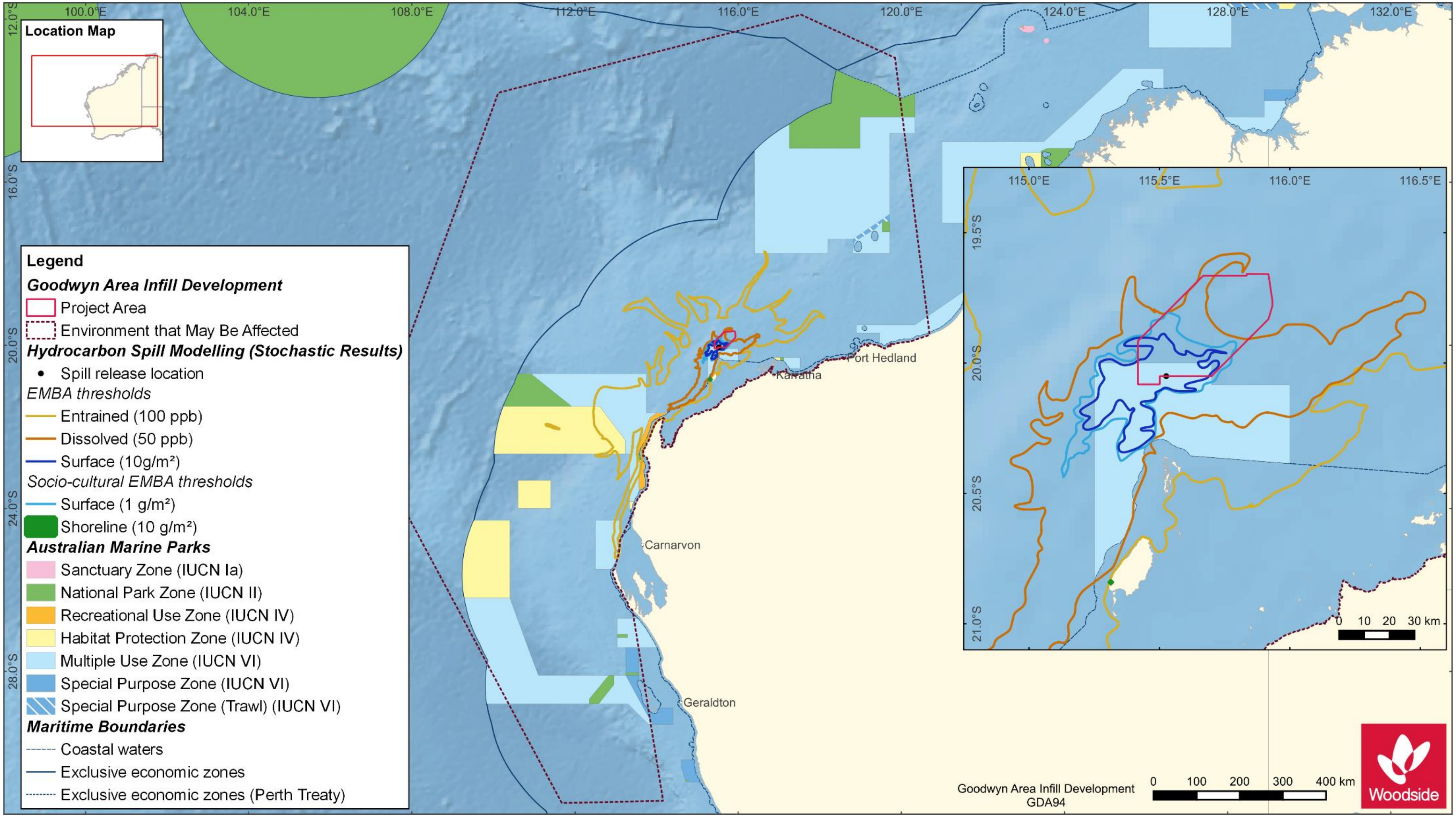
Characteristic	Value			
Density	0.829 g/m^3 (at 25 °C)			
Viscosity	4.0 cP (at 25 °C)			
Boiling Point	Volatile <180 °C	Semi-volatile 180–265 °C	Low volatility 265–380 °C	Residual >380 °C
	6.0%	34.6%	54.4%	5.0%

Modelling Outputs

The outputs of the quantitative hydrocarbon spill modelling are used to assess the environmental consequence by delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding selected hydrocarbon threshold concentrations if a credible hydrocarbon spill scenario occurred.

For the 2,000 m^3 MDO release within the Montebello Marine Park, stochastic modelling indicates:

- the maximum distance from the release location to the ≥1 g/m^2 visible surface threshold and the ≥10 g/m^2 surface impact threshold was ~60 km and ~39 km south-west respectively (Figure 9-11)
- no shoreline accumulation above the ≥100 g/m^2 impact threshold was predicted to occur
- the probability of contact to any shoreline at ≥10 g/m^2 visible threshold was 1%, with contact limited to only a single model cell on the west coast of Barrow Island (Figure 9-11); the predicted minimum time before shoreline contact was ~4.5 days and the maximum volume of oil ashore was <1 m^3
- the maximum distance from the release location to the 50 ppb dissolved impact threshold was ~215 km south-west (Figure 9-11)
- the maximum distance from the release location to the 100 ppb entrained impact threshold was ~630 km south-west (Figure 9-11)
- dissolved and entrained oil was predicted to typically remain in the surface layers, with exposure deeper within the water column occurring in proximity to the spill source.



Note: Stochastic outputs represent the total extent of all the locations where hydrocarbon thresholds could be exceeded from all 100 modelling runs (i.e. they are not representative of a single spill event).

Figure 9-11: Stochastic modelling contours—Surface release of 2,000 m^3 of MDO

9.2.7.2 Risk Identification and Environmental Value Screening

Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Change to water quality			✓				
Change to sediment quality		✓					
Potential changes to habitats and biological communities					✓		
Potential changes to fauna behaviour						✓	
Potential injury or mortality to fauna						✓	
Potential changes to the values and sensitivities of protected places					✓	✓	✓
Potential changes to the functions, interests, or activities of other users							✓

9.2.7.3 Consequence Evaluation

9.2.7.3.1 Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	A hydrocarbon release from a vessel collision will result in a change to water quality due to hydrocarbon contamination from entrained, dissolved, or surface hydrocarbon. MDO is a light persistent hydrocarbon, with a moderate proportion (~41%) of volatile and semi-volatile components. Therefore, when exposed to air on the water surface, evaporation rates will be significant. The low-volatility fraction (~54%) may take longer, in the order of days, to evaporate from the water surface. During the surface release, floating (surface) hydrocarbons will be susceptible to entrainment into the wave-mixed layer under typical wind conditions. The small (~5%) residual fraction is expected to persist in the environment until degradation processes occur. However, considering the spill volume, there is a low potential for dissolution of soluble aromatic compounds (RPS 2019). Due to the weathering processes of the hydrocarbon, impacts to water quality are anticipated to be minor and short-term. As such, the consequence of an unplanned release of marine fuel from a vessel collision on water quality has been assessed as D.

9.2.7.3.2 Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	A hydrocarbon release from a vessel collision may result in a change to sediment quality due to hydrocarbon contamination from entrained, dissolved or shoreline accumulated hydrocarbons. Due to the depth of water in the Project Area, and based on predictions in the stochastic modelling, marine sediments in offshore areas are unlikely to be exposed impacted by surface releases of hydrocarbons. MDO is typically remains within the surface layers of the water column, and would not interact with the seabed in deep waters. Entrained and dissolved hydrocarbons (at or above the defined impact thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coasts (see Figure 9-11). Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition shores or seabed habitat.

Receptor	Consequence Evaluation
	Stochastic modelling predicted that there is only 1% probability of any shoreline (Barrow Island)) being contacted over the visible shoreline accumulation threshold (10 g/m^2); with total volume ashore predicted to be less than 1 m^3 (RPS 2021; 2019). No shoreline exposure above the ecological impact threshold of 100 g/m^2 was predicted to occur. Therefore, no impacts to sediment quality are expected to occur onshore. Due to the weathering processes of the hydrocarbon, limited exposure to marine sediments, any impact to sediment quality is anticipated to be minor and short-term. As such, the consequence of an unplanned release of marine fuel from a vessel collision on sediment quality has been assessed as D.

9.2.7.3.3 Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Planktonic Communities	Physicochemical changes in water quality because of a hydrocarbon release from a vessel collision has the potential to change planktonic communities within the water column. The types of impacts that could occur to planktonic communities are described in Section 9.2.6.3. When first released, MDO has a higher toxicity due to the presence of the volatile components. Plankton in close contact to the hydrocarbon release at the time of the spill may be impacted, however, due to the generally low and patchy planktonic productivity within the NWMR it is unlikely that large populations will be affected at the sea surface above impact thresholds; noting that MDO will rapidly evaporate when exposed at sea surface exposure, and so is only expected to be present for days (and not an extended duration). Due to the weathering processes of the hydrocarbon, and limited exposure to planktonic communities, any impact to is anticipated to have minor and short-term effects. As such, the consequence of an unplanned release of marine fuel from a vessel collision on planktonic communities has been assessed as E.
Offshore Habitats and Biological Communities	Physicochemical changes in water or sediment quality because of a hydrocarbon release from a vessel collision has the potential to change offshore habitats and biological communities within the EMBA. However, as described above, due to the depth of water in most of the Project Area, and based on predictions in the stochastic modelling that indicate that MDO typically remains within the surface layers of the water column, no exposure to offshore habitats and biological communities is anticipated. Shallow geomorphic features located within the water column such as banks and shoals, however, may be impacted by dissolved or entrained hydrocarbons. Rankin Bank, Glomar Shoal, and Wilcox Shoal occur within the EMBA. Both Rankin Bank and Glomar Shoal are considered regionally significant habitats, and it is considered that Wilcox Shoal may also show similar biodiversity (Section 7.5.3.6). Types of benthic habitats and communities present known to be present at Rankin Bank and Glomar Shoal include coral reef, macroalgae, and sponges. Stochastic modelling indicated that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved was 1% for Rankin Bank, and <1% for Glomar Shoal (RPS 2021; 2019). Due to the weathering processes of the hydrocarbon, and limited exposure to banks and shoals, any impact to is anticipated to have slight and short-term effects. As such, the consequence of an unplanned release of marine fuel from a vessel collision on offshore benthic habitats and communities has been assessed as E.
Nearshore Habitats and Biological Communities	Physiochemical changes in water or sediment quality because of a hydrocarbon release from a vessel collision has the potential to change nearshore or coastal habitats and biological communities within the EMBA. Entrained and dissolved hydrocarbons (at or above the defined impact thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coasts (see Figure 9-11). No shoreline hydrocarbons (at or above the defined impact thresholds) are predicted to accumulate. **Coral reef, seagrass, and macroalgae** Nearshore coral reef, seagrass and macroalgae habitats are present within the EMBA, including at Montebello Islands, Barrow Island, Muiron Islands, and Ningaloo Reef (Section 7.5.4).

Receptor	Consequence Evaluation
	Stochastic modelling (RPS 2021; 2019) predicted that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved hydrocarbons was: • 5% and 1% respectively for Barrow Island • 8% and 1% respectively for Montebello Islands • 13% and 1% respectively for Montebello Islands Marine Park • 13% and <1% respectively for Muiron Islands Marine Management Area • 1% and <1% respectively for Ningaloo Coast World Heritage Area. Nearshore areas were not predicted to be exposed to surface hydrocarbons at concentrations above the impact (10 g/m^2) threshold. The types of impacts that could occur to coral reefs, seagrass or macroalgae habitats are described in Section 9.2.6.3. Due to the weathering processes of the hydrocarbon, and limited exposure to nearshore benthic habitats and communities, any impact to is anticipated to have slight short-term effect. As such, the consequence of an unplanned release of marine fuel from a vessel collision on nearshore benthic habitats and communities has been assessed as E. **Mangroves** Mangrove habitat is present within the EMBA, including at Montebello Islands, Barrow Island (north-east and southern coasts), and some bays on the west coast of North West Cape peninsula (e.g. Mangrove Bay) (Section 7.5.4). Stochastic modelling predicted no shoreline accumulation above the 100 g/m^2 impact threshold, and only a single model cell above visible impact 10 g/m^2 threshold (on the east coast of Barrow Island). Given the lack of shoreline accumulation, and low probabilities of exposure to entrained or dissolved hydrocarbons in nearshore waters, the consequence of an unplanned release of marine fuel from a vessel collision on coastal habitats and communities has been assessed as F.
Key Ecological Features	Physicochemical changes in water or sediment quality because of a hydrocarbon release from a vessel collision has the potential to habitats and biological communities associated with KEFs. As identified in Section 7.7, several KEFs occur within the EMBA. Those that occur within 200 km of the Project Area include: ancient coastline at 125 m depth contour (overlaps with the Project Area), continental slope demersal fish communities (~15 km north-west), and Glomar Shoal (~70 km east), Exmouth Plateau (~110 km north-west), and canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (~170 km south-west). These KEFs are primarily defined by seabed geomorphological features and have been classified as KEFs in recognition of the potential for increased biological productivity and, therefore, ecological significance. Potential impacts to these KEFs include the contamination of marine sediments, direct and indirect impacts to benthic habitats and communities, and associated impacts to demersal fish populations. Given the distance to most KEFs, the potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs. The Glomar Shoal KEF (which is essentially a buffer applied to Glomar Shoal itself, which has been discussed above) features marine primary producer habitat and site attached fishes, and provides foraging habitat for a number of species, as discussed under the respective sections above. As described above, due to the depth of water in most of the Project Area; and based on predictions in the stochastic modelling that indicate that MDO typically remains within the surface layers of the water column, no exposure to KEFs are anticipated. This includes the shallow Glomar Shoal, which stochastic modelling indicated that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved was <1% (RPS 2021; 2019). Therefore, due to the weathering processes of the hydrocarbon, and limited exposure to KEFs, any impact to is anticipated to have slight and short-term effects. As such, the consequence of an unplanned release of marine fuel from a vessel collision on KEFs has been assessed as E.

9.2.7.3.4 Potential changes to fauna behaviour, and/or potential injury or mortality to fauna

Receptor	Consequence Evaluation
Fish, Sharks and Rays	A hydrocarbon release from a vessel collision may cause disturbance, injury, or death to fish, sharks, and rays due to contamination from entrained or dissolved hydrocarbons in the water column, or surface hydrocarbons. **Presence of protected species** As identified in Section 7.6.1, several fish species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Of the BIAs identified within the EMBA (Table 7-9), the foraging BIAs for whale sharks are within the area predicted to be exposed to hydrocarbons from a loss of well containment (Figure 9-11). Other listed threatened species identified in the PMST report as potentially occurring within the EMBA include the grey nurse shark, white shark, dwarf sawfish, freshwater sawfish, and green sawfish (Table 7-8). There are no known areas of aggregation for these species in the offshore waters of the EMBA predicted to be exposed to hydrocarbons from a loss of well containment. **Pelagic and demersal fish communities** Demersal and pelagic fish species are associated with the following offshore features within the EMBA: • ancient coastline at the 125 m depth contour KEF • continental slope demersal fish communities KEF • Glomar Shoal KEF (and Glomar Shoal) • Rankin Bank. These KEFs and geomorphic features may host relatively diverse or abundant fish assemblages compared to the otherwise relatively featureless continental shelf habitats of the NWMR. However, as described above, exposure to KEFs at concentrations above impact thresholds is not predicted to occur; and the probability of exposure to Glomar Shoal was 1% for both entrained and dissolved hydrocarbon exposure. As such, impacts to pelagic and demersal fish communities as not anticipated to occur from an unplanned release of marine fuel from a vessel collision. **Potential impacts** The types of impacts that could occur to fish, sharks, and rays are described in Section 9.2.6.3. **Summary** A hydrocarbon release from a vessel collision has the potential to result in minor short-term impacts to fish, sharks, and rays; particularly to those that may forage within closer proximity to the source of the release (e.g. whale sharks within their foraging BIA). The consequence severity is dependent on the actual timing and extent of an unplanned release in relation to species' movements and distributions. Any duration of surface hydrocarbon exposure is expected to the limited to days; entrained hydrocarbon may persist for a longer duration but will be subject to degradation (and lose toxicity). As such, the consequence of an unplanned release of marine fuel from a vessel collision on fish, sharks, and rays has been assessed as D.
Marine Reptiles	A hydrocarbon release from a vessel collision may cause disturbance, injury, or death to marine reptiles due to contamination from entrained or dissolved hydrocarbons in the water column, or surface or shoreline hydrocarbons. **Presence of protected species** As identified in Section 7.6.2, several marine reptile species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Multiple BIAs for flatback, green, hawksbill, and the loggerhead turtle (Table 7-11) and habitat critical to the survival (Table 7-12) occur within the area predicted to be exposed to hydrocarbons from a loss of well containment (Figure 9-11). Nesting season for marine turtles in the Pilbara is over summer, and so presence of the various species is typically expected between October to March (and to May for loggerhead turtles) (Table 7-12). Flatback, green, and hawksbill turtles are known to nest on Barrow and Montebello islands; loggerhead turtles tend to nest further south around Exmouth and Ningaloo. Other listed threatened species identified in the PMST report as potentially occurring within the EMBA include the short-nosed seasnake, leaf-scaled seasnake, leatherback turtle, and olive ridley turtle (Table 7-10). There are no known areas of aggregation for these species in the offshore waters of the EMBA predicted to be exposed to hydrocarbons from a loss of well containment.

Receptor	Consequence Evaluation
	Potential impacts The types of impacts that could occur to marine reptiles are described in Section 9.2.6.3. **Summary** A hydrocarbon release from a vessel collision has the potential to result in minor short-term impacts to marine reptiles; particularly to those that may nest and forage within closer proximity to the source of the release (e.g. flatback and green turtles around Montebello or Barrow islands). The consequence severity is dependent on the actual timing and extent of an unplanned release in relation to species' movements and distributions. No shoreline accumulation above impact thresholds was predicted to occur, and no surface exposure above impact thresholds occurs in nearshore waters; therefore there is no exposure pathway to direct oiling of nesting adult turtles or hatchlings leaving nests from beaches. Entrained hydrocarbons in offshore and nearshore waters may persist for a longer duration but will be subject to degradation (and lose toxicity). As such, the consequence of an unplanned release of marine fuel from a vessel collision on marine reptiles has been assessed as D.
Marine Mammals	A hydrocarbon release from a vessel collision may cause disturbance, injury, or death to marine mammals due to contamination from entrained or dissolved hydrocarbons in the water column, or surface hydrocarbons. **Presence of protected species** As identified in Section 7.6.3, several marine mammals species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Of the BIAs identified within the EMBA (Table 7-14), those associated with pygmy blue, humpback, and southern right whales and dugongs occur within the area predicted to be exposed to hydrocarbons from a from a vessel collision (Figure 9-11). The seasonal presence of these marine mammal species is varied and associated with different biologically important behaviours (e.g. migration, foraging) (Table 7-17). Other listed threatened species identified in the PMST report as potentially occurring within the EMBA include the sei and fin whales (Table 7-13). There are no known areas of aggregation for these species in the offshore waters of the EMBA predicted to be exposed to hydrocarbons from a loss of well containment. **Potential impacts** The types of impacts that could occur to marine mammals are described in Section 9.2.6.3. **Summary** A hydrocarbon release from a vessel collision has the potential to result in minor short-term impacts to marine mammals. There are no known foraging or resting grounds within proximity to the Project Area (i.e. closer to a potential source of the release); however pygmy blue and humpback whales may opportunistically feed during migration. The consequence severity is dependent on the actual timing and extent of an unplanned release in relation to species' movements and distributions. Any duration of surface hydrocarbon exposure is expected to the limited to days; entrained hydrocarbon may persist for a longer duration but will be subject to degradation (and lose toxicity). As such, the consequence of an unplanned release of marine fuel from a vessel collision on marine mammals has been assessed as D.
Seabirds and Migratory Shorebirds	A hydrocarbon release from a vessel collision may cause disturbance, injury, or death to seabirds or migratory shorebirds due to contamination from entrained or dissolved hydrocarbons in the water column, or surface or shoreline hydrocarbons. **Presence of protected species** As identified in Section 7.6.4, several seabird and/or migratory shorebird species listed as either threatened and/or migratory under the EPBC Act have the potential to occur within the EMBA. Of the BIAs identified within the EMBA (Table 7-16), these are within the area predicted to be exposed to hydrocarbons from a vessel collision (Figure 9-11): • breeding (lesser crested tern, lesser frigatebird, roseate tern, wedge-tailed shearwater). Several other listed threatened species were identified in the PMST report as potentially occurring within the EMBA (Table 7-15). **Impacts** The types of impacts that could occur to seabirds and migratory shorebirds are described in Section 9.2.6.3.

Receptor	Consequence Evaluation
	Summary A hydrocarbon release from a vessel collision has the potential to result in minor short-term impacts to seabirds and migratory shorebirds; particularly to those that may nest and forage within closer proximity to the source of the release (e.g. wedge-tailed shearwaters around Barrow or Lowendal islands). The consequence severity is dependent on the actual timing and extent of an unplanned release in relation to species' movements and distributions. No shoreline accumulation above impact thresholds was predicted to occur, and no surface exposure above impact thresholds occurs in nearshore waters; therefore there is no exposure pathway to direct oiling of nesting adult birds or fledglings within nests on beaches. Entrained hydrocarbons in offshore and nearshore waters may persist for a longer duration but will be subject to degradation (and lose toxicity). As such, the consequence of an unplanned release of marine fuel from a vessel collision on marine reptiles has been assessed as D.

9.2.7.3.5 Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
Australian Marine Parks ***State Marine Protected Areas***	Physicochemical changes in water or sediment quality because of a hydrocarbon release from a vessel collision has the potential to change the values associated with marine protected areas within the EMBA. **Australian Marine Parks** Stochastic modelling (RPS 2021; 2019) predicted that the probability of exposure was: • 49% and 78% for ≥50 ppb for dissolved and ≥100 ppb for entrained hydrocarbons respectively at Montebello Marine Park • 100% for ≥10 g/m^2 surface hydrocarbons and ≥1 g/m^2 visible surface hydrocarbons at Montebello Marine Park • probabilities of exposure to other AMPs above dissolved or entrained hydrocarbon impact threshold were low or not predicted to occur • probabilities of exposure to other AMPs above surface hydrocarbon impact or visible threshold were not predicted to occur. **State marine protected areas** Stochastic modelling (RPS 2021; 2019) predicted that the probability of exposure above ≥100 ppb for entrained and ≥50 ppb for dissolved hydrocarbons was: • 5% and 1% respectively for Barrow Island • 8% and 1% respectively for Montebello Islands • 13% and 1% respectively for Montebello Islands Marine Park • 13% and <1% respectively for Muiron Islands Marine Management Area • 1% and <1% respectively for Ningaloo Coast World Heritage Area. Nearshore areas were not predicted to be exposed to surface hydrocarbons at concentrations above the impact (10 g/m^2) threshold. **Impacts** The Montebello Marine Park is at the highest risk of exposure; the types of impacts that could occur to the values of this marine protected areas are described in Section 9.2.6.3. **Summary** A hydrocarbon release from a vessel collision has the potential to result in minor short-term impacts to the values of marine protected areas. The consequence severity is dependent on the actual timing and extent of an unplanned release. Any duration of surface hydrocarbon exposure is expected to the limited to days; entrained hydrocarbon may persist for a longer duration but will be subject to degradation (and lose toxicity). As such, the consequence of an unplanned release of marine fuel from a vessel collision on the values of marine protected areas has been assessed as D.

9.2.7.3.6 Potential changes to the functions, interests, or activities of other users

Receptor	Consequence Evaluation
Commercial Fisheries and Aquaculture	Several commercial fisheries have management areas and recent fishing effort recorded within the EMBA (Sections 7.10.1). The types of impacts that could occur to commercial fisheries interest, activities, and functions are described in Section 9.2.6.3. Due to the weathering processes of the hydrocarbon, and limited exposure to pelagic and demersal fish, any impact to commercial fisheries is anticipated to be slight and short-term. As such, the consequence of an unplanned release of marine fuel from a vessel collision on commercial fisheries has been assessed as E.
Traditional Fisheries	Although no designated traditional fisheries have been identified within the EMBA (Section 7.10.2), it is recognised that First Nations communities fish in the shallow coastal and nearshore waters. Nearshore mainland areas around Ningaloo had low probabilities of exposure if a worst-case hydrocarbon release from a vessel collision were to occur. Impacts would be similar to those identified for commercial fishing. Thus, the consequence has been ranked as E.
Tourism and Recreation	Recreational fishers predominantly target tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish. Recreational angling activities include shore-based fishing, private boat and charter boat fishing, with the peak in activity between April and October (Smallwood et al. 2011). Limited recreational fishing takes place in the offshore waters of the Project Area due to the distance from land mass; however, some fishing may take place at Rankin Bank (Section 7.10.3). The main marine nature-based tourist activities within the EMBA are concentrated around and within the Ningaloo Coast World Heritage Area (Section 7.10.3). This location offers a number of amenities, such as fishing, swimming, snorkelling and other water-based activities, and utilisation of beaches and surrounds have a recreational value for local residents and visitors (regional, national and international). Due to the weathering processes of the hydrocarbon, limited exposure to pelagic and demersal fish, and to nearshore recreational areas like Ningaloo, any impact to tourism and recreation is anticipated to be slight and short-term. As such, the consequence of an unplanned release of marine fuel from a vessel collision on tourism and recreation has been assessed as E.
Petroleum Industry	An unplanned hydrocarbon release may impact functions, interests or activities of other petroleum titleholders within the affected area. Surface hydrocarbons from a worst-case hydrocarbon release may affect production from existing offshore petroleum facilities (e.g. platforms, FPSOs). For example, facility water intakes for cooling and fire hydrants could be shut off which could in turn lead to the temporary cessation of production activities. Spill exclusion zones established to manage the spill could also prohibit activity support vessel access as well as tankers approaching facilities on the NWS. The impact on ongoing operations of regional production facilities would be determined by the nature and scale of the spill and the metocean conditions at the time. Furthermore, decisions on the operation of production facilities in the event of a spill would be based primarily on health and safety considerations. The closest oil and gas facility to the Project Area are the GWA and Pluto platforms (operated by Woodside) and the Wheatstone platform (operated by Chevron Australia). Operation of these facilities may be affected in the event of a worst-case vessel collision hydrocarbon release. However, given that surface hydrocarbon exposure from a vessel collision event is expected to be relatively localised to the release location and evaporate within days, it is expected that no lasting effects would occur to oil and gas operations. Therefore, impacts from unplanned hydrocarbon release have been assessed as F.

9.2.7.4 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequence levels and residual risk rating from Unplanned Hydrocarbon Release: Marine Fuel, these have been determined as lower-order risks (Table 4-4); therefore, decision type A is considered appropriate for this aspect.

Key control measures adopted for the offshore project and relevant to managing this aspect are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-27**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth), *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth), and any subsequent marine orders • **CM-50**: In accordance with the Environment Regulations, a NOPSEMA-accepted Oil Pollution Emergency Plan must be in place before commencing the petroleum activity
Good Industry Practice	• **CM-46**: Implement Woodside's Marine Offshore Vessel Assurance Procedure • **CM-52**: A baseline environmental survey of Wilcox Shoal must be in place before commencing the petroleum activity • **CM-53**: Where required under the WMS, a project-specific SIMOPS Plan must be in place before commencing the petroleum activity

9.2.7.5 Likelihood Evaluation

Based on industry data, vessel collisions are considered rare, with only 3% of all marine incidents that occurred in Australian waters between 2005 and 2012 associated with a vessel collision event.

As most vessel collisions involve the LOC of a forward tank, which are generally double-lined and smaller than other tanks, the loss of the maximum credible volumes used in this scenario is unlikely.

Considering the inherent low likelihood of a collision occurring, the safeguards in place, and enactment of an OPEP, the potential likelihood of causing the consequences described in Section 9.2.7.3 is Highly Unlikely (1).

9.2.7.6 Risk Analysis Summary

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*	*Likelihood*	*Risk Rating*
Change to water quality	Physical Environment			✓					A	D	1	Moderate
Change to sediment quality	Physical Environment		✓							D	1	Moderate
Potential changes to habitats and biological communities	Planktonic Communities					✓				E	1	Low
	Offshore Habitats and Biological Communities					✓				E	1	Low
	Nearshore Habitats and Biological Communities					✓				E	1	Low
	Key Ecological Features					✓				E	1	Low
Potential changes to fauna behaviour Potential injury or mortality to fauna	Fish, Sharks and Rays						✓			D	1	Moderate
	Marine Reptiles						✓			D	1	Moderate
	Marine Mammals						✓			D	1	Moderate

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (including Odour)	Ecosystems or Habitats	Species	Socioeconomic and cultural	Decision Type	Consequence	Likelihood	Risk Rating
	Seabirds and Migratory Shorebirds						✓			D	1	Moderate
Potential changes to the values and sensitivities of protected places e	Australian Marine Parks					✓	✓	✓		D	1	Moderate
	State Marine Protected Areas					✓	✓	✓		D	1	Moderate
Potential changes to the functions, interests, or activities of other users	Commercial Fisheries and Aquaculture							✓		E	1	Low
	Traditional Fisheries							✓		E	1	Low
	Tourism and Recreation							✓		E	1	Low
	Petroleum Industry							✓		F	1	Low

9.2.7.7 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental risks associated with the Unplanned Hydrocarbon Release: Marine Fuel aspect for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable level for this aspect is **AL-10** Table 4-3 (and shown below in Section 9.2.7.8). The highest residual risk rating for this aspect is moderate (Section 9.2.7.6) which is better than the acceptable level (**AL-10**). In addition, s described in the consequence evaluation (Section 9.2.7.3), if this risk is realised the predicted environmental impacts associated with a worst-case hydrocarbon release from a vessel collision may result in up to moderate medium-term effects to species, habitats, or communities, and the values (natural, cultural, heritage, or socioeconomic) and/or natural resources (fisheries) associated with these attributes. However, recovery is expected to occur, and as such these impacts are not expected to substantially affect the biodiversity, ecosystem function, or integrity of the NWMR over the long-term. With the implementation of the key control measures, it is highly unlikely that such an event would occur.
Impact and Risk Classification, and Decision Type	The risks arising from an unplanned release of marine fuel within the Project Area are considered lower-order risks (decision type A) in accordance with Table 4-4, and as such are considered ‘broadly acceptable’. These risks are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.2.7.4).

Acceptability Criteria	Demonstration
Principles of ESD	These principles of ESD were considered for this aspect: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.2.6) risk analysis; therefore, the impact assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding an unplanned hydrocarbon release arising from the offshore project – this risk has been identified as a lower-order risk that can be managed to an acceptable level by implementing the key control measures (Section 9.2.7.4) • Precautionary Principle – the residual risk rating for this aspect is moderate; therefore, no potential for serious or irreversible environmental damage is expected – although serious or irreversible environmental damage is not predicted to occur, there is some scientific uncertainty associated with determining a worst-case hydrocarbon spill and the associated effects on the receiving environment – Woodside determined the conservative worst-case spill volume based on national guidance for vessel collisions – modelling of this conservative spill scenario has been used to inform the risk assessment and potential areas of exposure and receptors at risk – modelling was undertaken for a location at the southern boundary of the Project Area (and within the Montebello Marine Park), as this is closest to sensitive receptors – Woodside has previously established several research projects in order to understand the marine environments in which they operate, notably in the Exmouth Region and the Kimberley Region, and also Rankin Bank, Glomar Shoal, Enfield Canyon and Scott Reef – where scientific data do not exist, Woodside assumes that a pristine natural environment exists and therefore, implements all practicable steps to prevent damage • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – the existing environment (Section 7) identifies and describes relevant MNES, as defined in regulation 7(3) of the Environment Regulations; any relevant values and sensitivities are included within this (Section 9.2.6) risk analysis – as described above, if this risk is realised the predicted environmental impact is below the acceptable levels for this aspect, and thus is not considered to have the potential to affect biological diversity or ecological integrity.
Internal Context	These Woodside management processes or procedures were deemed relevant for this aspect: • Marine Offshore Vessel Assurance Procedure. Control measures related to these management processes or procedures have been described for this aspect (Section 9.2.7.4). Therefore, the impact and risk management is consistent with company policy, culture, and standards.
External Context	During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding and unplanned hydrocarbon release from the offshore project

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td rowspan="11">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Navigation Act 2012 (Cth)
Notice to Mariners</td><td>The requirements of this Act are incorporated into the key control measures (Section 9.2.7.4).</td></tr>
<tr><td>Marine Order 30
Gives effect to the Prevention of Collisions Convention</td><td>These requirements are incorporated into the key control measures (Section 9.2.7.4).</td></tr>
<tr><td>Marine Order 91
Gives effect to Annex I of MARPOL 73/78</td><td>These requirements are incorporated into the key control measures (Section 9.2.7.4).</td></tr>
<tr><td>North-west Marine Parks Network Management Plan
The Plan requires that '[a]ctions required to respond to oil pollution incidents, including environmental monitoring and remediation, in connection with mining operations authorised under the OPGGS Act may be conducted in all zones. The Director should be notified in the event of an oil pollution incident that occurs within, or may impact upon, an Australian Marine Park and, so far as reasonably practicable, prior to a response action being taken within a marine park.'</td><td>The key control measures (Section 9.2.7.4) provides for the management of an unplanned release provide for the response to, and environmental monitoring and remediation of, an oil pollution incident.
Requirements to report oil pollution incidents are included in Section 11.7.
Therefore, the Goodwyn Area Infill Development is not considered to be inconsistent with the North-west Marine Parks Network Management Plan (DNP 2018a).</td></tr>
<tr><td>Conservation Management Plan for the Blue Whale 2015–2025
No specific management action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Advice Balaenoptera borealis Sei Whale
No specific conservation action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Advice Balaenoptera physalus Fin Whale
No specific conservation action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Advice Rhincodon typus Whale Shark
No specific conservation action identified.</td><td>N/A</td></tr>
<tr><td>Recovery Plan for Marine Turtles in Australia
Management action A1.5: Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of marine turtles
Management action A1.5: Manage anthropogenic activities in BIAs to ensure that biologically important behaviour can continue
Management action A4.2: Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs</td><td>This section (Section 9.2.6) provides an impact assessment based on stochastic modelling of the worst-case hydrocarbon release from a vessel collision. As described above, while some disruption of biologically important behaviours or displacement from habitat critical to survival of marine turtles may occur if an unplanned hydrocarbon release occurred during turtle nesting season (i.e. when presence is expected on the NWS), this is not anticipated to be an ongoing or long-term affect to these areas. Given the nature and weathering of the hydrocarbon (MDO), once this is below impact thresholds, use of BIAs and habitat critical to survival is anticipated to return.
Assessment of spill risk strategies is within scope of the Oil Pollution Emergency Plan.</td></tr>
</table>

Acceptability Criteria	Demonstration	
		The requirement to have a NOPSEMA-accepted Oil Pollution Emergency Plan has been incorporated into the key control measures (Section 9.2.7.4). Therefore, the Goodwyn Area Infill Development is considered not to be inconsistent with the Recovery Plan for Marine Turtles in Australia.
	Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) No specific conservation action identified.	N/A
	Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area No specific management actions identified.	N/A
	Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves No specific management actions identified.	N/A

9.2.7.8 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted risk (Section 4.9). A risk-based EPO aligns with Woodside's risk management processes so that risk is maintained within a level that has been evaluated as being appropriate to the nature and scale of the risk. The WMS and key control measures are used to identify and treat potential step-outs (that may result in an increased likelihood) from expected controls performance or integrity envelopes. By focussing on prevention of the event occurring, and that any unplanned hydrocarbon release event has a low probability of occurrence, the principles of ESD are considered to be met (i.e. by preventing an unplanned event, no environmental change that would alter biodiversity or intergenerational equity would occur).

The EPO relevant to the Unplanned Hydrocarbon Release: Marine Fuel aspect is shown in the below table. For reference, the relevant acceptable level has also been shown against the EPO.

Acceptable Levels	Environmental Performance Outcomes
AL-10: The risk rating for environmental receptors from major unplanned hydrocarbon releases is less than or equal to high[60]	**EPO-23**: Woodside will manage its activities to prevent a significant loss of containment. During the petroleum activity a risk of release of hydrocarbon to the environment, from a vessel collision, will be limited to moderate[59].

9.3 Cultural Features and Heritage Values

9.3.1 Approach

As described in Section 7.9, the identification of cultural features and heritage values of the environment, as well as the social, economic, and cultural features of the broader environment important to First Nations people, is integral to understanding any potential impacts and risks.

In line with Woodside's First Nations Communities Policy (Appendix A), Woodside seeks to avoid damage or disturbance to cultural heritage (including intangible heritage) and, if avoidance is not

[60] Refer to Section 4.5.2.2.3 for risk ratings.

possible, minimise and mitigate the impacts, in consultation with First Nations communities and Traditional Custodians. Mitigation can include any measure or control aimed at ensuring the viability of the intangible cultural heritage and its intergenerational transmission. This can include reducing impacts and risks to environmental features that are associated with intangible cultural heritage (UNESCO 2003; Australia ICOMOS 2013).

It is important to note that where First Nations interests relate to the maintenance of the natural environment, these are adequately addressed through impact and risk assessments described in Sections 9.1 and 9.2 and are not further assessed below.

9.3.2 Environmental Value Screening

Impact or Risk	Environmental Value Potentially Impacted						
	Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*
Potential changes to cultural features or heritage values							✓

9.3.3 Impact and Risk Identification

The Goodwyn Area Infill Development has the potential impact cultural features and heritage values through the following ways:

- **archaeological heritage**—Places that are identified in the literature for their value as archaeological sites can be assumed to be impacted where there is an impact to the archaeological or scientific values of its tangible elements. This could include damage or disturbance of archaeological material or to the archaeological context.
- **intangible cultural heritage**—
  - *songlines*: Songlines can become lost, fragmented, or broken when there is a loss of Country or forced removal from Country (Neale and Kelly 2020). Physical sites that have been identified as comprising a component of a songline are important to protect to prevent the fragmenting or breaking apart of songlines and loss of sacred cultural knowledge. It is noted that oil and gas infrastructure exists in many areas of the NWS, and that songlines are still acknowledged and recognised. It is inferred that if there were to be any impacts to surviving songlines these would be significantly more likely to be described as qualitative (i.e. "weaken" a songline) rather than binary or absolute (i.e. destroy a songline).
  - *creation/dreaming sites, sacred sites, ancestral beings*: Activities that physically alter landscape features may be assumed to potentially impact values of creation/dreaming sites, sacred sites or ancestral beings.
  - *ceremonial sites*: Activities that prevent the performance of ceremony at these sites will directly impact its values.
  - *cultural obligations to care for Country*: Environmental impacts may be assumed to impact rights and obligations to care for Sea Country. Exclusion of Traditional Custodians from Sea Country (e.g. by restricting access) or decision-making processes (e.g. by not conducting ongoing consultation) are other potential sources of impact.
  - *knowledge of Country/customary law and transfer of knowledge*: Direct impact to communities practicing these skills will inherently occur when relevant aspects of the environment disappear, are displaced or suffer a reduction in population. Therefore, the

transmission of these skills is expected to be impacted where there are impacts at the species/population level. Limitations on access to sites or disruption/relocation of First Nations communities may have implications for the preservation of First Nations knowledge.

- *connection to Country*: Where people are displaced or disrupted (e.g. during colonisation) or where there is a loss of technical skills or environmental knowledge this may damage connection to Country (McDonald and Phillips 2021).
- *access to Country*: Impacts to access to Country may be classified as temporary (e.g. where exclusion zones exist around activities for safety reasons) or permanent (e.g. where infrastructure obstructs access or navigation). Impacts to access to Country can only occur in areas that were traditionally accessed by Traditional Custodians. This is anticipated to be focussed on areas adjacent to the coast.
- *cultural safety*: refers to respecting local Lore and culturally significant areas to protect individuals from cultural harm. There are many cultural implications for those (Aboriginal and non-Aboriginal) who do not follow cultural advice or access Country in culturally inappropriate ways.
- *kinship systems and totemic species*: It is assumed that marine species may have kinship/totemic relationships to Traditional Custodians, but it is understood that these relationships do not prohibit people outside of that “skin group” from hunting or eating that same species (Juluwarlu 2004). It is therefore inferred that the management of totemic or kinship species applies at the species/population level and not to individual plants and animals.
- *resource collection*: Direct impact to communities using these resources will inherently occur when the resource disappears, is displaced or suffers a reduction in population. Therefore, marine species (as resources) will be impacted where there is an impact at the species/population level.

• **marine ecosystems and species**—Marine ecosystems may hold both cultural and environmental value, with cultural and environmental values intrinsically linked (DCCEEW 2023g; MAC 2021 as cited in Woodside 2023d). It necessarily follows that an impact to marine ecosystems has the potential to impact cultural features where the impact is detectable within Sea Country—the seascape which Traditional Custodians view, interact with or hold knowledge of.

9.3.4 Impact and Risk Source

Table 9-29 provides a summary of the key aspects that may result in potential impacts or risks to cultural features or heritage values.

Further, the potential environmental impact and risk from the Goodwyn Area Infill Development to marine ecosystems (habitats and species) that have a cultural feature or heritage value have been summarised in Table 9-30 to provide the context related to the holistic impacts and risks on the cultural feature or heritage value.

Table 9-29: Key sources of potential impacts and risks to cultural features and heritage values

Aspect	Description
Planned Activities	
Physical Presence: Interaction with other Marine Users	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Their presence within the Project Area is temporary (e.g. a MODU and support vessels would be present for ~1–3 months per well during drilling; Section 5.3.1). The number of vessels in the Project Area will vary depending on activity but is expected to be greatest for short-term project phases (e.g. drilling or installation), with fewer vessels typically required during operations (e.g. IMMR campaigns). A

Aspect	Description
	500 m safety exclusion zone will be requested around the MODU and the installation vessel/s during their respective activities. Refer to Section 9.1.1 for further details.
Physical Presence: Disturbance to the Seabed	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will result in seabed disturbance within the Project Area. However, the two main sources of seabed disturbance is the installation of new subsea infrastructure and the MODU mooring systems in place during drilling activities. Refer to Section 9.1.2 for further details.
Routine Emissions: Light Generation	All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. External lighting on the MODU and vessels is required for navigation and safe operating conditions. Lighting ensures a safe working environment across 24-hour operations and communicates the presence (i.e. via navigation lights) of the MODU and support vessels to other marine users. Typically, lighting is bright white light (i.e. metal halide, halogen, fluorescent) and is not dissimilar to lighting used for other offshore activities, including fishing and shipping. Refer to Section 9.1.3 for further details.
Routine Acoustic Emissions: Continuous Sound Generation	There are various sources of continuous (non-impulsive) underwater acoustic emissions including vessels, MODUs, ROVs, helicopters, and operation of subsea infrastructure. However, the predominant source of continuous (non-impulsive) underwater acoustic emissions is the use of DP on the vessels and MODU (if a hybrid MODU is selected; Section 5.7.1). All phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development will be supported by various vessels and/or a MODU. Refer to Section 9.1.4 for further details.
Routine Acoustic Emissions: Impulsive Sound Generation	There are various sources of impulsive underwater acoustic emissions including acoustic positioning equipment, VSP, geophysical surveys that may be used during different activities for the Goodwyn Area Infill Development. However, the most significant source of impulsive underwater acoustic emissions is the use of impact piling (if pile moorings for the MODU is selected for use; Section 5.7.1.1). Refer to Section 9.1.5 for further details.
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	Up to 19 wells (Table 5-1) may be drilled within the Project Area as part of the Goodwyn Area Infill Development. Types of routine drilling discharges include drill cuttings, drilling fluids retained on cuttings, and bulk discharge of drilling fluids from mud pits. These may also be discharged as non-routine discharges associated with contingency activities (e.g. re-spud, sidetracking). For top-hole sections, drill cuttings and drilling fluids are discharged at the seabed (Section 5.3.3). For bottom-hole sections, cuttings and fluids are circulated back to the MODU via the riser, where the cuttings are separated from the drilling fluids by the SCE (Section 5.3.5). The cuttings (with adhered residual fluids) are discharged at or below the water surface. The mud pits form part of the drilling fluid circulating system and may be discharged at the end of specific well sections if the drilling fluid system needs to be changed or the drilling fluid cannot be re-used (e.g. due to deterioration/contamination). Drill cuttings or drilling fluids may also be discharged during operations (e.g. well intervention or workover) or decommissioning (e.g. well plugging or wellhead removal). Refer to Section 9.1.10 for further details.
Unplanned Events	
Unplanned Hydrocarbon Release: Gas and Condensate	There are various sources of an unplanned release of gas and condensate associated with the Goodwyn Area Infill Development; however, Woodside has identified an unplanned well blowout during drilling as the worst-case credible scenario for this aspect. The EMBA is the largest spatial extent where unplanned events could have an environmental consequence on the surrounding environment. As defined in Section 7.1, the EMBA for this OPP has been developed based on the outcome of stochastic spill modelling for the worst-case credible unplanned hydrocarbon release events, and then further broadened to incorporate a spatial buffer (a minimum of ~50 km) and extended inshore along most of the Pilbara and Gascoyne coast. The EMBA therefore covers a larger area than the area that would be affected during any one single unplanned hydrocarbon release (spill) event. In the event of a spill, the EMBA would be much smaller and typically travel away from the release location based on prevailing currents and winds directions.

Aspect	Description
	The spatial extent of the EMBA is typically driven by the distribution of the in-water (entrained, dissolved) hydrocarbons above impact thresholds. For the modelled scenario, the predicted spatial extent of entrained, dissolved, surface and shoreline hydrocarbons is shown in Figure 9-10. While there are islands located within the EMBA, these are not expected to be affected unless there is shoreline contact above impact thresholds. For the modelled scenario, shoreline contact above the ecological and socio-cultural impact thresholds (Table 7-1) was predicted at some of the Pilbara offshore islands, including Montebello Islands, Barrow Island and the Muiron Islands (Figure 9-10). Refer to Section 9.2.6 for further details.
Unplanned Hydrocarbon Release: Marine Fuel	There are various sources of an unplanned release of marine fuel associated with the Goodwyn Area Infill Development; however, Woodside has identified an unplanned vessel collision event as the worst-case credible scenario for this aspect. A typical project vessel (e.g. an installation or subsea support vessel) is likely to have multiple isolated fuel storage tanks distributed throughout the hull of the vessel. The largest volume of a single tank for these types of vessels is in the order of ~250 m^3 (for survey vessels, support vessels) to 2,000 m^3 (for a refuelling vessel). As described in Section 5.7.2, vessels will not use HFO within the Project Area; they will use a lighter marine fuel such as MDO or MGO. As described above, the EMBA covers a larger area than the area that would be affected during any one single unplanned hydrocarbon release (spill) event. For the modelled scenario, the predicted spatial extent of entrained, dissolved, surface and shoreline hydrocarbons is shown in Figure 9-11. While there are islands located within the EMBA, these are not expected to be affected unless there is shoreline contact above impact thresholds. For the modelled scenario, no shoreline contact above the ecological impact thresholds was predicted; and only a single model cell on the west coast of Barrow Island was predicted to be above the socio-cultural threshold for shoreline exposure (Figure 9-11). Refer to Section 9.2.7 for further details.

Table 9-30: Consequence summary for marine ecosystem receptors

Aspect	Receptor Group						
	Planktonic Communities	Offshore Habitats and Biological Communities	Nearshore and Coastal Habitats and Biological Communities	Fish, Sharks, and Rays	Marine Reptiles	Marine Mammals	Seabirds and Migratory Shorebirds
Planned Activities	***Consequence Level***						
Physical Presence: Disturbance to the Seabed	—	Minor (D)	—	—	—	—	—
Routine Emissions: Light Generation	—	—	—	No lasting effect (F)	No lasting effect (F)	—	No lasting effect (F)
Routine Acoustic Emissions: Continuous Sound Generation	No lasting effect (F)	—	—	No lasting effect (F)	—	Slight (E)	—
Routine Acoustic Emissions: Impulsive Sound Generation	No lasting effect (F)	—	—	Slight (E)	Slight (E)	Slight (E)	—
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	No lasting effect (F)	—	—	—	—	—	—
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	—	Minor (D)	—	—	—	—	—
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	—	Slight (E)	—	—	—	—	—
Downstream Discharges: Produced Water	Slight (E)	—	—	Slight (E)	Slight (E)	Slight (E)	—
Unplanned Events	***Risk Rating***						
Physical Presence: Interaction with Marine Fauna	—	—	—	Low	Low	Low	—
Physical Presence: Introduction of Invasive Marine Species	—	Low	—	—	—	—	—
Physical Presence: Unplanned Seabed Disturbance	—	Moderate	—	—	—	—	—
Unplanned Release: Hazardous and Non-hazardous Solid Wastes	—	—	—	Moderate	Moderate	Moderate	Moderate
Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment)	Moderate	—	—	Moderate	Moderate	Moderate	
Unplanned Hydrocarbon Release: Gas and Condensate	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Aspect	Receptor Group						
	Planktonic Communities	Offshore Habitats and Biological Communities	Nearshore and Coastal Habitats and Biological Communities	Fish, Sharks, and Rays	Marine Reptiles	Marine Mammals	Seabirds and Migratory Shorebirds
Unplanned Hydrocarbon Release: Marine Fuel	Low	Low	Low	Moderate	Moderate	Moderate	Moderate

9.3.5 Consequence Evaluation

9.3.5.1.1 Potential changes to cultural features or heritage values

Receptor	Consequence Evaluation
Cultural Features and Heritage Values (Archaeological Heritage)	**Onshore / intertidal archaeological sites** No coastal areas or islands exist within the Project Area. A review of the of DPLH’s Aboriginal Heritage Inquiry System identified 576 registered sites within the EMBA (Appendix D). These included sites along the coast of Barrow Island, the North West Cape, Murujuga (Burrup Peninsula), and other mainland coastal areas, registered for artefacts, ceremonial, mythological, middens, and rock shelters (Appendix D). Note: As defined in Section 7.1, the EMBA for this OPP has been developed based on the outcome of stochastic spill modelling for the worst-case credible unplanned hydrocarbon release events, and then further broadened to incorporate a spatial buffer (a minimum of ~50 km) and extended inshore along most of the Pilbara and Gascoyne coast. Predicted shoreline accumulation from unplanned hydrocarbon releases are shown in Figure 9-10 and Figure 9-11, and comprises much smaller extents of mainland coast compared to what is included in the EMBA. Notwithstanding, if a coast (island or mainland) was exposed to hydrocarbons from an unplanned hydrocarbon release event, there is no anticipated impact pathway to onshore archaeological sites above HAT. Archaeological sites may exist in intertidal landscapes within the EMBA and may be exposed to hydrocarbons from an unplanned hydrocarbon release event; however, there is no anticipated impact pathway from the presence of hydrocarbons on archaeological values, as this is not expected to impact the fabric or context of sites on an exposed shoreline site. Impacts to the heritage value of fish traps from hydrocarbons may occur indirectly through impacts to fish. However, it is expected that continued use of fish traps beyond their archaeological value will be preserved where fish species and distribution are maintained at a population level. With regard to fish, refer to the receptor-specific assessment below for further information, in addition to the impact and risk assessment in Sections 9.1 and 9.2. **Submerged archaeological sites** No archaeological sites have been identified beyond terrestrial or intertidal areas, with the exception of two sites at Murujuga in Cape Bruguieres Channel and Flying Foam Passage (Benjamin et al. 2020; 2023). Both of these sites are within the EMBA, but are inshore of the area predicted to be exposed to in-water hydrocarbons from an unplanned hydrocarbon releases (Figure 9-10, Figure 9-11). Based on a desktop assessment for submerged cultural heritage, there are no known shipwrecks or other items of UCH (including First Nations UCH) within the Project Area (Nutley 2023b). A review of historic sea level changes and seabed suggests that a complex coastal landscape of ridge lines, hills and an estuarine channel may have been present within the Project Area ~52–20 kya (Nutley 2023b). Given the complex landforms, and duration of exposure, these areas would have had high potential for the accumulation of significant deposits of archaeological materials as well as for the development of complex cultural and spiritual association (Nutley 2023b). As such additional controls have been adopted to mitigate the risk of disturbance to unidentified UCH. Submerged archaeological sites (locations undefined) may exist on the Ancient Landscape within the broader EMBA. However, given the spatial extent of the EMBA is predominantly driven by an unplanned hydrocarbon release (e.g. from a surface marine fuel spill, or a subsea loss of well control event), it is not expected to impact the seabed or archaeological material on or within it. Therefore, there is no anticipated impact pathway to submerged archaeological sites, if any, in the broader EMBA. **Rivers, waterholes, tidal channels, and seeps** A review of historic sea level changes and seabed morphology suggests that a complex coastal landscape of ridge lines, hills and an estuarine channel may have been present within the Project Area ~52–20 kya (Nutley 2023b). Submerged former water sources (e.g. river beds) may exist (locations undefined) which are archaeologically prospective or culturally significant. As such additional controls have been adopted to mitigate the risk of disturbance to unidentified UCH. The EMBA is predominantly driven by an unplanned hydrocarbon release. For the worst-case credible scenarios identified for the Goodwyn Area Infill Development (Sections 9.2.6 and 9.2.7), there is no anticipated impact pathway to submerged water sources in the broader offshore EMBA.

Receptor	Consequence Evaluation
	In the highly unlikely and unmitigated worst-case, an unplanned hydrocarbon release may reach nearshore and coastal environments, and receptors such as mangroves or shoreline habitats. These habitats may contain brackish or fresh water due to runoff from land. However, given the hydrocarbon characteristics and rapid weathering, an unplanned hydrocarbon release is expected to have no lasting effect on any freshwater sources along the shoreline. **Submerged calcarenite ridges/paleo beach barrier systems** Calcarenite ridges were identified on the “mid shelf” in UWA (2021). The ridges that were identified are considered to predate human occupation of the Australian continent, and therefore are not expected to contain archaeological material. However, it was noted that features on the “outer shelf” may contain archaeological material (UWA 2021). The Project Area for the Goodwyn Area Infill Development overlaps with areas of both the mid and outer shelf. There is no large-scale seabed disturbance of calcarenite features that may expose archaeological material within the Project Area. In addition controls have been adopted to mitigate the risk of disturbance. There is no anticipated impact pathway to calcarenite ridges in the broader EMBA from the Goodwyn Area Infill Development. **Submerged hills** A review of historic sea level changes and seabed morphology suggests that a complex coastal landscape of ridge lines, hills and an estuarine channel may have been present within the Project Area ~52–20 kya (Nutley 2023b). The submerged hill features on the “mid shelf” identified in UWA (2021) may be archaeologically prospective or culturally significant. There is no large-scale seabed disturbance of submerged hills that may impact archaeological material within the Project Area. Submerged hills (locations undefined) may occur in the broader EMBA. The EMBA is predominantly driven by an unplanned hydrocarbon release. For the worst-case credible scenarios identified for the Goodwyn Area Infill Development (Sections 9.2.6 and 9.2.7), there is no anticipated impact pathway to submerged hills in the broader offshore EMBA. **Madeleine Shoals** Madeleine Shoals is a potentially archaeologically prospective location on the submerged landscape (including igneous geology which has the potential to include rock art). Madeleine Shoals occur outside of the Project Area, and as such there is no anticipated impact pathway to the Madeleine Shoals from planned activities associated with the Goodwyn Area Infill Development. The Madeleine Shoals exist within the broader EMBA. However, the spatial extent of the EMBA is predominantly driven by an unplanned hydrocarbon release (e.g. from a surface marine fuel spill, or a subsea loss of well control event), and these events are not expected to impact the seabed or archaeological features on or within it. Therefore, there is no anticipated impact pathway to potentially archaeologically prospective sites at Madeleine Shoals from the Goodwyn Area Infill Development. **Karst depressions/ravines and valleys between submerged ridges** Karst depressions were identified on the “outer shelf” which may contain archaeological material (UWA 2021) in addition these features (locations undefined) may occur in the broader EMBA. Catch points have the potential to contain artefacts displaced by erosion during inundation which may be impacted by seabed disturbance. As such additional controls have been adopted to mitigate the risk of disturbance to unidentified UCH. **Conclusion** The impact and risk assessment for archaeological heritage has determined that the planned activities and unplanned events associated with the Goodwyn Area Infill Development are expected to have no lasting effect on cultural features and heritage values, and thus the consequence level is ranked as F.
Cultural Features and Heritage Values (Intangible Cultural Heritage)	**Songlines** Management of intangible cultural heritage can include reducing impacts and risks to environmental features that are associated with intangible cultural heritage (UNESCO 2003; Australia ICOMOS 2013). Impacts to marine plants, animals, and other cultural features associated with songlines might impact the intergenerational transmission of knowledge of songlines when individuals can no longer witness or interact with the cultural features tied to songlines on Country. Therefore, managing songlines may require environmental controls

Receptor	Consequence Evaluation
	protecting species at a population level, including migratory routes. Refer to receptor-specific assessment below for further information, in addition to the impact and risk assessment in Sections 9.1 and 9.2. Physical features comprising a component of a songline are important to protect to prevent the fragmenting or breaking apart of songlines and loss of sacred cultural knowledge. Songlines can become lost, fragmented, or broken when there is a loss of Country or impact to culturally important physical features (Neale and Kelly 2020). No specific details of songlines within the EMBA have been identified or provided (Section 7.9.6), and no landforms typical of songlines (e.g. mountains, rivers, caves and hills; (Higgins 2021)) are anticipated to be impacted by the Goodwyn Area Infill Development. In publicly available literature, Murujuga is acknowledged as a starting point for songlines, including the flying fox songline (MAC 2023a). Precise location of this songline, and features of this songline that might be impacted, are not clearly articulated in the reviewed sources, but it is stated that “the sea is a source of creation for flying foxes” (DEC 2013). Another potential songline in the vicinity was identified in Kearney et al. (2023) which notes a connection between the Kangaroo songline and a pair of submerged waterholes identified through seabed mapping by the Deep History of Sea Country project, which later found submerged artefacts in Flying Foam passage. Other terrestrial species with narratives originating or potentially originating from the sea at Murujuga noted by McDonald and Phillips (2021) include Tarnguna (emu) and Jugurru (dingo). Surveys and consultation undertaken by Woodside to date for activities on the NWS, do not indicate that these songlines overlap the EMBA, and these species do not occur within the EMBA. In publicly available literature, Murujuga is acknowledged as the starting point for the seven sisters songline (Bainger 2023). Precise location of this songline, and features of this songline that might be impacted, are not clearly articulated in the reviewed sources. Surveys and consultation undertaken by Woodside to date for activities on the NWS, do not indicate that this songline overlaps with the EMBA. The literature review has also identified culturally important features, which are known to be commonly associated with songlines (e.g. marine species and landforms; Section 4.8), and these have been separately assessed. Note further assessment of intangible values and marine mammals are provided below, in addition to the impact and risk assessments in Sections 9.1 and 9.2. **Creation/dreaming sites; sacred sites; ancestral beings** Literature and consultation undertaken by Woodside has identified a number of creation / dreaming sites e.g. Jarrkunpungu/ Solitary Island, however they are located onshore. In addition the review of relevant literature has identified creation, dreaming and ancestral narratives related to the sea more broadly without confirming where (if anywhere) these overlap the EMBA. These references are of a general nature, and do not identify any features or values requiring specific protection or management from the proposed Goodwyn Area Infill Development. Sea serpents or water serpents are common in Aboriginal creation narratives, and several references were identified in the reviewed literature. The majority of these refer to serpents residing within inland rivers or pools outside of the EMBA (e.g. Dury v Western Australia [2018] FCA 1849, Hayes v Western Australia [2008] FCA 1487, Barber and Jackson (2011), Juluwarlu (2004), Kalbarri Visitor Centre (2023), and Water Corporation (2019)). In some versions, the serpent originates from the sea or coast and creates the rivers as it heads inland. Barber and Jackson (2011) also recount a story where a freshwater serpent pushes a sea serpent back into the ocean where it presumably continues to reside. This does not provide the specificity required to determine the location of sea serpents within the sea, and it is possible that the ocean as a whole (out to and beyond other continents) should be viewed generally as housing the sea serpent(s). By analogy to other water serpent narratives across Australia, possible impact pathways may include interruption of its path by blocking or reducing flows of water, damaging sacred sites such as thalu or rock art sites or depleting water sources. No impacts to water flows (either tidal movement or ocean currents) or depletion of water sources are anticipated from the Goodwyn Area Infill Development. Features of the landscape with the potential for connection to creation/dreaming stories and ancestral beings were noted within the EMBA—notably nearshore submerged waterways and hills in the “mid shelf” identified by UWA (2021). However, there are no anticipated impact pathways to submerged landscape features within the broader EMBA from the Goodwyn Area Infill Development.

	Ceremonial sites Surveys and consultation undertaken by Woodside to date for activities on the NWS, has noted that all mentions of active ceremonial sites were confined to onshore locations. As such no direct impacts to ceremonial sites are anticipated from the Goodwyn Area Infill Development. However, indirect impacts may occur where ceremonies cannot be performed due to limitations on access, loss of knowledge or impacts to the environment, which are further described below. **Cultural obligations to care for Country** Caring for Country collectively refers to the cultural obligations of individuals and groups, as well as rituals and ceremonies required for the physical and spiritual health of the environment. Lack of access to coastal located cultural sites that carry songlines or remain ceremonially important can impact First Nations peoples’ livelihoods and impact their ability to carry out cultural obligations on Country. While there is potential for shoreline accumulation of hydrocarbons within the EMBA, therefore additional controls, engagement of relevant cultural authorities in the event of a spill, have been adopted to mitigate the risk. **Knowledge of Country/ customary law and transfer of knowledge** Cultural knowledge about Sea Country/customary law and the intergenerational transmission of knowledge are important values identified through consultation, assessments, and literature reviews. Transfer of knowledge includes continuing traditional practices to pass on practical skills. Direct impact to communities practicing these skills will inherently occur when relevant aspects of the environment disappear, are displaced, or suffer a reduction in population—for example traditional fishing methods require the survival of traditional fish resources. Therefore, ensuring the transmission of cultural knowledge may require environmental controls protecting species and migratory pathways at a population level. Refer to receptor-specific assessment below for further information, in addition to the impact and risk assessments in Sections 9.1 and 9.2. **Connection to Country** Connection to Country describes the multi-faceted relationship between First Nations people and the landscape, which is envisioned as having personhood and spirit. Connection to Country may be damaged where people are displaced or disrupted (e.g. during colonisation) or where there is a loss of technical skills or environmental knowledge (McDonald and Phillips 2021). No impacts of this nature are considered to arise from the Goodwyn Area Infill Development. **Access to Country** Access to Country, including Sea Country, is necessary for the continuation of other values including caring for Country and the transfer of traditional knowledge. Access is also a value in its own right, as a continuation of traditional Sea Country access and use. Access to areas within the Project Area may be limited where exclusion zones are established around vessels/MODUs for safety purposes; these safety exclusion zones are temporary. The ongoing presence of subsea infrastructure is not anticipated to affect navigation, particularly given the water depths within the Project Area. Access to country within the EMBA would be limited to temporary exclusion in areas where there are hydrocarbons present, including shoreline accumulation, in the event of an unplanned hydrocarbon release. Therefore additional controls, engagement of relevant cultural authorities in the event of a spill, have been adopted to mitigate the risk. **Cultural Safety** Cultural Safety refers to respecting local Lore and culturally significant areas to protect individuals from cultural harm. There are many cultural implications for those (Aboriginal and non-Aboriginal) who do not follow cultural advice or access Country in culturally inappropriate ways. Cultural safety may include observing gender restricted areas, respecting significant places and restricted areas as well as following the advice from those with cultural authority. While there is potential for shoreline accumulation of hydrocarbons within the EMBA additional controls, engagement of relevant cultural authorities in the event of a spill, have been adopted to mitigate the risk. **Kinship systems and totemic species** Individuals may have kinship to specific species (Smyth 2008; Juluwarlu 2004) and/or a responsibility to care for species (Muller 2008). These relationships are understood to impose obligations on Traditional Custodians. It is understood that these obligations do not impose restrictions on other people generally, but it is considered that impacts to species at a population level may inhibit Traditional Custodians with kinship relationships’ ability to perform their obligations where this results in reduced or displaced populations. It is therefore considered that

Receptor	Consequence Evaluation
	the management of totemic or kinship species applies at the species/population level and not to individual plants and animals. As such, impacts to individual marine fauna is not expected to impact on the totemic or kinship cultural connection. Totemic species identified during consultation include whales, fish, stingrays, and octopuses. Refer to the receptor-specific assessment below for further information, in addition to the impact and risk assessments in Sections 9.1 and 9.2. **Resource collection** A suite of marine species have been identified through consultation and literature as important resources, particularly as food sources. For example, Sea Country resources of noted relevance to Thalanyji people which may be present in the vicinity of the Montebello Islands include dugongs, majun (marine turtles), turtle eggs, fish and shellfish. Other resource species include marine mammals, fish, shellfish, crustaceans, seabirds, gastropods, sea urchins and mangrove seeds. In addition to their immediate value as sustenance, the gathering and preparation of these resources are informed by cultural knowledge, and an inability to use these resources may result in a loss of ability to transfer that knowledge to future generations. Direct impact to First Nations communities using these resources will inherently occur when the resource disappears, is displaced, or suffers a reduction in population. Therefore, these communities may be impacted where there is an impact at the species/population level. As assessed in Section 9.1, impacts from planned activities on the marine environment, including resources important to First Nations people, is expected to be limited to no lasting effect or slight and therefore impacts that result in population effects (e.g. population decline, changes in migration routes, etc.) are not expected. Impacts to potential resources within the EMBA, in the highly unlikely event of an unplanned hydrocarbon release, are described and risk assessed in Sections 9.2.6 and 9.2.7, and are not expected to result in species or population level impacts. There may be potential impacts to resource collection along the coast where there is shoreline accumulation of hydrocarbons. However, given the hydrocarbon characteristics and rapid weathering, an unplanned hydrocarbon release is not expected to have a substantial adverse impact resulting in population level changes. Therefore, impacts to resource collection would be limited to temporary exclusion in areas where there are hydrocarbons present, including shoreline accumulation. In addition engagement of relevant cultural authorities in the event of a spill has been adopted as a control to mitigate the risk. **Conclusion** The impact and risk assessment for intangible cultural heritage has determined that the planned activities and unplanned events associated with the Goodwyn Area Infill Development are expected to have no lasting effect on cultural features and heritage values, and thus the consequence level is ranked as F.
Cultural Features and Heritage Values (Marine Ecosystems)	**Marine mammals (whale, dolphins, dugongs)** There are increase ceremonies/rituals for species of animals and plants important to First Nations people, to enhance or maintain populations. Thalu are places where these increase ceremonies are performed. All mentions of active ceremonial sites in the reviewed literature were confined to onshore locations, though the values may extend offshore where, for example, the thalu relates to marine species populations. Reviewed literature (DBCA 2020c) includes information that is marked as information that cannot be copied, reproduced, or used without consent. The values described in the literature are environmental in nature, apply to marine mammal behaviours at a population level, and are managed through existing environmental controls in Sections 9.1 and 9.2. Related intangible cultural heritage may include the transmission of cultural knowledge about whales and whale behaviour, including birthing areas, whale communication, and migratory patterns. Such cultural knowledge may be associated with various cultural functions and activities that support the social and economic life of a community (Fijn 2021). Whale symbology expressed through stories, music, and dance can reflect a group’s connections with the sea, as well as marine fauna, which then comprise a group’s cultural values (Ardler 2021; Bursill et al. 2007; Cressey 1998). Whales also speak to a broader connection that exists between First Nation people and their surrounding environment. Beyond mythology and symbolism, whales can be connected with various economic and social functions associated with everyday life. Cultural knowledge of whales, whale migration, behaviour, and the related marine environment may all be important in ensuring the continuation of these socio-economic functions and other related activities that remain valuable to First Nations people (Fijn 2021). Where timing or performance is linked to sighting or engaging with these species, impacts may occur where numbers or migration behaviours are impacted at a population level. No impacts to First Nations

Receptor	Consequence Evaluation
	communities' ability to perform or transmit stories, music, or dance are anticipated from the Goodwyn Area Infill Development. First Nations groups have expressed interest about whale migratory routes and studies. Inter-generational transmission of cultural knowledge (including songlines) relating to marine mammals may be impacted where changes to population, or behaviour at a population level, results in reduced sightings (e.g. through population decline, changes to migration routes, or changes to migration seasonality). This transfer of knowledge may be integral to managing a group's intangible cultural heritage (UNESCO 2003). As described in the relevant environmental impact and risk assessments in Sections 9.1 and 9.2, potential impacts to marine mammals from planned activities are limited to behavioural or auditory impairment/injury impacts, which may include temporary and localised deviations from migratory pathways. However, no permanent impacts preventing marine mammals from entering or occupying areas have been identified. These impacts and risks are not considered to be ecologically significant at a population level, and hence are not expected to impact the value of marine mammals, including the transmission of cultural knowledge. As such, cultural values and intangible cultural heritage associated with these species are expected to be maintained. **Marine reptiles (turtles, sea snakes, crocodiles)** Turtles and their eggs have been identified through existing literature as an important resource, particularly as food sources. Direct impact to First Nation communities using these resources will inherently occur when the resource disappears, is displaced, or suffers a reduction in population. Therefore, these species (as resources) will be impacted where there is an impact at the species/population level. Intangible cultural heritage may also include the transmission of cultural knowledge about marine reptiles, such as nesting areas, hunting areas, and migratory patterns. Cultural knowledge may also be conveyed through stories, such as the turtle being trapped in the sea as a result of its greed for berries as recounted by Capewell (2020). Such cultural knowledge may be associated with various cultural functions and activities that support the social and economic life of a community (Fijn 2021). Activities that impact turtle populations and their marine environment may have an indirect impact on some First Nations communities as this can limit access to cultural sites or deplete hunting areas that would threaten local food security (Delisle et al. 2018). Inter-generational transmission of cultural knowledge (including songlines) relating to marine reptiles may be impacted where changes to population or behaviour results in reduced sightings (e.g. through population decline, changes to migration routes, or changes to migration seasonality). This transfer of knowledge may be integral to managing a group's intangible cultural heritage (UNESCO 2003). As described in the relevant environmental impact and risk assessments in Sections 9.1 and 9.2, potential impacts to marine reptiles are likely to be restricted to temporary behavioural changes, which are not considered to be ecologically significant at a population level, and hence not expected to impact the value of marine reptiles, including the transmission of cultural knowledge or use as a resource. As such, cultural values and intangible cultural heritage associated with these species are expected to be maintained. **Fish and Cephalopods** Fish and squid have been identified through consultation and existing literature as an important resource, particularly as food sources. Direct impact to First Nations communities using these resources will inherently occur when the resource disappears, is displaced, or suffers a reduction in population. Therefore these species (as resources) will be impacted where there is an impact at the species/population level. Through engagement, fish were identified as important agents in the management of the broader ecosystem. It may be assumed that intergenerational transmission of cultural knowledge relating to fish may be impacted where changes to population or behaviour results in reduced sightings (e.g. through population decline). This transfer of knowledge may be integral to managing a group's intangible cultural heritage (UNESCO 2003). Intangible cultural heritage associated with fish, including intergenerational knowledge regarding fishing techniques and migratory patterns, can be managed by reducing impacts to fish in nearshore marine environments to which this cultural knowledge is intrinsically connected. The octopus is an important totem to Ngarla people and features in the creation story of Solitary Island. There are increase ceremonies/rituals for species of squid and octopus to enhance or maintain populations. Thalu are places where these increase ceremonies are performed. All mentions of active ceremonial sites in the reviewed literature were confined to onshore locations, though the values may extend offshore where, for example, the thalu relates to marine species populations. As thalu ceremonies are preformed to maintain and increase populations of marine

Receptor	Consequence Evaluation
	species, it is inferred that management applies at the species/population level and not to individuals. As described in the relevant environmental impact and risk assessments in Sections 9.1 and 9.2, the potential impacts on fish are considered to be localised and with slight, short-term (<1-year) impact potential on species (or lower), but not affecting ecosystem function, physical or biological attributes. Impact potential is not considered to be ecologically significant at a population level. As such, cultural values and intangible cultural heritage associated with these species are expected to be maintained. **Seabirds** Seabirds, specifically shags, have been identified through literature as a culturally significant species (Sinclair 2021), as well as a resource (e.g. seabird eggs; (Smyth 2007)). Direct impact to communities using these resources will inherently occur when the resource disappears, is displaced, or suffers a reduction in population. Therefore, these species (as resources) will be impacted where there is an impact at the species/population level. Intangible cultural heritage may also include the transmission of cultural knowledge about seabirds, such as nesting areas, hunting areas, and migratory patterns. Such cultural knowledge may be associated with various cultural functions and activities that support the social and economic life of a community (Fijn 2021). Inter-generational transmission of cultural knowledge relating to seabirds may be impacted where changes to population or behaviour results in reduced sightings (e.g. through population decline, changes to migration routes, or changes to migration seasonality). This transfer of knowledge may be integral to managing a group's intangible cultural heritage (UNESCO 2003). As described in the relevant environmental impact assessments in Section 9.1, the potential impacts from planned activities on seabirds is assessed to be no lasting effect. The potential for temporary behavioural disturbance localised around vessels from light is not expected to result in a substantial adverse effect on species population, and light emissions will not seriously disrupt the lifecycle of an ecologically significant proportion any migratory bird species. In terms of risk, as described in Section 9.2, a change in behaviour or injury/mortality to seabirds and migratory shorebirds may occur due to a change in water or sediment quality following an unplanned hydrocarbon release. Given the hydrocarbon characteristics, expected rapid weathering to below impact thresholds, and the mobile transient nature of individuals, unplanned hydrocarbon releases are not expected to significantly adversely affect species at a population level. As such, cultural values and intangible cultural heritage associated with these species are expected to be maintained. **Benthic habitats and communities (coral, seagrass)** Through engagement and publicly available literature, First Nations groups identified benthic habitats as valuable for their ecological values, including corals attracting fish, and seagrass providing shelters for fauna, as well as an important habitat for dugongs. Additionally, coral is valued by MAC for its aesthetic values. As described in the relevant environmental impact assessments in Section 9.1, the potential impacts from planned activities on benthic habitats is assessed to be slight to minor. Specifically, the discharge of drill cuttings and drilling fluids, are predicted to result in a disturbance to localised areas of benthic habitats but not affect ecosystem. Elevated suspended sediment from seabed disturbances (e.g. from infrastructure installation) is predicted to result in temporary changes to water quality with no subsequent impact to benthic communities and habitats. The direct physical footprint resulting from infrastructure installation will result in the removal of relatively small areas of predominantly soft sediment habitat. In terms of risk, as described in Section 9.2, a change in benthic habitats and communities may occur due to a change in water or sediment quality following an unplanned hydrocarbon release. Given hydrocarbon characteristics and weathering behaviours, an unplanned hydrocarbon release is not expected to have a substantial adverse impact on marine ecosystem functioning or integrity. As such, cultural values and intangible cultural heritage associated with benthic habitats are expected to be maintained. **Shoreline habitats (mangroves, salt marshes)** Through engagement and publicly available literature, First Nations groups identified shoreline habitats as valuable for their ecological values, including mangroves for providing shelter to marine invertebrates, which are identified resources, and potential nursery for turtles. Literature also notes that mangroves are also valued for the flora and fauna they are associated with and support (CoA 2002) and Smyth (2007) reports that mangrove seeds are used as a resource by Ngarda-Ngarli.

Receptor	Consequence Evaluation
	There is no overlap between the Project Area and mangrove habitat, and there are no predicted impacts to mangroves from planned activities. In terms of risk, as described in Section 9.2, a change in habitat may occur due to a change in water or sediment quality following an unplanned hydrocarbon release. Given hydrocarbon characteristics and weathering behaviours, an unplanned hydrocarbon release is not expected to have a substantial adverse impact on marine ecosystem functioning or integrity. As such, cultural values and intangible cultural heritage associated with shoreline habitats are expected to be maintained. **Conclusion** The impact and risk assessment for cultural features and heritage values related to marine ecosystem receptors has determined that the planned activities and unplanned events associated with the Goodwyn Area Infill Development are expected to have no lasting effect, and thus the consequence level is ranked as F.
Cultural Features and Heritage Values (Murujuga Rock Art)	In the context of First Nations cultural heritage, Murujuga (Burrup Peninsula) is most widely known for its large collection of rock art (petroglyphs). The Traditional Owners of Murujuga have a deep cultural and spiritual connection to the rock art of the Burrup Peninsula, which provides a record of Aboriginal lore, dreamtime stories, customs, and local knowledge of the land and its resources (MAC 2019). To determine the relevance of atmospheric emissions from petroleum activities under this OPP to parts of the Burrup Peninsula outside of the Project Area, Woodside undertook an assessment. Woodside considers that the atmospheric emissions associated with the onshore processing of Goodwyn Area Infill Development hydrocarbons at the KGP are a downstream emission to be considered. As part of preparing the North West Shelf Project Extension approvals (currently under assessment; Section 1.4.2.1), the potential for accelerated weathering of rock art as a result of atmospheric emissions from KGP were considered. This process also considered the hypothesis that deposition of NO_X, SO_X and ammonia (NH_3) from anthropogenic industrial sources have the potential to increase the acidity of the rock surface through chemical and/or biological processes and that acidic conditions may then accelerate the weathering of rock patina, eroding or affecting the contrast of the rock art. Key emissions as they relate to KGPs power generation and process emissions include NO_X, VOCs, and a very minor contribution of SO_2. Although numerous academic, government and industry studies into this hypothesised potential impact pathway have been conducted since 2004, the findings from these studies to date has not been conclusive or provided credible standards for determining possible emissions levels. The WA Government is currently implementing the Murujuga Rock Art Strategy, which plans to develop a long-term framework to guide the management and protection of the rock art located on the Dampier Archipelago and the Burrup Peninsula which builds on these studies. The Department of Water and Environmental Regulation (DWER) has primary responsibility for the implementation of the Strategy, which is being undertaken in partnership with the MAC, representing the Traditional Owners of Murujuga, and in consultation with stakeholders, including the community and industry. Key aspects of the Strategy are to: • establish an Environmental Quality Management Framework which includes the development of guidelines and standards, based on sound scientific information, which will provide warning of potential harmful effects and if management actions are required to protect the rock art from harm • develop and implement a robust program of monitoring and analysis to determine whether change is occurring to the rock art on Murujuga • commission scientific studies to support the implementation of the monitoring and analysis program and management against environmental quality criteria • establish governance communication processes which involve key stakeholders. The Strategy is intended to provide a “transparent, risk-based and adaptive framework for monitoring and managing environmental quality to protect the rock art on Burrup Peninsula from industrial emissions” (DWER 2019). Woodside actively supports the implementation of the Murujuga Rock Art Strategy through membership of the Murujuga Rock Art Reference Group and provides funding associated with the Murujuga Rock Art Monitoring Program. Woodside also supports the coordinated approach for atmospheric deposition monitoring program to be established under the Strategy, and currently provides data to the program from the Woodside Atmospheric Monitoring Program.

Receptor	Consequence Evaluation
	Atmospheric emissions from onshore processing at KGP are managed under Ministerial Statement 536. Woodside expects that once further developed, the findings of Murujuga Rock Art Strategy will be implemented via appropriate regulatory measures.

9.3.6 Decision Type and Key Control Measures

Based on the decision support framework (Section 4.5.1) and the predicted consequence levels and residual risk ratings from Cultural Features and Heritage Values, these have been determined as lower-order impacts and risks (Table 4-4); therefore, decision type A is considered appropriate.

Key control measures adopted for the offshore project and relevant to managing Cultural Features and Heritage Values are described in the following table.

Type	Key Control Measures
Legislation, Codes and Standards	• **CM-54**: The offshore project must comply with legislative requirements, including the *Underwater Cultural Heritage Act 2018* (Cth) and *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth)
Good Industry Practice	• **CM-55**: Undertake a desktop assessment to identify any indicators of underwater cultural heritage within proposed areas of seabed disturbance for the Goodwyn Area Infill Development • **CM-56**: Engage with relevant cultural authorities that may be affected in the unlikely event of an unplanned hydrocarbon release
Professional Judgement	• **CM-57**: Implement a program of ongoing consultation with First Nations people whose functions, interests or activities may be affected by the petroleum activities to identify and reduce impacts to cultural features and heritage values • **CM-58**: Consider and implement a 'living heritage' management approach during the EP process to reduce impacts to identified cultural features and heritage values

9.3.7 Impact and Risk Analysis Summary

Risk	Receptor	Environmental Value							Evaluation			
		Soil and Groundwater	*Marine Sediment*	*Water Quality*	*Air Quality (including Odour)*	*Ecosystems or Habitats*	*Species*	*Socioeconomic and cultural*	*Decision Type*	*Consequence*	*Likelihood*	*Risk Rating*
Planned Activities												
Potential changes to cultural features or heritage values	Cultural features and heritage values							✓		F	–	–
Unplanned Events												
Potential changes to cultural features or heritage values	Cultural features and heritage values							✓		F	1	Low

9.3.8 Demonstration of Acceptability

In accordance with Section 4.7, the following table demonstrates that the environmental impacts and risks associated with Cultural Features and Heritage Values for the Goodwyn Area Infill Development can be managed to an acceptable level.

Acceptability Criteria	Demonstration
Comparison with Acceptable Level	Acceptable levels for the Goodwyn Area Infill Development are defined in Table 4-3. The acceptable levels were developed based on consideration of relevant context including the principles of ESD, relevant legislation and regulatory guidance (Section 4.7; Table 4-3). The acceptable levels for this aspect are **AL-11**, **AL-12**, and **AL-13** as defined in Table 4-3 (and shown below in Section 9.3.9). As described in the consequence evaluation (Section 9.3.5), the impacts and risks from the Goodwyn Area Infill Development are predicted to result in no lasting effect to cultural features and heritage values. Therefore, the predicted level of impact is better than the acceptable levels (**AL-11**, **AL-12**, **AL-13)**.
Impact and Risk Classification, and Decision Type	The impacts and risks to cultural features and heritage values are considered lower-order impacts and risks (decision type A) in accordance with Table 4-4, and as such are considered 'broadly acceptable'. These impacts and risks are considered to be managed to an acceptable level by meeting (where they exist) legislative requirements, industry codes and standards, applicable company requirements, and industry guidelines, and these have been adopted as key control measures for the offshore project (Section 9.3.6).
Principles of ESD	These principles of ESD were considered for cultural features and heritage values: • Integration Principle – the existing environment (Section 7) has been described consistent with the definition within regulation 5 of the Environment Regulations (i.e. includes ecological, socioeconomic, and cultural features), and any relevant values and sensitivities have been included within this (Section 9.3) impact and risk analysis; therefore, the impact and risk assessment process inherently includes economic, environmental and social considerations – during preliminary consultation (Section 8.4.1), no objections or claims were raised regarding potential affects to cultural features or heritage values arising from the offshore project – as described in Section 9.3.5, no adverse impact to the intergenerational transmission of knowledge is predicted to occur – the impacts and risks have been identified as a lower-order impacts and risks that can be managed to an acceptable level by implementing the key control measures (Section 9.3.6) • Precautionary Principle – the impact consequence rating and the residual risk rating for cultural features and heritage values is no lasting effect (F) and low respectively; therefore, no potential for serious or irreversible environmental damage is expected – although serious or irreversible environmental damage is not predicted to occur, Woodside acknowledge there is some uncertainty with the identification of cultural features and heritage values within the Project Area and EMBA – the proposed surveys/assessments, and ongoing program of First Nations consultation (see key control measures in Section 9.3.6) has been developed to enable Woodside to manage potential uncertainty on the impacts and risks to cultural features and heritage values • Intergenerational Principle – the acceptable levels were developed consistent with the principles of ESD, including that the environmental impacts and risks of the offshore project will not forego the health, diversity, or productivity of the environment for future generations – as described above, the predicted environmental impact is below the acceptable levels for cultural features and heritage values, and thus is not considered to have the potential to affect intergenerational equity • Biodiversity Principle – not considered applicable for cultural features and heritage values – where cultural feature and heritage values are associated with marine ecosystem receptors (e.g. species, habitats), the Biodiversity Principle has been assessed in Sections 9.1 and 9.2.

<table>
<tr><th>Acceptability Criteria</th><th colspan="2">Demonstration</th></tr>
<tr><td>Internal Context</td><td colspan="2">No specific Woodside management processes or procedures were deemed relevant for cultural features and heritage values
This Woodside management process or procedure was deemed relevant for this aspect:
• Cultural Heritage Management Procedure.
Control measures related to this management process or procedure have been described for this aspect (Section 9.3.6). Therefore, the impact and risk management is consistent with company policy, culture, and standards.</td></tr>
<tr><td>External Context</td><td colspan="2">During preliminary consultation (Section 8.4.1), no objections or claims were raised regarding potential affects to cultural features or heritage values from the offshore project.</td></tr>
<tr><td rowspan="12">Other Requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect, and a demonstration of how these requirements are met, are described below.</td></tr>
<tr><td>Requirement</td><td>Demonstration</td></tr>
<tr><td>Underwater Cultural Heritage Act (Cth)
Protection of Australia’s UCH</td><td>The requirements of this Act are incorporated into the key control measures (Section 9.3.6).</td></tr>
<tr><td>Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)
Protection of areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal traditions</td><td>The requirements of this Act are incorporated into the key control measures (Section 9.3.6).</td></tr>
<tr><td>North-west Marine Parks Network Management Plan
No specific zone rules identified.</td><td>N/A</td></tr>
<tr><td>North-west Marine Parks Network Management Plan: Implementation Plan 1, Foundation Phase 2018–2022
No specific actions or activities identified.</td><td>N/A</td></tr>
<tr><td>South-west Marine Parks Network Management Plan
No specific zone rules identified.</td><td>N/A</td></tr>
<tr><td>South-west Marine Parks Network Management Plan: Implementation Plan 1, Foundation Phase 2018–2022
No specific actions or activities identified.</td><td>N/A</td></tr>
<tr><td>Conservation Management Plan for the Blue Whale 2015–2025
No specific management action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Advice Balaenoptera borealis Sei Whale
No specific conservation action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Advice Balaenoptera physalus Fin Whale
No specific conservation action identified.</td><td>N/A</td></tr>
<tr><td>Conservation Advice Rhincodon typus Whale Shark
No specific conservation action identified.

Recovery Plan for Marine Turtles in Australia
No specific management action identified.</td><td>N/A

N/A</td></tr>
</table>

Acceptability Criteria	Demonstration	
	Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) No specific conservation action identified.	N/A
	Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area No specific management actions identified.	N/A
	Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves No specific management actions identified.	N/A

9.3.9 Environmental Performance Outcomes

The EPOs for the Goodwyn Area Infill Development were developed to be consistent with the principles of ESD, equivalent to or better than the defined acceptable level, and encompass either the acceptable level or the predicted impact or risk (Section 4.9).

The EPOs relevant to Cultural Features and Heritage Values are shown in the below table. For reference, the relevant acceptable levels have also been shown against the relevant EPOs.

Acceptable Levels	Environmental Performance Outcomes
AL-11: No adverse effect on underwater cultural heritage such that it prevents the long-term protection of values as conferred by the *Underwater Cultural Heritage Act 2018* (Cth) **AL-12**: No adverse effect on declared areas or objects of particular significance such that it prevents the long-term protection of values as conferred by the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth)	**EPO-24**: Prevent adverse changes to underwater cultural heritage (as protected under the *Underwater Cultural Heritage Act 2018* [Cth]), or to declared areas or objects of particular significance (as protected under the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* [Cth]) from petroleum activities
AL-13: No interference with native title rights or interests[61] within the petroleum permit area/s to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties as conferred to the titleholder	**EPO-25**: Woodside will support First Nations capacity for ongoing engagement and consultation on EPs for the purpose of avoiding impacts to cultural features and heritage values

[61] Where native title rights and interests is defined under section 233 of the *Native Title Act 1993* (Cth).

10 CUMULATIVE IMPACT ASSESSMENT

10.1 Overview

In alignment with NOPSEMA's OPP Decision Making Guideline (NOPSEMA 2024e) the intent of regulation 13(4)(c) includes a consideration of cumulative environmental impacts. NOPSEMA (2024a) notes that cumulative impacts of an offshore project may include the additive effects of activities within the same project, additive effects from other activities within the region or potentially affecting the same environmental receptors, or the long-term cumulative effects of a project lasting many years or decades.

For the cumulative impact assessment within this OPP, Woodside has adopted these definitions:

- **holistic impacts**: connections and interactions between impacts, and the overall impact of the offshore project on the environment as a whole
- **cumulative impacts**: the successive, incremental, and interactive impacts on the environment of the offshore project with one or more past, present, and reasonably foreseeable future activities (EPA 2021).

This section identifies and evaluates potential holistic effects from the different aspects associated with planned activities from the offshore project (i.e. holistic impacts), and potential cumulative effects from planned activities[62] associated with the offshore project in combination with other relevant marine activities (i.e. cumulative impacts).

10.2 Holistic Impact Assessment

10.2.1 Method

The impact assessment presented in Section 9.1 addresses the interaction of the Goodwyn Area Infill Development with the environment on a single-aspect basis. This section considers how receptors known to be impacted by individual aspects associated with the Goodwyn Area Infill Development may be subject to holistic effects from multiple aspects (associated with the Goodwyn Area Infill Development).

The holistic impact assessment was done by:

- screening aspect–receptor interactions and identifying the potential for holistic effects
- evaluating holistic impacts as per Woodside's impact and risk analysis process (Section 4.5).

The holistic impact assessment has been presented per receptor group below.

10.2.2 Impact Identification and Analysis

10.2.2.1 Physical Environment

The physical environment within the Project Area may be impacted throughout the offshore project's lifecycle. It is possible that holistic effects to water or sediment quality may occur during the different activities and aspects associated with the Goodwyn Area Infill Development (Table 10-1), and these are assessed further below. No holistic effects to air quality are expected from the NWS Infill Development (Table 10-1).

[62] Given the low likelihood of unplanned events (e.g. an unplanned hydrocarbon release) occurring during the Goodwyn Area Infill Development, risks from unplanned events were not considered in assessing holistic or cumulative impacts.

Table 10-1: Physical environmental receptors—screening for potential holistic effects from Goodwyn Area Infill Development aspects

Aspect	Receptors: Water Quality	Receptors: Marine Sediment	Receptors: Air Quality
Physical Presence: Interaction with other Marine Users			
Physical Presence: Disturbance to the Seabed	✓		
Routine Emissions: Light Generation			
Routine Acoustic Emissions: Continuous Sound Generation			
Routine Acoustic Emissions: Impulsive Sound Generation			
Routine and Non-routine Emissions: Atmospheric			✓
Routine and Non-routine Emissions: Greenhouse Gases			
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	✓		
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	✓		
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	✓	✓	
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	✓	✓	
Downstream Discharges: Produced Water	✓	✓	
Potential Holistic Effect to receptors from Goodwyn Area Infill Development	✓	✓	

10.2.2.1.1 Consequence Evaluation

Change to water quality

Receptor	Consequence Evaluation
Physical Environment (Water Quality)	Changes to water quality are predicted to occur during all phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development. Changes to water quality are associated with seabed disturbance, and liquid or solid discharges. The areas of exposure to seabed disturbance and planned discharges from the Goodwyn Area Infill Development activities will overlap, except for the downstream discharge of PW. The downstream PW discharges are released from the GWA platform (~2 km north-east of the Project Area), with water quality effects anticipated within ~200 m of the source (Section 9.1.12). The other sources of water quality change will all occur within the Project Area, and aspects may be generated concurrently. The impact to water quality from the seabed disturbance aspect are low, predominantly occurring from the displacement of sediment causing a temporary and highly localised increase in suspended sediment. Water quality is expected to recover rapidly following completion of the activity causing the seabed disturbance (e.g. subsea infrastructure installation). Therefore, the potential for impacts to water quality from this aspect to interact with other aspects is very limited. During the drilling phase, the surface discharge of drilling fluids may also occur at the same time as surface discharges from the MODU and vessels (e.g. sewage, drain water, cooling water). While these discharges will be occurring within the same area, the contaminants within each are different and are not expected to magnify or interact with each other. Rapid mixing and dispersion is also expected given the influence of regional wind and large-scale ocean current patterns on offshore marine waters. The largest subsea discharge during installation phase is associated with hydrotest discharge, and while this is unlikely to occur concurrently with other subsea discharges, the modelling of this subsea discharge indicated rapid mixing and dispersion (e.g. up to 1,214 dilutions within

Receptor	Consequence Evaluation
	~282 m). Thus the potential for impacts to water quality for subsea discharges to interact with each other is considered limited. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact water quality, holistic impacts are expected to have no lasting effects (F).

Change to sediment quality

Receptor	Consequence Evaluation
Physical Environment (Marine Sediments)	Changes to sediment quality are predicted to occur during all phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development; however most changes are predominantly associated with the drilling phase. As described in Section 9.1.10, localised (e.g. ~50–200 m) sedimentation around a well site, with thin veneers extending to >1 km were predicted due to the discharge of drill cuttings and drilling fluids. The predicted area of exposure for cementing operations was up to ~50 m around a well site (Section 9.1.11). Therefore, there is spatial and temporal overlap between the areas of exposure from these two discharge sources. However, while the discharge of drill cuttings and drilling fluids, and the discharge of cement, will affect the same area of marine sediments around each well site, the area of holistic impacts is highly localised (~50 m). Therefore, the potential holistic impacts are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual aspect. The downstream PW discharges are released from the GWA platform (~2 km north-east of the Project Area), therefore no spatial overlap in exposure areas is anticipated. Further, as described in Section 9.1.12, particulates within the PW discharge from the GWA platform are not expected to settle, and no lasting effect to sediment quality was predicted. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact sediment quality, holistic impacts are expected to have no lasting effects (F).

10.2.2.2 Habitat and Biological Communities

The habitat and biological communities within the Project Area may be impacted throughout the offshore project's lifecycle. It is possible that holistic effects to planktonic communities, offshore habitats and biological communities, and KEFs may occur during the different activities and aspects associated with the Goodwyn Area Infill Development (Table 10-2), and these are assessed further below.

Table 10-2: Habitat and biological communities receptors—screening for potential holistic effects from Goodwyn Area Infill Development aspects

Aspect	Receptors		
	Planktonic Communities	***Offshore Habitats and Biological Communities***	***Key Ecological Features***
Physical Presence: Interaction with other Marine Users			
Physical Presence: Disturbance to the Seabed		✓	✓
Routine Emissions: Light Generation			
Routine Acoustic Emissions: Continuous Sound Generation	✓		
Routine Acoustic Emissions: Impulsive Sound Generation	✓		
Routine and Non-routine Emissions: Atmospheric			
Routine and Non-routine Emissions: Greenhouse Gases	✓[1]	✓[1]	✓[1]

Aspect	Receptors		
	Planktonic Communities	*Offshore Habitats and Biological Communities*	*Key Ecological Features*
Routine and Non-routine Discharges: Hydrocarbons and Chemicals			
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	✓		
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids		✓	✓
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product		✓	✓
Downstream Discharges: Produced Water	✓		
Potential Holistic Effect to receptors from Goodwyn Area Infill Development	✓	✓	✓

1. While the GHG emission aspect has been screened in Table 10-2 as relevant to habitat and biological communities receptors, as described in Section 9.1.7, climate change or the impacts of climate change cannot be directly attributed to any one project, including the Goodwyn Area Infill Development. Climate change impacts upon Australian receptors cannot be linked to the Goodwyn Area Infill Development but are instead the result of the accumulation of GHG emissions in the atmosphere. A contextual evaluation of GHG emissions is provided in Section 9.1.7 and has not been repeated here.

10.2.2.2.1 Consequence Evaluation

Potential changes to habitats and biological communities

Receptor	Consequence Evaluation
Planktonic Communities	Changes to planktonic communities are predicted to occur during all phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development. Changes to planktonic communities are associated with acoustic emissions and liquid discharges. The areas of exposure to acoustic emissions and planned discharges from the Goodwyn Area Infill Development activities will overlap, except for the downstream discharge of PW. The downstream PW discharges are released from the GWA platform (~2 km north-east of the Project Area), with water quality effects (and thus potential planktonic community impacts) anticipated within ~200 m of the source (Section 9.1.12). The other aspects resulting in potential changes to planktonic communities will all occur within the Project Area, and aspects will be generated concurrently. Acoustic sound emissions (continuous and impulsive) will occur from a vessel and/or MODU, and therefore may occur at the same time as the intermittent operational surface discharges from the MODU and vessels (e.g. sewage, drain water, cooling water). These discharges and emissions affect planktonic communities differently, and the types of impacts and are not expected to magnify each other. Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (DEWHA 2008b), and any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact planktonic communities, holistic impacts are expected to have no lasting effects (F).
Offshore Habitats and Biological Communities	Changes to benthic habitats and biological communities are predicted to occur during all phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development; however most changes are predominantly associated with the drilling, installation, and decommissioning phases. The phases of the project are also typically sequential, however there may be some concurrent activities during drilling and installation phases. As described in Section 9.1.10, localised (e.g. ~50–200 m) sedimentation around a well site, with thin veneers extending to >1 km were predicted due to the discharge of drill cuttings and drilling fluids. The predicted area of exposure for cementing operations was up to ~50 m around a well

Receptor	Consequence Evaluation
	site (Section 9.1.11). Therefore, there is spatial and temporal overlap between the areas of exposure from these two discharge sources. However, while the discharge of drill cuttings and drilling fluids, and the discharge of cement, will affect the same area of benthic habitat around each well site, the area of holistic impacts is highly localised (~50 m). Therefore, the potential holistic impacts are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual aspect. Installation of subsea infrastructure (for both the phased development and potential future development) is estimated to have an infrastructure footprint of ~0.04 km^2 and potential infrastructure disturbance area of ~1.99 km^2 (Table 5-5, Table 5-6). This estimated extent of seabed disturbance is considered small in relation to the extent of the soft sediment habitats, which are broadly represented within the Project Area and the wider NWMR. Where subsea infrastructure installation occurs in proximity to a drill centre, an overlap in the disturbance area may occur. However, apart from within the direct footprint, recovery of short sediment habitats is expected to occur in <1 year (Dernie et al. 2003). The Goodwyn Area Infill Development is also a phased development, and as such the disturbance to different areas of the seabed from drilling and installation activities will occur over multiple years (i.e. not 19 wells and all subsea infrastructure within a single campaign). A literature review undertaken by Bakke et al. (2013) indicated that ecosystem and population-level effects from numerous drilling operations are not expected. While disturbance to habitats during decommissioning is expected to be similar areas to that disturbed during drilling and installation, given the duration between these phases, recovery from the initial disturbance is expected to occur prior to the decommissioning activities. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact benthic habitats and communities, holistic impacts are expected to have no lasting effects (F).
KEFs	The Project Area partially overlaps the ancient coastline at 125 m depth contour KEF. The phased development nominal infrastructure corridor intersects with ~133 km^2 of the 16,190 km^2 KEF (i.e. ~0.82% of the KEF). Any interaction with the KEF is restricted to the northern part of the Project Area, associated with project activities within WA-5-L, WA-6-L, WA-23L, and WA-24-L. The values of this KEF include providing areas of hard substrate that may result in higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment (Table 7-18). However, benthic habitat surveys in the vicinity of the Project Area (including within the ancient coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (RPS 2011; AIMS 2014b). Therefore, any holistic impacts to the KEF are expected to be similar to that described above for benthic habitats and communities. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact KEFs, holistic impacts are expected to have no lasting effects (F).

10.2.2.3 Protected Species

Protected species within the Project Area may be impacted throughout the offshore project's lifecycle. It is possible that holistic effects to fish, sharks, and rays, marine reptiles, and marine mammals may occur during the different activities and aspects associated with the Goodwyn Area Infill Development (Table 10-3), and these are assessed further below. No holistic effects to seabirds and migratory shorebirds are expected from the Goodwyn Area Infill Development (Table 10-3).

Table 10-3: Protected species receptors—screening for potential holistic effects from Goodwyn Area Infill Development aspects

Aspect	Receptors			
	Fish, Sharks, and Rays	*Marine Reptiles*	*Marine Mammals*	*Seabirds and Migratory Shorebirds*
Physical Presence: Interaction with other Marine Users				
Physical Presence: Disturbance to the Seabed				
Routine Emissions: Light Generation	✓	✓		✓
Routine Acoustic Emissions: Continuous Sound Generation	✓		✓	
Routine Acoustic Emissions: Impulsive Sound Generation	✓	✓	✓	
Routine and Non-routine Emissions: Atmospheric				
Routine and Non-routine Emissions: Greenhouse Gases	✓[1]	✓[1]	✓[1]	✓[1]
Routine and Non-routine Discharges: Hydrocarbons and Chemicals				
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine				
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids				
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product				
Downstream Discharges: Produced Water	✓	✓	✓	
Potential Holistic Effect to receptors from Goodwyn Area Infill Development	✓	✓	✓	

1. While the GHG emission aspect has been screened in Table 10-3 as relevant to marine fauna receptors, as described in Section 9.1.7, climate change or the impacts of climate change cannot be directly attributed to any one project, including the Goodwyn Area Infill Development. Climate change impacts upon Australian receptors cannot be linked to the Goodwyn Area Infill Development but are instead the result of the accumulation of GHG emissions in the atmosphere. A contextual evaluation of GHG emissions is provided in Section 9.1.7 and has not been repeated here.

10.2.2.3.1 Consequence Evaluation

Potential changes to fauna behaviour, and/or potential injury or mortality to fauna

Receptor	Consequence Evaluation
Fish, Sharks, and Rays	Potential impacts to marine fauna are predicted to occur during all phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development. The phases of the project are typically sequential, however there may be some concurrent activities during drilling and installation phases. The aspects screened as causing potential impacts are acoustic emissions (continuous and impulsive), artificial light emissions, and downstream PW discharges. Except for the downstream PW discharges, these emissions are all from MODU or vessel sources, and therefore there will be spatial and temporal overlap in exposure areas. Vessel and MODU presence from Goodwyn Area Infill Development will usually be low, peaking during drilling, installation, and decommissioning phases. During operations, only one to two vessels are likely to be within the Project Area, and then only intermittently (e.g. for IMMR activities). Light emissions and acoustic emissions may result in changes to fish, shark, or ray behaviour (Sections 9.1.3.3, 9.1.4, and 9.1.5). Light emissions may attract individuals towards the light source, but this is expected to be very localised to the source. Impulsive and continuous sounds were typically identified as having a moderate or high risk of causing behavioural changes, or masking, within the near (tens of metres) and intermediate (hundreds of metres) vicinity of a sound source. While the exposure areas do spatially and temporally overlap, given the different mechanisms the emissions are not anticipated to magnify any impact, and therefore the potential

Receptor	Consequence Evaluation
	holistic impacts are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual aspect. The only aspect with the potential to result in auditory impairment (TTS) or injury to fish, sharks, or rays is impulsive sound; and this will only occur if impact piling for MODU mooring systems is selected for use. The downstream PW discharges are released from the GWA platform (~2 km north-east of the Project Area), therefore no spatial overlap in exposure areas with other emissions within the Project Area is anticipated. The PW discharges will also predominantly occur during the operations phase, when acoustic and light emissions from vessel or MODU presence within the Project Area will only occur intermittently. Downstream PW discharges were assessed as having no lasting effect on fish, sharks, and rays. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact fish, sharks and rays, holistic impacts are expected to have no lasting effects (F).
Marine Reptiles	The aspects screened as causing potential impacts to marine reptiles are acoustic emissions (continuous and impulsive), artificial light emissions, and downstream PW discharges. Except for the downstream PW discharges, these emissions are all from MODU or vessel sources, and therefore there will be spatial and temporal overlap in exposure areas. Light emissions and impulsive sound emissions may result in changes to marine reptile behaviour (Sections 9.1.3.3 and 9.1.5). However, the emissions are occurring within an offshore marine environment (the closest coast is Montebello Island, ~30 km south of the Project Area). Pendoley Environmental (2020a) found no published or anecdotal evidence to suggest that internesting turtles are impacted by light from offshore vessels. Therefore, no changes to internesting behaviour due to light emissions from the MODU and vessels are expected. Behavioural changes from impulsive sound are predicted to occur during impact piling, or to a lesser extent from the use of geophysical survey techniques during multiple phases of the project (however the extent of this sound field is typically only hundreds of metres from the sound source). The only aspect with the potential to result in auditory impairment (TTS) or injury (PTS) to marine reptiles is impulsive sound; and this will only occur if impact piling for MODU mooring systems is selected for use. Potential auditory impairment (TTS) or injury (PTS) to marine reptiles from continuous sound emissions was not considered credible (Section 9.1.4). The downstream PW discharges are released from the GWA platform (~2 km north-east of the Project Area), therefore no spatial overlap in exposure areas with other emissions within the Project Area is anticipated. The PW discharges will also predominantly occur during the operations phase, when acoustic and light emissions from vessel or MODU presence within the Project Area will only occur intermittently. Downstream PW discharges were assessed as having no lasting effect on marine reptiles. Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact marine reptiles, holistic impacts are expected to have no lasting effects (F).
Marine Mammals	The aspects screened as causing potential impacts are acoustic emissions (continuous and impulsive), and downstream PW discharges. Continuous and impulsive sound emissions both occur within the Project Area, from MODU or vessel sources, and therefore there will be spatial and temporal overlap in exposure areas. Behavioural changes from impulsive sound are predicted to occur during impact piling, or to a lesser extent from the use of geophysical survey techniques during multiple phases of the project (however the extent of this sound field is typically only hundreds of metres from the sound source). The behavioural changes predicted to occur from continuous sound emissions will occur more often during the project as it is associated with standard vessel operations (e.g. use of engines and thrusters). The highest risk of auditory impairment (TTS) or injury (PTS) to marine mammals occurs from impact piling. During impact piling activities there would also be concurrent continuous sound emissions from vessels. For continuous sound emissions to result in potential impairment or injury, the marine mammals would need to remain within closer proximity to the sound source to that required for a potential impairment from impulsive sound. As such, the potential holistic impacts are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual aspect.

Receptor	Consequence Evaluation
	Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact marine mammals, holistic impacts are expected to have no lasting effects (F).

10.2.2.4 Protected Places

The protected places within the Project Area may be impacted throughout the offshore project's lifecycle. It is possible that holistic effects to AMPs may occur during the different activities and aspects associated with the Goodwyn Area Infill Development (Table 10-4), and these are assessed further below.

Table 10-4: Protected places receptors—screening for potential holistic effects from Goodwyn Area Infill Development aspects

Aspect	Receptor
	AMPs
Physical Presence: Interaction with other Marine Users	
Physical Presence: Disturbance to the Seabed	✓
Routine Emissions: Light Generation	✓
Routine Acoustic Emissions: Continuous Sound Generation	✓
Routine Acoustic Emissions: Impulsive Sound Generation	✓
Routine and Non-routine Emissions: Atmospheric	
Routine and Non-routine Emissions: Greenhouse Gases	✓[1]
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	✓
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	✓
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	✓
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	
Downstream Discharges: Produced Water	
Potential Holistic Effect to receptors from Goodwyn Area Infill Development	✓

1. *While the GHG emission aspect has been screened in Table 10-4 as relevant to the values of AMPs, as described in Section 9.1.7, climate change or the impacts of climate change cannot be directly attributed to any one project, including the Goodwyn Area Infill Development. Climate change impacts upon Australian receptors cannot be linked to the Goodwyn Area Infill Development but are instead the result of the accumulation of GHG emissions in the atmosphere. A contextual evaluation of GHG emissions is provided in Section 9.1.7 and has not been repeated here.*

10.2.2.4.1 Consequence Evaluation

Potential changes to the values and sensitivities of protected places

Receptor	Consequence Evaluation
AMPs	The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park); within this overlap, the phased development nominal infrastructure corridor intersects with ~27 km^2 (i.e. ~0.0.79% of the marine park). Any petroleum activity that may occur within or adjacent to the Montebello Marine Park is associated with the development in WA-7-R and the Wilcox reservoir. *Natural values* The natural values of the Montebello Marine Park (as described in Table 7-24) include:

Receptor	Consequence Evaluation
	• species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna • ecosystems representative of the Northwest Shelf Province, including areas of ancient coastline. Benthic habitat surveys within the northern section of the marine park indicate that it has a relatively flat and sandy seabed with variable coverage of benthic epifauna (e.g. sponges, corals) (Section 7.5.3.7; (Advisian 2019)). This is not dissimilar to the benthic habitats and communities expected to occur throughout most of the Project Area, which are broadly represented throughout the NWMR (Section 7.5.3.1). The aspects screened as having potential impacts to the values of the Montebello Marine Park are seabed disturbance, light emissions, acoustic emissions (continuous and impulsive) and planned discharges of hydrocarbons or chemicals, vessel-related discharges, and drill cuttings and drilling fluids. The receptors associated with these impacts are two distinct groups—benthic habitats and marine fauna. Seabed disturbance from the Goodwyn Area Infill Development within the boundary of the Montebello Marine Park will predominantly be from a MODU mooring system. Drilling (and associated discharges), and installation of subsea infrastructure will occur outside of the marine park boundary. Based on drill cuttings and drilling fluid dispersion modelling, only a thin veneer of sedimentation is predicted to occur within the marine park boundary (Section 9.1.10). While there may be spatial overlap between the mooring installation, and the low levels of sedimentation and TSS from drill cuttings and drilling discharges, the potential holistic impacts are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual aspect. Marine fauna were predicted as having either no lasting effect, or slight shot-term effects from continuous and impulsive sound emissions associated with the Goodwyn Area Infill Development. The major source of impulsive sound will occur during the drilling phase and is associated with impact piling for the MODU mooring system. If impact piling is selected for use at Wilcox, then marine fauna in proximity to the Montebello Marine Park may be exposed. Marine fauna will also be simultaneously exposed to continuous sound emissions from standard vessel operations. Given the different mechanisms, the potential holistic impacts are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual aspect. As described above, both marine fauna and benthic habitats are values associated with the Montebello Marine Park. The potential holistic impacts to the values of the marine park are not expected to exceed the impacts outlined in the consequence evaluations presented for each individual receptor. Negligible impacts are predicted during operations phase; while decommissioning is expected to have similar impacts to drilling and installation phases. Given the duration between these phases, recovery from the initial disturbance is expected to occur. *Cultural values* There is limited information about the cultural significance of this Marine Park; however, it is noted that Sea Country is valued for First Nations cultural identity, health, and wellbeing. Across Australia, First Nations people have been sustainably using and managing their Sea Country for tens of thousands of years. Potential impacts to cultural values of the Marine Park will closely tie in with the impacts to the natural values of the Marine Park. *Heritage values* There are no World, Commonwealth or National heritage listings that apply to the Marine Park. Two historic shipwrecks are located within the Marine Park. No impact to the heritage values of the Montebello Marine Park was predicted during impact and risk assessments for planned activities (Section 9.1), as such holistic impacts are not expected to occur. *Social and economic values* Tourism, commercial fishing, mining and recreation are important activities in the Marine Park. Potential impacts to tourism and recreation, and commercial fishing, of the Marine Park will closely tie in with the impacts to the natural values of the Marine Park. No impact to other mining activities within the Marine Park was predicted during impact and risk assessments for planned activities (Section 9.1), as such holistic impacts are not expected to occur. *Summary* Based on the consideration of potential interactions between environmental aspects from the Goodwyn Area Infill Development that may impact values of the Montebello Marine Park, holistic impacts are expected to have no lasting effects (F).

10.2.2.5 Socioeconomic and Cultural Environment

The socioeconomic and cultural environment within the Project Area may be impacted throughout the offshore project's lifecycle. It is possible that holistic effects to cultural features and heritage values, may occur during the different activities and aspects associated with the Goodwyn Area Infill Development (Table 10-5), and these are assessed further below. No holistic effects to commercial fisheries, tourism and recreation, or commercial shipping are expected from the Goodwyn Area Infill Development (Table 10-5).

Table 10-5: Socioeconomic and cultural environment receptors—screening for potential holistic effects from Goodwyn Area Infill Development aspects

Aspect	Receptors			
	Cultural Features and Heritage Values	*Commercial Fisheries*	*Tourism and Recreation*	*Commercial Shipping*
Physical Presence: Interaction with other Marine Users		✓	✓	✓
Physical Presence: Disturbance to the Seabed	✓			
Routine Emissions: Light Generation	✓			
Routine Acoustic Emissions: Continuous Sound Generation	✓			
Routine Acoustic Emissions: Impulsive Sound Generation	✓			
Routine and Non-routine Emissions: Atmospheric	✓[1]			
Routine and Non-routine Emissions: Greenhouse Gases	✓[2]	✓[2]	✓[2]	
Routine and Non-routine Discharges: Hydrocarbons and Chemicals				
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	✓			
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	✓			
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	✓			
Downstream Discharges: Produced Water	✓			
Potential Holistic Effect to receptors from Goodwyn Area Infill Development	✓			

1. *While the atmospheric emissions aspect has been screened in Table 10-5 as having potential impacts on cultural features and heritage values, this impact pathway is considered a downstream action, and a holistic impact assessment has been presented in Section 9.3.5 and has not been included here*
2. *While the GHG emission aspect has been screened in Table 10-5 as relevant to socioeconomic and cultural receptors, as described in Section 9.1.7, climate change or the impacts of climate change cannot be directly attributed to any one project, including the Goodwyn Area Infill Development. Climate change impacts upon Australian receptors cannot be linked to the Goodwyn Area Infill Development but are instead the result of the accumulation of GHG emissions in the atmosphere. A contextual evaluation of GHG emissions is provided in Section 9.1.7 and has not been repeated here.*

10.2.2.5.1 Consequence Evaluation

Potential changes to the functions, interests, or activities of other users

Cultural Features and Heritage Values (Archaeological Heritage)	Changes to cultural features and heritage values are predicted to occur during all phases (drilling, installation, operations, and decommissioning) of the Goodwyn Area Infill Development; however most potential changes are predominantly associated with the drilling, installation, and decommissioning phases. The phases of the project are also typically sequential, however there may be some concurrent activities during drilling and installation phases. There are no World, National, or Commonwealth heritage listed places within the Project Area (Sections 7.8.1, 7.8.2, 7.8.3). Therefore, no impacts to culturally historic sites of significance

	(Section 7.9.7) are predicted to occur and as such the potential for holistic impacts to this type of feature/value has not been evaluated further. The aspects screened as having potential impacts to historic underwater heritage (Section 7.9.8) are associated with seabed disturbance and drilling related discharges. Based on a desktop assessment for submerged cultural heritage, there are no known shipwrecks or other items of UCH (including First Nations UCH) within the Project Area (Nutley 2023b). A review of historic sea level changes and seabed suggests that a complex coastal landscape of ridge lines, hills and an estuarine channel may have been present within the Project Area ~52–20 kya (Nutley 2023b). Given the complex landforms, and duration of exposure, these areas would have had high potential for the accumulation of significant deposits of archaeological materials as well as for the development of complex cultural and spiritual association (Nutley 2023b). Woodside considers the Ancient Landscape (between the mainland and the ancient coastline at 125 m depth contour KEF) an area where potential First Nations archaeological material may exist on the seabed because it covers the full extent of possible First Nations occupation. Most of the Project Area occurs within this Ancient Landscape (Section 7.9.6.2). At the time of writing, Woodside understands that there is no First Nations archaeology is known to exist anywhere within Commonwealth waters. The predicted areas of exposure to drilling and subsea infrastructure installation are relatively small (e.g. ~0.04 km^2 for estimated infrastructure footprint; Section 5.2.1 and 5.2.2). The Goodwyn Area Infill Development is also a phased development, and as such the disturbance to different areas of the seabed from drilling and installation activities will occur over multiple years. A similar area to that disturbed during the drilling and installation phases, will also subsequently be disturbed during decommissioning phase. Of the identified archaeological cultural features and heritage values that may be present within the Project Area (Table 7-31), the holistic impact assessment in Section 9.3 indicates that planned activities from the Goodwyn Area Infill Development are expected to have no lasting effect on cultural features and heritage values, and thus the consequence level is ranked as F. It is acknowledged that if further cultural feature or heritage values are identified throughout the project's life, than the outcome of this consequence evaluation may change.
Cultural Features and Heritage Values (Intangible Cultural Heritage)	Intangible cultural heritage has been identified through consultation with First Nations people as culturally important. Cultural knowledge, as expressed through songlines, dreaming, dance and other cultural practices, can be associated with tangible objects and physical sites that are culturally important to First Nations people (Ardler 2021; Bursill et al. 2007). Intangible cultural heritage can also be embodied in the practices, representations, expressions, knowledge, uses and skills associated with physical sites (UNESCO 2003). As a result, physical features may have intangible dimensions (Australia ICOMOS 2013). Of the identified intangible cultural features and heritage values that may be present within the Project Area (Table 7-31), the holistic impact assessment in Section 9.3 indicates that planned activities from the Goodwyn Area Infill Development are expected to have no lasting effect on cultural features and heritage values, and thus the consequence level is ranked as F. It is acknowledged that if further cultural features or heritage values are identified throughout the project's life, than the outcome of this consequence evaluation may change.
Cultural Features and Heritage Values (Marine Ecosystems)	First Nations people have raised through consultation that they have a general interest in environmental management and ecosystem health (i.e. natural environment interest). This includes marine mammals, marine reptiles, fish, seabirds, plankton, benthic and shoreline habitats, and marine parks. First Nations people may identify cultural values associated with marine ecosystems as important to maintaining both tangible (physical cultural sites) and intangible (cultural knowledge) cultural heritage. Cultural values relating to the marine ecosystem can collectively capture 'Sea Country' which refers to a seascape that First Nations view, interact with, or hold knowledge of. As a result, marine fauna or communities may be culturally valued in relationship with broader marine environmental values that are of cultural importance to First Nations people (Smyth 2007). The aspects screened as having potential impacts to cultural features and heritage values associated with marine fauna or habitats include emissions (e.g. light, sound) and discharges (e.g. from vessels or drilling). Of the identified marine ecosystem cultural features and heritage values that may be present within the Project Area (Table 7-31), the holistic impact assessment in Section 9.3 indicates that planned activities from the Goodwyn Area Infill Development are expected to have no lasting effect on cultural features and heritage values, and thus the consequence level is ranked as F. It is acknowledged that if further cultural features or heritage values are identified throughout the project's life, than the outcome of this consequence evaluation may change.

10.3 Cumulative Impact Assessment

10.3.1 Method

The impact assessment presented in Section 9.1 addresses the interaction of the Goodwyn Area Infill Development with the environment. This section considers how the environment known to be impacted by the Goodwyn Area Infill Development may be subject to cumulative effects from the same aspects from other marine activities.

The cumulative impact assessment is undertaken by:

- defining boundaries for the assessment
- identifying other marine activities within the assessment boundaries
- screening activity–aspect interactions and identifying potential for cumulative effects
- evaluating cumulative impacts using Woodside's impact and risk analysis process (Section 4.5).

The cumulative impact assessment has been presented per environmental aspect below.

10.3.1.1 Assessment Boundary

10.3.1.1.1 Spatial Boundary

Woodside has defined the spatial boundary for the cumulative impact assessment as an area that captures all aspect interactions from planned activities (i.e. the predicted spatial extent of environmental impacts associated with each aspect as described in Section 9.1). The largest potential exposure areas for planned activities from the Goodwyn Area Infill Development are:

- artificial light generation—up to ~12.6 km from a MODU (based on conservative photometric measurements as described in Section 9.1.3
- continuous sound emissions—up to ~20.7 km from the sound source (based on a DP MODU, as described in Section 9.1.4)
- impulsive sound emission—up to ~22.6 km from the sound source (based on impact piling during mooring installation for a MODU, as described in Section 9.1.5)
- all other aspects—within the Project Area.

Therefore, as a conservative approach to identifying other marine activities to consider in the cumulative impact assessment, a ~45 km buffer (i.e. double the largest predicted exposure area) around the Project Area was used. Refer to further description in Section 10.3.1.2 for how activities were identified and screened for potential aspect interactions.

10.3.1.1.2 Temporal Boundary

Woodside has defined the temporal boundary for the cumulative impact assessment in alignment with the EPA's (2021) definition of cumulative impacts, and therefore the temporal period comprises past, present, and future activities.

The definition for cumulative impacts (Section 10.1) refers to 'reasonably foreseeable future activities'. Woodside has adapted a definition based the EPA's environmental impact assessment procedures (EPA 2021) such that 'reasonably foreseeable future activities' are defined as third-party (or proponent) activities that are already approved, are in a government approvals process, or are otherwise reasonably likely to proceed:

- for projects assessed under Part 2 of the Environment Regulations—from the time an OPP for an offshore project is published by NOPSEMA for public comment, or

- for activities assessed under Part 4 of the Environment Regulations—at the time an EP for the petroleum activity is submitted to NOPSEMA for assessment, or
- for activities assessed under the Petroleum (Submerged Lands) (Environment) Regulations 2012 (WA)—at the time an EP for the petroleum activity is submitted to DEMIRS for assessment, or
- for actions assessed under the EPBC Act—from the time a referral is submitted, and
- existing activities that are reasonably expected to be ongoing.

The future temporal boundary should extend until all impacts from the Goodwyn Area Infill Development have ceased and receptors have recovered to their pre-disturbance conditions. Similarly, the past temporal boundary should allow for pre-existing impacts to have recovered.

According to the environmental impact assessment undertaken (Section 9.1), recovery could take up to two years, based on:

- up to ~208 days for benthic habitats and communities to recover from physical seabed disturbance (Dernie et al. 2003)
- <1 year for ambient sediment quality to recover from planned discharges of drilling cuttings and fluids (Terrens, Gwyther, and Keogh 1998)
  - Note: Cement discharges can cause a more permanent change; however, given the very localised nature of the area affected, this was not evaluated further
- monitoring of pipeline burial via natural sedimentation, scour, and biological activity indicated most movement has occurred within ~2 years post-installation (Leckie et al. 2015)
  - Note: This timing only applies if any property is assessed as acceptable and ALARP to leave in situ on the seabed.

Therefore, the assessment's temporal boundary has been conservatively set as two years before starting the Goodwyn Area Infill Development, and two years after its decommissioning. Based on activities proposed to start during 2025/2026 (Table 5-2), this gives a conservative temporal extent for cumulative impact assessment of ~2023–2042.

Note: Existing activities and 'reasonably foreseeable future activities' that are included within the scope of the following cumulative impact assessment are those that can be publicly identified at the time of preparing and submitting this OPP. Woodside acknowledge that other future activities may occur, particularly given the temporal boundary relevant to the Goodwyn Area Infill Development. The EPs that will be prepared subsequent to this OPP will provide an opportunity to undertake additional cumulative impact assessments (where relevant) that consider additional activities known to, or are reasonably expected to, occur in the future that may be identified at a later date.

10.3.1.2 Identification of Activities

10.3.1.2.1 Petroleum Activities

In order to identify other petroleum activities within the cumulative assessment boundary, OPPs and EPs that are currently being assessed by NOPSEMA or approved[63] (but not yet conducted) were identified from the NOPSEMA website.

[63] EPs with an approved status and with either (i) an acceptance date beyond a 5-year in-force period, or (ii) with start and stop activity notifications dates indicating activities are complete, were not included in the assessment.

Woodside has identified these other petroleum activities within the spatial and temporal boundaries as defined above:

- before Goodwyn Area Infill Development (i.e. activities proposed 2023–2024):
  - Woodside's TPA03 well intervention
  - Woodside's Scarborough seabed intervention and trunkline installation
  - Woodside's WA-49-L Gemtree exploration drilling
  - Woodside's Julimar South-1 appraisal drilling and plug and abandonment
  - Woodside's Eaglehawk-1 wellhead decommissioning
  - Woodside's Balnaves plug and abandonment
  - Woodside's Echo Yodel subsea decommissioning
  - Woodside's Julimar Development Project Phase 3 (JDP3) drilling and subsea installation
  - Woodside's Goodwyn Area Infill geophysical and geotechnical survey
  - Santos' Campbell facility decommissioning.
- during and after Goodwyn Area Infill Development (existing activities, activities proposed from 2025 onwards):
  - Woodside's Julimar South-1 appraisal drilling and plug and abandonment
  - Woodsides' Echo Yodel subsea decommissioning
  - ongoing operations associated with Woodside's GWA, NRC, and Pluto platforms, and Julimar operations
  - ongoing operations associated with Chevron Australia's Wheatstone platform.

Several wells have previously been drilled within some of the Goodwyn Area Infill Development permits, but the most recent activity was in 2021. The environment is expected to have recovered from drilling activities since 2021; therefore, these past activities were not considered in this assessment.

Table 10-6 provides a summary of the potential for interaction from the above petroleum activities with the Goodwyn Area Infill Development.

10.3.1.2.2 Other Marine Activities

Woodside has identified these other marine activities within the spatial and temporal boundaries as defined above:

- before, during, and after Goodwyn Area Infill Development (existing activities, activities proposed from 2025 onwards):
  - commercial fisheries (Commonwealth and State)
  - commercial shipping.

Both of these activities are carried through to the cumulative impact assessment.

10.3.2 Impact Identification

It is possible that cumulative effects may occur from several aspect interactions between the Goodwyn Area Infill Development and other marine activities (Table 10-7).

Table 10-6: Other petroleum activities within vicinity of Goodwyn Area Infill Development

Titleholder	Activity	EP Status	Location	Potential for Interaction	
Woodside	TPA03 well intervention	Accepted	Within Project Area	✓	EP has proposed activity schedule of ~5–14 days commencing during H1 2024 or contingent in 2025. Given the location of the well within the Project Area, there is potential for the TPA03 well intervention to be undertaken within the temporal and spatial boundary of the cumulative assessment.
Woodside	Scarborough seabed intervention and trunkline installation	Accepted	Trunkline route traverses through Project Area	✓	EP has proposed trunkline installation schedule of ~6 months in 2023–2024. Given the location of the trunkline within the Project Area, there is potential for the activities to be undertaken within the temporal and spatial boundary of the cumulative assessment.
Woodside	WA-49-L Gemtree exploration drilling	Accepted	~32 km west of Project Area	x	EP has proposed activity schedule of ~50 days between 2021–2024. Proposed use of a moored MODU. Therefore, given the distance to the Project Area, no overlap in exposure areas for environmental aspects (including acoustic emissions[1]) is anticipated.
Woodside	Eaglehawk-1 wellhead decommissioning	Accepted	~42 km north-east of Project Area	x	EP has proposed activity schedule of ~10 days between 2023–2025. Proposed use of offshore support vessels for wellhead removal. Therefore, given the distance to the Project Area, no overlap in exposure areas for environmental aspects (including acoustic emissions[2]) is anticipated.
Woodside	Balnaves plug and abandonment	Accepted	~25 km east of Project Area	✓	Plug and abandonment activities finalised in November 2022. Removal of well infrastructure still to be completed; EP has proposed activity schedule of ~4 weeks during 2024. Proposed use of a vessel or moored MODU. Given the distance from the Balnaves wells to the Project Area (~25 km), overlap in exposure areas for some environmental aspects (i.e. acoustic emissions) may occur if activities at Balnaves and Wilcox were occurring concurrently.
Woodside	Echo Yodel subsea decommissioning	Accepted	Within Project Area	✓	EP has proposed activity schedule of up to ~8 months between 2022–2026 for removal of pipeline, EHU, and associated infrastructure. Given the location of the Echo Yodel pipeline within the Project Area, there is potential for these activities to be undertaken within the temporal and spatial boundary of the cumulative assessment.
Woodside	JDP3 drilling and subsea installation	Under assessment	~22.5 km east of Project Area	✓	Activities proposed to be included within the EP: • drilling of up to four wells within Julimar field, and one within the Penfolds prospect

Titleholder	Activity	EP Status	Location		Potential for Interaction
					– use of a moored semi-submersible MODU, DP MODU, or hybrid MODU – estimated duration of ~60 days per well for drilling and completions – scheduled to commence from Q3 2024 (wells may be developed as a single campaign, or a second shorter campaign may be required in 2026) • well interventions or workovers of existing Julimar or Brunello wells, or new JDP3 wells (contingency activity if required) – estimated duration of ~70 days per well • subsea installation, pre-commissioning and commissioning – estimated duration of ~60 days – scheduled to commence from Q1 2025. Given the distance from the proposed Julimar wells to the Project Area (~34 km), no overlap in exposure areas for environmental aspects (including acoustic emissions[1]) is anticipated. Given the distance from the proposed Brunello wells to the Project Area (~22.5 km), overlap in exposure areas for some environmental aspects (i.e. acoustic emissions) may occur if activities at Brunello and Wilcox were occurring concurrently.
Woodside	Goodwyn Area geophysical and geotechnical survey	Under assessment	Within (and adjacent to) Project Area	✓	Activities proposed to be included within the EP are geophysical and geotechnical surveys within four areas on the NWS; Operational Area A overlaps with the Project Area for the Goodwyn Area Infill Development, and Operational Area B and D are adjacent to the Project Area. Estimated activity duration (for all areas) is ~18 weeks, with activities scheduled to commence during H2 2024. Given the locations of Operational Areas within or adjacent to the Project Area, there is potential for the geophysical and geotechnical surveys to be undertaken within the temporal and spatial boundary of the cumulative assessment.
Santos	Santos Campbell facility decommissioning	Accepted (DEMIRS)	~40 km south of Project Area	x	EP has proposed activity schedule of ~14 days, commencing in early-2024. Activities include removal of platform topsides, substructure, and associated items, and pre- and post- site surveys. Therefore, given the distance to the Project Area, no overlap in exposure areas for environmental aspects (including acoustic emissions[2]) is anticipated.
Woodside	GWA Facility operations	Accepted	~2 km north-east of Project Area	✓	EP associated with ongoing operations of the existing subsea hydrocarbon system and platform.

Titleholder	Activity	EP Status	Location		Potential for Interaction
					Given distance to the Project Area, overlap in exposure areas for some environmental aspects are anticipated.
Woodside	NRC platform	Accepted	~25 km north-east of Project Area	x	EP associated with ongoing operations of the existing subsea hydrocarbon system and platform. Given distance to the Project Area, and types of petroleum activities (e.g. operation, IMMR) no overlap in exposure areas for environmental aspects are anticipated.
Woodside	Pluto facility platform	Accepted	~5 km east of Project Area	✓	EP associated with ongoing operations of the existing subsea hydrocarbon system and platform. Given distance to the Project Area, overlap in exposure areas for some environmental aspects are anticipated.
Woodside	Julimar operations	Accepted	~40 km west-southwest of Project Area	x	EP associated with ongoing operations of the existing subsea hydrocarbon system. Given distance to the Project Area, and types of petroleum activities (e.g. operation, IMMR) no overlap in exposure areas for environmental aspects are anticipated.
Chevron Australia	Wheatstone facility operations	Accepted	~3.5 km east of Project Area	✓	EP associated with ongoing operations of the existing subsea hydrocarbon system and platform. Given distance to the Project Area, overlap in exposure areas for some environmental aspects are anticipated.

1. Conservative assessment based on a maximum 22.6 km from impulsive sound and/or 20.6 km from continuous sound from Goodwyn Area Infill Development, and assuming the ~8.8 km continuous sound from a DP MODU (Table 9-6) is representative for Gemtree and Julimar drilling, there is no spatial overlap in exposure areas, and therefore no potential interaction.

2. Conservative assessment based on a maximum 22.6 km from impulsive sound and/or 20.6 km from continuous sound from Goodwyn Area Infill Development, and assuming the ~10.4 km continuous sound from an installation vessel (Table 9-8) is representative for an offshore support vessel for Eaglehawk wellhead decommissioning, and Campbell facility decommissioning, there is no spatial overlap in exposure areas, and therefore no potential interaction.

Table 10-7: Screening for potential cumulative effects from Goodwyn Area Infill Development and other marine activities

Aspect	Activities												Potential Cumulative Effect to environment from Goodwyn Area Infill Development and Other Activities
	Goodwyn Area Infill Development	*Commercial Fisheries*	*Commercial Shipping*	*TPA03 Well Intervention*	*Scarborough Seabed Intervention and Trunkline Installation*	*Balnaves Plug and Abandonment*	*Echo Yodel Subsea Decommissioning*	*JDP3 Drilling and Subsea Installation*	*Goodwyn Area Geophysical and Geotechnical Survey*	*GWA Facility Operations*	*Pluto Facility Operations*	*Wheatstone Facility Operations*	
Physical Presence: Interaction with other Marine Users	✓	✓	✓	✓	✓		✓		✓				✓
Physical Presence: Disturbance to the Seabed	✓			✓	✓		✓		✓				✓
Routine Emissions: Light Generation	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Routine Acoustic Emissions: Continuous Sound Generation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Routine Acoustic Emissions: Impulsive Sound Generation	✓			✓	✓		✓		✓				✓
Routine and Non-routine Emissions: Atmospheric	✓	✓	✓	✓	✓		✓		✓	✓			✓
Routine and Non-routine Emissions: Greenhouse Gases	✓	✓	✓	✓	✓		✓		✓	✓			✓
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	✓						✓						✓
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	✓	✓	✓	✓	✓		✓		✓				✓

Aspect	Activities												Potential Cumulative Effect to environment from Goodwyn Area Infill Development and Other Activities
	Goodwyn Area Infill Development	Commercial Fisheries	Commercial Shipping	TPA03 Well Intervention	Scarborough Seabed Intervention and Trunkline Installation	Balnaves Plug and Abandonment	Echo Yodel Subsea Decommissioning	JDP3 Drilling and Subsea Installation	Goodwyn Area Geophysical and Geotechnical Survey	GWA Facility Operations	Pluto Facility Operations	Wheatstone Facility Operations	
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	✓								✓				✓
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	✓			✓									✓
Downstream Discharges: Produced Water	✓									✓			✓

10.3.3 Impact Analysis

10.3.3.1 Physical Presence: Interaction with other Marine Users

Section 9.1.1 describes the impacts associated with the Goodwyn Area Infill Development on other marine users, specifically a change in the functions, interests, or activities of those users. These impacts were assessed as being localised with no lasting effects to all receptors because the Goodwyn Area Infill Development will generate a low volume of vessel traffic throughout the project's lifecycle, and a 500 m safety exclusion zone around the MODU and installation vessels will be established to inform other marine users of their physical presence. Predicted impacts from physical presence attributed to the Goodwyn Area Infill Development are limited to the Project Area.

Vessel and MODU presence from Goodwyn Area Infill Development will usually be low, peaking during drilling, installation, and decommissioning phases. During operations, only one to two vessels are likely to be within the Project Area, and then only intermittently (e.g. for IMMR activities).

The shipping fairway that directs northbound and southbound vessel traffic from Barrow Island and the southern Montebello Islands overlaps the eastern extent of the Project Area (Figure 7-45). Despite this, vessel traffic within the Project Area is relatively low. Vessel tracking data suggest vessel traffic is higher to immediately to the west and north-east of the Project Area, likely associated with existing oil and gas facilities (e.g. GWA, NRC, Pluto, and Wheatstone platforms).

Management areas for several State-managed commercial fisheries overlap the Project Area; however, potential interaction is only expected to occur for three (Mackerel Managed Fishery, Pilbara Line Fishery, and Pilbara Trap Managed Fishery; Table 7-33). No Commonwealth-managed fisheries are expected to be active within the Project Area. Fishing effort recorded within the Project Area for the State-managed fisheries is typically low—during the last five seasons (2017–2022):

- the Mackerel Managed Fishery recorded ≤3 vessels present within the 10 nm fishery grid blocks that intersect with the Project Area
- the Pilbara Line Fishery had <3–5 vessels within the 60 nm fishery grid blocks that intersect with the Project Area
- the Pilbara Trap Managed Fishery had <3 vessels present within the 60 nm fishery grid blocks that intersect with the Project Area.

Given the low number of vessels, and if required, only minor deviation around MODU or project vessels, the physical presence of the MODU and support vessels is not expected to substantially affect the functions, interests, or activities of the commercial fisheries.

Petroleum activities within the Project Area that are under Woodside's operational control are associated with the existing GWA Facility, the proposed Scarborough Project, or this proposed Goodwyn Area Infill Development. Based on the proposed timing for the TPA03 well intervention, Scarborough trunkline installation, or Goodwyn Area geophysical and geotechnical survey activities (Table 10-6), there will be no temporal overlap with vessel/MODU presence from the Goodwyn Area Infill Development. However, there is potential for subsea decommissioning at Echo Yodel (Table 10-6) to occur concurrently with Phase I of the Goodwyn Area Infill Development (Table 5-2); any temporal overlap will depend on the actual timing of each of the respective petroleum activities. If an overlap did occur, the number of vessels associated with the Echo Yodel activities is also low, and is unlikely to significantly increase any interaction with other marine users within the Project Area.

Based on the consideration of potential interactions between the Goodwyn Area Infill Development and other activities that may interact with marine users within the Project Area, cumulative impacts to relevant receptors are expected to have no lasting effects (F).

10.3.3.2 Physical Presence: Disturbance to the Seabed

Section 9.1.2 describes the impacts associated with the Goodwyn Area Infill Development on seabed disturbance. These impacts were assessed as ranging from minor and short-term impacts to benthic habitats and communities, to no lasting effects on water quality. Predicted impacts from seabed disturbance attributed to the Goodwyn Area Infill Development are intended to be within the Project Area (for both the phased development any potential future development).

Petroleum activities within the Project Area are under Woodside's operational control and are associated with the existing GWA Facility, the proposed Scarborough Project, or this proposed Goodwyn Area Infill Development. Based on the proposed timing for the TPA03 well intervention, Scarborough trunkline installation, or Goodwyn Area geophysical and geotechnical survey activities (Table 10-6), there will be no temporal overlap with seabed disturbance from the Goodwyn Area Infill Development. Note: The EP for the Scarborough trunkline installation is still under assessment with NOPSEMA, and as such it is likely that the proposed timing of 2023, may extend into 2024. There is potential for subsea decommissioning at Echo Yodel (Table 10-6) to occur concurrently with Phase I of the Goodwyn Area Infill Development (Table 5-2); any temporal overlap will depend on the actual timing of each of the respective petroleum activities. The TPA03 wells and the Echo Yodel assets are located within the phased development nominal infrastructure corridor for the Goodwyn Area Infill Development; however the Scarborough trunkline is located ~2.5 km south of the phased development nominal infrastructure corridor. As such, there will also be no spatial overlap with seabed disturbance areas from the Scarborough trunkline installation and the Goodwyn Area Infill Development.

The benthic habitat within the Project Area is expected to be predominantly soft sediment with sparsely associated infauna and epifauna; this habitat is broadly represented throughout the NWMR (Section 7.5.3.1). Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure). These infauna communities are also representative of the Northwest Shelf Province—low abundance and dominated by polychaetes and crustaceans (RPS 2012b). Experiments on the effects of physical disturbance to the habitat and fauna of a sheltered sandflat showed that post-disturbance benthic recovery occurred within ~64 days (lower intensity disturbance) and ~208 days (higher intensity disturbance) (Dernie et al. 2003).

Seabed disturbance from the TPA03 activities are expected to be limited to equipment laydown, disturbance from ROV operations, or subsea cleaning of infrastructure; and have been assessed as resulting in localised impacts with no lasting effect[64]. Similarly, seabed disturbance from the proposed Goodwyn Area geotechnical testing is expected to be limited to the immediate vicinity of any sampling (e.g. coring, penetration testing). Given the types of seabed disturbance, based on Dernie et al. (2003) recovery would be expected within months. Therefore, these habitats would have recovered before any Goodwyn Area Infill Development activities commenced from 2025 onwards.

The removal of subsea infrastructure and ROV operations associated with the Echo Yodel decommissioning is predicted to result in minor localised physical modification (within tens of metres of the infrastructure) to the seabed[65]. Note: While the Operational Area for the Echo Yodel activities overlaps with the ancient coastline at 125 m depth contour KEF, the seabed within the Operational Area has been confirmed as soft sediment habitat. Given the type of seabed disturbance, based on Dernie et al. (2003) recovery would be expected within <1 year.

Based on the consideration of potential interactions between the Goodwyn Area Infill Development and other activities that may result in seabed disturbance within the Project Area, cumulative impacts to relevant receptors are expected to have no lasting effects (F).

[64] A description of the TPA03 well intervention is available from: https://info.nopsema.gov.au/activities/498/show_public

[65] A description of the Echo Yodel decommissioning is available from: https://info.nopsema.gov.au/activities/420/show_public

10.3.3.3 Routine Emissions: Light Generation

Section 9.1.3 describes the impacts associated with the Goodwyn Area Infill Development from artificial light emissions. These impacts were assessed as having no lasting effect to marine fauna. Artificial light emissions attributed to the Goodwyn Area Infill Development were predicted to extend up to ~12.6 km from a MODU, or ~1.8 km from an installation vessel. It is acknowledged that the distance predicted for MODUs is likely very conservative as it was based on available photometric light measurements, compared to the biologically relevant radiance modelling for the vessel. These predicted exposure areas are predominantly within the Project Area for vessels, but may extend beyond the Project Area for MODUs (Figure 9-3, Figure 9-4).

Vessel and MODU presence from Goodwyn Area Infill Development will usually be low, peaking during drilling, installation, and decommissioning phases. During operations, only one to two vessels are likely to be within the Project Area, and then only intermittently (e.g. for IMMR activities).

No fixed shipping or commercial fisheries facilities occur in the offshore area within the vicinity of the Goodwyn Area Infill Development. However, the eastern extent of the Project Area does overlap with a shipping fairway. Assuming that vessels require navigational lights, any vessels passing within the vicinity of the Goodwyn Area Infill Development have the potential to result in cumulative impacts. However, these impacts will be temporary, ceasing once the vessel has moved away from the Project Area. Due to their intermittent and transient nature, no cumulative impacts from shipping and fishing are expected and are not discussed further in this assessment.

Therefore, this cumulative assessment focuses on other proposed petroleum activities and the adjacent petroleum facilities.

As described in Section 10.3.3.1, no temporal overlap with vessel activities (and therefore artificial light emissions) from the TPA03 well intervention, Scarborough trunkline installation, or Goodwyn Area geophysical and geotechnical survey is expected; and recovery from any related impacts to receptors is expected prior to the start of the Goodwyn Area Infill Development. However, dependant on actual activity timing, there is potential for subsea decommissioning at Echo Yodel to occur concurrently with Phase I of the Goodwyn Area Infill Development. If activities occurred in proximity to each other, cumulative impacts from light emissions may occur. However, given the offshore location, these impacts are primarily expected to be associated with any change in migratory or offshore foraging behaviour for seabirds and migratory shorebirds.

Fixed sources of artificial light emissions within the vicinity of the Project Area include the GWA, Pluto, and Wheatstone platforms, located ~2 km north-east, ~5 km east, and ~3.5 km east respectively.

Woodside reviewed publicly available literature and information to determine if light emissions for the adjacent facilities had been assessed and if a potential exposure area for light emissions had been defined. No assessment of a potential exposure area for light emissions from the facilities was publicly available; therefore, as a conservative approach the outcomes of the MODU light modelling (Section 9.1.3) was applied these platforms (i.e. a 12.6 km buffer around each of the platforms). On this basis, there may be an overlap in artificial light emissions from the MODU undertaking activities for the Goodwyn Area Infill Development and the existing adjacent platforms. This predicted overlap occurs in an offshore marine environment, distant to any islands or mainland coast. The potential for cumulative impacts are also only temporary (i.e. when a MODU is within the Project Area for drilling phases). It is also noted that light intensity is inversely proportional to the distance from the source, and therefore the potential overlap in emissions is not occurring for the highest light intensities.

Based on the consideration of potential interactions between the Goodwyn Area Infill Development and other activities that may result in light emissions within the Project Area, cumulative impacts to relevant receptors are expected to have a slight short-term effect (E).

10.3.3.4 Routine Emissions: Acoustic Continuous Sound Generation

Section 9.1.4 describes the impacts associated with the underwater continuous sound emissions from the Goodwyn Area Infill Development. These impacts are assessed as ranging from no lasting effect to slight and short-term impacts to marine fauna. The generation of continuous sound will vary during different phases of the Goodwyn Area Infill Development, with drilling and installation expected to have the highest emissions (refer to modelling results in Section 9.1.4.1). For example, predicted ensonified areas for behavioural disturbance on cetaceans range from ~8.85 km for a moored MODU, ~10.4 km from an installation vessel, to ~20.7 km for a DP MODU.

No fixed shipping or commercial fisheries facilities occur in the offshore area within the vicinity of the Goodwyn Area Infill Development. However, the eastern extent of the Project Area does overlap with a shipping fairway. Assuming that vessels will generate some sound emissions (from using engines, DP, etc.), any vessels passing within the vicinity of the Goodwyn Area Infill Development have the potential to result in cumulative impacts. However, these impacts will be temporary, ceasing once the vessel has moved away from the Project Area. Due to their intermittent and transient nature, no cumulative impacts from shipping and fishing are expected and are not discussed further in this assessment.

As described in Section 9.1.4, underwater sound emissions from the operation of subsea hydrocarbon systems are typically minor, extending up to ~100 m from a source (e.g. flowline). Given the scale of these impacts, no cumulative impacts from the operation of existing subsea hydrocarbon systems (i.e. those associated with the existing GWA Facility) are expected and are not discussed further in this assessment. Similarly, according to Gales (1982), underwater sound resulting from platform operations may be within ~110–142 dB re 1 µPa @ 100 m. The resultant sound field is expected to be limited (up to ~1.37 km under conservative detection), and within typical ambient underwater sound levels. Therefore no cumulative underwater sound emissions from the operation of adjacent platforms is expected.

Therefore, this cumulative assessment focuses on other proposed petroleum activities.

As described in Section 10.3.3.1, no temporal overlap with vessel activities (and therefore continuous sound emissions) from the TPA03 well intervention, Scarborough trunkline installation, Balnaves well infrastructure removal, or Goodwyn Area geophysical and geotechnical survey is expected; and recovery from any related impacts to receptors is expected prior to the start of the Goodwyn Area Infill Development. However, dependant on actual activity timing, there is potential for subsea decommissioning at Echo Yodel, and Brunello well interventions (JDP3), to occur concurrently with Phase I of the Goodwyn Area Infill Development. If activities occurred in proximity to each other, cumulative impacts from underwater sound emissions may occur.

The underwater sound emissions from decommissioning activities include those associated with vessels and subsea cutting equipment. Predictions of ensonified areas for different auditory impacts and species varied but extended up to ~1.75 km for behavioural disturbance on cetaceans; and these impacts have been assessed as resulting in localised impacts with no lasting effect[66]. Therefore, the ensonified areas associated with the decommissioning activities are much smaller than those predicted for drilling and/or installation activities for the Goodwyn Area Infill Development.

The proposed JDP3 drilling and subsea installation EP[67] includes the possibility of well interventions at some of the Brunello wells. The closest Goodwyn Area Infill Development asset is the Wilcox reservoir (~26.5 km and ~30.5 km from Brunello wells to phased development nominal infrastructure corridor boundary and nominal Wilcox wells respectively). Using the installation vessel modelling completed for this OPP (Section 9.1.4) as a proxy for a well intervention vessel, predicted ensonified areas could be up to ~10.4 km for behavioural disturbance on cetaceans. If vessel operations within the proposed Goodwyn Area Infill Development phased development nominal infrastructure corridor

[66] A description of the Echo Yodel subsea decommissioning is available from: https://info.nopsema.gov.au/activities/420/show_public

[67] A description of the JDP3 drilling and subsea installation activities is available from: https://info.nopsema.gov.au/environment_plans/652/show_public

occurred concurrently with Brunello well interventions, concurrent ensonified areas would occur, however no spatial overlap in these areas is predicted to occur. Depending on the type of MODU selected for drilling at Wilcox (e.g. if a DP MODU was used with a predicted ensonified area of ~20.7 km for behavioural disturbance on cetaceans), a small overlap (up to ~0.6 km) in ensonified areas may occur during concurrent drilling activities at Wilcox and well intervention activities at Brunello. Based on the consideration of potential interactions between the Goodwyn Area Infill Development and other activities that may result in continuous sound generation within the Project Area, cumulative impacts to relevant receptors are expected to slight short-term effect (E).

10.3.3.5 Routine Emissions: Acoustic Impulsive Sound Generation

Section 9.1.5 describes the impacts associated with the underwater impulsive sound emissions from the Goodwyn Area Infill Development. These impacts are assessed as ranging from no lasting effect to slight and short-term impacts to marine fauna.

The generation of impulsive sound will vary during different phases of the Goodwyn Area Infill Development, with the drilling phase expected to have the highest emissions due to the use of impact piling for MODU mooring systems (refer to modelling results in Section 9.1.5). Predictions of ensonified areas for different auditory impacts and species varied but extended up to ~22.6 km for TTS on low-frequency cetaceans (or ~9 km for pygmy blue whales when accounting for movement of the marine fauna in animat modelling). The generation of impulsive sound during other phases of the Goodwyn Area Infill Development (e.g. use of geophysical survey equipment) have limited sound fields associated with them.

As described in Section 10.3.3.1, no temporal overlap with the activities (and therefore impulsive sound emissions) from the TPA03 well intervention, Scarborough trunkline installation, or Goodwyn Area geophysical and geotechnical survey is expected; and recovery from any related impacts to receptors is expected prior to the start of the Goodwyn Area Infill Development. However, dependant on actual activity timing, there is potential for subsea decommissioning at Echo Yodel to occur concurrently with Phase I of the Goodwyn Area Infill Development. If activities occurred in proximity to each other, cumulative impacts from underwater sound emissions may occur.

The sources of impulsive sound from the Echo Yodel subsea decommissioning are associated with acoustic positioning equipment and geophysical survey equipment. These types of impulsive sound fields typically extend in the order of hundreds of metres. Given the scale of these impacts, no cumulative impacts from are expected from the Goodwyn Area Infill Development and the Echo Yodel subsea decommissioning.

Therefore, given the highly localised areas disturbed by Goodwyn Area Infill Development and other petroleum activities, and the unlikely occurrence of impacts from multiple activities impacting in combination on a receptor, no cumulative impacts from the generation of underwater impulsive sound are expected.

10.3.3.6 Routine and Non-routine Emissions: Atmospheric

Section 9.1.6 describes the potential impacts associated with atmospheric emissions from the Goodwyn Area Infill Development. These impacts are assessed as no lasting effect to air quality. Predicted impacts from atmospheric emissions are limited to the Project Area.

No fixed shipping or commercial fisheries facilities occur in the offshore area within the vicinity of the Goodwyn Area Infill Development. However, the eastern extent of the Project Area does overlap with a shipping fairway. Any vessels passing within the vicinity of the Goodwyn Area Infill Development have the potential to result in cumulative impacts from atmospheric emissions. However, these impacts will be temporary, ceasing once the vessel has moved away from the Project Area. Due to their intermittent and transient nature, no cumulative impacts from shipping and fishing are expected and are not discussed further in this assessment.

Therefore, this cumulative assessment focuses on other proposed petroleum activities and the adjacent petroleum facilities.

As described in Section 10.3.3.1, no temporal overlap with vessel activities (and therefore atmospheric emissions) from the TPA03 well intervention, Scarborough trunkline installation, or Goodwyn Area geophysical and geotechnical survey is expected; and recovery from any related impacts to receptors is expected prior to the start of the Goodwyn Area Infill Development. However, dependant on actual activity timing, there is potential for subsea decommissioning at Echo Yodel to occur concurrently with Phase I of the Goodwyn Area Infill Development. Given that atmospheric emissions from vessel activities are limited to a highly localised air shed around the vessel, and that air quality is expected to return to pre-disturbance levels once the source of emissions is removed from the Project Area, no cumulative impacts from the Goodwyn Area Infill Development and the Echo Yodel subsea decommissioning are expected, and are not discussed further in this assessment.

Therefore, given the highly localised areas disturbed by Goodwyn Area Infill Development and other petroleum activities, and the unlikely occurrence of impacts from multiple activities impacting in combination on a receptor, no cumulative impacts from routine and non-routine atmospheric emissions are expected.

10.3.3.7 Routine and Non-routine Emissions: Greenhouse Gases

As described in Section 9.1.7, climate change or the impacts of climate change cannot be directly attributed to any one project, including the Goodwyn Area Infill Development. GHG emissions associated with the Goodwyn Area Infill Development are not predicted to materially or substantially contribute to Australia's total GHG emissions, and climate change impacts upon Australian receptors cannot be linked to the Goodwyn Area Infill Development.

From a cumulative perspective, GHG emissions need to be considered in context of global emissions and associated global-scale climate changes and ecosystem impacts. GHGs accumulate over time and mix on a global scale and therefore emissions from a single entity (individual, community, company, country, etc.) will mix with and affect the emissions of other entities. As such, assessing cumulative impacts only for existing industries or activities within proximity to the Goodwyn Area Infill Development is not considered appropriate (or relevant).

A contextual evaluation of GHG emissions is provided in Section 9.1.7 and has not been repeated here.

10.3.3.8 Routine and Non-routine Discharges: Hydrocarbons and Chemicals

Section 9.1.7 describes the impacts associated with routine and non-routine discharges of hydrocarbons and chemicals from the Goodwyn Area Infill Development. These impacts are assessed as no lasting effect to water quality. Predicted impacts from routine and non-routine discharges are limited to the Project Area.

As described in Section 10.3.3.1, dependant on actual activity timing, there is potential for subsea decommissioning at Echo Yodel to occur concurrently with Phase I of the Goodwyn Area Infill Development. If activities occurred in proximity to each other, cumulative impacts from routine and non-routine discharges of hydrocarbons and chemicals may occur. The sources of discharges associated with the Echo Yodel subsea decommissioning include operational fluids and cleaning chemicals, which have been assessed as having no lasting effect.

If discharges did occur from the Goodwyn Area Infill Development and the Echo Yodel subsea decommissioning within the same area and at the same time, the contaminants within each are not expected to magnify or interact with each other. Rapid mixing and dispersion is also expected given the influence of regional wind and large-scale ocean current patterns on offshore marine waters.

Therefore, based on the consideration of potential interactions between the Goodwyn Area Infill Development and other activities that may result in hydrocarbon or chemical discharges within the Project Area, cumulative impacts to relevant receptors are expected to have no lasting effects (F).

10.3.3.9 Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, Brine

Section 9.1.9 describes the impacts associated with the typical discharges associated with operating vessels and the MODU in the Goodwyn Area Infill Development. These impacts were assessed as having no lasting effects to water quality or planktonic communities. Vessel presence from Goodwyn Area Infill Development will usually be low, peaking during drilling, installation, and decommissioning phases. During operations, only one to two vessels are likely to be within the Project Area, and then only intermittently (e.g. for IMMR activities). Discharges from vessels will quickly dissipate in the high-energy marine environment of the NWS, with impacts to receptors expected to remain within the Project Area. Discharge monitoring and modelling suggests that vessel discharges are typically mixed within hundreds of metres from the source (Section 9.1.9.3).

No fixed shipping or commercial fisheries facilities occur in the offshore area within the vicinity of the Goodwyn Area Infill Development. However, the eastern portion of the Project Area does overlap with a shipping fairway. If a transiting vessel is discharging when passing through the Project Area there is the potential to result in cumulative impacts. However, these impacts will be temporary, ceasing once the vessel has moved away from the Project Area. Due to the intermittent and transient nature of transiting vessels, and the small mixing zone associated with vessel discharges, no cumulative impacts from shipping and fishing are expected and are not discussed further in this assessment.

As described in Section 10.3.3.1, no temporal overlap with vessel activities (and therefore vessel emissions) from the TPA03 well intervention, Scarborough trunkline installation, or Goodwyn Area geophysical and geotechnical survey is expected; and recovery from any related impacts to receptors is expected prior to the start of the Goodwyn Area Infill Development. However, dependant on actual activity timing, there is potential for subsea decommissioning at Echo Yodel to occur concurrently with Phase I of the Goodwyn Area Infill Development. Given that discharges from vessel activities are limited to a highly localised areas around the vessel, the discharges are intermittent. and that water quality is expected to return to pre-disturbance levels once the source of discharge is removed from the Project Area, no cumulative impacts from the Goodwyn Area Infill Development and the Echo Yodel subsea decommissioning are expected.

Therefore, given the low vessel traffic, the highly localised areas disturbed by Goodwyn Area Infill Development and other petroleum activities, and the unlikely occurrence of impacts from multiple activities impacting in combination on a receptor, no cumulative impacts from routine and non-routine vessel or MODU discharges are expected.

10.3.3.10 Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids

Section 9.1.10 describes the impacts associated with the discharge of drill cuttings and drilling fluids from the Goodwyn Area Infill Development. These impacts were assessed as ranging from no lasting effects on water and sediment quality to minor short-term impacts to benthic habitats and communities. Marine dispersion modelling for the Goodwyn Area Infill Development predicted that local sedimentation would occur as a mound around the well sites, and that the thickness of the deposits generated by the particles settling on the seabed decreases exponentially with distance from the drilling location (RPS 2023a). Modelling indicated that the distance to ecological impact threshold (6.5 mm) is up to ~0.2 km for 95th and 99th percentile exposures. The modelling also indicated that there is no potential for thin (0.1 mm) deposits of sediment to settle out at distances >1 km.

Based on the proposed timing for the Goodwyn Area geophysical and geotechnical survey activities (Table 10-6), there will be no temporal overlap with drilling activities from the Goodwyn Area Infill

Development. The discharge of drill cuttings and drilling fluids from the Goodwyn Area geotechnical testing is associated with collecting core samples. Coring will generate minor quantities of cuttings and drilling fluids, and these are expected to rapidly disperse within open offshore environment. Given the scale of these impacts, and time between geotechnical testing and proposed production well drilling (i.e. allowing for recovery to occur within soft sediment habitats), no cumulative impacts from are expected from the Goodwyn Area Infill Development and the geotechnical core sampling.

Therefore, given the lack of temporal overlap, the localised area of exposure around each well site, and the unlikely occurrence of impacts from multiple activities impacting in combination on a receptor, no cumulative impacts from routine and non-routine drill cuttings and drilling fluid discharges are expected.

10.3.3.11 Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product

Section 9.1.11 describes the impacts associated with the typical discharges associated with drilling or well operations (excluding drill cuttings or drilling fluids) from the Goodwyn Area Infill Development. These impacts were assessed as ranging from no lasting effects on water and sediment quality to slight short-term impacts to benthic habitats and communities. Predicted impacts were limited the immediate vicinity around each well site, within the nominal infrastructure corridor for the phased development (and within Project Area for any potential future development).

Petroleum activities within the Project Area that may result in subsea discharges of operational fluids include the proposed TPA03 well intervention activities. However, as described above, there is no temporal overlap between this activity and the Goodwyn Area Infill Development.

Therefore, given the lack of temporal overlap, the limited area of exposure due to rapid mixing and dispersion in offshore marine environments, and the unlikely occurrence of impacts from multiple activities impacting in combination on a receptor, no cumulative impacts from routine and non-routine well operational discharges are expected.

10.3.3.12 Downstream PW discharges

Section 9.1.12 describes the impacts associated with PW discharge attributable to the Goodwyn Area Infill Development. These impacts were assessed as no lasting effect to water or sediment quality and marine fauna. The downstream PW discharge occurs from the GWA platform, and the predicted impacts were estimated to occur within ~200 m of the source (Section 9.1.12).

As described in Section 9.1.12, the existing GWA PW system has been designed to process a maximum of 7,500 m^3/day. The Approved Mixing Zone for PW from the GWA platform has been developed using PW discharge modelling and PNEC values based on WET testing results. Monitoring has confirmed that water quality and sediment quality impacts do not occur beyond the Approved Mixing Zone. PW discharge rates from existing GWA Facility operations ranged from 339–2,155 m^3/day during 2020, which is well below the allowable daily maximum discharge.

The addition of the Goodwyn Area Infill Development PW discharge to the existing GWA PW discharge will not exceed the maximum design volume. As such, the Approved Mixing Zone is considered appropriate, and no cumulative impacts beyond this zone are predicted to occur.

10.4 Montebello Marine Park

The Project Area overlaps ~195 km^2 of the 3,413 km^2 Montebello Marine Park (i.e. ~5.7% of the marine park); more specifically the phased development nominal infrastructure corridor intersects with ~27 km^2 (i.e. ~0.79% of the marine park). Any petroleum activity that may occur within or adjacent to the Montebello Marine Park is associated with the development in WA-7-R and the Wilcox reservoir.

Guidance regarding petroleum activities with AMPs, requires that the evaluation of impacts and risks for a proposed petroleum activity should also include consideration of the way the proposed petroleum activity may interact with other petroleum activities and contribute to simultaneous or sequential cumulative impacts to the values of the marine park (NOPSEMA and Parks Australia 2024).

Using the same temporal and spatial boundaries as defined above for the cumulative impact assessment, a search of the published OPPs and EPs on the NOPSEMA website was done to identify other petroleum activities that will occur within the Montebello Marine Park. In addition to the Goodwyn Area Infill Development, the following petroleum activities occur within the Montebello Marine Park:

- Woodside's Scarborough seabed intervention and trunkline installation.

As described above, the trunkline installation activities are scheduled to occur ~2 years before the Goodwyn Area Infill Development.

The seabed disturbance associated with trunkline installation occurs ~2.5 km south of the phased development nominal infrastructure corridor for the Goodwyn Area Infill Development. Seabed disturbance from the Goodwyn Area Infill Development within the boundary of the Montebello Marine Park will predominantly be from a MODU mooring system. Drilling (and associated discharges), and installation of subsea infrastructure will occur outside of the marine park boundary (refer to key control measure **CM-35**). Based on Dernie et al. (2003) recovery of benthic habitats would be expected within less than a year.

The potential cumulative impacts to the values of the Montebello Marine Park are provided below.

10.4.1 Natural values

The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline that is thought to be an important seafloor feature and migratory pathway for humpback whales. A KEF of this Marine Park is the ancient coastline at the 125 m depth contour where rocky escarpments are thought to provide biologically important habitat in areas otherwise dominated by soft sediments. The Marine Park supports a range of species including those listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include breeding habitat for seabirds; internesting, foraging, mating, and nesting habitat for marine turtles; a migratory pathway for humpback whales; and foraging habitat for whale sharks.

Only the Scarborough trunkline installation has a potential interaction with the ancient coastline KEF within the Montebello Marine Park; as such cumulative impacts to the KEF within the Montebello Marine Park are not expected to occur.

While impacts to transient and migratory marine fauna may occur from the sequential petroleum activities, as described above, the time between these disturbances is predicted to allow for recovery. As such cumulative impacts to values based on marine fauna are expected to have no lasting effect (F).

10.4.2 Cultural values

There is limited information about the cultural significance of this Marine Park; however, it is noted that Sea Country is valued for First Nations cultural identity, health, and wellbeing. Across Australia, First Nations people have been sustainably using and managing their Sea Country for tens of thousands of years. Potential impacts to cultural values of the Marine Park will closely tie in with the impacts to the natural values of the Marine Park.

10.4.3 Heritage values

There are no World, Commonwealth or National heritage listings that apply to the Marine Park. Two historic shipwrecks are located within the Marine Park.

None of the petroleum activities identified above predict an impact to the heritage values of the Montebello Marine Park, as such cumulative impacts are not expected to occur.

10.4.4 Social and economic values

Tourism, commercial fishing, mining and recreation are important activities in the Marine Park that contribute to the wellbeing of regional communities and the prosperity of the nation.

Impacts to social and economic values may occur from the sequential petroleum activities identified above, including the Goodwyn Area Infill Development. However, given the relatively short duration of disturbances from any of the planned petroleum activities (e.g. weeks to months), and the time between these disturbances, cumulative impacts to social and economic values are expected to have no lasting effect (F).

10.4.5 Summary

Based on the consideration of potential interactions between the Goodwyn Area Infill Development and other petroleum activities that may occur within the Montebello Marine Park, cumulative impacts to natural, cultural, heritage, or socioeconomic values of the marine are expected to have no lasting effects (F).

10.5 Summary

The holistic impact assessment determined that holistic impacts may occur to the physical environment, habitats and biological communities, protected species, protected places, and socioeconomic and cultural environment receptors. However, this assessment also determined that holistic impacts would not significantly increase the predicted levels of impact as already assessed, and thus all holistic impacts were classified as having no lasting effect (F).

The cumulative impact assessment determined that cumulative impacts may occur due to concurrent petroleum activities within the Project Area. However, no long-term impacts were predicted, and any changes are predicted to affect individuals and/or limited areas only with no population-level impacts predicted. The assessment showed that biologically important lifecycle behaviours, such as breeding, are not predicted to be impacted.

The implementation of key control measures, in particular:

- **CM-12**: Consider and implement appropriate light mitigation and management measures (e.g. as described in the National Light Pollution Guidelines for Wildlife) during the EP process to reduce impacts to marine fauna to ALARP
- **CM-14**: Consider and implement appropriate acoustic mitigation and adaptive management measures during the EP process to reduce impacts to marine fauna to ALARP
- **CM-35**: No top-hole locations within the Montebello Marine Park
- **CM-53**: Where required under the WMS, a project-specific SIMOPS Plan must be in place before to the commencement of the petroleum activity
- **CM-57**: Implement a program of ongoing consultation with First Nations people whose functions, interests or activities may be affected by the petroleum activities to identify and reduce impacts to cultural features and heritage values
- **CM-58**: Consider and implement a ‘living heritage’ management approach during the EP process to reduce impacts to identified cultural features and heritage values.

are considered appropriate to manage the potential holistic and cumulative impacts associated with the Goodwyn Area Infill Development to an acceptable level.

The EPOs as defined in Sections 9.1, 9.2, and 9.3 are considered appropriate to manage the environmental impacts and risks, including holistic and cumulative impacts, associated with the Goodwyn Area Infill Development to an acceptable level.

11 ENVIRONMENTAL PERFORMANCE FRAMEWORK

11.1 Overview

The Goodwyn Area Infill Development will be undertaken in accordance with this OPP and subsequent activity-specific EPs.

The environmental performance framework for the offshore project identifies key processes that are in place to direct, review, and manage the offshore project so environmental impacts and risks are managed to an acceptable level, and that the EPOs outlined in this OPP are achieved.

11.2 Systems, Practices, and Procedures

All operational activities are planned and carried out in accordance with relevant legislation and internal environment standards and procedures identified in this OPP (Sections 3 and 9).

Processes are implemented to verify controls to manage environmental impacts and risks to:

- an acceptable level
- meet EPOs.

Woodside is responsible for ensuring the offshore project is managed in accordance with this OPP and the WMS (Section 2). The ‘operate’ activity under the Value Stream activities group (Figure 2-2) includes two overarching processes (Operate Plant Process and Maintain Assets Process) that are directly relevant to the environmental management of petroleum activities.

The systems, practices, and procedures that will be implemented include those listed in the key control measures contained in this OPP (Section 9). Further information on the systems, practices, and procedures relevant to the implementing this OPP will be identified and described in the subsequent activity-specific EPs.

11.3 Change Management

Woodside’s Change Management Procedure describes the requirements for change management at Woodside-owned or -controlled operations/sites.

Change management is used if there is no existing approved business baseline (e.g. a process, procedure, or accepted practice), or where conformance with an approved baseline is not possible or intended (e.g. due to equipment fault or failure or a recently discovered issue that will take time to rectify). Change management is also used when the baseline is changed (e.g. a process is modified). It applies to management of temporary, permanent, planned or unplanned change encompassing one or more of these:

- plant (equipment, plant, technology, facilities, operations, or materials)
- projects (budget, schedule)
- people (organisation structure, performance, roles)
- process (WMS content, processes, procedures, standards, legislation, information).

Figure 11-1 shows Woodside’s change management process hierarchy, which has sub-processes that address the different types of change that occur at Woodside.

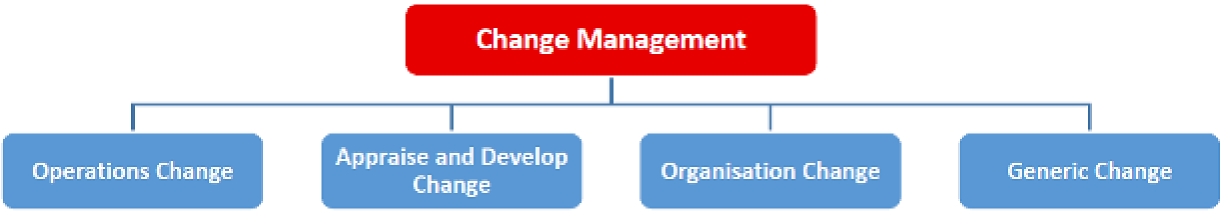


Figure 11-1: Change management hierarchy

11.3.1 OPP Management of Change

Management of changes relevant to this OPP will be managed in accordance with Woodside's Environmental Approval Requirements Australia Commonwealth Guideline. Such changes may include:

- changing the scope of the project description (Section 5), including review of advances in technology at stages where new equipment may be selected
- changes in understanding of the environment, including all current advice on species protected under EPBC Act and current requirements for Australian Marine Parks (Section 7)
- potential new advice from external stakeholders (Section 8).

Woodside's Environmental Approval Requirements Australia Commonwealth Guideline provides guidance on the Environment Regulations that may trigger a revision and resubmission of approvals. This document also provides guidance on what may constitute new source-based or receptor-based impacts and risks, or a significant increase in an existing source of environmental risk. A risk assessment will be conducted in accordance with the Environmental Risk Management Methodology (Section 4.2) to determine the significance of any potential new environmental impacts or risks not provided for in this OPP.

Minor changes, where a review of the activity and the environmental impacts and risks of the project do not trigger a requirement for a revision, will be considered a 'minor revision'. Minor administrative changes to this OPP, where an assessment of the environmental impacts and risks is not required (e.g. document references, terminology, grammar and typographic corrections), will also be considered a 'minor revision'. Minor revisions, as defined above, will be made to this OPP using Woodside's document control process.

11.4 Emergency Preparedness and Response

Woodside has Emergency Response Plans (ERPs) in place for all its petroleum activities. The ERPs provide activity-specific procedural guidance to control, coordinate, and respond to an emergency or incident, including hydrocarbon spills.

Under regulation 22(8) of the Environment Regulations, the implementation strategy for petroleum activity EPs must contain an Oil Pollution Emergency Plan (OPEP), and provide for the updating of the OPEP. Regulation 22(9) outlines the requirements for the OPEP, including adequate arrangements for responding to, and monitoring of, oil pollution.

Woodside has in place an overarching plan to describe the arrangements and processes in place for responding to an oil spill from a petroleum activity (Oil Pollution Emergency Arrangements – Australia – Guideline). Activity-specific response plans are detailed in the relevant OPEP and/or Oil Pollution First Strike Plan.

11.5 Monitoring

The effective application of EPOs provided in this OPP will be demonstrated through the implementation of subsequent EPs.

Woodside and its contractors will undertake a program of monitoring when carrying out a petroleum activity (under activity-specific EPs). The information collected will be based on the EPOs and key control measures (as outlined in Section 9 this OPP), and the additional control measures and EPSs (as outlined in subsequent EPs).

As a minimum, the information collected includes the data (evidence) referred to in the measurement criteria (as outlined in subsequent EPs). This collected data will form part of the record of compliance maintained by Woodside and form the basis for demonstrating that the EPOs are met. Compliance is summarised in a series of routine reporting documents (Section 11.7.1).

11.6 Assurance

Environmental assurance for the Goodwyn Area Infill Development will be implemented in accordance with Woodside's Provide Assurance Procedure and the Provide Assurance Guideline. Environmental assurance activities will be conducted to:

- verify environmental impacts and risks are being managed in accordance with the EPOs and EPSs detailed in this OPP and subsequent activity-specific EPs
- monitor, review, and evaluate the effectiveness of the EPOs and EPSs detailed in this OPP and subsequent activity-specific EPs
- verify the effectiveness of the subsequent activity-specific EPs' implementation strategy
- identify potential non-conformances.

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

Further details including the schedule for environmental performance auditing will be provided in subsequent activity-specific EPs.

11.7 Reporting

To meet the EPOs outlined in this OPP, Woodside undertakes reporting at several levels; these reporting arrangements are outlined below.

11.7.1 Environmental Performance Review and Reporting

In accordance with applicable environmental legislation for the petroleum activities, Woodside is required to report information on environmental performance to the appropriate regulator. Table 11-1 summarises the routine regulatory reporting requirements.

Table 11-1: Routine external reporting requirements

Report	Recipient	Frequency	Content
Monthly Recordable Incident Report	NOPSEMA	Monthly, no later than 15 days after the end of the calendar month	As required by regulation 50 of the Environment Regulations, details of recordable incidents that have occurred under the EP for the previous calendar month. See Section 11.7.2.2 for more detail.
Annual EP Performance Report	NOPSEMA	Annually, with the first report submitted within 12 months of the commencement of the petroleum activity covered by the EP	As required by regulation 22(7) and 51, reports compliance with the EPOs outlined in this OPP (and subsequent EPs), and the controls

Report	Recipient	Frequency	Content
			and standards outlined in subsequent EPs.
NPI Report[1]	DCCEEW	Annual, by 30 September each year	Summary of the emissions to land, air, and water. Reporting period: 1 July to 30 June each year.
NGER[1]	Clean Energy Regulator	Annual, by 31 October each year	Summary of energy use and GHG emissions. Reporting period: 1 July to 30 June each year.

1. NPI reporting and NGER for the Goodwyn Area Infill Development will be incorporated into existing reporting requirements for the NWS Project.

11.7.2 Incident Reporting

11.7.2.1 Reportable Incidents

A reportable incident is defined under regulation 5 of the Environment Regulations as 'an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage'.

A reportable incident for the offshore project is:

- an incident that has caused environmental damage with a consequence level[68] of Moderate C or above.
- an incident that has the potential to cause environmental damage with a consequence level of Moderate C or above .

The environmental impact and risk assessment (Section 9) for the offshore project identifies those impacts and risks with a potential consequence level of Moderate C or above for environment. The incidents that have the potential to cause this level of impact include hydrocarbon LOC events to ocean resulting from:

- loss of well containment.

Any such incidents represent potential events, which would be reportable incidents. Reporting of incidents is undertaken with consideration of NOPSEMA guidance (NOPSEMA 2024d) stating, 'if in doubt, notify NOPSEMA', and assessed case-by-case to determine if they trigger a reportable incident.

11.7.2.1.1 Notification

NOPSEMA will be notified of all reportable incidents, according to the requirements of regulations 47, 48, and 49 of the Environment Regulations, including:

- regulation 47(2)—verbally notify NOPSEMA as soon as practicable, but within two hours of the incident or of its detection by Woodside
- regulation 47(3)—provide a written record of the notification to NOPSEMA, the National Offshore Petroleum Titles Administrator (NOPTA), and the WA DEMIRS as soon as practicable after the verbal notification
- regulation 48—complete a written report for the reportable incident which must be submitted to NOPSEMA as soon as practicable, but within three days of the incident or of its detection by Woodside

[68] Consequence levels are defined in Section 4.5.

- regulation 48(3)—provide a copy of the written report to NOPTA and DEMIRS within seven days of the written report being provided to NOPSEMA.

11.7.2.2 Recordable Incidents

A recordable incident for an activity for which there is an EP in force is defined under regulation 5 of the Environment Regulations as a 'breach of an EPO for the activity, or an EPS relating to the activity, that is not a reportable incident'.

Any breach of the EPOs (as presented within this OPP and subsequent EPs) or EPSs (as presented within subsequent EPs) will be raised as a recordable incident and managed as per the notification and reporting requirements outlined below.

11.7.2.2.1 Notification

NOPSEMA will be notified of all recordable incidents, according to the requirements of regulation 50 of the Environment Regulations, including:

- regulation 50(2)—provide a written report which must be submitted to NOPSEMA not later than 15 days after the end of the calendar month.

11.7.2.3 Other External Reporting Requirements

In addition to the notification and reporting of environmental incidents defined under the Environment Regulations, the following incident reporting requirements also apply when undertaking a petroleum activity within the Project Area:

- unintentional death or injury to an EPBC listed threatened species (except a conservation dependent species), migratory species, cetacean species, or marine species in a Commonwealth area, and where the activity was not authorised by a permit, the Secretary of the DCCEEW should be notified within seven days of becoming aware of the results of the activity (02 6274 111, EPBC.Permits@environment.gov.au)
- if an oil or gas pollution incident occurs within an AMP, or is likely to impact on an AMP, the DNP Marine Duty Officer should be verbally notified as soon as practicable, and followed with a written notification (0419 293 465. marine.compliance@environment.gov.au).

11.8 Implementing Requirements of the OPP in Future EPs

The Environment Regulations require that Woodside develop and implement EPs for all petroleum activities within the scope of this OPP. Each EP must be assessed and accepted by NOPSEMA before the petroleum activity commences. EPs for activities within the scope of this OPP may not be submitted until this OPP has been accepted by NOPSEMA.

Broadly, the purpose of an EP is for the titleholder to demonstrate that the environmental impacts and risks of the petroleum activity will be reduced to ALARP and will be of an acceptable level. EPs will contain EPOs, EPSs, measurement criteria, and a detailed implementation strategy. The EPOs in the EPs will maintain an equivalent level of environmental performance to that stated in this OPP.

Table 11-2 summarises the EPOs and key control measures relative to each aspect of the Goodwyn Area Infill Development.

Table 11-2: Summary of environmental performance outcomes and key control measures for the Goodwyn Area Infill Development

Aspect	EPOs	Key Control Measures
Planned Activities		
Physical Presence: Interaction with other Marine Users	**EPO-01**: No interference with other marine users to a greater extent than is necessary for the exercise of rights and performance of duties as conferred to the titleholder	**CM-01**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth) and any subsequent marine orders **CM-02**: If property is accepted to be decommissioned in situ, this activity must comply with the *Environmental Protection (Sea Dumping) Act 1981* (Cth) **CM-03**: Establish and maintain a 500 m safety exclusion zone around the MODU and installation vessel/s for the duration of the relevant petroleum activity **CM-04**: Remove all property above the mudline unless a comparative assessment demonstrates an equal or better environmental outcome for an alternative decommissioning approach, and this has been accepted within an EP submitted under the Environment Regulations
Physical Presence: Disturbance to the Seabed	**EPO-02**: No adverse effects greater than a D consequence (minor, not affecting ecosystem function) to benthic habitats and communities from planned seabed disturbance during the petroleum activity **EPO-03**: No long-term adverse effects to the values of Australian Marine Parks from the petroleum activity	**CM-02**: (see above) **CM-04**: (see above) **CM-05**: Undertake project-specific Mooring Design Analysis **CM-06**: Undertake project-specific Basis of Well Design, which includes assessing seabed sensitivity **CM-07**: Consider and implement appropriate adaptive management measures during the EP process to reduce impacts on banks and shoals to ALARP **CM-08**: Subsea installation activities will not occur on identified shoals within the Project Area **CM-09**: Top hole locations will not occur within 500 m of identified shoals within the Project Area
Routine Emissions: Light Generation	**EPO-03**: (see above) **EPO-04**: No adverse effects greater than an F consequence (localised, no lasting effect) to marine fauna from artificial light emissions during the petroleum activity **EPO-05**: The petroleum activity will not be undertaken in a manner that is inconsistent with any threatened species or community recovery plan, or threat abatement plan, as made or adopted under the EPBC Act	**CM-10**: Limit lighting to the minimum required for navigational and safety requirements, except for emergency events **CM-11**: Manage lighting in accordance with Woodside's Offshore Seabird Management Plan **CM-12**: Consider and implement appropriate light mitigation and management measures (e.g. as described in the National Light Pollution Guidelines for Wildlife) during the EP process to reduce impacts to marine fauna to ALARP
Routine Acoustic Emissions: Continuous Sound Generation	**EPO-03**: (see above) **EPO-05**: (see above) **EPO-06**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to marine fauna from	**CM-13**: Vessels and helicopters must comply with legislative requirements for interacting with cetaceans, including Part 8 Division 8.1 of the EPBC Regulations 2000 (Cth)

Aspect	EPOs	Key Control Measures
	underwater sound emissions during the petroleum activity	**CM-14**: Consider and implement appropriate acoustic mitigation and adaptive management measures during the EP process to reduce impacts to marine fauna to ALARP
Routine Acoustic Emissions: Impulsive Sound Generation	**EPO-03**: (see above) **EPO-05**: (see above) **EPO-06**: (see above)	**CM-14**: (see above) **CM-15**: Implement Woodside's Vertical Seismic Profile Procedure
Routine and Non-routine Emissions: Atmospheric	**EPO-07**: No adverse effects greater than an F consequence (localised, no lasting effect) to air quality from atmospheric emissions during the petroleum activity	**CM-01**: (see above) **CM-16A**: Comply with legislative requirements for emissions reporting, including National Pollutant Inventory (NPI) **CM-23**: Maintain flare on GWA platform to maximise efficiency of combustion and minimise venting, incomplete combustion waste products, and smoke emissions
Routine and Non-routine Emissions: Greenhouse Gases	**EPO-08**: Indirect GHG Emissions associated with the Goodwyn Area Infill Development and that are directly within operator influence, shall assist in NWS Project achieving GHG reductions under reformed Safe Guard Mechanism (inclusive of legislated net zero emissions by 2050). **EPO-09**: Woodside to support customers and suppliers to reduce their GHG emissions by Woodside complying with relevant Corporate Woodside policies, including those designed to monitor market developments related to hydrocarbons in the energy transition.	**CM-01**: (see above) **CM-16B**: Comply with legislative requirements for emissions reporting, including National Greenhouse and Energy Reporting (NGER) scheme **CM-17**: Comply with emissions intensity requirements for reservoir carbon dioxide from new gas fields as described under Division 11, section 35A in Part 19 of Schedule 1 of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth) **CM-18**: Apply for and manage NWS Project GHG emissions to within the relevant baseline under the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth) **CM-19**: Contracting strategy and evaluation for hire of vessels includes consideration of vessel emissions parameters and low carbon/alternate fuels **CM-20**: Maintain a program to monitor market developments related to the contribution of natural gas in the energy transition **CM-21**: Forecast, measure, monitor and/or estimate facility GHG emissions (in accordance with NGER/NPI) to inform optimisation management practices and minimise environmental impact of GWA platform GHG emissions **CM-22**: Implement relevant methane management measures at GWA platform **CM-23**: (see above)
Routine and Non-routine Discharges: Hydrocarbons and Chemicals	**EPO-03**: (see above) **EPO-10**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality from routine and non-routine hydrocarbon and chemical discharges during the petroleum activity	**CM-24**: Implement Woodside's Engineering Standard Pipelines Flooding, Cleaning, Gauging and Hydrotesting **CM-25**: Implement Woodside's Chemical Selection and Assessment Environment Guideline

Aspect	EPOs	Key Control Measures
		CM-26: Implement Woodside's Engineering Operating Standard (Subsea Isolation) Procedure
Routine and Non-routine Discharges: Sewage, Putrescible Waste, Greywater, Bilge Water, Drain Water, Cooling Water, and Brine	**EPO-03**: (see above) **EPO-11**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality and biological communities from routine and non-routine MODU/vessel discharges during the petroleum activity	**CM-25**: (see above) **CM-27**: Vessels must comply with legislative requirements, including the *Navigation Act 2012* (Cth), *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth), and any subsequent marine orders
Routine and Non-routine Discharges: Drill Cuttings and Drilling Fluids	**EPO-03**: (see above) **EPO-12**: No adverse effects greater than an F consequence (localised, no lasting effect) to water quality from routine and non-routine drill cuttings and drilling fluid discharges during the petroleum activity **EPO-13**: No adverse effects greater than a D consequence (minor, not affecting ecosystem function) to benthic habitats and communities from routine and non-routine drill cuttings and drilling fluid discharges during the petroleum activity	**CM-07**: (see above) **CM-25**: (see above) **CM-28**: Implement Woodside's Drilling Fluid Best Practice guidelines **CM-29**: Implement Woodside's Reservoir, Drilling and Completions Fluids Guideline **CM-30**: Where NWBM are selected for use, implement overburden Drilling Fluids Environmental Requirements process **CM-31**: SCE used to treat drill cuttings returned to the MODU prior to discharge **CM-32**: Discharge drill cuttings from the MODU below the waterline **CM-33**: Maintain average OOC at <6.9% by weight on wet cuttings (for sections drilled with NWBM) **CM-34**: Prohibit bulk overboard discharge of NWBM **CM-35**: No top-hole locations within the Montebello Marine Park **CM-36**: Limit stock barite to a maximum of 1 mg/kg dry weight of mercury, and a maximum 3 mg/kg dry weight of cadmium
Routine and Non-routine Discharges: Cement, Cementing Fluids, Subsea Well Fluids, Produced Water, Unused Bulk Product	**EPO-14**: No adverse effects greater than an F consequence (localised, no lasting effect) to water or sediment quality from routine and non-routine cement and other drilling related discharges during the petroleum activity **EPO-15**: No adverse effects greater than an E consequence (slight, not affecting ecosystem function) to benthic habitats and communities from routine and non-routine cement and other drilling related discharges during the petroleum activity	**CM-25**: (see above) **CM-28**: (see above) **CM-29**: (see above) **CM-35**: (see above) **CM-36**: (see above) **CM-37**: Consider options for using excess bulk cement, bentonite, or barite, and implement as appropriate during the EP process **CM-38**: During well unloading and completion activities (to MODU), process any produced water through the well test water filtration treatment package before discharging to the environment
Downstream Discharges: Produced Water	**EPO-16**: No impact to ecosystem integrity from PW outside the Approved Mixing Zone boundary	**CM-25**: (see above) **CM-39**: Implement Woodside's Offshore Marine Discharges Adaptive Management Plan **CM-40**: Non-routine (potential high OIW) PW discharge activities will not occur concurrently

Aspect	EPOs	Key Control Measures
		CM-41: Temporary OIW skid used during commissioning (initial start-up)
Unplanned Events		
Physical Presence: Interaction with Marine Fauna	**EPO-17**: No vessel strikes on EPBC Act listed cetaceans or other marine megafauna during the petroleum activity	**CM-13**: (see above)
Physical Presence: Introduction of Invasive Marine Species	**EPO-18**: No introduction and establishment of an invasive marine species (IMS) into the Project Area as a result of the petroleum activity	**CM-42**: Vessels must comply with legislative requirements, including *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* (Cth), *Biosecurity Act 2015* (Cth) and any subsequent marine orders, and any national best practice guidance **CM-43**: Implement Woodside's Invasive Marine Species Management Plan
Physical Presence: Unplanned Seabed Disturbance	**EPO-19**: No unplanned seabed disturbance within the Project Area resulting in greater than a D consequence (minor, not affecting ecosystem function) during the petroleum activity	**CM-05**: (see above) **CM-44**: Station-keeping systems and mooring system testing implemented as per project-specific Mooring Design Analysis
Unplanned Release: Hazardous and Non-hazardous Solid Wastes	**EPO-20**: No unplanned release of hazardous or non-hazardous solid waste within the Project Area resulting in greater than an E consequence (slight, not affecting ecosystem function) during the petroleum activity	**CM-01**: (see above) **CM-45**: Implement waste management procedures which provide for safe handling and transportation, segregation and storage, and appropriate classification of all waste generated
Unplanned Release: Hydrocarbon and Chemicals (Minor Loss of Containment)	**EPO-21**: No minor loss of containment of hydrocarbons or chemicals within the Project Area resulting in greater than an E consequence (slight, not affecting ecosystem function) during the petroleum activity	**CM-25**: (see above) **CM-27**: (see above) **CM-46**: Implement Woodside's Marine Offshore Vessel Assurance Procedure **CM-47**: Consider options for the storage, handling, and transfer of hydrocarbons and chemicals, and implement as appropriate during the EP process
Unplanned Hydrocarbon Release: Gas and Condensate	**EPO-22**: Woodside will manage its activities to prevent a significant loss of containment. During the petroleum activity a risk of well loss of containment to the environment will be limited to high[59].	**CM-48**: In accordance with the Resource Management and Administration Regulations, a NOPSEMA-accepted Well Operations Management Plan must be in place before commencing the petroleum activity **CM-49**: In accordance with the Safety Regulations, a NOPSEMA-accepted Safety Case for pipelines must be in place before commencing the petroleum activity **CM-50**: In accordance with the Environment Regulations, a NOPSEMA-accepted Oil Pollution Emergency Plan must be in place before commencing the petroleum activity **CM-51**: A project-specific Source Control Emergency Response Plan must be in place before commencing the petroleum activity **CM-52**: A baseline environmental survey of Wilcox Shoal must be in place before commencing the petroleum activity

Aspect	EPOs	Key Control Measures
Unplanned Hydrocarbon Release: Marine Fuel	**EPO-23**: Woodside will manage its activities to prevent a significant loss of containment. During the petroleum activity a risk of hydrocarbons released to the environment, from a vessel collision, to the environment will be limited to moderate[59].	**CM-27**: (see above) **CM-46**: (see above) **CM-50**: (see above) **CM-52**: (see above) **CM-53**: Where required under the WMS, a project-specific SIMOPS Plan must be in place before commencing the petroleum activity
Cultural Features and Heritage Values		
All	**EPO-24**: Prevent adverse changes to underwater cultural heritage (as protected under the *Underwater Cultural Heritage Act 2018* [Cth]), or to declared areas or objects of particular significance (as protected under the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* [Cth])from the petroleum activity **EPO-25**: Woodside will support First Nations capacity for ongoing engagement and consultation on EPs for the purpose of avoiding impacts to cultural features and heritage values	**CM-54**: The offshore project must comply with legislative requirements, including the *Underwater Cultural Heritage Act 2018* (Cth) and *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) **CM-55**: Undertake a desktop assessment to identify any indicators of underwater cultural heritage within proposed areas of seabed disturbance for the Goodwyn Area Infill Development **CM-56**: Engage with relevant cultural authorities that may be affected in the unlikely event of an unplanned hydrocarbon release **CM-57**: Implement a program of ongoing consultation with First Nations people whose functions, interests or activities may be affected by the petroleum activities to identify and reduce impacts to cultural features and heritage values **CM-58**: Consider and implement a 'living heritage' management approach during the EP process to reduce impacts to identified cultural features and heritage values

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13 LIST OF TERMS AND ACRONYMS

Term or Acronym	Description
~	Approximately
<	Less / fewer than
ABARES	Australian Bureau of Agricultural and Resource Economics
ABF	Australian Border Force
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACF	Australian Conservation Foundation
ACN	Australian Company Number
AEMO	Australian Energy Market Operator
AEP	Australian Energy Producers (formerly Australian Petroleum Production and Exploration Association [APPEA]; from 13 September 2023)
AFMA	Australian Fisheries Management Authority
AFS Convention	International Convention on Harmful Anti Fouling Systems 2001
AFZ	Australian Fishing Zone
AHO	Australian Hydrographic Office
AIMS	Australian Institute of Marine Science
AL	Acceptable level
ALA	Atlas of Living Australia
ALARP	As low as reasonably practicable
AMCS	Australian Marine Conservation Society
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZG	Australian and New Zealand Guidelines (water quality)
APPEA	Former Australian Petroleum Production and Exploration Association (to 12 September 2023; now Australian Energy Producers [AEP])
AR	Ashmore Reef
AR6	Sixth Assessment Report (IPCC)
AS	Australian Standard
AS/NZS	Australian Standard/New Zealand Standard
ASBTIA	Australian Southern Bluefin Tuna Association
ATSIHP Act	*Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth)
Basel Convention	International Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989
BHA	Bottom-hole assembly
BIA	Biologically Important Area
Bonn Convention	International Convention on the Conservation of Migratory Species of Wild Animals
BOP	Blowout preventer
BP	Before present
BRS	Bureau of Rural Sciences

Term or Acronym	Description
BTAC	Buurabalayji Thalanyji Aboriginal Corporation
BTEX	Benzene, toluene, ethylbenzene and xylene
CALM	Former Western Australian Department of Conservation and Land Management
CAMBA	China–Australia Migratory Bird Agreement
CAPL	Chevron Australia Pty Ltd
CATAMI	Collaborative and Automated Tools for the Analysis of Marine Imagery
CCG	Cape Conservation Group
CCS	Carbon capture and storage
CCU	Carbon capture and utilisation
CCWA	Conservation Council of Western Australia
CER	Clean Energy Regulator
CFA	Commonwealth Fisheries Association
CHMP	Cultural Heritage Management Plan
CITES	International Convention on International Trade in Endangered Species of Wild Fauna and Flora
CITHP	Closed in tubing head pressure
Class Approval	On 27 February 2014, the then Federal Minister for the Environment approved a class of actions under section 146B of the EPBC Act which, if undertaken in accordance with the endorsed Program, will not require separate referral, assessment, and approval under the EPBC Act. The Class Approval is valid until 31 December 2040.
CLC Convention	International Convention on Civil Liability for Oil Pollution Damage 1969
CLG	Community Liaison Group
CM	Control measure
cm	Centimetre
CME	Chamber of Minerals and Energy of Western Australia
CO	Carbon monoxide
CO_2	Carbon dioxide
CoP	Cessation of Production
COP28	28th Conference of the Parties of the United Nations Framework Convention on Climate Change
COVID-19	An infectious coronavirus disease caused by the SARS-CoV-2 virus
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTE	Critical technology element
Cth	Commonwealth of Australia
cui	Cubic inch
DAFF	Commonwealth Department of Agriculture, Fisheries and Forestry
DAWE	Former Commonwealth Department of Agriculture, Water and The Environment
dB re 1 µPa	Decibels relative to one micropascal; the unit used to measure the intensity of an underwater sound
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water

Term or Acronym	Description
DEC	Former Western Australian Department of Environment and Conservation
DEH	Former Commonwealth Department of Environment and Heritage
DEMIRS	Western Australian Department of Energy, Mines, Industry Regulation and Safety (from 1 December 2023; formerly Department of Mines, Industry Regulation and Safety [DMIRS])
DEWHA	Former Commonwealth Department of the Environment, Water, Heritage and the Arts
DHOSNRTC	Deepwater Horizon Oil Spill Natural Resource Trustee Council
DHSC	Deep History of Sea Country
DISER	Former Commonwealth Department of Industry, Science, Energy and Resources
DISR	Commonwealth Department of Industry, Science and Resources
DJTSI	Western Australian Department of Jobs, Tourism, Science and Innovation (DJTSI)
DMIRS	Former Western Australian Department of Mines, Industry Regulation and Safety (now Department of Energy, Mines, Industry Regulation and Safety [DEMIRS])
DNP	Director of National Parks
DoD	Department of Defence
DP	Dynamic positioning
DPAW	Former Western Australian Department of Parks and Wildlife
DPI	NSW Department of Primary Industries
DPIRD	Western Australian Department of Primary Industries and Regional Development
DPLH	Western Australian Department of Planning, Lands and Heritage
DSDMP	Dredging and Spoil Disposal Management Plan
DSEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population and Communities
DST	Drill stem test
DWER	Western Australian Department of Water and Environmental Regulation
e.g.	For example
EAAF	East Asian–Australian Flyway
EDS	Emergency disconnect sequence
EDU	Electrical distribution unit
EEZ	Exclusive Economic Zone
EFL	Electrical flying lead
EHU	Electro-hydraulic umbilical
EIO	East Indian Ocean
EIS-ERMP	Environmental Impact Statement – Environmental Review and Management Program
EMBA	Environment that may be affected
ENVID	Environmental Impact and Risk Identification workshop
Environment Regulations	Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
EOFL	End of field life
EP	Environment Plan
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Term or Acronym	Description
EPBC Regulations	Commonwealth Environment Protection and Biodiversity Conservation Regulations 2000
EPO	Environmental performance outcome
EPS	Environmental performance standard
$ER_{95\%}$	Exposure range (95th percentile)
ERP	Emergency response plan
ES	Executive Summary
ESD	Ecologically sustainable development
FCA	Federal Court of Australia
FCAFC	Federal Court of Australia – Full Court
FCGT	Flooded, cleaned, gauged and tested
FEED	Front end engineering design
FEWD	Formation evaluation while drilling
FID	Final investment decision
FLET	Flowline end termination
GAP	Greenpeace Australia Pacific
GH	Goodwyn H
GHG	Greenhouse gas
GIS	Geographic Information System
GPS	Global Positioning System
GVP	Gross value of production
GWA	Goodwyn A
GWA Facility	In accordance with Schedule 3 of the OPGGS Act, the GWA Facility comprises the GWA platform and the subsea hydrocarbon system (production wells and infield infrastructure)
GWF	Greater Western Flank
HAT	Highest astronomical tide
HFL	Hydraulic flying lead
HFO	Heavy fuel oil
HIPPS	High integrity pressure protection systems
HMAS	His Majesty’s Australian Ship (during World War II)
HPI	High-pressure intensifier
HSE	Health, Safety and Environment
HSK	Ship of the German Navy (during World War II)
Hz	Hertz
i.e.	That is
IBC	Intermediate bulk container
ICOMOS	International Council on Monuments and Sites
IEA	International Energy Agency
IFAW	International Fund for Animal Welfare
IFL	Interfield line

Term or Acronym	Description
IFSEC	International Fire and Security Exhibition and Conference
ILT	In-line tree
ILUA	Indigenous Land Use Agreements
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMMR	Inspection, Monitoring, Maintenance and Repair
IMO	International Maritime Organization
IMS	Invasive marine species
IOGP	International Association of Oil and Gas Producers
IPA	Indigenous Protected Area
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organization for Standardization
ISQG	Interim Sediment Quality Guideline
ITF	Indonesian Throughflow
ITOPF	International Tanker Owners Pollution Federation Limited
IUCN	International Union for Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
JASMINE	JASCO Animal Simulation Model Including Noise Exposure
KEF	Key ecological feature
kg	Kilogram
KGP	Karratha Gas Plant
kHz	Kilohertz
KLC	Kimberley Land Council
km	Kilometre
KM & YM	Kuruma Marthudunera and Yamatji Marlpa
KSCS	Kimberley Science and Conservation Strategy
kya	Thousand years ago.
L	Litre
LBL	Long baseline
LNG	Liquefied natural gas
LOC	Loss of containment
LOWC	Loss of well control
LPA	Lady Nora–Pemberton
lux	A standard for measuring light; equal to the amount of visible light per square metre incident on a surface. 1 lux = 1 lumen/square metre or 0.093 foot-candles.
LWI	Light well intervention
m	Metre
MAC	Murujuga Aboriginal Corporation
MAE	Major accident event

Term or Acronym	Description
MARPOL	International Convention for the Prevention of Pollution from Ships, London, 1973/1978
MBES	Multibeam echo sounder
MDO	Marine diesel oil
MEE	Major environmental event
MEG	Monoethylene glycol
mg	Milligram
MGO	Marine gas oil
MGP	Methane Guiding Principles
MIMI	Japan Australia LNG (company)
mm	millimetre
MMA	Marine Management Area
MNES	Matters of National Environmental Significance
MODIS	Moderate resolution imaging spectrometer
MODU	Mobile offshore drilling unit
MOU	Memorandum of Understanding
MPSC	Marine Pest Sectoral Committee
MSPS	Management system performance standard
MSR	Mean spring range
N/A	Not applicable
NAC	Ngarluma Aboriginal Corporation
NCWHAC	Ningaloo Coast World Heritage Advisory Committee
NDC	Nationally Determine Contribution
NEPM	National Environment Protection Measure
NERA	National Energy Resources Australia
NGAF	National Greenhouse Accounts Factor
NGER	National Greenhouse and Energy Reporting
NIMS	Non-indigenous marine species
NKAC	Nyangumarta Karajarri Aboriginal Corporation
nm	Nautical mile
NMFS	National Marine Fisheries Service (US)
NOAA	National Oceanic and Atmospheric Administration (US)
NOEC	No observed effect concentration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NO_x	Nitrogen oxides
NPI	National Pollutant Inventory
NRC	North Rankin Complex
NRDA	Natural Resource Damage Assessment (US)
NSW	New South Wales

Term or Acronym	Description
NT	Northern Territory
NTGAC	Nganhurra Thanardi Garrbu Aboriginal Corporation
NTRB	Native Title Representative Body
NW	North-west
NWAC	Nyangumarta Warrarn Aboriginal Corporation a
NWBM	Non–water-based muds
NWMR	North-West Marine Region
NWS	North West Shelf
NWS Project	The NWS Project includes processing, storage, and offloading facilities associated with operations at the KGP, as well as two export trunklines that extend from the North Rankin Complex in Commonwealth waters to the onshore KGP.
NWSJV	North West Shelf Joint Venture
NWSTF	North West Slope Trawl Fishery
NZE	Net Zero Emissions
NZS	New Zealand Standard
OA	Operational Area
OCNS	Offshore Chemical Notification Scheme
OEUK	Offshore Energies UK
OIW	Oil in water
OMDAMP	Offshore Marine Discharges Adaptive Management Plan
OOC	Oil on cuttings
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPP	Offshore Project Proposal
ORO	Other resource owners
OSMP	Operational and Scientific Monitoring Plan
OSPAR	Oslo–Paris Convention for the Protection of the Marine Environment of the North East Atlantic
OWS	Oily water separator
P&A	Plug and Abandonment
PAD	Pump and dump
PAH	Polycyclic aromatic hydrocarbons
PAR	Pre-arrival report
PBC	Prescribed Body Corporate
PCPT	Piezocone penetration test
pH	Acidity or basicity of a solution
PK	Peak sound pressure level
PK-Pk	Peak-peak sound pressure level
PLET	Pipeline end termination
PLONOR	Pose little or no risk

Term or Acronym	Description
PMST	Protected Matters search tool
PNEC	Predicted no-effect concentration
POB	Persons on board
PPA	Pilbara Ports Authority
PPE	Personal protective equipment
Program	On 27 February 2014, the then Federal Minister for the Environment endorsed NOPSEMA's process set out in the *Program Report – Strategic Assessment of the environmental management authorisation process for petroleum and greenhouse gas storage activities administered by the National Offshore Petroleum Safety and Environmental Management Authority under the Offshore Petroleum and Greenhouse Gas Storage Act 2006* dated February 2014 (referred to as the Program) as meeting the requirements of Part 10 of the EPBC Act.
PTS	Permanent threshold shift – acoustic trauma
PW	Produced water
PYA-01	Pyxis 01 well
RAAF	Royal Australian Air Force
Resource Management and Administration Regulations	Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011
RFSU	Ready for start-up
R_{max}	Maximum range
RMS	Root mean square
RNTBC	Registered Native Title Body Corporate
RO	Reverse osmosis
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
ROV	Remotely operated vehicle
RTIO	Rio Tinto Iron Ore
s	Second (time)
SA	South Australia
Safety Regulations	Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009
SBP	Sub-bottom profiler
SBTF	Southern Bluefin Tuna Fishery
SCE	Solids control equipment
SCERP	Source Control Emergency Response Plan
SCSSV	Surface-controlled subsurface safety valve
SDG	Sustainable development goals
SEL	Sound exposure level
SIMAP	Spill Impact Mapping and Analysis Program
SIMOPS	Simultaneous operations
SNZ	Standards New Zealand
SOLAS	Safety of Life at Sea

Term or Acronym	Description
SOS	Save Our Songlines
SO_X	Sulfur oxides
SPF	Small Pelagic Fishery
SPL	Sound pressure level
SSS	Side-scan sonar
STEPS	Stated policies scenario
SWMR	South-West Marine Region
t	Tonne
TAP	Threat abatement plan
TD	Total depth
TEC	Threatened ecological community
TOL	Top of line
TPH	Total petroleum hydrocarbons
TS	Torosa South
TSS	Total suspended solids
TSSC	Threatened Species Scientific Committee
TTS	Temporary threshold shift
UCH	Underwater cultural heritage
UCON	Universal connection system
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea 1982
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USBL	Ultra-short baseline
UTA	Umbilical termination assembly
UWA	University of Western Australia
VOC	Volatile organic compounds
VSP	Vertical seismic profile
WA	Western Australia
WAC	Wirrawandi Aboriginal Corporation
WAFIC	Western Australian Fishing Industry Council
WAITOC	Western Australian Indigenous Tourism Operators Council
WAMSI	Western Australian Marine Science Institution
WBF	Water-based fluid
WBM	Water-based mud
WDCS	The Whale and Dolphin Conservation Society
WEL	Woodside Energy Ltd
WET	Whole effluent toxicity

Term or Acronym	Description
WGI	AR6 Working Group I
WGII	AR6 Working Group II
WMS	Woodside Management System
WOMP	Well Operations Management Plan
Woodside	Woodside Energy Ltd.
WSTF	Western Skipjack Tuna Fishery
WTBF	Western Tuna and Billfish Fishery
WWF	World Wildlife Fund for Nature
YAC	Yinggarda Aboriginal Corporation
YMAC	Yamatji Marlpa Aboriginal Corporation

APPENDIX A WOODSIDE POLICIES

Woodside Energy

Environment and Biodiversity Policy

OBJECTIVE

Woodside recognises the intrinsic value of nature and the importance of conserving biodiversity and ecosystem services to support the sustainable development of our society. We are committed to doing our part. We understand and embrace our responsibility to undertake activities in an environmentally sustainable way.

PRINCIPLES

Woodside commits to:

- Implementing a systematic approach to the management of the impacts and risks of our operating activities on an ongoing basis, including emissions and air quality, discharge and waste management, water management, biodiversity and protected areas.
- Applying the mitigation hierarchy principle (avoid, minimise, restore) and a continuous improvement approach to ensure we maintain compliance, improve resource use efficiency and reduce our environmental impacts.
- Embedding environmental and biodiversity management, and opportunities, in our business planning and decision making processes.
- Complying with relevant laws and regulations and applying responsible standards where laws do not exist.
- Not undertaking new exploration or development of hydrocarbons within the boundaries of natural sites on the UNESCO World Heritage List (as specified at 1 December 2022). Existing activity may continue if compatible with maintenance of the listed outstanding universal values.
- Not undertaking new exploration or development of hydrocarbons within IUCN Protected Areas (as specified at 1 December 2022) unless compatible with management plans in place for the area. Existing activity may continue if compatible with management plans in place for the area.
- Achieving net zero deforestation[1] associated with new projects that take a Final Investment Decision (FID) after 1 December 2022.
- Developing Biodiversity Action Plans for all new major projects (CAPEX >USD$2 billion) that take a FID after 1 December 2022.
- Supporting positive biodiversity outcomes in regions and areas in which we operate.
- Setting targets and publicly reporting on our environmental and biodiversity performance.

APPLICABILITY

Responsibility for the application of this Policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this Policy in non-operated joint ventures.

This Policy will be reviewed regularly and updated as required.

Reviewed by the Woodside Energy Group Ltd Board in December 2023.

[1] Definition of Forest: 'trees higher than 5 metres and a canopy cover of more than 10 percent on the land to be cleared'.

APPROVED

Climate Policy

BACKGROUND

The Intergovernmental Panel on Climate Change has stated that “it is unequivocal that human influence has warmed the atmosphere, ocean and land”. An objective of the Paris Agreement is to hold “the increase in the global average temperature to well below 2ºC above pre-industrial levels” and to pursue “efforts to limit the temperature increase to 1.5ºC”. Many countries have set targets to reduce greenhouse gas emissions, including by changing the way they produce and consume energy.

OBJECTIVE

Woodside’s objective is to thrive in this energy transition as a low cost, lower carbon energy provider.

PRINCIPLES

Woodside aims to achieve the objective by:

- Setting science-based[1] near, mid, and long-term net emissions reduction targets that are consistent with Paris-aligned[2] scenarios, covering equity scope 1 and 2 emissions, both operated and non-operated.[3]
- Developing and operating oil and gas projects in a manner that is consistent with these targets. This includes the deployment of lower-emission technologies (Design Out), supporting efficient operations (Operate Out) and use of robust offsets (Offset) as methods to reduce and offset greenhouse gas emissions.
- Investing in new energy products and lower carbon services to reduce customers’ emissions (part of Woodside’s Scope 3 emissions), including but not limited to hydrogen, ammonia and carbon capture, utilisation and storage.
- Publishing transparent climate-related disclosures aligned to the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) or other recognised global reporting standards.
- Aligning our advocacy to the principles of this Climate Policy.

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[1] Woodside is using the draft Prototype IFRS Sustainability Disclosure Standard definition of “science-based” (published 2021) which states “targets are considered ‘science-based’ if they are in line with what the most recent climate science sets out is necessary to meet the goals of the Paris Agreement—limiting global warming to below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit warming to 1.5 degrees Celsius.”. See https://www.ifrs.org/content/dam/ifrs/groups/trwg/trwg-climate-related-disclosures-prototype.pdf (Appendix A).

[2] Woodside is using the draft Prototype IFRS Sustainability Disclosure Standard definition of “Paris-aligned scenarios” (published 2021) which states “scenarios consistent with limiting global warming to below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit warming to 1.5 degrees Celsius.” See https://www.ifrs.org/content/dam/ifrs/groups/trwg/trwg-climate-related-disclosures-prototype.pdf (Appendix A).

[3] Equity emissions means the share of the total emissions arising from an activity that are attributable to Woodside in proportion to Woodside’s ownership interest in the activity, irrespective of whether Woodside operates the activity. Operated emissions are the total emissions arising from an activity that Woodside operates, irrespective of Woodside’s ownership interest.

APPROVED

APPLICABILITY

Responsibility for the application of this Policy rests with all Woodside employees, contractors and joint venture participants engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this Policy in non-operated joint ventures.

This Policy will be reviewed regularly and updated as required.

Reviewed by the Woodside Energy Group Ltd Board in December 2023.

Risk Management Policy

OBJECTIVES

Woodside recognises that risk is inherent in our business and the effective management of risk is vital to deliver our strategic objectives, continued growth and success. We are committed to managing risks in a proactive and effective manner as a source of competitive advantage.

Our approach protects us against potential negative impacts, enables us to take risk for reward and improves our resilience against emerging risks. The objective of our risk management framework is to provide a single consolidated view of risks across the company to understand our full risk exposure and prioritise risk management and governance.

The success of our approach lies in the responsibility placed on everyone at all levels to proactively identify, assess and treat risks relating to the objectives they are accountable for delivering.

PRINCIPLES

Woodside achieves these objectives by:

- Applying a structured and comprehensive framework for the identification, assessment and treatment of current risks and response to emerging risks;
- Ensuring line of sight of financial and non-financial risks at appropriate levels of the organisation;
- Demonstrating leadership and commitment to integrating risk management into our business activities and governance practices;
- Recognising the value of stakeholder engagement, best available information and proactive identification of potential changes in external and internal context;
- Embedding risk management into our critical business processes and control framework;
- Understanding our exposure to risk and tolerance for uncertainty to inform our decision making and assure that Woodside is operating with due regard to the risk appetite endorsed by the Board; and
- Evaluating and improving the effectiveness and efficiency our approach.

APPLICABILITY

The Managing Director of Woodside is accountable to the Board of Directors for ensuring this Policy is effectively implemented.

Responsibility for the application of this Policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this Policy in non-operated joint ventures.

This Policy will be reviewed regularly and updated as required.

Reviewed by the Woodside Energy Group Ltd Board in December 2023.

APPROVED

First Nations Communities Policy

OBJECTIVE

Woodside partners and engages with First Nations communities to create positive economic, social and cultural outcomes that leave a lasting legacy. We do this through building respectful relationships and partnerships with First Nations communities where we are active, in the areas where they are most interested in. We acknowledge the unique connection that First Nations communities have to land, waters and the environment.

PRINCIPLES

We will achieve this by:

- Complying with laws relevant to First Nations communities' rights, interests and obligations where these apply.
- Being guided by the United Nations Declaration on the Rights of Indigenous Peoples.
- Engaging with affected communities of First Nations in ways that are consistent with the principles of seeking Free, Prior and Informed Consent (FPIC).
- Ensuring our management of cultural heritage is thorough, transparent and underpinned by consultation and continued engagement with First Nations communities.
- Avoiding future damage or disturbance to cultural heritage and, if avoidance is not possible, we will minimise and mitigate the impacts, in close consultation with First Nation communities and Traditional Custodians.
- Ensuring the voices, views and aspirations of First Nations communities and leaders are heard and understood within Woodside.
- Supporting First Nations self-determination, truth telling, economic empowerment, strong corporate governance, leadership and cultural heritage protection.

APPLICABILITY

Responsibility for the application of this Policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this Policy in non-operated joint ventures.

This Policy will be reviewed regularly and updated as required.

Reviewed by the Woodside Energy Group Ltd Board in December 2023.

APPROVED

APPENDIX B EPBC PROTECTED MATTERS SEARCH REPORTS

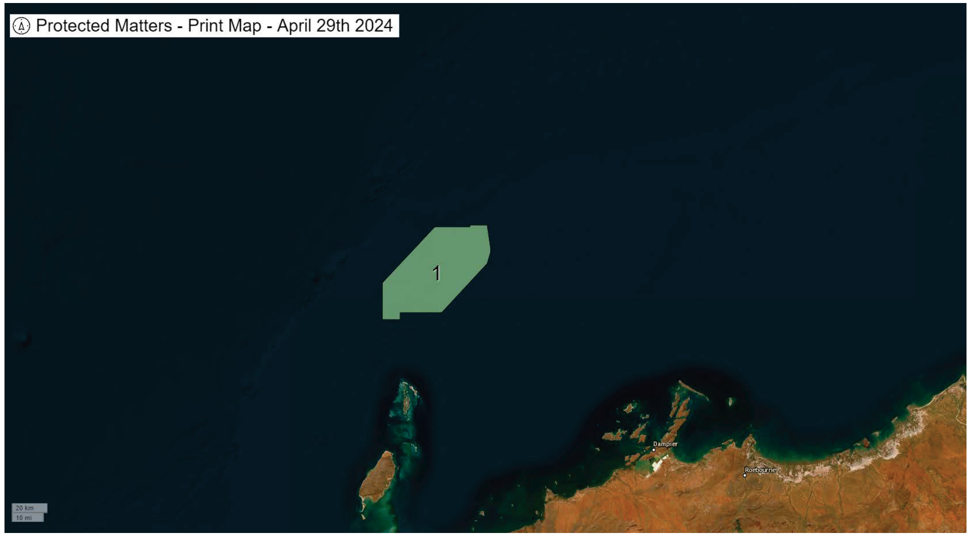
Australian Government
Department of Climate Change, Energy, the Environment and Water

PROJECT AREA

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 29-Apr-2024



Summary

Matters of National Environment Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	26
Listed Migratory Species:	38

Other Matters Protected by the EPBC Act

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

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

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

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	70
Whales and Other Cetaceans:	28
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1
Habitat Critical to the Survival of Marine Turtles:	1

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	45
Key Ecological Features (Marine):	2
Biologically Important Areas:	8
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Calidris acuminata		
Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus		
Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda westralis		
Red-tailed Tropicbird (Indian Ocean), Indian Ocean Red-tailed Tropicbird [91824]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
FISH		
Thunnus maccoyii		
Southern Bluefin Tuna [69402]	Conservation Dependent	Breeding known to occur within area
MAMMAL		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
REPTILE		
Aipysurus apraefrontalis		
Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus foliosquama		
Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
SHARK		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sphyrna lewini Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat known to occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Isurus oxyrinchus		
Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus		
Longfin Mako [82947]		Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]		Breeding known to occur within area
Mobula alfredi as Manta alfredi		
Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat known to occur within area
Mobula birostris as Manta birostris		
Giant Manta Ray [90034]		Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area

Scientific Name	Threatened Category	Presence Text
Orcaella heinsohni		
Australian Snubfin Dolphin [81322]		Species or species habitat may occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus		
Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa sahulensis as Sousa chinensis		
Australian Humpback Dolphin [87942]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptile		
Aipysurus apraefrontalis Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Aipysurus duboisii Dubois' Sea Snake, Dubois' Seasnake, Reef Shallows Sea Snake [1116]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus laevis Olive Sea Snake, Olive-brown Sea Snake [1120]		Species or species habitat may occur within area
Aipysurus mosaicus as Aipysurus eydouxii Mosaic Sea Snake [87261]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Sea Snake, Mjoberg's Sea Snake [1121]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Ephalophis greyae as Ephalophis greyi Mangrove Sea Snake [93738]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrelaps darwiniensis Port Darwin Sea Snake, Black-ringed Mangrove Sea Snake [1100]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hydrophis czeblukovi Fine-spined Sea Snake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Sea Snake, Bar-bellied Sea Snake [1104]		Species or species habitat may occur within area
Hydrophis kingii as Disteira kingii Spectacled Sea Snake [93511]		Species or species habitat may occur within area
Hydrophis macdowelli as Hydrophis mcdowelli MacDowell's Sea Snake, Small-headed Sea Snake, [75601]		Species or species habitat may occur within area
Hydrophis major as Disteira major Olive-headed Sea Snake [93512]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Sea Snake, Ornate Reef Sea Snake [1111]		Species or species habitat may occur within area
Hydrophis peronii as Acalyptophis peronii Horned Sea Snake [93509]		Species or species habitat may occur within area
Hydrophis platura as Pelamis platurus Yellow-bellied Sea Snake [93746]		Species or species habitat may occur within area
Hydrophis stokesii as Astrotia stokesii Stokes' Sea Snake [93510]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia sima Dwarf Sperm Whale [85043]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa sahulensis Australian Humpback Dolphin [87942]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Park Name	Zone & IUCN Categories
Montebello	Multiple Use Zone (IUCN VI)

Habitat Critical to the Survival of Marine Turtles [Resource Information]

Scientific Name	Behaviour	Presence
Aug - Sep		
Natator depressus Flatback Turtle [59257]	Nesting	Known to occur

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Browse to North West Shelf Development, Indian Ocean, WA	2018/8319		Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Project Highclere Cable Lay and Operation	2022/09203		Completed
Controlled action			
Construct and operate LNG & domestic gas plant including onshore and offshore facilities - Wheatston	2008/4469	Controlled Action	Post-Approval
Echo-Yodel Production Wells	2000/11	Controlled Action	Post-Approval
Equus Gas Fields Development Project, Carnarvon Basin	2012/6301	Controlled Action	Completed
Gorgon Gas Development 4th Train Proposal	2011/5942	Controlled Action	Post-Approval
Pluto Gas Project	2005/2258	Controlled Action	Completed
Pluto Gas Project Including Site B	2006/2968	Controlled Action	Post-Approval
Not controlled action			
'Goodwyn A' Low Pressure Train Project	2003/914	Not Controlled Action	Completed
Echo A Development WA-23-L, WA-24-L	2005/2042	Not Controlled Action	Completed
Exploration of appraisal wells	2006/3065	Not Controlled Action	Completed
Maia-Gaea Exploration wells	2000/17	Not Controlled Action	Completed
North Rankin B gas compression facility	2005/2500	Not Controlled Action	Completed
Pipeline System Modifications Project	2000/3	Not Controlled Action	Completed
Project Highclere Geophysical Survey	2021/9023	Not Controlled Action	Completed
Searipple gas and condensate field development	2000/89	Not Controlled Action	Completed
sub-sea tieback of Perseus field wells	2004/1326	Not Controlled Action	Completed
Telstra North Rankin Spur Fibre Optic Cable	2016/7836	Not Controlled Action	Completed
To construct and operate an offshore submarine fibre optic	2014/7373	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
cable, WA			
Western Flank Gas Development	2005/2464	Not Controlled Action	Completed
Wheatstone 3D seismic survey, 70km north of Barrow Island	2004/1761	Not Controlled Action	Completed
Not controlled action (particular manner)			
'Tourmaline' 2D marine seismic survey, permit areas WA-323-P, WA-330-P and WA-32	2005/2282	Not Controlled Action (Particular Manner)	Post-Approval
"Leanne" offshore 3D seismic exploration, WA-356-P	2005/1938	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey in WA 457-P & WA 458-P, North West Shelf, offshore WA	2013/6862	Not Controlled Action (Particular Manner)	Post-Approval
Aperio 3D Marine Seismic Survey, WA	2012/6648	Not Controlled Action (Particular Manner)	Post-Approval
Balnaves Condensate Field Development	2011/6188	Not Controlled Action (Particular Manner)	Post-Approval
Cable Seismic Exploration Permit areas WA-323-P and WA-330-P	2008/4227	Not Controlled Action (Particular Manner)	Post-Approval
CGGVERITAS 2010 2D Seismic Survey	2010/5714	Not Controlled Action (Particular Manner)	Post-Approval
Cue Seismic Survey within WA-359-P, WA-361-P and WA-360-P	2007/3647	Not Controlled Action (Particular Manner)	Post-Approval
DAVROS MC 3D marine seismic survey northwaet of Dampier, WA	2013/7092	Not Controlled Action (Particular Manner)	Post-Approval
Deep Water Northwest Shelf 2D Seismic Survey	2007/3260	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Demeter 3D Seismic Survey, off Dampier, WA	2002/900	Not Controlled Action (Particular Manner)	Post-Approval
Foxhound 3D Non-Exclusive Marine Seismic Survey	2009/4703	Not Controlled Action (Particular Manner)	Post-Approval
Greater Western Flank Phase 1 gas Development	2011/5980	Not Controlled Action (Particular Manner)	Post-Approval
Harmony 3D Marine Seismic Survey	2012/6699	Not Controlled Action (Particular Manner)	Post-Approval
Julimar Brunello Gas Development Project	2011/5936	Not Controlled Action (Particular Manner)	Post-Approval
Moosehead 2D seismic survey within permit WA-192-P	2005/2167	Not Controlled Action (Particular Manner)	Post-Approval
Santos Winchester three dimensional seismic survey - WA-323-P & WA-330-P	2011/6107	Not Controlled Action (Particular Manner)	Post-Approval
Stag 4D & Reindeer MAZ Marine Seismic Surveys, WA	2013/7080	Not Controlled Action (Particular Manner)	Post-Approval
Tidepole Maz 3D Seismic Survey Campaign	2007/3706	Not Controlled Action (Particular Manner)	Post-Approval
West Panaeus 3D seismic survey	2006/3141	Not Controlled Action (Particular Manner)	Post-Approval
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval
Wheatstone 3D MAZ Marine Seismic Survey	2011/6058	Not Controlled Action (Particular Manner)	Post-Approval
Wheatstone Iago Appraisal Well Drilling	2008/4134	Not Controlled Action (Particular Manner)	Post-Approval
Wheatstone Iago Appraisal Well Drilling	2007/3941	Not Controlled Action (Particular Manner)	Post-Approval

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Continental Slope Demersal Fish Communities	North-west

Biologically Important Areas [Resource Information]

Scientific Name	Behaviour	Presence
Marine Turtles		
Chelonia mydas Green Turtle [1765]	Internesting buffer	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Internesting buffer	Known to occur
Natator depressus Flatback Turtle [59257]	Internesting buffer	Known to occur
Seabirds		
Ardenna pacifica Wedge-tailed Shearwater [84292]	Breeding	Known to occur
Sharks		
Rhincodon typus Whale Shark [66680]	Foraging	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur

Scientific Name	Behaviour	Presence
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Migration	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north and south)	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

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

Threatened, migratory and marine species

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

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

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

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

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

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

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

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

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

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

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

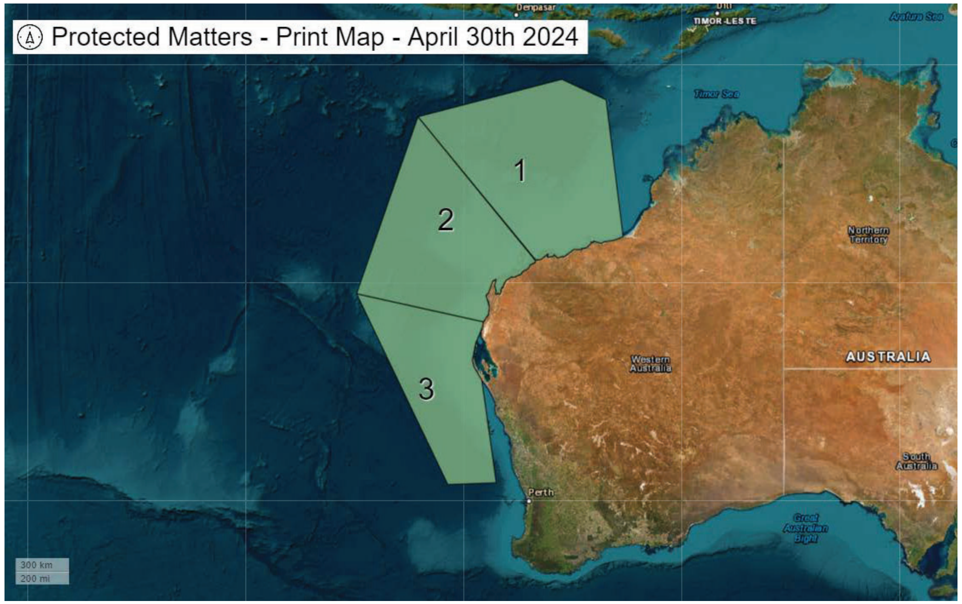
Australian Government
Department of Climate Change, Energy, the Environment and Water

ENVIRONMENT THAT MAY BE AFFECTED (Parts 1, 2, and 3)

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 30-Apr-2024



Summary

Matters of National Environment Significance

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

World Heritage Properties:	2
National Heritage Places:	6
Wetlands of International Importance (Ramsar	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	6
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	90
Listed Migratory Species:	97

Other Matters Protected by the EPBC Act

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

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

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

Commonwealth Lands:	137
Commonwealth Heritage Places:	4
Listed Marine Species:	172
Whales and Other Cetaceans:	40
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	28
Habitat Critical to the Survival of Marine Turtles:	4

Extra Information

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

State and Territory Reserves:	69
Regional Forest Agreements:	None
Nationally Important Wetlands:	9
EPBC Act Referrals:	323
Key Ecological Features (Marine):	14
Biologically Important Areas:	74
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Legal Status
Shark Bay, Western Australia	WA	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Places [Resource Information]

Name	State	Legal Status
Historic		
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
Batavia Shipwreck Site and Survivor Camps Area 1629 - Houtman Abrolhos	WA	Listed place
Dirk Hartog Landing Site 1616 - Cape Inscription Area	WA	Listed place
Indigenous		
Dampier Archipelago (including Burrup Peninsula)	WA	Listed place
Natural		
Shark Bay, Western Australia	WA	Listed place
The Ningaloo Coast	WA	Listed place

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity
Eighty-mile beach	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)

Feature Name
Commonwealth Marine Areas (EPBC Act)

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Aphelocephala leucopsis Southern Whiteface [529]	Vulnerable	Species or species habitat likely to occur within area
Arenaria interpres Ruddy Turnstone [872]	Vulnerable	Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Vulnerable	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Endangered	Species or species habitat may occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Endangered	Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]	Endangered	Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Malurus leucopterus leucopterus White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren [26004]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda westralis Red-tailed Tropicbird (Indian Ocean), Indian Ocean Red-tailed Tropicbird [91824]	Endangered	Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis squatarola Grey Plover [865]	Vulnerable	Roosting known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]	Endangered	Species or species habitat known to occur within area
Turnix varius scintillans Painted Button-quail (Houtman Abrolhos) [82451]	Endangered	Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]	Vulnerable	Roosting known to occur within area
CRUSTACEAN		
Kumonga exleyi Cape Range Remipede [86875]	Vulnerable	Species or species habitat known to occur within area
FISH		
Milyeringa veritas Cape Range Cave Gudgeon, Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Breeding known to occur within area
MAMMAL		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Bettongia lesueur lesueur Burrowing Bettong (Shark Bay), Boodie [66659]	Vulnerable	Species or species habitat known to occur within area
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Isoodon auratus barrowensis		
Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus		
Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus bernieri		
Rufous Hare-wallaby (Bernier Island) [66662]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies		
Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Lagorchestes hirsutus dorreae		
Rufous Hare-wallaby (Dorre Island) [66663]	Vulnerable	Species or species habitat known to occur within area
Lagostrophus fasciatus fasciatus		
Banded Hare-wallaby, Merrnine, Marnine, Munning [66664]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Neophoca cinerea		
Australian Sea-lion, Australian Sea Lion [22]	Endangered	Breeding known to occur within area
Osphranter robustus isabellinus		
Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Perameles bougainville		
Shark Bay Bandicoot [278]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Petrogale lateralis lateralis		
Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Pseudomys fieldi		
Shark Bay Mouse, Djoongari, Alice Springs Mouse [113]	Vulnerable	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
PLANT		
Minuria tridens		
Minnie Daisy [13753]	Vulnerable	Species or species habitat known to occur within area
REPTILE		
Aipysurus apraefrontalis		
Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama		
Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus zastictus		
Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Egernia stokesii badia		
Western Spiny-tailed Skink, Baudin Island Spiny-tailed Skink [64483]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Lerista nevinae Nevin's Slider [85296]	Endangered	Species or species habitat known to occur within area
Liasis olivaceus barroni Pilbara Olive Python [66699]	Vulnerable	Species or species habitat known to occur within area
Liopholis kintorei Great Desert Skink, Tjakura, Warrarna, Mulyamiji, Tjalapa, Nampu [83160]	Vulnerable	Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
SHARK		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Congregation or aggregation known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Centrophorus uyato Little Gulper Shark [68446]	Conservation Dependent	Species or species habitat likely to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sphyrna lewini Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat known to occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Species or species habitat may occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]		Breeding known to occur within area
Mobula alfredi as Manta alfredi Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat known to occur within area
Mobula birostris as Manta birostris Giant Manta Ray [90034]		Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa sahulensis as Sousa chinensis		
Australian Humpback Dolphin [87942]		Species or species habitat known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]	Vulnerable	Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]	Vulnerable	Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Vulnerable	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta		
Long-toed Stint [861]		Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Vulnerable	Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala		
Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura		
Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]	Endangered	Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]	Vulnerable	Roosting known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]	Endangered	Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]	Vulnerable	Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

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

Commonwealth Land Name	State
Defence	
Defence - EXMOUTH ADMIN & HF TRANSMITTING [50127]	WA
Defence - EXMOUTH ADMIN & HF TRANSMITTING [50128]	WA
Defence - EXMOUTH ADMIN & HF TRANSMITTING [50129]	WA
Defence - EXMOUTH ADMIN & HF TRANSMITTING [50126]	WA
Defence - EXMOUTH ADMIN & HF TRANSMITTING [50124]	WA
Defence - EXMOUTH ADMIN & HF TRANSMITTING [50125]	WA
Defence - EXMOUTH VLF TRANSMITTER STATION [50122]	WA
Defence - EXMOUTH VLF TRANSMITTER STATION [50123]	WA
Defence - LEARMONTH - AIR WEAPONS RANGE [50193]	WA

Commonwealth Land Name	State
Defence - LEARMONTH - RAAF BASE [50109]	WA
Defence - LEARMONTH - RAAF BASE [50100]	WA
Defence - LEARMONTH - RAAF BASE [50108]	WA
Defence - LEARMONTH - RAAF BASE [50103]	WA
Defence - LEARMONTH - RAAF BASE [50102]	WA
Defence - LEARMONTH - RAAF BASE [50106]	WA
Defence - LEARMONTH - RAAF BASE [50105]	WA
Defence - LEARMONTH - RAAF BASE [50101]	WA
Defence - LEARMONTH - RAAF BASE [50107]	WA
Defence - LEARMONTH - RAAF BASE [50097]	WA
Defence - LEARMONTH RADAR SITE - TWIN TANKS EXMOUTH [50002]	WA
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH [50001]	WA
Defence - LEARMONTH TRANSMITTING STATION [50239]	WA
Unknown	
Commonwealth Land - [51714]	WA
Commonwealth Land - [51712]	WA
Commonwealth Land - [51713]	WA
Commonwealth Land - [51667]	WA
Commonwealth Land - [51718]	WA
Commonwealth Land - [51717]	WA
Commonwealth Land - [51710]	WA
Commonwealth Land - [51711]	WA
Commonwealth Land - [51669]	WA
Commonwealth Land - [51666]	WA
Commonwealth Land - [51668]	WA
Commonwealth Land - [51707]	WA

Commonwealth Land Name	State
Commonwealth Land - [51704]	WA
Commonwealth Land - [51699]	WA
Commonwealth Land - [51449]	WA
Commonwealth Land - [51696]	WA
Commonwealth Land - [51698]	WA
Commonwealth Land - [51695]	WA
Commonwealth Land - [51693]	WA
Commonwealth Land - [50385]	WA
Commonwealth Land - [52110]	WA
Commonwealth Land - [51442]	WA
Commonwealth Land - [51443]	WA
Commonwealth Land - [51448]	WA
Commonwealth Land - [51445]	WA
Commonwealth Land - [51444]	WA
Commonwealth Land - [51447]	WA
Commonwealth Land - [51446]	WA
Commonwealth Land - [51700]	WA
Commonwealth Land - [51706]	WA
Commonwealth Land - [52201]	WA
Commonwealth Land - [51672]	WA
Commonwealth Land - [51705]	WA
Commonwealth Land - [51709]	WA
Commonwealth Land - [51475]	WA
Commonwealth Land - [52104]	WA
Commonwealth Land - [51670]	WA
Commonwealth Land - [51671]	WA
Commonwealth Land - [51454]	WA

Commonwealth Land Name	State
Commonwealth Land - [51455]	WA
Commonwealth Land - [50976]	WA
Commonwealth Land - [50977]	WA
Commonwealth Land - [51451]	WA
Commonwealth Land - [51703]	WA
Commonwealth Land - [50978]	WA
Commonwealth Land - [51708]	WA
Commonwealth Land - [52236]	WA
Commonwealth Land - [51054]	WA
Commonwealth Land - [51055]	WA
Commonwealth Land - [51677]	WA
Commonwealth Land - [51452]	WA
Commonwealth Land - [51453]	WA
Commonwealth Land - [51458]	WA
Commonwealth Land - [51459]	WA
Commonwealth Land - [51053]	WA
Commonwealth Land - [51702]	WA
Commonwealth Land - [51466]	WA
Commonwealth Land - [51467]	WA
Commonwealth Land - [51464]	WA
Commonwealth Land - [51465]	WA
Commonwealth Land - [51472]	WA
Commonwealth Land - [51468]	WA
Commonwealth Land - [52195]	WA
Commonwealth Land - [51462]	WA
Commonwealth Land - [51460]	WA
Commonwealth Land - [51461]	WA

Commonwealth Land Name	State
Commonwealth Land - [51463]	WA
Commonwealth Land - [52205]	WA
Commonwealth Land - [51884]	WA
Commonwealth Land - [50349]	WA
Commonwealth Land - [50325]	WA
Commonwealth Land - [51947]	WA
Commonwealth Land - [52109]	WA
Commonwealth Land - [52098]	WA
Commonwealth Land - [52099]	WA
Commonwealth Land - [51450]	WA
Commonwealth Land - [52198]	WA
Commonwealth Land - [52097]	WA
Commonwealth Land - [52131]	WA
Commonwealth Land - [52100]	WA
Commonwealth Land - [51720]	WA
Commonwealth Land - [51719]	WA
Commonwealth Land - [51715]	WA
Commonwealth Land - [52220]	WA
Commonwealth Land - [52214]	WA
Commonwealth Land - [50975]	WA
Commonwealth Land - [52106]	WA
Commonwealth Land - [52108]	WA
Commonwealth Land - [51939]	WA
Commonwealth Land - [51104]	WA
Commonwealth Land - [52105]	WA
Commonwealth Land - [52107]	WA
Commonwealth Land - [51456]	WA

Commonwealth Land Name	State
Commonwealth Land - [52111]	WA
Commonwealth Land - [51686]	WA
Commonwealth Land - [51457]	WA
Commonwealth Land - [51476]	WA
Commonwealth Land - [51477]	WA
Commonwealth Land - [51473]	WA
Commonwealth Land - [51474]	WA
Commonwealth Land - [51470]	WA
Commonwealth Land - [51471]	WA
Commonwealth Land - [50974]	WA
Commonwealth Land - [51716]	WA
Commonwealth Land - [51469]	WA
Commonwealth Land - [51887]	WA
Commonwealth Land - [51691]	WA
Commonwealth Land - [51692]	WA
Commonwealth Land - [51403]	WA
Commonwealth Land - [51404]	WA
Commonwealth Land - [52103]	WA
Commonwealth Land - [52101]	WA
Commonwealth Land - [50324]	WA
Commonwealth Land - [50326]	WA
Commonwealth Land - [52102]	WA

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Historic		
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
Natural		
Learmonth Air Weapons Range Facility	WA	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica as Puffinus pacificus Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Arenaria interpres Ruddy Turnstone [872]	Vulnerable	Roosting known to occur within area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area overfly marine area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area overfly marine area
Calidris tenuirostris Great Knot [862]	Vulnerable	Roosting known to occur within area overfly marine area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area overfly marine area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area overfly marine area
Chroicocephalus novaehollandiae as Larus novaehollandiae Silver Gull [82326]		Breeding known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area overfly marine area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area overfly marine area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area overfly marine area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area overfly marine area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area overfly marine area
Hydroprogne caspia as Sterna caspia Caspian Tern [808]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area overfly marine area
Limnodromus semipalmatus Asian Dowitcher [843]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]	Endangered	Roosting known to occur within area overfly marine area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area overfly marine area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Onychoprion anaethetus as Sterna anaethetus Bridled Tern [82845]		Breeding known to occur within area
Onychoprion fuscatus as Sterna fuscata Sooty Tern [90682]		Breeding known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding likely to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area overfly marine area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]	Vulnerable	Roosting known to occur within area overfly marine area
Pterodroma macroptera Great-winged Petrel [1035]		Foraging, feeding or related behaviour known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Puffinus assimilis Little Shearwater [59363]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Puffinus huttoni Hutton's Shearwater [1025]		Foraging, feeding or related behaviour known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area overfly marine area
Rostratula australis as Rostratula benghalensis (sensu lato) Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area
Stercorarius antarcticus as Catharacta skua Brown Skua [85039]		Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons as Sterna albifrons Little Tern [82849]		Breeding known to occur within area
Sternula nereis as Sterna nereis Fairy Tern [82949]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Roosting known to occur within area overfly marine area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Thalasseus bengalensis as Sterna bengalensis Lesser Crested Tern [66546]		Breeding known to occur within area
Thalasseus bergii as Sterna bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes as Heteroscelus brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area overfly marine area
Tringa nebularia Common Greenshank, Greenshank [832]	Endangered	Species or species habitat known to occur within area overfly marine area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area overfly marine area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area overfly marine area
Xenus cinereus Terek Sandpiper [59300]	Vulnerable	Roosting known to occur within area overfly marine area
Fish		

Scientific Name	Threatened Category	Presence Text
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammal		

Scientific Name	Threatened Category	Presence Text
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Breeding known to occur within area
Reptile		
Aipysurus apraefrontalis Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Sea Snake, Dubois' Seasnake, Reef Shallows Sea Snake [1116]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus laevis Olive Sea Snake, Olive-brown Sea Snake [1120]		Species or species habitat may occur within area
Aipysurus mosaicus as Aipysurus eydouxii Mosaic Sea Snake [87261]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Sea Snake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Sea Snake, Mjoberg's Sea Snake [1121]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Emydocephalus annulatus Eastern Turtle-headed Sea Snake [1125]		Species or species habitat may occur within area
Ephalophis greyae as Ephalophis greyi Mangrove Sea Snake [93738]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Port Darwin Sea Snake, Black-ringed Mangrove Sea Snake [1100]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Sea Snake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Sea Snake, Bar-bellied Sea Snake [1104]		Species or species habitat may occur within area
Hydrophis kingii as Disteira kingii Spectacled Sea Snake [93511]		Species or species habitat may occur within area
Hydrophis macdowelli as Hydrophis mcdowelli MacDowell's Sea Snake, Small-headed Sea Snake, [75601]		Species or species habitat may occur within area
Hydrophis major as Disteira major Olive-headed Sea Snake [93512]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Sea Snake, Ornate Reef Sea Snake [1111]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hydrophis peronii as Acalyptophis peronii		
Horned Sea Snake [93509]		Species or species habitat may occur within area
Hydrophis platura as Pelamis platurus		
Yellow-bellied Sea Snake [93746]		Species or species habitat may occur within area
Hydrophis stokesii as Astrotia stokesii		
Stokes' Sea Snake [93510]		Species or species habitat may occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata		
Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis		
Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area

Current Scientific Name	Status	Type of Presence
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata		
Pygmy Right Whale [39]		Species or species habitat may occur within area
Delphinus delphis		
Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Feresa attenuata		
Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus		
Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas		
Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus		
Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Hyperoodon planifrons		
Southern Bottlenose Whale [71]		Species or species habitat may occur within area
Indopacetus pacificus		
Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps		
Pygmy Sperm Whale [57]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Kogia sima Dwarf Sperm Whale [85043]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Breeding known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area

Current Scientific Name	Status	Type of Presence
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa sahulensis Australian Humpback Dolphin [87942]		Species or species habitat known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area

Current Scientific Name	Status	Type of Presence
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris		
Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Park Name	Zone & IUCN Categories
Abrolhos	Habitat Protection Zone (IUCN IV)
Carnarvon Canyon	Habitat Protection Zone (IUCN IV)
Dampier	Habitat Protection Zone (IUCN IV)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Dampier	Multiple Use Zone (IUCN VI)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Multiple Use Zone (IUCN VI)
Montebello	Multiple Use Zone (IUCN VI)
Shark Bay	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	National Park Zone (IUCN II)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Dampier	National Park Zone (IUCN II)
Gascoyne	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Ningaloo	Recreational Use Zone (IUCN IV)
Abrolhos	Special Purpose Zone (IUCN VI)
Abrolhos	Special Purpose Zone (IUCN VI)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)

Habitat Critical to the Survival of Marine Turtles [Resource Information]

Scientific Name	Behaviour	Presence
Aug - Sep		
Natator depressus		
Flatback Turtle [59257]	Nesting	Known to occur
Dec - Jan		
Chelonia mydas		
Green Turtle [1765]	Nesting	Known to occur
Nov-Feb		
Caretta caretta		
Loggerhead Turtle [1763]	Nesting	Known to occur
Nov - May		
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Nesting	Known to occur

Extra Information

State and Territory Reserves		[Resource Information]
Protected Area Name	Reserve Type	State
Abrolhos Islands	Fish Habitat Protection Area	WA
Airlie Island	Nature Reserve	WA
Barrow Island	Nature Reserve	WA
Barrow Island	Marine Management Area	WA
Barrow Island	Marine Park	WA
Bedout Island	Nature Reserve	WA
Bernier And Dorre Islands	Nature Reserve	WA
Bessieres Island	Nature Reserve	WA
Boodie, Double Middle Islands	Nature Reserve	WA
Bundegi Coastal Park	5(1)(h) Reserve	WA
Burnside And Simpson Island	Nature Reserve	WA
Cape Range	National Park	WA
Cape Range (South)	National Park	WA
Dirk Hartog Island	National Park	WA
Eighty Mile Beach	Marine Park	WA
Giralia	NRS Addition - Gazettal in Progress	WA
Gnandaroo Island	Nature Reserve	WA
Great Sandy Island	Nature Reserve	WA
Houtman Abrolhos Islands	National Park	WA
Jarrkunpungu	Nature Reserve	WA
Jurabi Coastal Park	5(1)(h) Reserve	WA
Koks Island	Nature Reserve	WA
Kujungurru Warrarn	Nature Reserve	WA
Kujungurru Warrarn	Conservation Park	WA
Protected Area Name	Reserve Type	State
Little Rocky Island	Nature Reserve	WA
Locker Island	Nature Reserve	WA
Lowendal Islands	Nature Reserve	WA
Montebello Islands	Conservation Park	WA
Montebello Islands	Conservation Park	WA
Montebello Islands	Marine Park	WA
Muiron Islands	Nature Reserve	WA
Muiron Islands	Marine Management Area	WA
Murujuga	5(1)(h) Reserve	WA
Murujuga	National Park	WA
Ningaloo	Marine Park	WA
North Sandy Island	Nature Reserve	WA
North Turtle Island	Nature Reserve	WA
Nyangumarta Warrarn	Indigenous Protected Area	WA
Nyangumarta Warrarn	Indigenous Protected Area	WA
Nyingguulu (Ningaloo) Coastal Reserve	5(1)(h) Reserve	WA
Rocky Island	Nature Reserve	WA
Round Island	Nature Reserve	WA
Rowley Shoals	Marine Park	WA
Serrurier Island	Nature Reserve	WA
Shark Bay	Marine Park	WA
Tent Island	Nature Reserve	WA
Thevenard Island	Nature Reserve	WA
Unnamed WA26400	5(1)(h) Reserve	WA
Unnamed WA36907	5(1)(h) Reserve	WA

Protected Area Name	Reserve Type	State
Unnamed WA36909	5(1)(h) Reserve	WA
Unnamed WA36910	5(1)(h) Reserve	WA
Unnamed WA36913	Nature Reserve	WA
Unnamed WA36915	Nature Reserve	WA
Unnamed WA37338	5(1)(h) Reserve	WA
Unnamed WA37383	5(1)(h) Reserve	WA
Unnamed WA37500	5(1)(g) Reserve	WA
Unnamed WA38287	5(1)(h) Reserve	WA
Unnamed WA40322	5(1)(h) Reserve	WA
Unnamed WA40828	5(1)(h) Reserve	WA
Unnamed WA40877	5(1)(h) Reserve	WA
Unnamed WA41080	5(1)(h) Reserve	WA
Unnamed WA44665	5(1)(h) Reserve	WA
Unnamed WA44667	5(1)(h) Reserve	WA
Unnamed WA44672	5(1)(h) Reserve	WA
Victor Island	Nature Reserve	WA
Weld Island	Nature Reserve	WA
Whalebone Island	Nature Reserve	WA
Whitmore,Roberts,Doole Islands And Sandalwood Landing	Nature Reserve	WA
Y Island	Nature Reserve	WA

Nationally Important Wetlands [Resource Information]

Wetland Name	State
Bundera Sinkhole	WA
Cape Range Subterranean Waterways	WA
De Grey River	WA
Eighty Mile Beach System	WA
Exmouth Gulf East	WA
Learmonth Air Weapons Range - Saline Coastal Flats	WA
Leslie (Port Hedland) Saltfields System	WA
Mermaid Reef	EXT
Shark Bay East	WA

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Ashburton Infrastructure Project	2021/9064		Completed
Balla Balla Export Facilities ? Design Variation	2022/09254		Assessment
Browse to North West Shelf Development, Indian Ocean, WA	2018/8319		Approval
Burrup Common User Transmission Infrastructure	2022/09407		Assessment
Burrup Peninsula Seawater Supply Scheme Upgrade	2023/09698		Referral Decision
Dampier Seawater Desalination Plant	2022/09395		Completed
Gorgon Gas Development	2003/1294		Post-Approval
Midwest Offshore Wind Farm	2022/09264		Assessment
Ningaloo Lighthouse Development, 17km north west Exmouth, Western Australia	2020/8693		Approval
North West Shelf Project Extension, Carnarvon Basin, WA	2018/8335		Approval
Optimised Mardie Solar Salt Project	2022/9169		Assessment
Project Highclere Cable Lay and Operation	2022/09203		Completed
Ridley Magnetite Project	2023/09477		Referral Decision
Single Jetty Deep Water Port Renewable Hub, WA	2021/8942		Assessment

Action clearly unacceptable

Title of referral	Reference	Referral Outcome	Assessment Status
Action clearly unacceptable			
Asian Renewable Energy Hub Revised Proposal, WA	2021/8891	Action Clearly Unacceptable	Completed
Highlands 3D Marine Seismic Survey	2012/6680	Action Clearly Unacceptable	Completed
Controlled action			
'Van Gogh' Petroleum Field Development	2007/3213	Controlled Action	Post-Approval
2-D seismic survey Scott Reef	2000/125	Controlled Action	Post-Approval
Additional Rail Infrastructure between Herb Elliott Port Facility and Cloudbreak Mine Site	2010/5513	Controlled Action	Post-Approval
Ammonium Nitrate Project	2010/5423	Controlled Action	Completed
Anketell Point Iron Ore Processing & Export Port	2009/5120	Controlled Action	Post-Approval
Balmoral South Iron Ore Mine	2008/4236	Controlled Action	Post-Approval
Binowee Iron Ore Project	2001/366	Controlled Action	Proposed Decision
Boating Facility	2002/830	Controlled Action	Completed
Burrup North East Sand Mining Project	2008/4611	Controlled Action	Completed
Cape Lambert Port B Development	2008/4032	Controlled Action	Post-Approval
Construct and operate LNG & domestic gas plant including onshore and offshore facilities - Wheatston	2008/4469	Controlled Action	Post-Approval
Construction and operation of a Solar Salt Project, SW Onslow, WA	2016/7793	Controlled Action	Assessment Approach
Develop Jansz-Io deepwater gas field in Permit Areas WA-18-R, WA-25-R and WA-26-	2005/2184	Controlled Action	Post-Approval
Development of Angel gas and condensate field, North West Shelf	2004/1805	Controlled Action	Post-Approval
Development of an iron ore mine and associated infrastructure	2010/5630	Controlled Action	Assessment Approach

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Development of Browse Basin Gas Fields (Upstream)	2008/4111	Controlled Action	Completed
Development of Coniston/Novara fields within the Exmouth Sub-basin	2011/5995	Controlled Action	Post-Approval
Development of Stybarrow petroleum field incl drilling and facility installation	2004/1469	Controlled Action	Post-Approval
Duplication of the Dampier Highway Stages 2 & 6	2010/5419	Controlled Action	Post-Approval
Echo-Yodel Production Wells	2000/11	Controlled Action	Post-Approval
Enfield full field development	2001/257	Controlled Action	Post-Approval
Equus Gas Fields Development Project, Carnarvon Basin	2012/6301	Controlled Action	Completed
Eramurra Industrial Salt Project	2021/9027	Controlled Action	Assessment Approach
Eramurra Industrial Salt Project, near Karratha, WA	2019/8448	Controlled Action	Completed
Gorgon Gas Development 4th Train Proposal	2011/5942	Controlled Action	Post-Approval
Gorgon Gas Revised Development	2008/4178	Controlled Action	Post-Approval
Greater Enfield (Vincent) Development	2005/2110	Controlled Action	Post-Approval
Greater Gorgon Development - Optical Fibre Cable, Mainland to Barrow Island	2005/2141	Controlled Action	Completed
Great Northern Pipeline - 630 km buried gas pipeline	2009/5257	Controlled Action	Completed
Learmonth Bundle Site and Launchway, WA	2017/8079	Controlled Action	Completed
Light Crude Oil Production	2001/365	Controlled Action	Post-Approval
Mardie Project, 80 km south west of Karratha, WA	2018/8236	Controlled Action	Post-Approval
Mauds Landing Marina	2000/98	Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Nava-1 Cable System	2001/510	Controlled Action	Completed
North Star Magnetite Project	2012/6689	Controlled Action	Post-Approval
North West Shelf Gas Venture Phase VI Expansion	2007/3436	Controlled Action	Referral Decision
Perdaman Urea Project, near Karratha, WA	2018/8383	Controlled Action	Post-Approval
Pluto Gas Project	2005/2258	Controlled Action	Completed
Pluto Gas Project Including Site B	2006/2968	Controlled Action	Post-Approval
Port Hedland Outer Harbour Development and associated marine and terrestrial in	2008/4159	Controlled Action	Post-Approval
Port Hedland Spoilbank Marina, WA	2019/8520	Controlled Action	Post-Approval
Proposed technical ammonium nitrate production facility	2008/4546	Controlled Action	Post-Approval
Proposed West Pilbara Iron Ore Project	2009/4706	Controlled Action	Post-Approval
Pyrenees Oil Fields Development	2005/2034	Controlled Action	Post-Approval
Simpson Development	2000/59	Controlled Action	Completed
Simpson Oil Field Development	2001/227	Controlled Action	Post-Approval
site preparations	2005/2391	Controlled Action	Post-Approval
The Scarborough Project - FLNG & assoc subsea infrastructure, Carnarvon Basin	2013/6811	Controlled Action	Post-Approval
Vincent Appraisal Well	2000/22	Controlled Action	Post-Approval
Widening and resurfacing two principal roads servicing the Dampier Port Authori	2010/5677	Controlled Action	Completed
Yannarie Solar Salt Project	2004/1679	Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Yardie Creek Road Realignment Project	2021/8967	Controlled Action	Assessment Approach
Not controlled action			
'Goodwyn A' Low Pressure Train Project	2003/914	Not Controlled Action	Completed
'Van Gogh' Oil Appraisal Drilling Program, Exploration Permit Area WA-155-P(1)	2006/3148	Not Controlled Action	Completed
Airlie Island soil and groundwater investigations, Exmouth Gulf, offshore Pilbara coast	2014/7250	Not Controlled Action	Completed
Ammonia Plant	2001/199	Not Controlled Action	Completed
APX-West Fibre-optic telecommunications cable system, WA to Singapore	2013/7102	Not Controlled Action	Completed
archaeological surveys & excavation at historic sites, Cape Inscription	2006/3027	Not Controlled Action	Completed
Baniyas-1 Exploration Well, EP-424, near Onslow	2007/3282	Not Controlled Action	Completed
Barrow Island 2D Seismic survey	2006/2667	Not Controlled Action	Completed
Boating Facility	2002/832	Not Controlled Action	Completed
Bollinger 2D Seismic Survey 200km North of North West Cape WA	2004/1868	Not Controlled Action	Completed
Bultaco-2, Laverda-2, Laverda-3 and Montesa-2 Appraisal Wells	2000/103	Not Controlled Action	Completed
Cape Lambert Port A Marine Structures Refurbishment Project	2018/8370	Not Controlled Action	Completed
Carnarvon 3D Marine Seismic Survey	2004/1890	Not Controlled Action	Completed
Cazadores 2D seismic survey	2004/1720	Not Controlled Action	Completed
Construct 110km buried natural gas pipeline from Onslow, connecting to Dampier/Bunbury natural gas p	2013/7039	Not Controlled Action	Completed
Construction and operation of an unmanned sea platform and	2004/1703	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
connecting pipeline to Varanus Island for			
Construction of a Commodities Berth, Wharf and Associated Infrastructure	2008/4129	Not Controlled Action	Completed
Construction of Loadout Facility and Laydown Area	2002/598	Not Controlled Action	Completed
Controlled Source Electromagnetic Survey	2007/3262	Not Controlled Action	Completed
Deep Gorge Boardwalk, Murujuga National Park, WA	2018/8283	Not Controlled Action	Completed
Development of Halyard Field off the west coast of WA	2010/5611	Not Controlled Action	Completed
Development of Industrial Land, Port of Dampier	2003/1293	Not Controlled Action	Completed
Development of iron ore facilities	2013/7013	Not Controlled Action	Completed
Development of iron ore resources in eastern Pilbara region, including port at P	2004/1562	Not Controlled Action	Completed
Development of Mutineer and Exeter petroleum fields for oil production, Permit	2003/1033	Not Controlled Action	Completed
Differential Global Positioning System (DGPS)	2001/445	Not Controlled Action	Completed
Dimethyl ether plant	2001/509	Not Controlled Action	Completed
Drilling between Kalbarri and Cliff Head	2005/2185	Not Controlled Action	Completed
Drilling of an exploration well Gats-1 in Permit Area WA-261-P	2004/1701	Not Controlled Action	Completed
Drilling of exploration wells, Permit areas WA-301-P to WA-305-P	2002/769	Not Controlled Action	Completed
Eagle-1 Exploration Drilling, North West Shelf, WA	2019/8578	Not Controlled Action	Completed
Echo A Development WA-23-L, WA-24-L	2005/2042	Not Controlled Action	Completed
Expansion of the Sino Iron Ore Mine and export facilities, Cape Preston, WA	2017/7862	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Expansion Proposal, Mineralogy Cape Preston Iron Ore Project, Cape Preston, WA	2009/5010	Not Controlled Action	Completed
Exploration drilling well WA-155-P(1)	2003/971	Not Controlled Action	Completed
Exploration of appraisal wells	2006/3065	Not Controlled Action	Completed
Exploration Well (Taunton-2)	2002/731	Not Controlled Action	Completed
Exploration Well in Permit Area WA-155-P(1)	2002/759	Not Controlled Action	Completed
Exploratory drilling in permit area WA-225-P	2001/490	Not Controlled Action	Completed
Extension of Simpson Oil Platforms & Wells	2002/685	Not Controlled Action	Completed
Extention to the existing Blind Strait Black Lip Pearl Oyster Farm	2004/1342	Not Controlled Action	Completed
Gulf Fishing Lodge	2010/5499	Not Controlled Action	Completed
Hadda 1,Flying Foam 1,Magnat 1 exploration drill	2004/1697	Not Controlled Action	Completed
HCA05X Macedon Experimental Survey	2004/1926	Not Controlled Action	Completed
Hess Exploration Drilling Programme	2007/3566	Not Controlled Action	Completed
Horizon Power South Hedland Transmission Line, WA	2012/6551	Not Controlled Action	Completed
Huascaran-1 exploration well (WA-292-P)	2001/539	Not Controlled Action	Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
INDIGO West Submarine Telecommunications Cable, WA	2017/8126	Not Controlled Action	Completed
Infill Production Well (Griffin-9)	2001/417	Not Controlled Action	Completed
Iron Bridge Port Facility, Port Hedland, WA	2015/7565	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Jansz-2 and 3 Appraisal Wells	2002/754	Not Controlled Action	Completed
King Bay East Rock Quarry & Industrial Estate Development	2003/1150	Not Controlled Action	Completed
Klammer 2D Seismic Survey	2002/868	Not Controlled Action	Completed
Mahimahi Aquaculture Facility	2002/891	Not Controlled Action	Completed
Maia-Gaea Exploration wells	2000/17	Not Controlled Action	Completed
Manaslu - 1 and Huascaran - 1 Offshore Exploration Wells	2001/235	Not Controlled Action	Completed
Mermaid Marine Australia Desalination Project	2011/5916	Not Controlled Action	Completed
Methanol manufacturing	2001/528	Not Controlled Action	Completed
Methanol plant	2001/521	Not Controlled Action	Completed
Montesa-1 and Bultaco-1 Exploration Wells	2000/102	Not Controlled Action	Completed
Murujuga archaeological excavation, collection and sampling, Dampier Archipelago, WA	2014/7160	Not Controlled Action	Completed
North Rankin B gas compression facility	2005/2500	Not Controlled Action	Completed
Oman Australia Cable Installation, WA	2021/8922	Not Controlled Action	Completed
Oman Australia Cable - Marine Route Survey	2020/8731	Not Controlled Action	Completed
Onslow Power Infrastructure Upgrade Project, Onslow, WA	2014/7314	Not Controlled Action	Completed
Onslow Water Supply Infrastructure Upgrade Project, Onslow, WA	2014/7329	Not Controlled Action	Completed
Pilbara Bulk Ore Transport System Project, WA	2016/7637	Not Controlled Action	Completed
Pipeline System Modifications Project	2000/3	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Pluto-North West Shelf Interconnector, Burrup Peninsula, WA	2018/8353	Not Controlled Action	Completed
Port Expansion and Dredging	2003/1265	Not Controlled Action	Completed
Port Hedland Channel Risk and Optimisation Project, WA	2017/7915	Not Controlled Action	Completed
Project Highclere Geophysical Survey	2021/9023	Not Controlled Action	Completed
Rail and Port Facilities	2001/474	Not Controlled Action	Completed
Scientific Sonar Trial	2002/680	Not Controlled Action	Completed
Searipple gas and condensate field development	2000/89	Not Controlled Action	Completed
Seismic Survey, Bremer Basin, Mentelle Basin and Zeewyck Sub-basin	2004/1700	Not Controlled Action	Completed
Spool Base Facility	2001/263	Not Controlled Action	Completed
Stages 1 & 2 Port of Dampier Security Upgrade & Associated Works	2004/1751	Not Controlled Action	Completed
Subsea Gas Pipeline From Stybarrow Field to Griffin Venture Gas Export Pipeline	2005/2033	Not Controlled Action	Completed
sub-sea tieback of Perseus field wells	2004/1326	Not Controlled Action	Completed
Telfer Gold Mine Project - Mine and Borefield Extensions and Upgrade of Storage	2002/787	Not Controlled Action	Completed
Telstra North Rankin Spur Fibre Optic Cable	2016/7836	Not Controlled Action	Completed
Thevenard Island Retirement Project	2015/7423	Not Controlled Action	Completed
To construct and operate an offshore submarine fibre optic cable, WA	2014/7373	Not Controlled Action	Completed
WA-295-P Kerr-McGee Exploration Wells	2001/152	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Walkway Lighting Upgrade	2009/4965	Not Controlled Action	Completed
Wanda Offshore Research Project, 80 km north-east of Exmouth, WA	2018/8293	Not Controlled Action	Completed
Western Flank Gas Development	2005/2464	Not Controlled Action	Completed
Wheatstone 3D seismic survey, 70km north of Barrow Island	2004/1761	Not Controlled Action	Completed
Widening of MOF Road	2005/2305	Not Controlled Action	Completed
Woodside Project Facilities Increase	2006/3191	Not Controlled Action	Completed
Yellowfin Tuna Aquaculture Trial	2003/1115	Not Controlled Action	Completed
Not controlled action (particular manner)			
'Kate' 3D marine seismic survey, exploration permits WA-320-P and WA-345-P, 60km	2005/2037	Not Controlled Action (Particular Manner)	Post-Approval
'Tourmaline' 2D marine seismic survey, permit areas WA-323-P, WA-330-P and WA-32	2005/2282	Not Controlled Action (Particular Manner)	Post-Approval
"Leanne" offshore 3D seismic exploration, WA-356-P	2005/1938	Not Controlled Action (Particular Manner)	Post-Approval
2D and 3D seismic surveys	2005/2151	Not Controlled Action (Particular Manner)	Post-Approval
2D marine seismic survey	2012/6296	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey in Permit Area WA-337-P	2003/1158	Not Controlled Action (Particular Manner)	Post-Approval
2D seismic survey	2008/4493	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
2D Seismic Survey	2005/2146	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Survey Permit Area WA-352-P	2008/4628	Not Controlled Action (Particular Manner)	Post-Approval
2D seismic survey within permit WA-291	2007/3265	Not Controlled Action (Particular Manner)	Post-Approval
3D marine seismic survey	2008/4281	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey (WA-482-P, WA-363-P), WA	2013/6761	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey in Permit Areas WA-15-R, WA-18-R, WA-205-P, WA-253-P, WA-267-P and WA-268-P	2003/1271	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey in WA 457-P & WA 458-P, North West Shelf, offshore WA	2013/6862	Not Controlled Action (Particular Manner)	Post-Approval
3D marine seismic survey over petroleum title WA-268-P	2007/3458	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Surveys - Contos CT-13 & Supertubes CT-13, offshore WA	2013/6901	Not Controlled Action (Particular Manner)	Post-Approval
3D seismic survey	2006/2715	Not Controlled Action (Particular Manner)	Post-Approval
3D Seismic Survey, WA	2008/4428	Not Controlled Action (Particular Manner)	Post-Approval
3D Seismic Survey in the Carnarvon Bsin on the North West Shelf	2002/778	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
3D sesmic survey	2006/2781	Not Controlled Action (Particular Manner)	Post-Approval
Acheron Non-Exclusive 2D Seismic Survey	2009/4968	Not Controlled Action (Particular Manner)	Post-Approval
Acheron Non-Exclusive 2D Seismic Survey	2008/4565	Not Controlled Action (Particular Manner)	Post-Approval
Additional Rail Infrastructure	2012/6314	Not Controlled Action (Particular Manner)	Post-Approval
Agrippina 3D Seismic Marine Survey	2009/5212	Not Controlled Action (Particular Manner)	Post-Approval
Algae Farm and Processing Facilities	2012/6596	Not Controlled Action (Particular Manner)	Post-Approval
Ammonia Plant, Murujuga Burrup Peninsula - Renewable Hydrogen Project	2020/8739	Not Controlled Action (Particular Manner)	Post-Approval
Apache Northwest Shelf Van Gogh Field Appraisal Drilling Program	2007/3495	Not Controlled Action (Particular Manner)	Post-Approval
Aperio 3D Marine Seismic Survey, WA	2012/6648	Not Controlled Action (Particular Manner)	Post-Approval
Artemis-1 Drilling Program (WA-360-P)	2010/5432	Not Controlled Action (Particular Manner)	Post-Approval
Australia to Singapore Fibre Optic Submarine Cable System	2011/6127	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Babylon 3D Marine Seismic Survey, Commonwealth Waters, nr Exmouth WA	2013/7081	Not Controlled Action (Particular Manner)	Post-Approval
Balnaves Condensate Field Development	2011/6188	Not Controlled Action (Particular Manner)	Post-Approval
Bonaventure 3D seismic survey	2006/2514	Not Controlled Action (Particular Manner)	Post-Approval
Cable Seismic Exploration Permit areas WA-323-P and WA-330-P	2008/4227	Not Controlled Action (Particular Manner)	Post-Approval
Cape Preston East - Iron Ore Export Facilities, Pilbara, WA	2013/6844	Not Controlled Action (Particular Manner)	Post-Approval
Cerberus exploration drilling campaign, Carnarvon Basin, WA	2016/7645	Not Controlled Action (Particular Manner)	Post-Approval
CGGVERITAS 2010 2D Seismic Survey	2010/5714	Not Controlled Action (Particular Manner)	Post-Approval
Charon 3D Marine Seismic Survey	2007/3477	Not Controlled Action (Particular Manner)	Post-Approval
Consturction & operation of the Varanus Island kitchen & mess cyclone refuge building, compression p	2013/6952	Not Controlled Action (Particular Manner)	Post-Approval
Coverack Marine Seismic Survey	2001/399	Not Controlled Action (Particular Manner)	Post-Approval
Cue Seismic Survey within WA-359-P, WA-361-P and WA-360-P	2007/3647	Not Controlled Action (Particular Manner)	Post-Approval
CVG 3D Marine Seismic Survey	2012/6654	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Dampier Marine Services Facility including 300m Wharf and Dredging Works	2009/5108	Not Controlled Action (Particular Manner)	Post-Approval
DAVROS MC 3D marine seismic survey northwaet of Dampier, WA	2013/7092	Not Controlled Action (Particular Manner)	Post-Approval
Decommissioning of the Legendre facilities	2010/5681	Not Controlled Action (Particular Manner)	Post-Approval
Deep Water Drilling Program	2010/5532	Not Controlled Action (Particular Manner)	Post-Approval
Deep Water Northwest Shelf 2D Seismic Survey	2007/3260	Not Controlled Action (Particular Manner)	Post-Approval
Demeter 3D Seismic Survey, off Dampier, WA	2002/900	Not Controlled Action (Particular Manner)	Post-Approval
Diesel Fuel Bunker Operation	2012/6289	Not Controlled Action (Particular Manner)	Post-Approval
Draeck 3D Marine Seismic Survey, WA-205-P	2006/3067	Not Controlled Action (Particular Manner)	Post-Approval
Dredging of marine sediment to enable construction of eight berths and a turnin	2010/5678	Not Controlled Action (Particular Manner)	Post-Approval
Drilling 35-40 offshore exploration wells in deep water	2008/4461	Not Controlled Action (Particular Manner)	Post-Approval
Earthworks for kitchen/mess, cyclone refuge building & Compression Plant, Varanus Island	2013/6900	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Eendracht Multi-Client 3D Marine Seismic Survey	2009/4749	Not Controlled Action (Particular Manner)	Post-Approval
Effect of marine seismic sounds to demersal fish and pearl oysters, north-west WA	2018/8169	Not Controlled Action (Particular Manner)	Post-Approval
Enfield M3 & Vincent 4D Marine Seismic Surveys	2008/3981	Not Controlled Action (Particular Manner)	Completed
Enfield M3 4D, Vincent 4D & 4D Line Test Marine Seismic Surveys	2008/4122	Not Controlled Action (Particular Manner)	Post-Approval
Enfield M4 4D Marine Seismic Survey	2008/4558	Not Controlled Action (Particular Manner)	Post-Approval
Enfield oilfield 3D Seismic Survey	2006/3132	Not Controlled Action (Particular Manner)	Post-Approval
Exmouth West 2D Marine Seismic Survey	2008/4132	Not Controlled Action (Particular Manner)	Post-Approval
Exploration drilling of Zeus-1 well	2008/4351	Not Controlled Action (Particular Manner)	Post-Approval
Fletcher-Finucane Development, WA26-L and WA191-P	2011/6123	Not Controlled Action (Particular Manner)	Post-Approval
Foxhound 3D Non-Exclusive Marine Seismic Survey	2009/4703	Not Controlled Action (Particular Manner)	Post-Approval
Gazelle 3D Marine Seismic Survey in WA-399-P and WA-42-L	2010/5570	Not Controlled Action (Particular Manner)	Post-Approval
Geco Eagle 3D Marine Seismic Survey	2008/3958	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Glencoe 3D Marine Seismic Survey WA-390-P	2007/3684	Not Controlled Action (Particular Manner)	Post-Approval
Greater Western Flank Phase 1 gas Development	2011/5980	Not Controlled Action (Particular Manner)	Post-Approval
Grimalkin 3D Seismic Survey	2008/4523	Not Controlled Action (Particular Manner)	Post-Approval
Guacamole 2D Marine Seismic Survey	2008/4381	Not Controlled Action (Particular Manner)	Post-Approval
Harmony 3D Marine Seismic Survey	2012/6699	Not Controlled Action (Particular Manner)	Post-Approval
Harpy 1 exploration well	2001/183	Not Controlled Action (Particular Manner)	Post-Approval
Honeycombs MC3D Marine Seismic Survey	2012/6368	Not Controlled Action (Particular Manner)	Post-Approval
Huzzas MC3D Marine Seismic Survey (HZ-13) Carnarvon Basin, offshore WA	2013/7003	Not Controlled Action (Particular Manner)	Post-Approval
Huzzas phase 2 marine seismic survey, Exmouth Plateau, Northern Carnarvon Basin, WA	2013/7093	Not Controlled Action (Particular Manner)	Post-Approval
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
John Ross & Rosella Off Bottom Cable Seismic Exploration Program	2008/3966	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Judo Marine 3D Seismic Survey within and adjacent to WA-412-P	2008/4630	Not Controlled Action (Particular Manner)	Post-Approval
Judo Marine 3D Seismic Survey within and adjacent to WA-412-P	2009/4801	Not Controlled Action (Particular Manner)	Post-Approval
Julimar Brunello Gas Development Project	2011/5936	Not Controlled Action (Particular Manner)	Post-Approval
Kingtree & Ironstone-1 Exploration Wells	2011/5935	Not Controlled Action (Particular Manner)	Post-Approval
Klimt 2D Marine Seismic Survey	2007/3856	Not Controlled Action (Particular Manner)	Post-Approval
Laverda 3D Marine Seismic Survey and Vincent M1 4D Marine Seismic Survey	2010/5415	Not Controlled Action (Particular Manner)	Post-Approval
Laying a submarine optical fibre telecommunications cable, Perth to Singapore and Jakarta	2014/7332	Not Controlled Action (Particular Manner)	Post-Approval
Leopard 2D marine seismic survey	2005/2290	Not Controlled Action (Particular Manner)	Post-Approval
Lion 2D Marine Seismic Survey	2007/3777	Not Controlled Action (Particular Manner)	Post-Approval
Macedon Gas Field Development	2008/4605	Not Controlled Action (Particular Manner)	Post-Approval
Marine Geotechnical Drilling Program	2008/4012	Not Controlled Action (Particular Manner)	Post-Approval
Marine reconnaissance survey	2008/4466	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Mariner Non-Exclusive 2D Seismic Survey	2011/6172	Not Controlled Action (Particular Manner)	Post-Approval
Marine Seismic Survey in Permit WA-481P	2012/6626	Not Controlled Action (Particular Manner)	Post-Approval
Millstream 20GL Pipeline, Bungaroo, Borefield Integration	2012/6379	Not Controlled Action (Particular Manner)	Post-Approval
MOF Road Widening and Resurfacing Works	2011/5843	Not Controlled Action (Particular Manner)	Post-Approval
Moosehead 2D seismic survey within permit WA-192-P	2005/2167	Not Controlled Action (Particular Manner)	Post-Approval
Munmorah 2D seismic survey within permits WA-308/9-P	2003/970	Not Controlled Action (Particular Manner)	Post-Approval
Nelson Point Dredging	2009/4920	Not Controlled Action (Particular Manner)	Post-Approval
Nickol Bay Quarry Eastern Extension Proposal, Burrup Peninsula, WA	2013/6915	Not Controlled Action (Particular Manner)	Post-Approval
North Perth Marine Survey	2011/6067	Not Controlled Action (Particular Manner)	Post-Approval
Ocean Bottom Cable Seismic Program, WA-264-P	2007/3844	Not Controlled Action (Particular Manner)	Post-Approval
Ocean Bottom Cable Seismic Survey	2005/2017	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Offshore Canning Multi Client 2D Marine Seismic Survey	2010/5393	Not Controlled Action (Particular Manner)	Post-Approval
Offshore Drilling Campaign	2011/5830	Not Controlled Action (Particular Manner)	Post-Approval
Offshore Fibre Optic Cable Network Construction & Operation, Port Hedland WA to Darwin NT	2014/7223	Not Controlled Action (Particular Manner)	Post-Approval
Onslow Seawater Desalination Plant Marine Geophysical Investigation	2020/8794	Not Controlled Action (Particular Manner)	Post-Approval
Orcus 3D Marine Seismic Survey in WA-450-P	2010/5723	Not Controlled Action (Particular Manner)	Post-Approval
Osprey and Dionysus Marine Seismic Survey	2011/6215	Not Controlled Action (Particular Manner)	Post-Approval
Outer Canning exploration drilling program off NW coast of WA	2012/6618	Not Controlled Action (Particular Manner)	Post-Approval
Palta-1 exploration well in Petroleum Permit Area WA-384-P	2011/5871	Not Controlled Action (Particular Manner)	Post-Approval
Phoenix 3D Seismic Survey, Bedout Sub-Basin	2010/5360	Not Controlled Action (Particular Manner)	Post-Approval
Pomodoro 3D Marine Seismic Survey in WA-426-P and WA-427-P	2010/5472	Not Controlled Action (Particular Manner)	Post-Approval
Port Headland Outer Harbour Pre-construction Pilling program	2012/6341	Not Controlled Action (Particular Manner)	Post-Approval
Port of Port Hedland channel marker replacement project, WA	2017/8010	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Port Walcott upgrade, dredging & spoil disposal, & channel realignment	2006/2806	Not Controlled Action (Particular Manner)	Post-Approval
Pyrenees 4D Marine Seismic Monitor Survey, HCA12A	2012/6579	Not Controlled Action (Particular Manner)	Post-Approval
Pyrenees-Macedon 3D marine seismic survey	2005/2325	Not Controlled Action (Particular Manner)	Post-Approval
Quiberon 2D Seismic Survey, permit area WA-385P, offshore of Carnarvon	2009/5077	Not Controlled Action (Particular Manner)	Post-Approval
Realignment of the Great Northern Highway	2010/5793	Not Controlled Action (Particular Manner)	Post-Approval
Reindeer gas reservior development, Devil Creek, Carnarvon Basin - WA	2007/3917	Not Controlled Action (Particular Manner)	Post-Approval
Repsol 3d & 2D Marine Seismic Survey	2012/6658	Not Controlled Action (Particular Manner)	Post-Approval
Rose 3D Seismic Program	2008/4239	Not Controlled Action (Particular Manner)	Post-Approval
Rydal-1 Petroleum Exploration Well, WA	2012/6522	Not Controlled Action (Particular Manner)	Post-Approval
Salsa 3D Marine Seismic Survey	2010/5629	Not Controlled Action (Particular Manner)	Post-Approval
Santos Winchester three dimensional seismic survey - WA-323-P & WA-330-P	2011/6107	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Scarborough Development nearshore component, NWS, WA	2018/8362	Not Controlled Action (Particular Manner)	Post-Approval
search for HMAS Sydney	2006/3071	Not Controlled Action (Particular Manner)	Post-Approval
Skorpion Marine Seismic Survey WA	2001/416	Not Controlled Action (Particular Manner)	Post-Approval
Sovereign 3D Marine Seismic Survey	2011/5861	Not Controlled Action (Particular Manner)	Post-Approval
Stag 4D & Reindeer MAZ Marine Seismic Surveys, WA	2013/7080	Not Controlled Action (Particular Manner)	Post-Approval
Stag Off-bottom Cable Seismic Survey	2007/3696	Not Controlled Action (Particular Manner)	Post-Approval
Stybarrow 4D Marine Seismic Survey	2011/5810	Not Controlled Action (Particular Manner)	Post-Approval
Stybarrow Baseline 4D marine seismic survey	2008/4530	Not Controlled Action (Particular Manner)	Post-Approval
Tantabiddi Boat Ramp Sand Bypassing	2015/7411	Not Controlled Action (Particular Manner)	Post-Approval
The Dampier Heavy Load Out Facility Berth and Swing Basin Expansion	2012/6271	Not Controlled Action (Particular Manner)	Post-Approval
Tidepole Maz 3D Seismic Survey Campaign	2007/3706	Not Controlled Action (Particular Manner)	Post-Approval
Tortilla 2D Seismic Survey, WA	2011/6110	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Triton 3D Marine Seismic Survey, WA-2-R and WA-3-R	2006/2609	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a 3D marine seismic survey	2010/5695	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a three dimensional marine seismic survey	2010/5679	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a three dimensional marine seismic survey	2010/5715	Not Controlled Action (Particular Manner)	Post-Approval
upgrade of 3 community recreation sites	2005/2349	Not Controlled Action (Particular Manner)	Post-Approval
Vampire 2D Non Exclusive Seismic Survey, WA	2010/5543	Not Controlled Action (Particular Manner)	Post-Approval
Veritas Voyager 2D Marine Seismic Survey	2009/5151	Not Controlled Action (Particular Manner)	Post-Approval
Vincent M1 and Enfield M5 4D Marine Seismic Survey	2010/5720	Not Controlled Action (Particular Manner)	Post-Approval
Warramunga Non-Inclusive 3D Seismic Survey	2008/4553	Not Controlled Action (Particular Manner)	Post-Approval
West Anchor 3D Marine Seismic Survey	2008/4507	Not Controlled Action (Particular Manner)	Post-Approval
West Panaeus 3D seismic survey	2006/3141	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval
Wheatstone 3D MAZ Marine Seismic Survey	2011/6058	Not Controlled Action (Particular Manner)	Post-Approval
Wheatstone Iago Appraisal Well Drilling	2008/4134	Not Controlled Action (Particular Manner)	Post-Approval
Wheatstone Iago Appraisal Well Drilling	2007/3941	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
3D Marine Seismic Survey in the offshore northwest Carnarvon Basin	2011/6175	Referral Decision	Completed
3D Seismic Survey	2008/4219	Referral Decision	Completed
Bianchi 3D Marine Seismic Survey, Carnavon Basin, WA	2013/7078	Referral Decision	Completed
construction of a new loadout facility and associated laydown area south of the	2002/579	Referral Decision	Completed
CVG 3D Marine Seismic Survey	2012/6270	Referral Decision	Completed
Enfield 4D Marine Seismic Surveys, Production Permit WA-28-L	2005/2370	Referral Decision	Completed
Mardie Salt Project, Pilbara region, WA	2018/8183	Referral Decision	Completed
Outer Harbour Development and associated marine and terrestial infrastructure	2008/4148	Referral Decision	Completed
Relocation of 2 heritage sites to National Heritage Place	2010/5709	Referral Decision	Completed
Rose 3D Seismic acquisition survey	2008/4220	Referral Decision	Completed
Stybarrow Baseline 4D Marine Seismic Survey (Permit Areas WA-255-P, WA-32-L, WA-	2008/4165	Referral Decision	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Referral decision			
Two Dimensional Transition Zone Seismic Survey - TP/7 (R1)	2010/5507	Referral Decision	Completed
Varanus Island Compression Project	2012/6698	Referral Decision	Completed

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Ancient coastline at 90-120m depth	South-west
Canyons linking the Argo Abyssal Plain with the Scott Plateau	North-west
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	North-west
Commonwealth marine environment surrounding the Houtman Abrolhos Islands	South-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	North-west
Perth Canyon and adjacent shelf break, and other west coast canyons	South-west
Wallaby Saddle	North-west
Western demersal slope and associated fish communities	South-west
Western rock lobster	South-west

Biologically Important Areas [Resource Information]

Scientific Name	Behaviour	Presence
Dugong		
Dugong dugon Dugong [28]	Breeding	Known to occur
Dugong dugon Dugong [28]	Calving	Known to occur
Dugong dugon Dugong [28]	Foraging	Known to occur
Dugong dugon Dugong [28]	Foraging (high density seagrass beds)	Known to occur
Dugong dugon Dugong [28]	Nursing	Known to occur
Marine Turtles		
Caretta caretta Loggerhead Turtle [1763]	Foraging	Known to occur
Caretta caretta Loggerhead Turtle [1763]	Internesting	Known to occur
Caretta caretta Loggerhead Turtle [1763]	Internesting buffer	Known to occur
Caretta caretta Loggerhead Turtle [1763]	Nesting	Known to occur
Chelonia mydas Green Turtle [1765]	Aggregation	Known to occur
Chelonia mydas Green Turtle [1765]	Basking	Known to occur
Chelonia mydas Green Turtle [1765]	Foraging	Likely to occur
Chelonia mydas Green Turtle [1765]	Foraging	Known to occur
Chelonia mydas Green Turtle [1765]	Internesting	Known to occur
Chelonia mydas Green Turtle [1765]	Internesting buffer	Known to occur

Scientific Name	Behaviour	Presence
Chelonia mydas Green Turtle [1765]	Mating	Known to occur
Chelonia mydas Green Turtle [1765]	Migration corridor	Known to occur
Chelonia mydas Green Turtle [1765]	Nesting	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Foraging	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Foraging	Likely to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Internesting	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Internesting buffer	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Mating	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Migration corridor	Known to occur
Eretmochelys imbricata Hawksbill Turtle [1766]	Nesting	Known to occur
Natator depressus Flatback Turtle [59257]	Aggregation	Known to occur
Natator depressus Flatback Turtle [59257]	Foraging	Known to occur
Natator depressus Flatback Turtle [59257]	Internesting	Known to occur
Natator depressus Flatback Turtle [59257]	Internesting buffer	Known to occur

Scientific Name	Behaviour	Presence
Natator depressus Flatback Turtle [59257]	Mating	Known to occur
Natator depressus Flatback Turtle [59257]	Migration corridor	Known to occur
Natator depressus Flatback Turtle [59257]	Nesting	Known to occur
River shark		
Pristis clavata Dwarf Sawfish [68447]	Foraging	Known to occur
Pristis clavata Dwarf Sawfish [68447]	Nursing	Known to occur
Pristis clavata Dwarf Sawfish [68447]	Pupping	Known to occur
Pristis pristis Freshwater Sawfish [60756]	Foraging	Known to occur
Pristis pristis Freshwater Sawfish [60756]	Pupping	Likely to occur
Pristis zijsron Green Sawfish [68442]	Foraging	Known to occur
Pristis zijsron Green Sawfish [68442]	Nursing	Known to occur
Pristis zijsron Green Sawfish [68442]	Pupping	Known to occur
Seabirds		
Anous stolidus Common Noddy [825]	Foraging (provisioning young)	Known to occur
Anous tenuirorstris melanops Australian Lesser Noddy [26000]	Foraging (provisioning young)	Known to occur

Scientific Name	Behaviour	Presence
Ardenna pacifica Wedge-tailed Shearwater [84292]	Breeding	Known to occur
Ardenna pacifica Wedge-tailed Shearwater [84292]	Foraging (in high numbers)	Known to occur
Fregata ariel Lesser Frigatebird [1012]	Breeding	Known to occur
Hydroprogne caspia Caspian Tern [808]	Foraging (provisioning young)	Known to occur
Larus pacificus Pacific Gull [811]	Foraging (in high numbers)	Known to occur
Onychoprion anaethetus Bridled Tern [82845]	Foraging (in high numbers)	Known to occur
Onychoprion fuscata Sooty Tern [82847]	Foraging	Known to occur
Pelagodroma marina White-faced Storm petrel [1016]	Foraging (in high numbers)	Known to occur
Phaethon lepturus White-tailed Tropicbird [1014]	Breeding	Known to occur
Pterodroma mollis Soft-plumaged Petrel [1036]	Foraging (in high numbers)	Known to occur
Puffinus assimilis tunneyi Little Shearwater [59363]	Foraging (in high numbers)	Known to occur
Sterna dougallii Roseate Tern [817]	Breeding	Known to occur
Sterna dougallii Roseate Tern [817]	Foraging (provisioning young)	Known to occur
Sternula albifrons sinensis Little Tern [82850]	Breeding	Known to occur
Sternula albifrons sinensis Little Tern [82850]	Resting	Known to occur
Sternula nereis Fairy Tern [82949]	Breeding	Known to occur
Sternula nereis Fairy Tern [82949]	Foraging (in high numbers)	Known to occur
Sula leucogaster Brown Booby [1022]	Breeding	Known to occur
Thalasseus bengalensis Lesser Crested Tern [66546]	Breeding	Known to occur
Seals		
Neophoca cinerea Australian Sea Lion [22]	Foraging (male)	Likely to occur
Neophoca cinerea Australian Sea Lion [22]	Foraging (male and female)	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Foraging	Known to occur
Rhincodon typus Whale Shark [66680]	Foraging	Known to occur
Rhincodon typus Whale Shark [66680]	Foraging (high density prey)	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur

Scientific Name	Behaviour	Presence
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Migration	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north)	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north and south)	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Resting	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

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

Threatened, migratory and marine species

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

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

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

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

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

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

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

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

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

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

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

APPENDIX C PROPOSED FUTURE ENVIRONMENTAL MONITORING TO SUPPORT THE GOODWYN AREA INFILL DEVELOPMENT

PROPOSED ENVIRONMENTAL SURVEY SCOPES

Environmental data via an environmental survey (ES) will be collected at key locations to further characterise the environment in the Project Area. The ES will support the statutory approval and assessment and will help inform the development of key management controls, that will be put in place during installation and operation of the proposed development.

It is proposed to phase the ES into two focus areas. The first phase will focus on Wilcox Shoal which is small (approximately 2.5 km^2) un-surveyed shoal located approximately 1.2 km from the phased development nominal infrastructure corridor, and a smaller un-named and un-surveyed shoal to the southwest of Wilcox, with the survey at Wilcox Shoal being the initial focus.

There is paucity of information pertaining to these shoals but based on data from other similar shoals in the area, they are likely to be characterised by habitats such as coral and agal reefs, carbonate pinnacles, and fish communities. The ES for these shoals is currently in the planning phase with a target date to complete the survey in H2 2024.

The second phase ES will focus on representative areas where key infrastructure is likely to be placed, such as drill centres and flow line corridors, piling and anchoring locations and will also be guided by modelling results. This survey is planned to take place once the data from the geophysical and geotechnical survey becomes available as these data will help identify key features that will form part of the ES. The target date of this survey is late-2024.

The objectives of ES are to collate sufficient baseline data to:

- broadly map, analyse, and characterise the key ecological values of Wilcox Shoal, nearby un-named shoal, and areas where key infrastructure is likely to be placed
- support the preparation of statutory environmental approvals documentation
- inform the environmental impact assessment
- influence key engineering decisions that result in reduced risk of environmental impact
- support the development and implementation of environmental controls to ensure the risks of environmental impact are managed accordingly.

The design of the ES will reflect the main installation and operational activities and will be informed by dispersion modelling results from studies undertaken to inform the OPP. Adequate buffers around key infrastructure sites, as well as reference sites away from the nominal infrastructure locations, will also be included in the ES. Specifically, the design of the ES will take into consideration the following project activities and the potential risks of these activities impacting the ecological values of the development area:

- drilling
- flowline installation and operations
- vessel operations
- anchoring
- pilling
- planned and unplanned marine discharges

The ES will be designed to gain a broad understanding of the key ecological features and will focus on:

- demersal fish communities
- benthic habitats

- background physio-chemical seabed sediment quality
- background water quality
- document the presence of marine megafauna from opportunistic sightings
- document other notable environmental values from opportunistic observations.

The survey method will be refined and finalised to enable the ES methodology to be fit for purpose and a survey that can be executed in the field with a high probability of success.

APPENDIX D ABORIGINAL CULTURAL HERITAGE INQUIRY SYSTEM REPORT

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

Search Criteria

786 Aboriginal Cultural Heritage (ACH) Directory in Shapefile - EMBA_V6_GDA94. Warning: Search area complex so results may be inaccurate. Contact DPLH for assistance.

Disclaimer

The *Aboriginal Cultural Heritage Act 2021 (Act)* recognises, protects, conserves, and preserves Aboriginal cultural heritage (ACH), and recognises the fundamental importance of ACH to Aboriginal people and its role in Aboriginal communities past, present and future. The Act recognises the value of ACH to Aboriginal people as well as to the wider Western Australian community.

Aboriginal cultural heritage in Western Australia is protected, whether or not the ACH has been reported to the ACH Council or exists on the Directory.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at AboriginalHeritage@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

Terminology

ID: Reported ACH is assigned a unique ID by the Department of Planning, Lands and Heritage using the format: ACH-00000001. For ACH places on the former Register the ID numbers remain unchanged and use the new format. For example the ACH ID of the place Swan River was previously '3536' and is now 'ACH-00003536'.

Access and Restrictions:

- **Boundary Reliable (Yes/No):** Indicates whether the location and extent of the ACH boundary is considered reliable.
- **Boundary Restricted = No:** ACH location is shown as accurately as the information submitted allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the ACH is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- **Culturally Sensitive = No:** Availability of information that the Department of Planning, Lands and Heritage holds in relation to the ACH is not restricted in any way.
- **Culturally Sensitive = Yes:** Some of the information that the Department of Planning, Lands and Heritage holds in relation to the ACH is restricted if it is considered culturally sensitive information. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the people who provided the information. To request access please contact AboriginalHeritage@dplh.wa.gov.au.
- **Culturally Sensitive Nature:**
  - **No Gender / Initiation Restrictions:** *Anyone* can view the information.
  - **Men only:** Only *males* can view restricted information.
  - **Women only:** Only *females* can view restricted information.

Status:

- **ACH Directory**: Aboriginal cultural heritage place or cultural landscape.
- **Pending**: Aboriginal cultural heritage place or cultural landscape with information in a verification stage.
- **Historic**: Aboriginal heritage places determined to not meet the criteria of Section 5 of the Aboriginal Heritage Act 1972. Includes places that no longer exist as a result of land use activities with existing approvals.

ACH Type:

- **Cultural Landscape:** a group of areas interconnected through the tangible elements of Aboriginal culture heritage present.
- **Place**: an area in which tangible elements of Aboriginal cultural heritage are present.

Place Type: The type of Aboriginal cultural heritage place. For example an artefact scatter place or engravings place.

Legacy Place Status: A status determined under the previous *Aboriginal Heritage Act 1972*:

- **Registered Site:** the place was assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- **Lodged:** Information was received in relation to the place, but an assessment was not completed to determine if it met section 5 of the *Aboriginal Heritage Act 1972.*
- **Stored Data/Not a Site:** The place was assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place.

Coordinates

Map coordinates are based on the GDA 94 Datum.

Basemap Copyright

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
369	ROCKY CREEK 2.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07546
508	POINT MURAT 03	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07503
560	ROEBOURNE MIDDEN	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07498
563	POINT MURAT 01	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07501
564	POINT MURAT 02	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07502
580	WICKHAM 27	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07469
600	UPPER BULBARLI WELL 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07442
621	WICKHAM 11.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Historical; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07453
628	CAMP THIRTEEN BURIAL	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	P07434
678	NYARTAWKA NYUKA	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial	*Registered Knowledge Holder names available from DPLH	Registered Site	P07391
810	URALA 94 A	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P07321
811	URALA 94 B	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07322

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
873	MONTEBELLO IS: NOALA CAVE.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Registered Site	P07287
883	BARROW ISLAND 01	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07291
884	BARROW ISLAND 02	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07292
885	BARROW ISLAND 03	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07293
886	BARROW ISLAND 04	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07294
887	BARROW ISLAND 05	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07295
888	BARROW ISLAND 06 A-F	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07296
889	BARROW ISLAND 07	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07297
890	BARROW ISLAND 08	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07298
891	BARROW ISLAND 09	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07299
892	BARROW ISLAND 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07300
893	BARROW ISLAND 11	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07301

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
894	BARROW ISLAND 12	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P07302
911	40 MILE - EASTERN POINT	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07271
912	40 MILE - EASTERN DUNES	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07272
919	ENDERBY IS.27: GOODWYN VIEW	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07279
925	MOUNT BEACH DUNE	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07285
926	MONTEBELLO IS: HAYNES CAVE.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Sub surface cultural material; Artefacts / Scatter; Midden; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Registered Site	P07286
927	ENDERBY IS.16: WHITE BASIN	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07233
929	ENDERBY IS.18: MANGROVE CK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P07235
930	ENDERBY IS.19: MANGROVE CK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P07236
931	ENDERBY IS.20: MANGROVE CK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07237
932	ENDERBY IS.21: BACK QUARRY	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P07238
933	ENDERBY IS.22: TEREBRALIA	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07239

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
934	ENDERBY IS.23: GRINDING	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	P07240
935	ENDERBY IS.24: LIMESTONE	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Lodged	P07241
936	ENDERBY IS.25: DINGHY MIDDEN	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07242
937	ENDERBY IS.26: NORTH POINT	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P07243
966	ROSEMARY IS.11: CHOOKIE BAY	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07219
967	ROSEMARY IS.12: CHOOKIE BAY	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P07220
968	ROSEMARY IS.13	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07221
969	ROSEMARY IS.14	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07222
970	ROSEMARY IS.15: AIRSTRIP	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07223
971	ROSEMARY IS.16: AIRSTRIP	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P07224
972	ROSEMARY IS.17: AIRSTRIP	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P07225
973	ROSEMARY IS.18: DEEP WATER	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07226

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
974	ROSEMARY IS.19: CHITON	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07227
975	ROSEMARY IS.20: HALFWAY CK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07228
976	ROSEMARY IS.21: HALFWAY CK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Traditional Structure	*Registered Knowledge Holder names available from DPLH	Lodged	P07229
977	ROSEMARY IS.22	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P07230
978	ROSEMARY IS.23: WADJURU R/H	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Traditional Structure; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P07231
979	ROSEMARY IS.24: HUNGERFORD	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07232
1062	LEGENDRE 11	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P07204
1103	LEGENDRE HILL	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07193
1104	LEGENDRE 01.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P07194
1105	LEGENDRE 02	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07195
1106	LEGENDRE 03.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P07196
1109	LEGENDRE 06.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P07199

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
1110	LEGENDRE 07.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P07200
1111	LEGENDRE 08.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Traditional Structure; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	P07201
1112	LEGENDRE 09.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P07202
1113	LEGENDRE 10.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Rock Shelter; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P07203
5927	WEST INTERCOURSE SCATTER	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07188
5928	WEST INTERCOURSE MOUNDS 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P07189
5929	WEST INTERCOURSE MOUNDS 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07190
5946	WEST INTERCOURSE ISLAND 11	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07153
5999	WEST INTERCOURSE ISLAND 09.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P07151
6000	WEST INTERCOURSE ISLAND 10	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07152
6015	KING BAY	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07113
6022	BEAGLE BEACH 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07120

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6023	WRECK POINT, DEPUCH ISLAND	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P07121
6044	DEPUCH IS: NARROW GORGE.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Shell; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P07091
6078	ROSEMARY ISLAND 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07019
6079	ENDERBY ISLAND 12	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P07020
6080	ENDERBY ISLAND 13	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07021
6081	ENDERBY ISLAND 14	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07022
6082	ENDERBY ISLAND 15	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07023
6115	EXMOUTH NORTH-EAST	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P07004
6182	EAST LEWIS ISLAND: SW.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06915
6183	EAST LEWIS ISLAND: NE.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Grinding areas / Grooves; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P06916
6184	ENDERBY ISLAND 09: SE	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Fish Trap; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06917
6185	ENDERBY ISLAND 10: N.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P06918

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6186	ENDERBY ISLAND 11: NE.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Ritual / Ceremonial; Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06919
6187	ANGEL ISLAND: NW.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Registered Site	P06920
6227	MALUS ISLAND.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06908
6228	WEST LEWIS ISLAND: SW.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Grinding areas / Grooves; Midden; Other; Quarry; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P06909
6229	WEST LEWIS ISLAND: NW ARM 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Ritual / Ceremonial; Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06910
6230	WEST LEWIS ISLAND: NW ARM 2	Yes	Yes	Yes	Men only	ACH Directory	Place	Artefacts / Scatter; Ritual / Ceremonial; Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06911
6231	WEST LEWIS ISLAND: NE	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Fish Trap; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06912
6232	WEST LEWIS ISLAND: N	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06913
6233	EAST LEWIS ISLAND: S.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06914

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6311	POINT MURAT.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Camp; Midden; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P06628
6312	EXMOUTH NORTH-EAST	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P06629
6325	COWERIE WELL	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	P06642
6334	MUNDA STATION BURIAL 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	P06651
6345	MYSTERY ROAD SANDPIT	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06609
6346	MT SALT	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P06610
6375	MUD FLATS 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06586
6376	MUD FLATS 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06587
6498	DIRK HARTOG ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P06448
6541	URALA STATION WEST	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial	*Registered Knowledge Holder names available from DPLH	Registered Site	P06438
6567	TABBA TABBA MOUTH 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06412
6575	JINTA 1 MIDDEN	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06370

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6596	POINT ANDERSON.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Hunting Place; Midden; Shell; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P06341
6606	CRAYFISH BAY 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P06351
6607	CRAYFISH BAY 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P06352
6608	ZUYTDORP POINT	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06353
6617	BURUBARLADJI	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Registered Site	P06362
6618	DEW TALU.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P06363
6619	JINTA 1.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P06364
6723	MULANDA 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06257
6724	MULANDA 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06258
6754	OSPREY BAY 6	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06165
6755	OSPREY BAY INTERDUNAL 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06166
6757	BLOODWOOD CREEK MIDDEN 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06168

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6758	BLOODWOOD CREEK MIDDEN 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06169
6759	BLOODWOOD CREEK MIDDEN 3	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06170
6760	BLOODWOOD CREEK SHORELINE	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06171
6761	LOW POINT MIDDEN	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06172
6762	MILYERING MIDDEN	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06173
6764	CAMP 17 SOUTH MIDDENS	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06175
6765	CAMP 17 NORTH MIDDENS	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06176
6766	DAMPIER ISLAND WEST 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P06177
6767	DAMPIER ISLAND WEST 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06178
6768	DAMPIER ISLAND WEST 3	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P06179
6769	MULANDA 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06180
6782	28 MILE CREEK NORTH 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06140

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6783	28 MILE CREEK NORTH 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P06141
6784	MANDU MANDU CREEK SOUTH	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06142
6785	MANDU MANDU CREEK NORTH	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06143
6786	LAKESIDE COASTAL PLAIN	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P06144
6789	TURQUOISE BAY NORTH	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P06147
6790	YARDIE CREEK SOUTH 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06148
6799	YARDIE BEACH MIDDEN	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06157
6800	OYSTER STACKS MIDDEN	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06158
6801	NORTH T-BONE BAY	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06159
6802	OSPREY BAY 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06160
6803	OSPREY BAY 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06161
6804	OSPREY BAY 3	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06162

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
6805	OSPREY BAY 4	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06163
6806	OSPREY BAY 5	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06164
6827	CORAL BAY SKELETON	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	P06132
6831	GNARALOO STATION	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P06136
6833	WEST MOORE ISLAND	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P06138
6965	ENDERBY ISLAND 07	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P05954
6966	ENDERBY ISLAND 08	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P05955
7055	CONZINC BURIAL & MIDDEN	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05882
7059	FOUR MILE CREEK MIDDEN	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05890
7083	HARDING MOUTH CAMP.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P05857
7126	MESA CAMP	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05792
7127	EAST INTERCOURSE ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P05793

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
7133	ANGEL ISLAND BEACON	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P05799
7203	BAUBOODJOO POINT (Bruboodjoo Midden Site)	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Hunting Place; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05707
7204	CHABJUWARDOO BAY.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Hunting Place	*Registered Knowledge Holder names available from DPLH	Lodged	P05708
7205	TWIN HILL FISHING PLACE.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Hunting Place	*Registered Knowledge Holder names available from DPLH	Registered Site	P05709
7206	WEALJUGOO MIDDEN.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Hunting Place; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05710
7208	MILYERING ROCKS.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Hunting Place	*Registered Knowledge Holder names available from DPLH	Lodged	P05712
7209	BULBARLI POINT COMPLEX.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P05713
7210	UPPER BULBARLI WELL.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Hunting Place	*Registered Knowledge Holder names available from DPLH	Lodged	P05714
7211	MAUD LANDING.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Camp; Meeting Place; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P05715
7212	GREYLING CLIFFS.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Hunting Place	*Registered Knowledge Holder names available from DPLH	Lodged	P05716
7254	SANDY BAY NORTH	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05652
7265	LAKE SIDE VIEW	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05664

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
7286	KAPOK WELL BURIAL	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	P05632
7299	YARDIE CREEK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05645
7300	MANDU MANDU CK ROCKSHELTERS	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P05646
7303	TULKI WELL MIDDEN	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05649
7304	PILGRAMUNNA BAY MIDDEN	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05650
7305	MANGROVE BAY.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Hunting Place; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05651
7316	HEARSON COVE WEST	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05611
7332	URALA STATION 12	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05574
7333	URALA STATION 13	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P05575
7380	URALA STATION 08	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P05568
7382	ROCKY POINT MIDDEN COMPLEX	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05570
7385	URALA STATION 11	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P05573

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
7442	WATERING COVE (Burrup Peninsula J12)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P05468
7786	BAALYINNYE.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P05055
7859	CAPE LAMBERT BURIAL	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	P05009
7866	EAST LEWIS MIDDEN 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P04966
7899	MALUS ISLAND	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P04947
7906	DELAMBRE ISLAND SOUTH.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P04954
7907	ROE POINT, EAST LEWIS	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P04955
7908	EAST LEWIS ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P04956
7910	CONZINC ISLAND 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P04958
7911	CONZINC ISLAND 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P04959
7914	EAST LEWIS MIDDEN 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P04962
8008	CAPE LAMBERT MIDDEN 01	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P04659

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
8299	BEADON CREEK	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P04351
8797	POINT SAMSON 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P03722
8950	BOAT BEACH	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P03541
9033	BOONGAREE COAST 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P03459
9061	COBBLE BEACH 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P03350
9070	SPOTTED SLUGS	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P03441
9071	DANCING DOGS	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P03442
9072	SMASHED ROO	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P03443
9216	HAUL ROAD SOUTH 07	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P03108
9246	STEEP KNOLL	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P03081
9488	DRD AREA C-45	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02696
9507	DRD AREA C-09	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P02660

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
9521	DRD AREA C-23	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P02674
9522	DRD AREA C-24	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P02675
9525	DRD AREA C-27	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02678
9558	DRD AREA C-05	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P02656
9560	DRD AREA C-07	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P02658
9568	EAGLE ROCK	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02611
9596	GRAVEL BANDIT SHELTERS.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Traditional Structure; Midden; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Registered Site	P02584
9615	WHITE SANDS	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02603
9679	WILD HARRY'S DREAM	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P02500
9735	GIDLEY PASSAGE	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02447
9736	PASTORAL SETTLEMENT	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02448
9737	ENDERBY ISLAND 06: BOILER B	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P02449

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
9782	SPEAR THROWER SITE	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02381
9794	FISHERMANS BASKET	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02393
9795	STORM POINT	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02394
9811	DRD AREA A-05	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Creation / Dreaming Narrative; Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P02355
9813	DRD AREA A-07	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P02357
9818	CLIMBING MEN COMPLEX (Burrup Peninsula F1)	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P02362
9827	DRD AREA A-17	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02371
9919	DAMPIER, WOODSIDE A	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02249
9920	DAMPIER, WOODSIDE B	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P02250
9921	DAMPIER, WOODSIDE C	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02251
9922	DAMPIER, WOODSIDE D	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P02252
10057	CAPE LAMBERT.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp	*Registered Knowledge Holder names available from DPLH	Lodged	P02121

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
10058	CAPE LAMBERT DUNE BLOWOUT.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp	*Registered Knowledge Holder names available from DPLH	Registered Site	P02122
10099	POINT MAUD, CORAL BAY	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P02064
10100	GNARALOO BAY	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P02065
10305	NO NAME POINT SOUTH.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Traditional Structure; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P01891
10326	KING BAY WOODSIDE 20	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01851
10328	KING BAY WOODSIDE 22	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01853
10381	VLAMING HEAD	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Registered Site	P01799
10577	DAMPIER ARCHIPELAGO	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01575
10578	DAMPIER ARCHIPELAGO 04	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01576
10582	DAMPIER ARCHIPELAGO	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01580
10583	DAMPIER ARCHIPELAGO 06	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01581
10585	DAMPIER ARCHIPELAGO	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P01584

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
10590	DAMPIER ARCHIPELAGO 07	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01589
10591	DAMPIER ARCHIPELAGO 08	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01590
10592	DAMPIER ARCHIPELAGO 09	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01591
10593	DAMPIER ARCHIPELAGO 10	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P01592
10595	CORAL BAY BURIAL	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P01594
10597	DAMPIER ARCHIPELAGO 11	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P01596
10600	NO NAME POINT	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P01599
10602	DAMPIER ARCHIPELAGO	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	P01601
10617	WITHNELL BAY WEST 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P01561
10618	WITHNELL BAY WEST 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	P01562
10623	NO NAME POINT SOUTH.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Traditional Structure; Midden; Other; Plant Resource; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P01568

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
10626	SEARIPPLE PASSAGE 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P01571
10627	NO NAME POINT 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P01572
10628	NO NAME POINT 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P01573
10635	WHIM CREEK 27, PACKSADDLE.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Modified Tree; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Lodged	P01526
10726	NICKOL BAY	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	P01460
10999	CRAYFISH BAY.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Historical; Traditional Structure; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P01151
11328	GAP WELL	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00836
11397	PARDOO 1	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Repository / Storage Place	*Registered Knowledge Holder names available from DPLH	Registered Site	P00747
11402	URALA DUNE BURIAL	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00752
11442	COWERIE WELL	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P00738
11448	23 MILE CREEK	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00744
11458	NINGALOO (near)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Painting	*Registered Knowledge Holder names available from DPLH	Registered Site	P00701

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11461	BULBARLI WELL.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Camp; Hunting Place; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00704
11552	FALSE ENTRANCE.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00634
11587	KARRATHA BURIAL 3.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	P00558
11612	DAWSON CREEK BURIAL.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Camp; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P00529
11624	HUNTERS POOL	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00541
11625	DEPUCH ISLAND	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P00542
11626	WATERING VALLEY	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P00543
11627	JANE CREEK	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00544
11628	ANCHOR HILL, DEPUCH ISLAND	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00545
11636	PORT HEDLAND SOUTH-WEST	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00553
11639	DOLPHIN LOCATION 6 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00503
11640	DOLPHIN LOCATION 6 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00504

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11641	DOLPHIN LOCATION 7 NO. 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00505
11642	DOLPHIN LOCATION 7 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00506
11643	DOLPHIN LOCATION 7 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00507
11644	DOLPHIN ISLAND EMU	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00508
11645	DOLPHIN LOCATION 8 NO. 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00509
11646	DOLPHIN LOCATION 8 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00510
11647	DOLPHIN LOCATION 8 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00511
11648	DOLPHIN ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00512
11649	DEBBY'S DUNE (DIXON ISLAND 4)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00513
11650	GAYLEEN BAY (DIXON IS. 6).	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Sub surface cultural material; Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00514
11651	CHRISTINE BAY (DIXON IS.5).	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	P00515
11652	LANDING SITE (DIXON IS. 1)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P00516

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11653	BOBBY'S FLAT E(DIXON IS.2)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00517
11654	BOBBY'S FLAT (DIXON IS. 3)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00518
11655	LIMESTONE PTF (DIXON IS.8)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P00519
11656	SUSAN BAY (DIXON ISLAND 7)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00520
11667	ENZOS LANDING	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00479
11668	DOLPHIN LOCATION 3 NO. 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P00480
11669	DOLPHIN LOCATION 3 NO. 4	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P00481
11670	DOLPHIN LOCATION 3 NO. 6	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	P00482
11671	DOLPHIN LOCATION 4 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00483
11672	DOLPHIN LOCATION 4 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00484
11673	DOLPHIN LOCATION 4 NO. 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00485
11674	DOLPHIN LOCATION 5 NO. 5	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00486

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11675	DOLPHIN LOCATION 5 NO. 4	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00487
11677	NW CORNER POINT 5 (Sea Ripple Rock Art)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00489
11683	DOLPHIN LOCATION 5 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00495
11684	DOLPHIN LOCATION 5 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00496
11685	DOLPHIN LOCATION 5 NO. 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00497
11686	TOZER ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Fish Trap	*Registered Knowledge Holder names available from DPLH	Registered Site	P00498
11687	DOLPHIN LOCATION 7 NO. 4	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00499
11688	DOLPHIN LOCATION 7 NO. 5	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00500
11689	BOAT PASSAGE 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00501
11690	BOAT PASSAGE 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00502
11693	SNAKE POINT, DOLPHIN ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00452
11694	DOLPHIN LOCATION 1 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00453

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11695	DOLPHIN LOCATION 1 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00454
11696	DOLPHIN LOCATION 1 NO. 4	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P00455
11697	DOLPHIN LOCATION 2 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00456
11698	ANGELA COVE	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00457
11699	GIDLEY BAY, GIDLEY ISLAND.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00458
11700	NW CORNER POINT 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00459
11701	NW CORNER POINT 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00461
11702	EAGLES NEST	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00462
11703	DOLPHIN ISLAND SW 2a, b	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00463
11704	THREE FISH SITE	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00464
11705	DOLPHIN LOCATION 1 NO. 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00465
11706	DOLPHIN ISLAND SW 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00466

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11707	DOLPHIN LOCATION 2 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00467
11708	DOLPHIN LOCATION 3 NO. 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00468
11709	DOLPHIN LOCATION 3 NO. 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00469
11710	DOLPHIN LOCATION 3 NO. 5	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00470
11711	DOLPHIN ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00471
11712	MUSEUM BAY, DOLPHIN IS	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00472
11713	LAST ENCOUNTER COVE.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00473
11714	GIDLEY ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00474
11715	RIM ROCK GORGE.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00475
11716	NW CORNER POINT 4	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00476
11723	DOLPHIN ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00428
11725	NW CORNER POINT 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00430

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11726	WITHNELL BAY 06	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00431
11727	WITHNELL BAY 07	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00432
11728	WITHNELL BAY 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00433
11729	NGARLUMA POINT, GIDLEY IS.	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P00434
11730	MORS HILL, GIDLEY ISLAND.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Engraving; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P00435
11731	FISH POOL, DAMPIER	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00436
11734	ANGEL ISLAND 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00440
11735	ANGEL ISLAND 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00441
11736	VIRILI COVE, DAMPIER (Burrup Peninsula K12 &13)	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Quarry; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	P00442
11740	NW CORNER BEACH 3	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00446
11741	NW CORNER BEACH 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	P00447
11744	EAST LEWIS 5	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00395

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11745	EAST LEWIS 6	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00396
11746	EAST LEWIS 7	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00397
11747	EAST LEWIS 8	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00398
11748	EAST LEWIS 9	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00399
11749	EAST LEWIS 4	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00400
11750	EAST LEWIS 3	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00401
11752	EAST LEWIS 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00403
11753	EAST LEWIS 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00404
11754	GOANNA POOL	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P00405
11759	WEST LEWIS ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00410
11760	KING BAY 4 SITE 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00411
11761	KING BAY 4 SITE 2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00412

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11762	KING BAY 3, DAMPIER	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P00413
11763	KING BAY, DAMPIER	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00414
11764	PHILLIP POINT 1	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00415
11766	WITHNELL BAY 02	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00417
11767	FISH POINT, GIDLEY ISLAND	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00418
11768	PHILLIP POINT 2.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P00419
11771	ENDERBY ISLAND 05	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00368
11772	ROSEMARY ISLAND 09	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00369
11773	ROSEMARY ISLAND 08	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	P00370
11774	ROSEMARY ISLAND 07	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00371
11775	ROSEMARY ISLAND 06	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00372
11776	ROSEMARY ISLAND 04.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00373

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11777	ROSEMARY ISLAND 03	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00374
11789	ROSEMARY ISLAND 01	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	P00386
11790	WEST INTERCOURSE ISLAND 06	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00387
11791	WEST INTERCOURSE ISLAND 07	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00388
11792	WEST INTERCOURSE ISLAND 02	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00389
11793	WEST INTERCOURSE ISLAND 03	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00390
11794	WEST INTERCOURSE ISLAND 04	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00391
11795	WEST INTERCOURSE ISLAND 05	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00392
11796	WEST INTERCOURSE ISLAND 01	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00393
11797	WEST INTERCOURSE ISLAND 08	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00394
11801	COASTAL MIDDEN, 5 MILE	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Lodged	P00345
11818	ROSEMARY ISLAND 02	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00362

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
11819	ROSEMARY ISLAND 05	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00363
11820	ENDERBY ISLAND 01	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00364
11821	ENDERBY ISLAND 02	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00365
11822	ENDERBY ISLAND 03	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P00366
11823	ENDERBY ISLAND 04	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00367
11859	BALLA BALLA	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Lodged	P00296
11943	TWO MILE RIDGE, NELSON POINT	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P00219
12023	KARRATHA BURIAL 1 & 2.	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Sub surface cultural material	*Registered Knowledge Holder names available from DPLH	Registered Site	P00143
12069	SOUTH WEST CREEK 1,2,3.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Creation / Dreaming Narrative; Engraving; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	P00088
12071	SOUTH WEST CREEK 4.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Sub surface cultural material; Artefacts / Scatter; Camp; Ritual / Ceremonial; Engraving; Traditional Structure; Midden; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	P00090
12072	SOUTH WEST CREEK 5:BOODARI.	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Engraving; Hunting Place; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	P00091

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
12550	CONDINI LANDING WEST	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	K02698
12963	CAPE KERAUDREN 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	K02264
12965	CAPE KERAUDREN 3.	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Camp; Midden; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	K02266
12967	CAPE KERAUDREN 5	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	K02268
12968	CAPE KERAUDREN 6	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	K02269
12969	WARRA MURRANGA TALU	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Registered Site	K02270
14341	SHELLBOROUGH 1-3.	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial; Artefacts / Scatter; Camp; Grinding areas / Grooves; Traditional Structure; Midden; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	K00773
15726	EAST INTERCOURSE ISLAND 01	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07942
15727	EAST INTERCOURSE ISLAND 02	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	P07943
15728	EAST INTERCOURSE ISLAND 03	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	P07944
16215	North West Intercourse Island Site 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16216	North West Intercourse Island Site 13	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16217	North West Intercourse Island Site 36	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16218	North West Intercourse Island Site 181	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16219	North West Intercourse Island Site 96	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16220	North West Intercourse Island Site 84	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16223	South West Burrup Peninsula Site 19	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16225	North West Intercourse Island Site 149	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16226	South West Burrup Peninsula Site 111	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16229	West Mid Intercourse Island Site 16	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16230	South West Burrup Peninsula Site 63	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16232	North West Intercourse Island Site 153	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16233	North West Intercourse Island Site 139	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16234	North West Intercourse Island Site 134	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16235	North West Intercourse Island Site 4	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16236	North West Intercourse Island Site 140	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16237	North West Intercourse Island Site 83	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16238	West Mid Intercourse Island Site 15	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16239	North West Intercourse Island Site 69	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16240	North West Intercourse Island Site 16	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16241	North West Intercourse Island Site 123	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16242	North West Intercourse Island Site 150	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16243	North West Intercourse Island Site 156	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16244	West Mid Intercourse Island Site 17	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16246	South West Burrup Peninsula Site 70	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16247	North West Intercourse Island Site 13	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16248	North West Intercourse Island Site 159	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16249	North West Intercourse Island Site 19	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16251	North West Intercourse Island Site 59	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Other; Quarry; Rock Shelter; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16252	North West Intercourse Island Site 8	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16253	North West Intercourse Island Site 73	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16254	South West Burrup Site 108	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden; Other; Quarry; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16255	North West Intercourse Island Site 197	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16256	North West Intercourse Island Site 119	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16263	North West Intercourse Island Site 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16265	North West Intercourse Island Site 7	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16267	North West Intercourse Island Site 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16268	North West Intercourse Island Site 11	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16269	North West Intercourse Island Site 12	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16270	North West Intercourse Island Site 14	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16271	North West Intercourse Island Site 15	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16272	West Mid Intercourse Island Site 9	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	
16274	North West Intercourse Island Site 44	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16275	North West Intercourse Island Site 17	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16276	North West Intercourse Island Site 18	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16277	North West Intercourse Island Site 20	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16279	North West Intercourse Island Site 22	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16280	North West Intercourse Island Site 23	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16281	North West Intercourse Island Site 24	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16282	North West Intercourse Island Site 25	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16283	North West Intercourse Island Site 26	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16284	North West Intercourse Island Site 27	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16285	North West Intercourse Island Site 28	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16286	North West Intercourse Island Site 29	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16287	North West Intercourse Island Site 30	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16288	North West Intercourse Island Site 31	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16289	North West Intercourse Island Site 32	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16290	North West Intercourse Island Site 33	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16291	North West Intercourse Island Site 34	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16292	North West Intercourse Island Site 35	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden; Landscape / Seascape Feature; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16293	North West Intercourse Island Site 37	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16294	North West Intercourse Island Site 38	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16295	North West Intercourse Island Site 39	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16296	North West Intercourse Island Site 40	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16297	North West Intercourse Island Site 41	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16298	North West Intercourse Island Site 42	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16299	North West Intercourse Island Site 43	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16300	North West Intercourse Island Site 45	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16301	North West Intercourse Island Site 46	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16302	North West Intercourse Island Site 47	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16303	North West Intercourse Island Site 48	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16304	North West Intercourse Island Site 49	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16305	North West Intercourse Island Site 50	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16306	North West Intercourse Island Site 51	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16307	North West Intercourse Island Site 52	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16308	North West Intercourse Island Site 53	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16309	North West Intercourse Island Site 54	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16310	North West Intercourse Island Site 55	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16312	North West Intercourse Island Site 57	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16313	North West Intercourse island Site 58	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16314	North West Intercourse Island Site 60	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16317	North West Intercourse Island Site 63	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16319	North West Intercourse Island Site 65	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16320	North West Intercourse Island Site 66	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16321	North West Intercourse Island Site 67	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16322	North West Intercourse Island Site 68	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16325	North West Intercourse Island Site 72	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16326	North West Intercourse Island Site 74	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16327	North West Intercourse Island Site 75	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16328	North West Intercourse Island Site 76	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16329	North West Intercourse Island Site 77	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
16330	North West Intercourse Island Site 78	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16331	North West Intercourse Island Site 79	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16332	North West Intercourse Island Site 80	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16333	North West Intercourse Island Site 81	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16334	North West Intercourse Island Site 82	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16335	North West Intercourse Island Site 85	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16336	North West Intercourse Island Site 86	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16337	North West Intercourse Island Site 87	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16338	North West Intercourse Island Site 88	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16339	North West Intercourse Island Site 89	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16340	North West Intercourse Island Site 90	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16341	North West Intercourse Island Site 91	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16342	North West Intercourse Island Site 92	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16343	North West Intercourse Island Site 93	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16344	North West Intercourse Island Site 94	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
16345	North West Intercourse Island Site 95	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16346	North West Intercourse Island Site 97	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16347	North West Intercourse Island Site 98	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
16348	North West Intercourse Island Site 99	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Meeting Place; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16349	North West Intercourse Island Site 100	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16350	North West Intercourse Island Site 101	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16351	North West Intercourse Island Site 102	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16352	North West Intercourse Island Site 103	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16353	North West Intercourse Island Site 104	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16354	North West Intercourse Island Site 105	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16355	North West Intercourse Island Site 106	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16356	North West Intercourse Island Site 107	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16357	North West Intercourse Island Site 108	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16358	North West Intercourse Island Site 109	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16359	North West Intercourse Island Site 110	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16360	North West Intercourse Island Site 111	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16361	North West Intercourse Island Site 112	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16362	North West Intercourse Island Site 113	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16363	North West Intercourse Island Site 114	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16364	North West Intercourse Island Site 115	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16365	North West Intercourse Island Site 116	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16366	North West Intercourse Island Site 117	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16367	North West Intercourse Island Site 118	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16368	North West Intercourse Island Site 120	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Landscape / Seascape Feature; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16369	North West Intercourse Island Site 121	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16370	North West Intercourse Island Site 122	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16371	North West Intercourse Island Site 123	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16372	North West Intercourse Island Site 124	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16373	North West Intercourse Island Site 125	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16374	North West Intercourse Island Site 126	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16375	North West Intercourse Island Site 127	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	
16376	North West Intercourse Island Site 128	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16377	North West Intercourse Island Site 129	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16378	North West Intercourse Island Site 130	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16379	North West Intercourse Island Site 131	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16380	North West Intercourse Island Site 132	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16381	North West Intercourse Island Site 133	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16382	North West Intercourse Island Site 135	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16383	North West Intercourse Island Site 136	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16384	North West Intercourse Island Site 137	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16385	North West Intercourse Island Site 138	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16386	North West Intercourse Island Site 141	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16387	North West Intercourse Island Site 142	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16388	North West Intercourse Island Site 143	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16389	North West Intercourse Island Site 144	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16390	North West Intercourse Island Site 145	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16391	North West Intercourse Island Site 146	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16392	North West Intercourse Island Site 147	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16393	North West Intercourse Island Site 148	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16394	North West Intercourse Island Site 151	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16395	North West Intercourse Island Site 152	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16396	North West Intercourse Island Site 154	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Landscape / Seascape Feature; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16397	North West Intercourse Island Site 155	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16398	North West Intercourse Island Site 157	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Other; Quarry; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16399	North West Intercourse Island Site 158	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16400	North West Intercourse Island Site 160	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16401	North West Intercourse Island Site 161	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16402	North West Intercourse Island Site 162	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16403	North West Intercourse Island Site 163	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16405	North West Intercourse Island Site 165	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16406	North West Intercourse Island Site 166	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16407	North West Intercourse Island Site 167	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16408	North West Intercourse Island Site 168	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16409	North West Intercourse Island Site 169	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16410	North West Intercourse Island Site 170	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16411	North West Intercourse Island Site 171	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16412	North West Intercourse Island Site 172	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16413	North West Intercourse Island Site 173	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16414	North West Intercourse Island Site 174	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16415	North West Intercourse Island Site 175	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16416	North West Intercourse Island Site 176	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16417	North West Intercourse Island Site 177	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16418	North West Intercourse Island Site 178	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16419	North West Intercourse Island Site 179	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16420	North West Intercourse Island Site 180	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16421	North West Intercourse Island Site 182	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16422	North West Intercourse Island Site 183	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16423	North West Intercourse Island Site 184	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16424	North West Intercourse Island Site 185	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16425	North West Intercourse Island Site 186	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16426	North West Intercourse Island Site 187	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16427	North West Intercourse Island Site 188	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16428	North West Intercourse Island Site 189	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16429	North West Intercourse Island Site 190	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16430	North West Intercourse Island Site 191	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16431	North West Intercourse Island Site 192	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16432	North West Intercourse Island Site 193	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16433	North West Intercourse Island Site 194	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place		*Registered Knowledge Holder names available from DPLH	Lodged	
16434	North West Intercourse Island Site 195	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Lodged	
16435	North West Intercourse Island Site 196	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16436	North West Intercourse Island Site 198	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16437	North West Intercourse Island Site 199	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16438	North West Intercourse Island Site 200	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Landscape / Seascape Feature	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16439	North West Intercourse Island Site 201	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16440	North West Intercourse Island Site 202	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16441	North West Intercourse Island Site 203	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16442	North West Intercourse Island Site 204	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16443	North West Intercourse Island Site 205	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16444	North West Intercourse Island Site 206	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16445	West Mid Intercourse Island Site 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16446	West Mid Intercourse Island Site 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Midden; Other; Quarry; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16447	West Mid Intercourse Island Site 3	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16448	West Mid Intercourse Island Site 4	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16449	West Mid Intercourse Island Site 5	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16450	West Mid Intercourse Island Site 6	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16451	West Mid Intercourse Island Site 7	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16452	West Mid Intercourse Island Site 8	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16453	West Mid Intercourse Island Site 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16454	West Mid Intercourse Island Site 11	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16455	West Mid Intercourse Island Site 12	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16456	West Mid Intercourse Island Site 13	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16457	West Mid Intercourse Island Site 14	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Landscape / Seascape Feature; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16458	West Mid Intercourse Island Site 17	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16459	West Mid Intercourse Island Site 18	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16460	West Mid Intercourse Island Site 19	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16461	West Mid Intercourse Island Site 20	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16462	West Mid Intercourse Island Site 21	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16463	West Mid Intercourse Island Site 22	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16464	South West Burrup Site 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
16465	South West Burrup Site 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16469	South West Burrup Site 6	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16471	South West Burrup Site 8	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16473	South West Burrup Site 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16474	South West Burrup Site 11	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16476	South West Burrup Site 14	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16479	South West Burrup Site 18	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16487	South West Burrup Site 29	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16499	South West Burrup Site 41	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16500	South West Burrup Site 42	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16501	South West Burrup Site 43	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16504	South West Burrup Site 46	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16505	South West Burrup Site 47	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16506	South West Burrup Site 48	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16507	South West Burrup Site 49	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16508	South West Burrup Site 50	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16519	South West Burrup Site 62	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16531	South West Burrup Site 77	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16536	South West Burrup Site 84	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16537	South West Burrup Site 85	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
16543	South West Burrup Site 91	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16546	South West Burrup Site 94	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16547	South West Burrup Site 95	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16548	South West Burrup Site 96	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16551	South West Burrup Site 99	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16552	South West Burrup Site 100	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	
16557	South West Burrup Site 105	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Midden; Landscape / Seascape Feature; Other; Quarry; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16558	South West Burrup Site 106	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
16559	South West Burrup Site 107	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
16561	South West Burrup Site 110	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
16562	Mainland (Maitland River) Site 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
16563	Mainland (Maitland River) Site 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
16597	Baler Bluff	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
16792	Site A	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
16793	Site B	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
17192	Exmouth Station	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	
17193	Ningaloo Station	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	
17640	West Intercourse Island	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
18854	Cape Preston 51	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19026	DRD 02	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19027	DRD 03	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19028	DRD 05	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19029	DRD 06	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19030	DRD 07	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19031	DRD 09	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
19032	DRD 10	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Grinding areas / Grooves; Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
19033	DRD 14	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19034	DRD 15	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19057	DRD 04	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19058	DRD 08	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19075	DRD 38	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19088	DRD 55	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19089	DRD 56	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19090	DRD 57	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19093	DRD 60	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19094	DRD 61	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19100	DRD 69	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
19160	DRD 73	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
19171	Ceremonial Ground	Yes	Yes	Yes	Men only	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19188	DRD 28	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Traditional Structure; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19189	DRD 33	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
19190	DRD 48	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
19217	DRD 117	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Lodged	
19642	Woodside Extension Area 25	Yes	No	Yes	Men only	ACH Directory	Place	Creation / Dreaming Narrative; Engraving; Grinding areas / Grooves; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	
19670	Woodside Extension Area 55	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Traditional Structure	*Registered Knowledge Holder names available from DPLH	Registered Site	
19674	Woodside Extension Area 59	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
19675	Holden Point Quarry A	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	
19676	Holden Point Quarry B	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Traditional Structure; Midden; Other; Quarry	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
19677	Woodside Extension Area 64	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
19702	Woodside Haul Road 05	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Other	*Registered Knowledge Holder names available from DPLH	Registered Site	
20367	DP-285	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
20369	DP-287	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
20370	DP-288	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
20372	PP-03	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Registered Site	
20375	PP-19	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
20396	PR-1	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
20621	Bedout Island	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Creation / Dreaming Narrative; Landscape / Seascape Feature; Other	*Registered Knowledge Holder names available from DPLH	Lodged	
20838	PP-06/21	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
21312	Woodside Extension Area 62	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	
21499	Dolphin Island RAMMC1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
21500	Gidley Island RAMMC2	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
21503	Gidley Island RAMMC9	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
21607	Roller/Skate Site 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
21817	Parker Point 49 (PP-49)	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
21818	Parker Point 50 (PP-50)	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
21974	Parker Point 57 (PP-57)	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
21998	DP-285 (Relocated 01/02/2004)	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
22000	PP-03 (Partially Relocated 01/02/2004)	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
22002	DP-287 (Relocated 01/02/2004)	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
22121	Realignment Site 1	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
22796	PHPF57 (FMGP04-002)	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden	*Registered Knowledge Holder names available from DPLH	Registered Site	
22874	Marapikurrinya Yintha Site	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
22943	Flacourt Bay 01	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Rock Shelter	*Registered Knowledge Holder names available from DPLH	Lodged	
23198	PE 1 Camping Beach Area	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Hunting Place; Meeting Place	*Registered Knowledge Holder names available from DPLH	Lodged	
23199	PE 2 Meeting Place	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
23200	PE 3 Men's and Ceremonial Engravings	Yes	No	Yes	Men only	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
23201	PE 4 Women's Place	Yes	Yes	Yes	Women only	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
23202	PE 5 Men's Engravings A, B & C	Yes	No	Yes	Men only	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
23203	PE 6 Access Gully	Yes	No	Yes	Men only	ACH Directory	Place	Ritual / Ceremonial; Engraving; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	
23204	PE 7 Men and Women Restricted Place	Yes	No	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving; Meeting Place	*Registered Knowledge Holder names available from DPLH	Registered Site	
23205	PE 8 Men's Only Area	Yes	No	Yes	Men only	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving; Landscape / Seascape Feature; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	
23340	Woodside Pluto Area B 68	Yes	Yes	Yes	Men only	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
23372	Woodside Pluto Area B 100	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
23736	WGTO PB 152	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
24247	Woodside Audit Site 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
25578	WE010 (BMIEA)	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Traditional Structure; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Lodged	
26005	Site No. 18	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
26006	Site No. 25	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	
26416	Burrup Peninsula N1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Quarry; Shell	*Registered Knowledge Holder names available from DPLH	Lodged	
26417	Burrup Peninsula P2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Traditional Structure; Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
26453	Burrup Peninsula V34	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Engraving; Grinding areas / Grooves; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
26736	ACHM - 09-05	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	
27561	Sam's Creek Burial Site	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Registered Site	
28615	MP08-53	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Ritual / Ceremonial; Creation / Dreaming Narrative; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	
29198	CL10ENG16	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Registered Site	

Aboriginal Cultural Heritage Inquiry System

List of Aboriginal Cultural Heritage (ACH) Directory

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
29549	Boodie Soak	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
31762	Site 1	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
31763	Site 2	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
32041	PIL3381	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Midden; Shell	*Registered Knowledge Holder names available from DPLH	Registered Site	
32710	Mourambine Kariyarra 3	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Lodged	
32879	Lower Fortescue River (Mardathuni)	No	No	No	No Gender / Initiation Restrictions	ACH Directory	Place	Camp; Creation / Dreaming Narrative; Hunting Place; Landscape / Seascape Feature; Plant Resource; Water Source	*Registered Knowledge Holder names available from DPLH	Registered Site	
35246	Relocation Zone 8	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Engraving; Repository / Storage Place	*Registered Knowledge Holder names available from DPLH	Lodged	
35746	LAN18-11-01	Yes	Yes	Yes	Men only	ACH Directory	Place	Sub surface cultural material; Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
36199	Boodie Cave	No	Yes	No		ACH Directory	Place	Artefacts / Scatter; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Lodged	
36200	John Wayne Country Rockshelter	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Rock Shelter	*Registered Knowledge Holder names available from DPLH	Lodged	
36234	South End structures, Barrow Island.	No	No	No		ACH Directory	Place	Historical; Traditional Structure	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
36261	G-13-S0001	No	Yes	No		ACH Directory	Place	Quarry	*Registered Knowledge Holder names available from DPLH	Lodged	
36262	H-24-S0001	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36263	H-24-S0002	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36264	I-23-S0001	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36265	I-23-S0002	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36266	I-24-S0003	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36267	J-23-S0001	No	Yes	No		ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
36268	J-23-S0002	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36269	J-23-S0003	No	Yes	No		ACH Directory	Place	Modified Tree	*Registered Knowledge Holder names available from DPLH	Lodged	
36270	M-03-S0001	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36271	N-02-S0001	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36272	O-02-S0002	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
36273	O-05-S0003	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36344	N-05-S0002	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36345	N-05-S0001	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36346	O-05-S0001	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36347	O-05-S0002	No	Yes	No	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36348	P-04-S0001	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Lodged	
36718	Skeleton Bay	Yes	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Burial	*Registered Knowledge Holder names available from DPLH	Lodged	
37522	Mindurru (Ashburton River)	Yes	Yes	Yes		ACH Directory	Place	Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Registered Site	
38533	Cape Bruguieres Channel	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	
38628	Flying Foam Passage submerged freshwater spring	No	Yes	No		ACH Directory	Place	Artefacts / Scatter	*Registered Knowledge Holder names available from DPLH	Registered Site	
38707	MAC_CB001	Yes	Yes	Yes	Men only	ACH Directory	Place		*Registered Knowledge Holder names available from DPLH	Lodged	
38708	MAC_CB002	Yes	Yes	Yes	Men only	ACH Directory	Place		*Registered Knowledge Holder names available from DPLH	Lodged	

ID	Name	Boundary Restricted	Boundary Reliable	Culturally Sensitive	Culturally Sensitive Nature	Status	ACH Type	Place Type	Knowledge Holders	Legacy Place Status	Legacy ID
38709	MAC_CB003	Yes	Yes	Yes	Men only	ACH Directory	Place	Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
38710	MAC_CB004	Yes	Yes	Yes	Men only	ACH Directory	Place		*Registered Knowledge Holder names available from DPLH	Lodged	
38729	MAC Withnell Bay 15	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
38732	MAC Withnell Bay 18	Yes	Yes	Yes	Initiated men only	ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
38736	MAC CONZINC BAY 012	Yes	Yes	Yes	Men only	ACH Directory	Place	Engraving; Grinding areas / Grooves	*Registered Knowledge Holder names available from DPLH	Lodged	
38754	MAC CONZINC BAY 030	Yes	Yes	Yes	Men only	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
38759	MAC CONZINC BAY 035	No	Yes	No		ACH Directory	Place	Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	
39191	Warnangura (Cape Range) Cultural Precinct	No	Yes	Yes	No Gender / Initiation Restrictions	ACH Directory	Place	Artefacts / Scatter; Ritual / Ceremonial; Creation / Dreaming Narrative; Engraving; Midden; Rock Shelter; Water Source	*Registered Knowledge Holder names available from DPLH	Lodged	
39215	Cossack (Bajinhurrba) Creek	No	Yes	No		ACH Directory	Place	Creation / Dreaming Narrative	*Registered Knowledge Holder names available from DPLH	Lodged	
39276	WPA-R1	Yes	Yes	Yes	Initiated men only	ACH Directory	Place	Artefacts / Scatter; Engraving	*Registered Knowledge Holder names available from DPLH	Lodged	

Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Cultural Heritage Inquiry System

Map of Aboriginal Cultural Heritage (ACH) Directory

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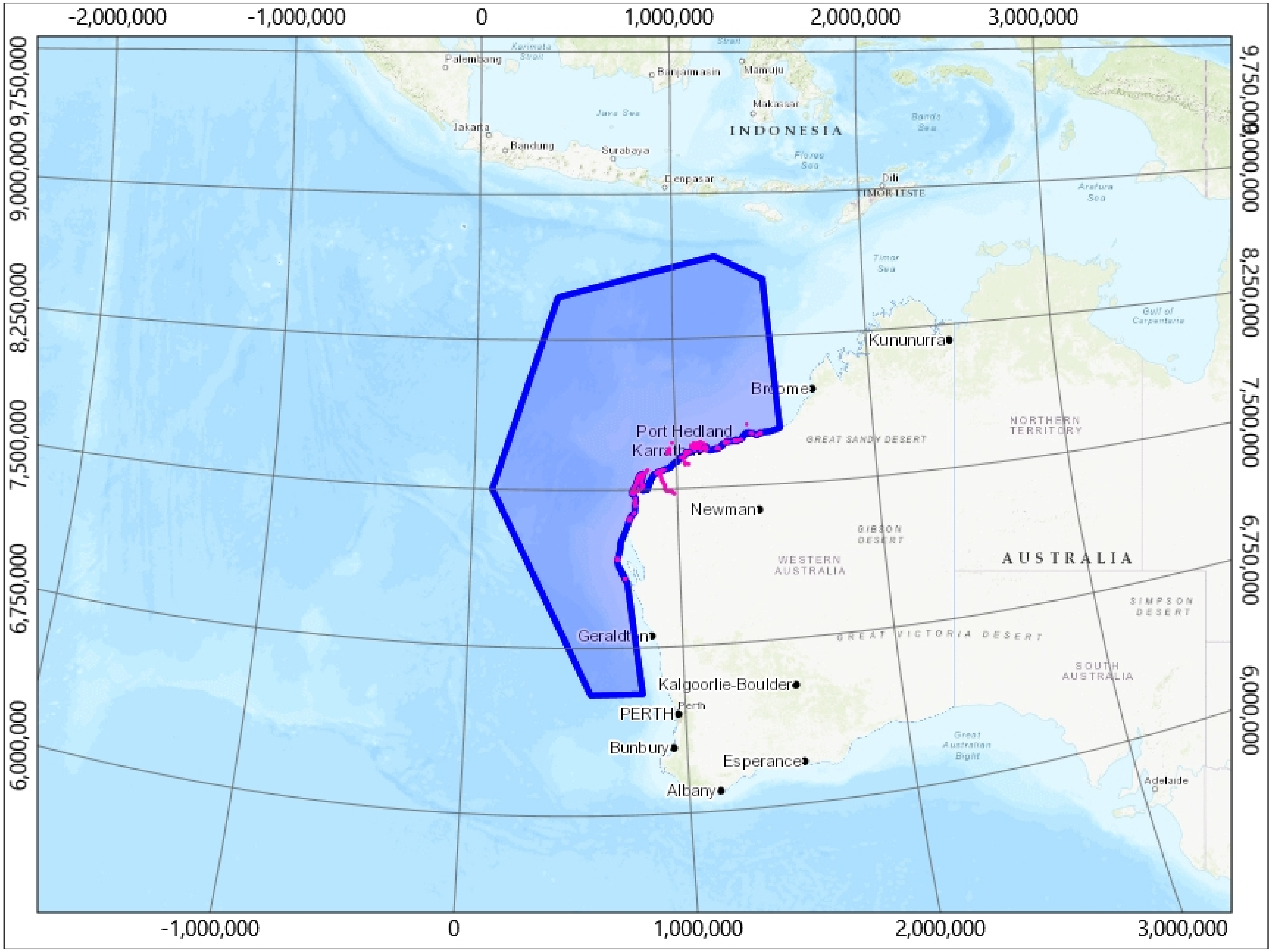

Legend

- Aboriginal Cultural Heritage (ACH) Directory
- Search Area
- Aboriginal Community
  - *Permanent*
  - *Seasonal*
  - *Town Based*
- Town
- Road
- River
- Local Government Authority

1,013.98 kilometres

Map Scale 1 : 30,730,000

MGA Zone 49 (GDA94)

APPENDIX E ACOUSTIC MODELLING FOR A CONSTRUCTION VESSEL

Woodside GWA Area Infill Development OPP

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

JASCO Applied Sciences (Australia) Pty Ltd

22 September 2023

Authors:
Alina M. Muellenmeister
Steven C. Connell
Matthew W. Koessler

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Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences (JASCO) undertook a modelling study of underwater sound levels associated with the proposed activity of a construction vessel for the North West Shelf Project's Goodwyn Alpha (GWA) Area Infill Development OPP.

The modelling study considered one scenario describing the activity of the construction vessel under dynamic positioning (DP) at the Wilcox-1 location.

The modelling study assessed distances from operations where underwater sound levels reached thresholds corresponding to various levels of potential impact to marine fauna. The animals considered here included marine mammals, sea turtles, and fish. Due to the variety of species considered, there are several different thresholds for evaluating effects, including: behavioural disturbance, impairment (temporary reduction in hearing sensitivity or temporary threshold shift; TTS), and injury (permanent threshold shift or PTS).

The methodology considered scenario specific source levels and range-dependent environmental properties. Estimated underwater acoustic levels for non-impulsive (continuous) noise sources are presented as sound pressure levels (SPL, L_p), and as accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria. In this report, the duration of the SEL accumulation is defined as integrated over a 24 hour period.

The SEL_{24h} is a cumulative metric that reflects the dosimetric effect of noise levels within a 24-hour exposure period, based on the assumption that a receiver (e.g., an animal) is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii represent an unlikely worst-case scenario. More realistically, marine mammals (as well as fish and turtles) would not stay in the same location for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be effected or impaired, but rather that an animal could be exposed to the sound level associated with impairment if it remained in that location for 24 hours.

For the results below, the distances to isopleths/thresholds were reported from the single source. Maps are provided in the report to assist with contextualising tabulated distances.

Marine mammals

The maximum distances to the (NOAA) (2019) marine mammal behavioural response criterion of 120 dB re 1 µPa (SPL) are presented in Table 1. The distances to the criteria from Southall et al. (2019) for marine mammal TTS for the vessel operations were assessed. The maximum distances and total ensonified areas are presented in Table 2.

Table 1. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to the marine mammal behavioural response criterion of 120 dB re 1 µPa (SPL) from the Wilcox-1 location.

Scenario	Description	R_{max} (km)	$R_{95\%}$ (km)
1	Construction Vessel under DP (24 hrs)	10.4	9.10

Table 2. Summary: Maximum (R_{max}) horizontal distances (in km) and ensonified area (km^2) for the frequency-weighted LF-cetacean SEL_{24h} TTS threshold from the Wilcox-1 location.

Vessel	Description	R_{max} (km)	Area (km^2)
Construction Vessel	Construction Vessel under DP (24 hrs)	3.89	31.6

Sea turtles

The threshold criteria from Finneran et al. (2017) was used to assess PTS and TTS for sea turtles. PTS is not predicted to occur within the modelling resolution (20 m), while TTS occurs up to a maximum range of 130 m from the source.

Fish

The guidelines presented in Popper et al. (2014) were used to assess recoverable injury and TTS for fish, with these effects predicted to occur in close proximity to the sound sources, less than 20 and 60 m respectively, and only if fish remain at these distances for 48 or 12 hours respectively.

1. Introduction

Woodside Energy Ltd. (Woodside) plans to develop the gas supply capabilities to the North West Shelf Project's Goodwyn Alpha (GWA) platform with a subsea tieback from hydrocarbon fields in the vicinity. This development project is called the GWA Area Infill Development OPP and proposes several production wells in multiple drill centres tied back to the GWA platform by a subsea pipeline. JASCO Applied Sciences (JASCO) performed a modelling study of underwater acoustic noise levels associated with the proposed operation of a construction vessel, incorporating site-specific environmental parameters that affect the propagation of underwater sound. The vessel considered within the study is a nominal construction vessel under DP representing the type and class of vessel likely to be used for the project.

The modelling study predicted the distances from operations at which underwater sound levels reached noise thresholds and criteria for marine mammals, sea turtles and fish. The marine mammal thresholds include levels associated with behavioural response, temporary threshold shift (TTS), and permanent threshold shift (PTS), and the marine mammal functional hearing groups considered were low-, high- and very high-frequency cetaceans. Behavioural response, TTS and PTS are also considered for the sea turtle functional hearing group while for fish, recoverable injury and TTS are considered. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), and accumulated sound exposure levels (over 24 hours) (SEL_{24h}, $L_{E,24h}$), as appropriate for non-impulsive (continuous) noise sources.

This report is structured as follows: the remainder of Section 1 provides details on the scenario considered for modelling, Section 2 explains the metrics used to represent underwater acoustic fields and the effect criteria considered. Section 3 details the methodology for predicting the source levels and modelling the sound propagation, including the specifications of the considered sound sources and the environmental parameters. The acoustic modelling results are presented in Section 4 then discussed in Section 5.

1.1. Details of Modelling Scenarios

This study considered the sound-producing activities associated with the operation of a construction vessel under dynamic positioning (DP) at the Wilcox-1 location. Woodside has indicated that the construction vessel is likely to be of a similar type and class to the vessel *Seven Vega*.

Figure 1 displays an overview of the modelling area showing the modelled site, the nearby pygmy blue whale Biologically Important Area (BIA), and the regional bathymetry. Tables 3 and 4 outline the modelled site location and scenario.

Table 3. Location details for the modelled site.

Site	Designation	Latitude (S)	Longitude (E)	MGA[1] Zone 50 (GDA94)		Water Depth (m)
				X (m)	Y (m)	
1	Wilcox-1	20° 00' 04.92"	115° 29' 19.03"	341 889	7 787 654	72.0

[1] Map Grid of Australia (MGA)

Table 4. Summary of the modelled scenario.

Scenario	Associated Site(s)	Scenario description	Operation Time
1	1	1x Construction Vessel under DP	24 h

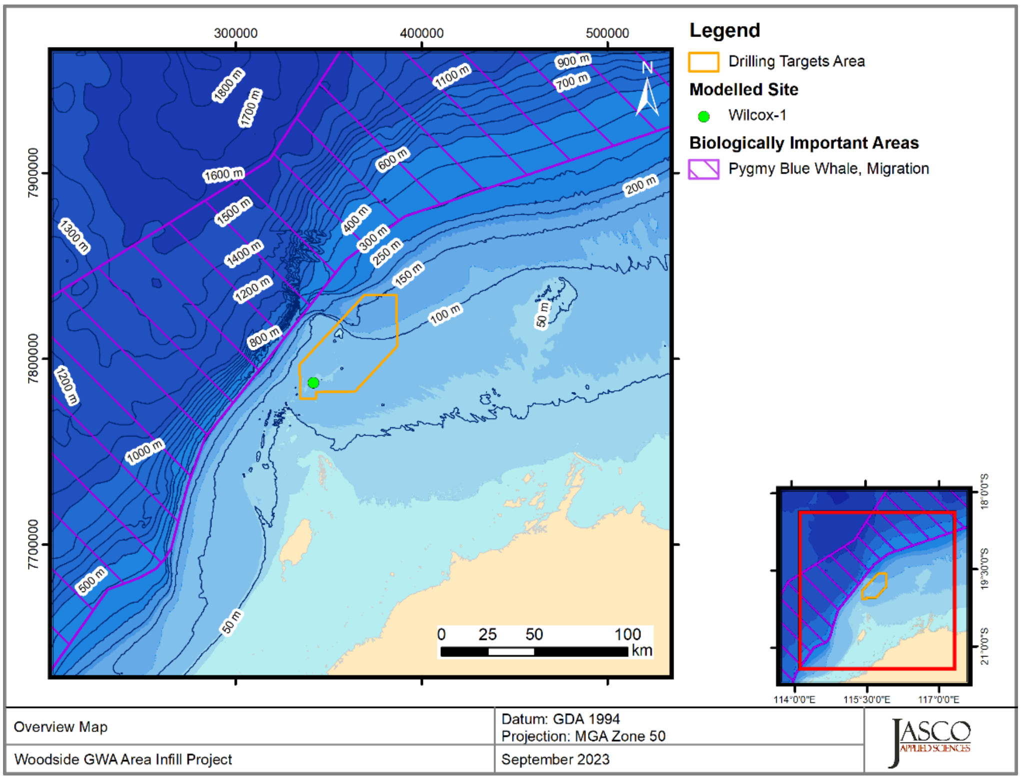

Figure 1. Overview map of the modelled site, biologically important areas, and features of the Woodside GWA Area Infill Development OPP.

2. Noise Effect Criteria

To assess the potential effects of a sound-producing activity, it is necessary to first establish exposure criteria (thresholds) for which sound levels may be expected to have an adverse effect on animals. Whether acoustic levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that investigate the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

Two sound level metrics, SPL and SEL, are commonly used to evaluate non-impulsive noise and its effects on marine life. In this report, the duration of the SEL accumulation is defined as integrated over a 24-hour period. The acoustic metrics in this report reflect the ANSI and ISO standards for acoustic terminology, ANSI S1.1 (S1.1-2013) and ISO 18405:2017 (2017).

The following thresholds and guidelines for this study were chosen because they represent the best available science:

1. Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Southall et al. (2019) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals for non-impulsive sound sources.
2. Marine mammal behavioural threshold based on the current interim US National Oceanic and Atmospheric Administration (NOAA) (2019) criterion for marine mammals of 120 dB re 1 µPa (SPL; L_p) for non-impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).
4. Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in sea turtles.

Section 2.1, along with Appendix A.3 and A.4, expands on the thresholds, guidelines, and sound levels for marine mammals. Section 2.2 expands on the criteria for fish and sea turtles.

2.1. Marine Mammals

Cetaceans represent a potentially sensitive receptor group of marine mammals and given the proximity to the pygmy blue whale migration BIA, were the focus of this assessment. The criteria applied in this study to assess possible effects of non-impulsive noise sources on marine mammals are summarised in Table 5 and further explained in Sections 2.1.1 and 2.1.2. Details on thresholds related to auditory threshold shifts or hearing loss and behavioural response are provided in Appendix A.3, with frequency weighting explained in detail in Appendix A.4.

Table 5. Criteria for effects of non-impulsive noise exposure, including vessel noise, for marine mammals: Unweighted SPL and weighted SEL_{24h} thresholds.

Hearing group	NOAA (2019)	Southall et al. (2019)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
Low-frequency (LF) cetaceans	120	199	179
High-frequency (HF) cetaceans		198	178
Very High-frequency (VHF) cetaceans		173	153

L_p denotes sound pressure level and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa^2·s.

2.1.1. Behavioural Response

The NOAA non-pulsed noise criterion was selected for this assessment because it represents the most commonly applied behavioural response criterion by regulators. Accordingly, behavioural responses were assumed to occur in areas ensonified above an unweighted SPL of 120 dB re 1 µPa (NOAA 2019). Appendix A.3 provides more information about the development of this criteria.

Southall et al. (2021) provide recommendations and discusses the nuances of assessing behavioural response, however the authors of the study do not present new numerical thresholds for onset of behavioural responses for marine mammals, so the previously established guidelines from the US National Oceanic and Atmospheric Administration (NOAA) (2019) have been used.

2.1.2. Injury and Hearing Sensitivity Changes

There are two categories of auditory threshold shifts or hearing loss: permanent threshold shift (PTS), a physical injury to an animal's hearing organs; and temporary threshold shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of receptor hair cells in the cochlea becoming fatigued.

To assist in assessing the potential for effect on marine mammals, this report applies the criteria recommended by Southall et al. (2019), considering both PTS and TTS (see Table 5). Appendix A.3 provides more information about the Southall et al. (2019) criteria.

2.2. Fish, Sea turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Sea Turtles was formed to continue developing noise exposure criteria for fish and sea turtles, work begun by a NOAA panel two years earlier. The Working Group developed guidelines with specific thresholds for different levels of effects for several species groups (Popper et al. 2014). The guidelines define quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death,
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma, and
- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. However, as these depend upon activity-based subjective ranges, these effects are not addressed in this report and are included in Table 6 for completeness only.

For fish, because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure depends on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Sea turtles, fish eggs, and fish larvae are considered separately.

Table 6 lists the relevant effects thresholds from Popper et al. (2014) for shipping and continuous noise, most of which are qualitative. Some evidence suggests that fish sensitive to acoustic pressure show a recoverable loss in hearing sensitivity, or injury when exposed to high levels of noise (Scholik and Yan (2002), Amoser and Ladich (2003), Smith et al. (2006)); this is reflected in the SPL thresholds for fish with a swim bladder involved in hearing (shaded cells in Table 6). Finneran et al. (2017) presented revised quantitative thresholds for turtle injury, considering frequency weighted SEL, which have been applied in this study for vessels (Table 7).

Table 6. Criteria for non-impulsive (vessel) noise exposure for fish, adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB SPL for 48 h	158 dB SPL for 12 h	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Sound pressure level dB re 1 µPa.
Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

Table 7. Acoustic effects of non-impulsive noise on sea turtles, weighted SEL_{24h}, Finneran et al. (2017).

PTS onset thresholds* (received level)	TTS onset thresholds* (received level)
220	200

3. Methods

The following sections describe the inputs used for this underwater noise modelling study. Section 3.1 details the modelled source for the nominal vessel and Sections 3.2 and 3.3 provide details on the applied modelling techniques and model configuration information.

3.1. Vessel Noise Sources

Underwater sound that radiates from vessels is produced mainly by propeller and thruster cavitation, with a smaller fraction of noise produced by sound transmitted through the hull, such as by engines, gearing, and other mechanical systems. Sound levels tend to be the highest when thrusters are used to position the vessel and when the vessel is transiting at high speeds. A vessel's sound signature depends on the vessel's size, power output, propulsion system (e.g., conventional propellers vs. Voith Schneider propulsion), and the design characteristics of the given system (e.g., blade shape and size). A vessel produces broadband noise emissions with most of the energy emitted below a few kilohertz. Sound from onboard machinery, particularly sound below 200 Hz, dominates the sound spectrum before cavitation begins (Spence et al. 2007).

The energy source level (ESL) spectra for the modelled vessel is shown in Figure 2; additional detail on the source is provided in Section 3.1.1.

3.1.1. Construction Vessel

The construction vessel planned for the GWA Area Infill Development OPP will be similar to the *Seven Vega*. The *Seven Vega* is a DP Class 3 reel-lay vessel designed to install complex rigid flowlines including pipe-in-pipe systems, piggyback systems, and electrical trace heating. The vessel has an overall length, breadth, and draft of 149.2, 33 and 8.3 m, respectively.

No publicly available underwater noise measurements of the *Seven Vega* under DP are available, therefore this vessel has been modelled using the spectra of the publicly available *Siem Sapphire* (McPherson et al. 2021). The overall broadband level of the *Siem Sapphire* has been scaled down as it is a vessel with more installed power (22840 kW compared to 18800 kW of the *Seven Vega*). The broadband (10 Hz to 25 kHz) source level of the construction vessel under DP has been modelled as 193.2 dB re 1 μPa^{2}m^2·s (Figure 2).

The source depth of the *Seven Vega* has been modelled as 70% of the vessel draft (draft of 8.3 m, resulting in a source depth of 5.8 m), per ISO 17208-1 (2016).

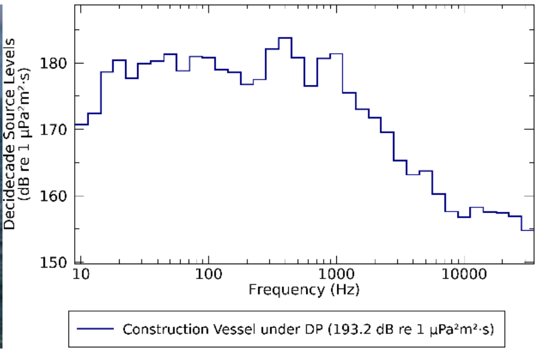

Figure 2. Energy source level (ESL) spectra (in decidecade frequency-band) for the construction vessel under DP (Photo source: Subsea 7).

3.2. Geometry and Modelled Regions

JASCO's Marine Operations Noise Model (MONM-BELLHOP; see Appendix B.2.2) was used to predict the acoustic field at frequencies of 10 Hz to 25 kHz for the considered source. To supplement the MONM results, high-frequency results for propagation loss were modelled using BELLHOP (Porter and Liu 1994) for frequencies from 1.25 to 25 kHz. The MONM and BELLHOP results were combined to produce results for the full frequency range of interest. Modelling calculated propagation loss up to 80 km from the source, with a horizontal separation of 20 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta = 2.5°$ for a total of N = 144 radial planes. Receiver depths were chosen to span the entire water column over the modelled areas, from 2 m to a maximum of 1500 m.

To produce the maps of received sound level isopleths, and to calculate distances to specified sound level thresholds, the maximum-over-depth level was calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth levels were then resampled (by linear triangulation) to produce a regular Cartesian grid. The contours and threshold ranges were calculated from these grids of the modelled acoustic field.

3.3. Accumulated SEL

In this study, the sound source was considered to be continuously operating with new sound energy constantly being introduced to the environment. The reported source levels are usually in terms of sound pressure levels (SPL), representing the average instantaneous acoustic level of a considered source. The evaluation of the cumulative sound field (i.e., in terms of SEL_{24h}) depends on the number of seconds of operation during the accumulation period.

The SPL modelling results were converted to SEL by the duration of the activity, which is appropriate for non-impulsive noise sources. SEL was assessed over 24 h and for a stationary vessel/source. The conversion from SPL was obtained by increasing the levels by $10*\log_{10}(T)$, where T is 86,400 s (the number of seconds in 24 h). Additional information on acoustic metrics can be found in Appendix A.1.

4. Results

4.1. Acoustic Modelling Tabulated Results

Table 8 presents the maximum and 95% distances (defined in Appendix B.3) to SPL isopleths. Table 9 presents the maximum distances to frequency-weighted SEL_{24h} thresholds, as well as total ensonified area.

For the results below, the distances to isopleths/thresholds were reported from the single source. Maps are provided in Section 4.2 to assist with contextualising tabulated distances.

Table 8. *SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL). Scenario description is given in Table 4.

SPL (L_p; dB re 1 µPa)	Scenario 1	
	R_{max} (km)	$R_{95\%}$ (km)
170[a]	–	–
160	0.06	0.06
158[b]	0.06	0.06
150	0.20	0.19
140	1.08	0.99
130	4.27	3.76
120[c]	10.4	9.10
110	24.0	21.2

[a] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).
[b] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).
[c] Threshold for marine mammal behavioural response to non-impulsive noise (NOAA 2019).
A dash indicates the level was not reached within the limits of the modelled resolution (20 m).

Table 9. *Weighted SEL$_{24h}$*: Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on Southall et al. (2019) and Finneran et al. (2017) from the sound source, and ensonified area (km^2).Scenario description is given in Table 4.

Hearing group	Frequency-weighted SEL$_{24h}$ threshold ($L_{E,24h}$; dB re 1 µPa^2·s)	Scenario 1	
		R_{max} (km)	Area (km^2)
PTS			
LF cetaceans	199	0.17	0.09
HF cetaceans	198	–	–
VHF cetaceans	173	0.10	0.03
Sea Turtles	220	–	–
TTS			
LF cetaceans	179	3.89	31.6
HF cetaceans	178	0.09	0.02
VHF cetaceans	153	1.19	4.23
Sea Turtles	200	0.13	0.05

A dash indicates the level was not reached within the limits of the modelled resolution (20 m).

4.2. Sound Field Maps and Graphs

Maps of the estimated sound fields, threshold contours, and isopleths of interest for SPL and SEL_{24h} sound fields are presented for the construction vessel scenario. The SPL results are presented in Figure 3 (Section 4.2.1), whilst the SEL_{24h} results are presented in Figure 4 (Section 4.2.2).

4.2.1. Instantaneous SPL Sound Level Contour Maps

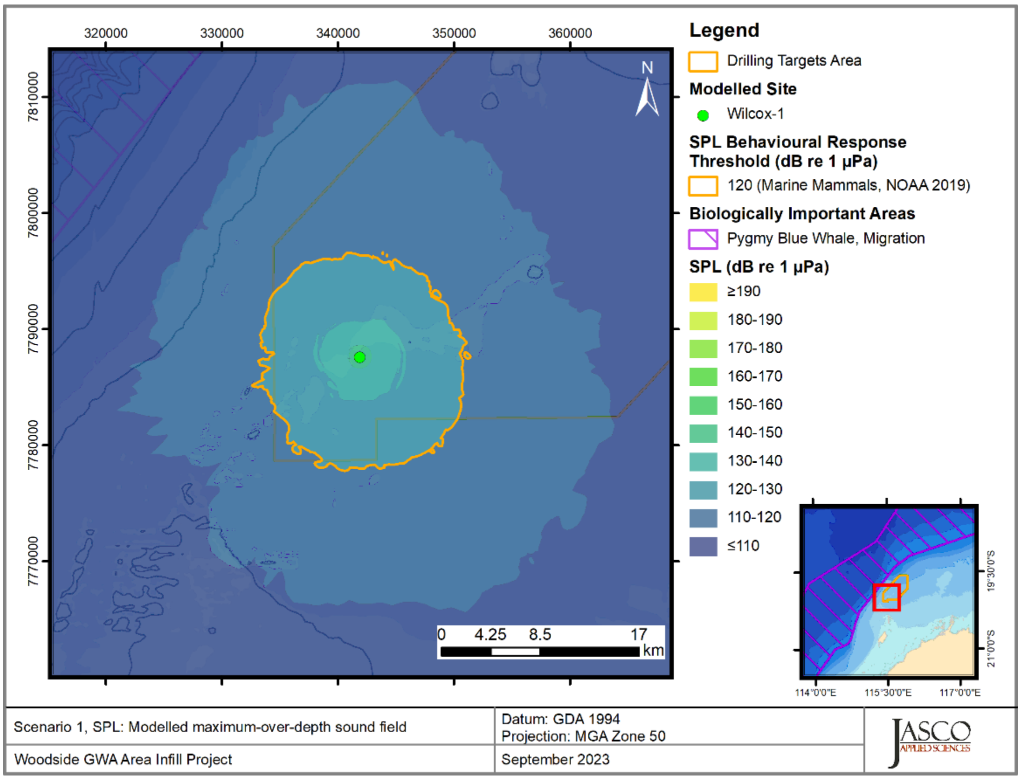

Figure 3. *Scenario 1, construction vessel under DP*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth for behavioural response threshold for marine mammals.

4.2.2. Accumulated SEL_{24h} Sound Level Contour Maps

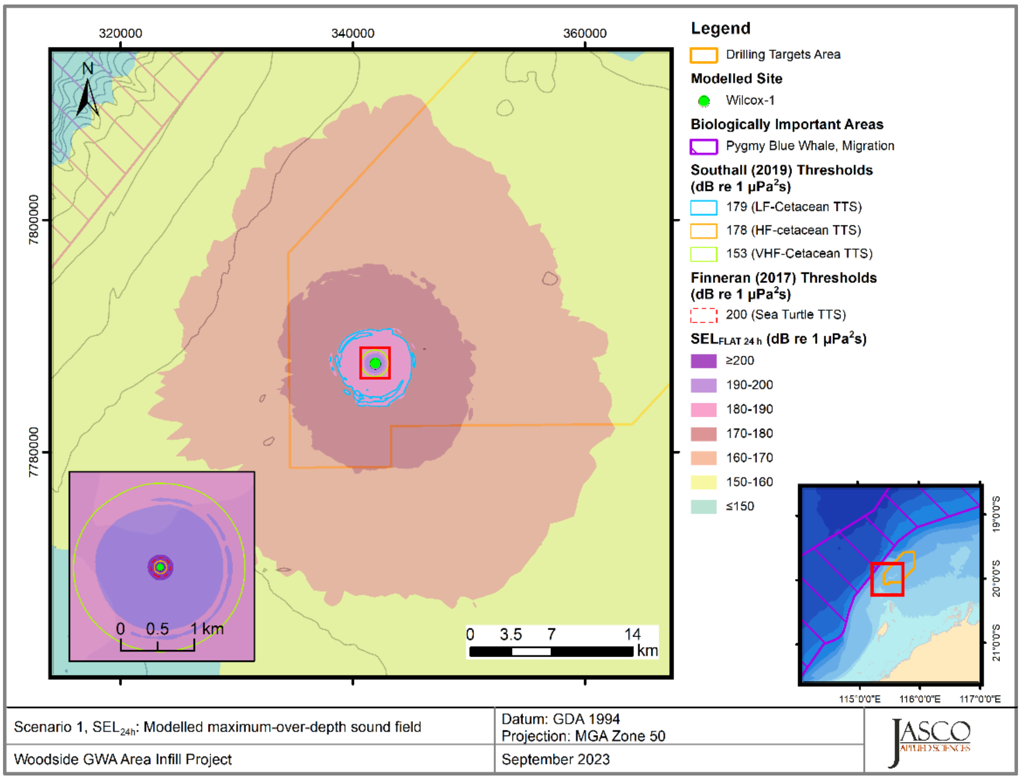

Figure 4. *Scenario 1, construction vessel under DP*, *SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, with isopleths for TTS in low-, high- and very-high-frequency cetaceans and sea turtles.

5. Discussion and Conclusion

This modelling study predicted underwater sound levels associated with Woodside's proposed construction activities for the GWA Area Infill Development OPP within the vicinity of Rankin Bank on the North West Shelf of Western Australia. The underwater sound field was modelled for a construction vessel at site Wilcox-1. The vessel was modelled as a single point source with a source level spectrum representative of the cumulative contribution of all thrusters.

A September yearly average sound speed profile (Appendix B.1.2) was conservatively selected as part of the approach to estimate distances to received sound level thresholds. The sound speed profile was primarily downwards refracting until about 900 m water depth. The profile had a minimum sound speed at the sound channel axis at about 900 m. At shallow depths, sound speed was greater due to higher temperatures, and below 900 m the sound speed also increased at a gradual rate due to increasing pressure. Near the sea surface, a slightly upward refracting layer was present and extended to about 25 m water depth. Modelling also accounted for site-specific bathymetric variations (Appendix B.1.1) and local geoacoustic properties (Appendix B.1.3).

The modelled site was situated over a water depth of 72 m and the modelled area comprised one defined geological area with a single representative water column profile. The bathymetry within the modelled area varied little in the immediate vicinity of the modelling site but descended steeply at 30 – 60 km toward the north/northwest of the modelling site (refer to Appendix B.1.1). The majority of the modelled area was shallower than 1000 m depth, although the maximum depth within the modelling area was 1534 m. The maximum-over-depth sound footprint maps (Section 4.2) assist in demonstrating the influence of the bathymetry, sound speed profile and seabed composition on the sound field.

For the results tables presented in Section 4.1, where a dash is used in place of a horizontal distance, these thresholds may or may not be reached. Due to the discretely sampled 20 m calculation grids of the modelled sound fields, distances to these levels could not be estimated for practicable computational purposes. It is likely that SPL isopleths could be reached at distances between the source and the modelled horizontal resolution (20 m); however, distances to injurious accumulated SEL thresholds may not be reached at any range due the species-specific frequency weighing functions. Additionally, if close-to-source radii are comparable to the dimensions of the modelled vessel then they may only be reached within close proximity to a vessel, if at all.

Table 10 summarises the maximum horizontal distances to behavioural (unweighted SPL) and physiological effects (weighted PTS and TTS) thresholds across the modelled scenario.

Table 10. Summary of maximum (R_{max}) horizontal distances (in km) from the modelled scenario considered to the marine mammal behavioural response criterion of 120 dB re 1 µPa (unweighted SPL) and frequency-weighted LF-cetacean SEL_{24h} TTS threshold based on Southall et al. (2019) and Finneran et al. (2017) for sea turtles.

Scenario Number	Description	Marine Mammal Behavioural Response [a]	LF-cetacean TTS [b]	Sea Turtle TTS [c]
		R_{max} (km)	R_{max} (km)	R_{max} (km)
1	Construction Vessel under DP (24 hrs)	10.4	3.89	0.13

Noise exposure criteria: [a] NOAA (2019) and [b] Southall et al. (2019) or [c] Finneran et al. (2017).
A dash indicates the level was not reached within the limits of the modelled resolution (20 m).

Glossary

1/3-octave

One third of an octave. *Note*: A 1/3-octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec).

absorption

The conversion of sound energy to heat energy. Specifically, the reduction of sound pressure amplitude due to particle motion energy converting to heat in the propagation medium.

acoustic noise

Sound that interferes with an acoustic process.

acoustic self-noise

Sound at a receiver caused by the deployment, operation, or recovery of a specified receiver, and its associated platform (ISO 18405:2017).

agent-based modelling

A computer simulation of autonomous agents (sometimes called animats) acting in an environment, used to assess the agents' experience of the environment and/or their effect on the environment. See also animal movement modelling.

ambient sound

Sound that would be present in the absence of a specified activity (ISO 18405:2017). It is usually a composite of sound from many sources near and far, e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

animal movement modelling

Simulation of animal movement based on behavioural rules for the purpose of predicting an animal's experience of an environment. A type of agent-based modelling.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium. Attenuation depends on frequency—higher frequency sounds are attenuated faster than lower frequency sounds.

audiogram

A graph or table of hearing threshold as a function of frequency that describes the hearing sensitivity of an animal over its hearing range.

auditory frequency weighting

The process of applying an auditory frequency-weighting function. An example for marine mammals are the auditory frequency-weighting functions published by Southall et al. (2007).

auditory frequency-weighting function

Frequency-weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.

background noise

Combination of ambient sound, acoustic self-noise, and, where applicable, sonar reverberation (ISO 18405:2017) that is detected, measured, or recorded with a signal.

bandwidth

A range within a continuous band of frequencies. Unit: hertz (Hz).

broadband level

The total level measured over a specified frequency range. If the frequency range is unspecified, the term refers to the entire measured frequency range.

cavitation

A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean

Member of the order Cetacea. Cetaceans are aquatic mammals and include whales, dolphins, and porpoises.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called a longitudinal wave. In seismology/geophysics, it's called a primary wave or P-wave. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

conductivity-temperature-depth (CTD)

Measurement data of the ocean's conductivity, temperature, and depth; used to compute sound speed profiles and salinity.

continuous sound

A sound whose sound pressure level remains above the background noise during the observation period and may gradually vary in intensity with time, e.g., sound from a marine vessel.

critical band

The auditory bandwidth within which background noise strongly contributes to masking of a single tone. Unit: hertz (Hz).

critical ratio level

The difference between the sound pressure level of a masked tone, which is barely audible, and the spectral density level of the background noise at similar frequencies, referenced to 1 Hz. Unit: decibel (dB).

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006). For example, one decade up from 1000 Hz is 10,000 Hz, and one decade down is 100 Hz.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Especially suited to quantify variables with a large dynamic range.

decidecade

One tenth of a decade. Approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct), and for this reason sometimes referred to as a 1/3-octave.

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

delphinid

Member of the family of oceanic dolphins (Delphinidae), composed of approximately 35 extant species, including dolphins, porpoises, and killer whales.

energy source level

A property of a sound source equal to the sound exposure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2 s$.

ensonified

Exposed to sound.

equal-loudness-level contour

Curve that shows, as a function of frequency, the sound pressure level required to produce a given loudness for a listener having normal hearing, listening to a specified kind of sound in a specified manner (ANSI S1.1-2013).

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

frequency

The rate of oscillation of a periodic function measured in cycles per unit time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency-weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function (ISO 18405:2017). For sound of a given frequency, the frequency-weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency-weighting function*: compensatory frequency-weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency-weighting function*: frequency-weighting function describing the sensitivity of an acoustic recording system, which typically consists of a hydrophone, one or more amplifiers, and an analog-to-digital converter.

functional hearing group

Category of animal species when classified according to their hearing sensitivity, hearing anatomy, and susceptibility to sound. For marine mammals, initial groupings were proposed by Southall et al. (2007), and revised groupings are developed as new research/data becomes available. Revised groupings proposed by Southall et al. (2019) include low-frequency cetaceans, high-frequency cetaceans, very high-frequency cetaceans, phocid carnivores in water, other carnivores in water, and sirenians. See auditory frequency-weighting functions, which are often applied to these groups. Example hearing groups for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

geoacoustic

Relating to the acoustic properties of the seabed.

harmonic

A sinusoidal sound component that has a frequency that is an integer multiple of the frequency of a sound to which it is related. For a sound with a fundamental frequency of f, the harmonics have frequencies of $2f$, $3f$, $4f$, etc.

hearing threshold

For a given species or functional hearing group, the sound level for a given signal that is barely audible (i.e., that would be barely audible for a given individual in the presence of specified background noise during a specific percentage of experimental trials).

hertz (Hz)

Unit of frequency defined as one cycle per second. Often expressed in multiples such as kilohertz (1 kHz = 1000 Hz).

high-frequency (HF) cetaceans

See functional hearing group. *Note*: The mid- and high-frequency cetaceans groups proposed by Southall et al. (2007) were renamed high- and very-high-frequency cetaceans, respectively, by Southall et al. (2019).

hydrophone

An underwater sound pressure transducer. A passive electronic device for recording or listening to underwater sound.

hydrostatic pressure

The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

impulsive sound

Qualitative term meaning sounds that are typically transient, brief (less than 1 s), broadband, with rapid rise time and rapid decay. They can occur in repetition or as a single event. Sources of impulsive sound include, among others, explosives, seismic airguns, and impact pile drivers.

isopleth

A line drawn on a map through all points having the same value of some specified quantity (e.g., sound pressure level isopleth).

knot (kn)

Unit of vessel speed equal to 1 nautical mile per hour.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. For example, a value of sound pressure level with reference to 1 μPa^2 can be written in the form *x* dB re 1 μPa^2.

low-frequency (LF) cetaceans

See functional hearing group.

masking

Obscuring of sounds of interest by other sounds at similar frequencies.

median

The 50th percentile of a statistical distribution.

mid-frequency (MF) cetaceans

See functional hearing group. *Note*: The mid-frequency cetaceans group proposed by Southall et al. (2007) was renamed high-frequency cetaceans by Southall et al. (2019).

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point source (monopole). Often used to quantify source levels of vessels or industrial operations from measurements. See also radiated noise level.

Monte Carlo simulation

A method of investigating the distribution of a non-linear multi-variate function by random sampling of its input variable distributions.

multiple linear regression

A statistical method that seeks to explain the response of a dependent variable using multiple explanatory variables.

M-weighting

A set of auditory frequency-weighting functions proposed by Southall et al. (2007).

mysticete

Member of the Mysticeti, a suborder of cetaceans. Also known as baleen whales, mysticetes have baleen plates (rather than teeth) that they use to filter food from water (or from sediment as for grey whales). This group includes rorquals (Balaenopteridae, such as blue, fin, humpback, and minke whales), right and bowhead whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

***N* percent exceedance level**

The sound level exceeded *N* % of the time during a specified time interval. See also percentile level.

non-impulsive sound

Sound that is not an impulsive sound. Not necessarily a continuous sound.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete

Member of Odontoceti, a suborder of cetaceans. These whales, dolphins, and porpoises have teeth (rather than baleen plates). Their skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid

Member of the family Otariidae, one of the three groupings of pinnipeds (along with phocids and walrus). These eared seals, commonly called fur seals and sea lions, are adapted to semi-aquatic life; they use their large fore flippers for propulsion underwater and can walk on all four limbs on land.

otariid pinnipeds underwater (OW)

See functional hearing group.

other marine carnivores in water (OCW)

See functional hearing group.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of backscattered sound (which are negligible for most ocean-acoustic propagation problems), simplifying the computation of propagation loss.

particle acceleration, particle displacement, particle motion, particle velocity

See sound particle acceleration, sound particle displacement, sound particle motion, sound particle velocity.

peak sound pressure level (PK), zero-to-peak sound pressure level

The level (L_{pk}) of the squared maximum magnitude of the sound pressure (p_{pk}^2) in a stated frequency band and time window. Defined as $L_{\mathrm{pk}} = 10\log_{10}(p_{\mathrm{pk}}^2/p_0^2) = 20\log_{10}(p_{pk}/p_0)$. Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 μPa^2.

peak-to-peak sound pressure

The difference between the maximum and minimum sound pressure over a specified frequency band and time window. Unit: pascal (Pa).

percentile level

The sound level not exceeded *N* % of the time during a specified time interval. The *N*th percentile level is equal to the (100−*N*) % exceedance level. See also N percent exceedance level.

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. Considered auditory injury. Compare with temporary threshold shift.

phocid

Member of the family Phocidae, one of the three groupings of pinnipeds (along with otariids and walrus). These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves underwater.

phocid pinnipeds underwater (PW), phocid carnivores in water (PCW)

See functional hearing group.

pinniped

Member of the superfamily Pinnipedia, which is composed of phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source

A source that radiates sound as if from a single point.

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, $\mathrm{PL}(x) = \mathrm{SL} - L(x)$.
Unit: decibel (dB). See also transmission loss.

radiated noise level (RNL)

A source level that has been calculated assuming sound pressure decays geometrically with distance from the source, with no influence of the sea-surface or seabed. Often used to quantify source levels of vessels or industrial operations from measurements. See also monopole source level.

received level

The level of a given field variable measured (or that would be measured) at a given location.

reference value

Standard value of a quantity used for calculating underwater sound level. The reference value depends on the quantity for which the level is being calculated:

Quantity	Reference value
Sound pressure	p_0^2 = 1 μPa^2 or p_0 = 1 μPa
Sound exposure	E_0 = 1 μPa^2 s
Sound particle displacement	δ_0^2 = 1 pm^2
Sound particle velocity	u_0^2 = 1 nm^2/s^2
Sound particle acceleration	a_0^2 = 1 μm^2/s^4

sensation level

Difference between the sound pressure level and hearing threshold at a specified frequency.
Unit: decibel (dB).

shear wave

A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called a secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sirenians (SI)

Members of the order Sirenia, which includes several manatee species and the dugong. See also functional hearing group.

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium. In common meaning, a form of energy that propagates through media (e.g., water, air, ground) as pressure waves.

sound exposure

Time integral of squared sound pressure over a stated time interval in a stated frequency band. The time interval can be a specified time duration (e.g., 24 h) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: pascal squared second (Pa^2 s). Symbol: E.

sound exposure level (SEL)

The level (L_E) of the sound exposure (E) in a stated frequency band and time window: $L_E = 10\log_{10}(E/E_0)$ (ISO 18405:2017). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 μPa^2 s.

sound exposure spectral density

Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ISO 18405:2017). Unit: pascal squared second per hertz (Pa^2 s/Hz).

sound field

Region containing sound waves.

sound intensity

Product of the sound pressure and the sound particle velocity (ISO 18405:2017). The magnitude of the sound intensity is the sound energy flowing through a unit area perpendicular to the direction of propagation per unit time. Unit: watt per metre squared (W/m^2). Symbol: I.

sound particle acceleration

The rate of change of sound particle velocity. Unit: metre per second squared (m/s^2). Symbol: a.

sound particle motion

Movement caused by the action of sound of the smallest volume of a medium that represents its mean physical properties. Important for determining effects of underwater noise on fishes and invertebrates because their hearing organs sense particle motion rather than sound pressure.

sound particle displacement

Displacement of a material element caused by the action of sound, where a material element is the smallest element of the medium that represents the medium's mean density (ISO 18405:2017). Unit: metre (m). Symbol: δ.

sound particle velocity

The velocity of a particle in a material moving back and forth in the direction of the pressure wave. Unit: metre per second (m/s). Symbol: u.

sound pressure

The contribution to total pressure caused by the action of sound (ISO 18405:2017). Unit: pascal (Pa). Symbol: p.

sound pressure level (SPL), rms sound pressure level

The level (L_p) of the time-mean-square sound pressure (p^2_{rms}) in a stated frequency band and time window: $L_p = 10\log_{10}(p^2_{\mathrm{rms}}/p^2_0) = 20\log_{10}(p_{rms}/p_0)$, where rms is the abbreviation for root-mean-square. Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 µPa^2. SPL can also be expressed in terms of the root-mean-square (rms) with a reference value of p_0 = 1 µPa. The two definitions are equivalent.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

soundscape

The characterization of the ambient sound in terms of its spatial, temporal, and frequency attributes, and the types of sources contributing to the sound field (ISO 18405:2017).

source level (SL)

A property of a sound source equal to the sound pressure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 µPa^2 m^2.

spectrogram

A visual representation of acoustic amplitude over time and frequency. A spectrogram's resolution in the time and frequency domains should generally be stated as it determines the information content of the representation.

spectrum

Distribution of acoustic signal content over frequency, where the signal's content is represented by its power, energy, mean-square sound pressure, or sound exposure.

surface duct

The upper portion of a water column within which the gradient of the sound speed profile causes sound to refract upward and therefore reflect repeatedly off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity caused by noise exposure. Compare with permanent threshold shift.

thermocline

A depth interval near the ocean surface that experiences larger temperature gradients than the layers above and below it due to warming or cooling by heat conduction from the atmosphere and by warming from the sun.

transmission loss (TL)

The difference between a specified level at one location and that at a different location: $\mathrm{TL}(x_1,x_2) = L(x_1) - L(x_2)$ (ISO 18405:2017). Unit: decibel (dB). See also propagation loss.

unweighted

Term indicating that no frequency-weighting function is applied.

very high-frequency (VHF) cetaceans

See functional hearing group.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Acoustic Metrics

This section describes in detail the acoustic metrics, impact criteria, and frequency weighting relevant to the modelling study.

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI S1.1-2013).

The sound pressure level (SPL or L_p; dB re 1 µPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\, p^2(t)\, dt \Big/ p_0^2\right) \text{dB} \tag{A-1}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function.

The sound exposure level (SEL or L_E; dB re 1 µPa^2·s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\, dt \Big/ T_0 p_0^2\right) \text{dB} \tag{A-2}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right) \text{dB}\,. \tag{A-3}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.4). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should also be specified.

A.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3 octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{\frac{i}{10}}\ \text{kHz} \tag{A-4}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{lo,i} = 10^{\frac{-1}{20}} f_c(i) \quad \text{and} \quad f_{hi,i} = 10^{\frac{1}{20}} f_c(i) \tag{A-5}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band 10 ($f_c(10)$ = 10 Hz) to band 44 ($f_c(44)$ = 25 kHz).

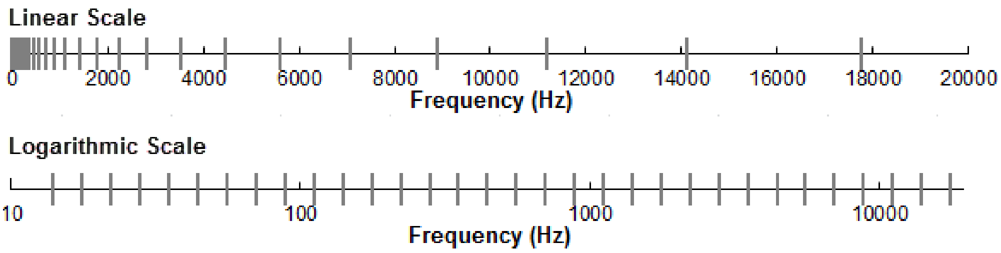

Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{lo,i}$ and $f_{hi,i}$:

$$L_{p,i} = 10\,log_{10} \int_{f_{lo,i}}^{f_{hi,i}} S(f)\,df\ \ \text{dB} \tag{A-6}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10\log_{10} \sum_i 10^{\frac{L_{p,i}}{10}}\ \text{dB} \tag{A-7}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient sound signal. Because the decidecade bands are wider than 1 Hz, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

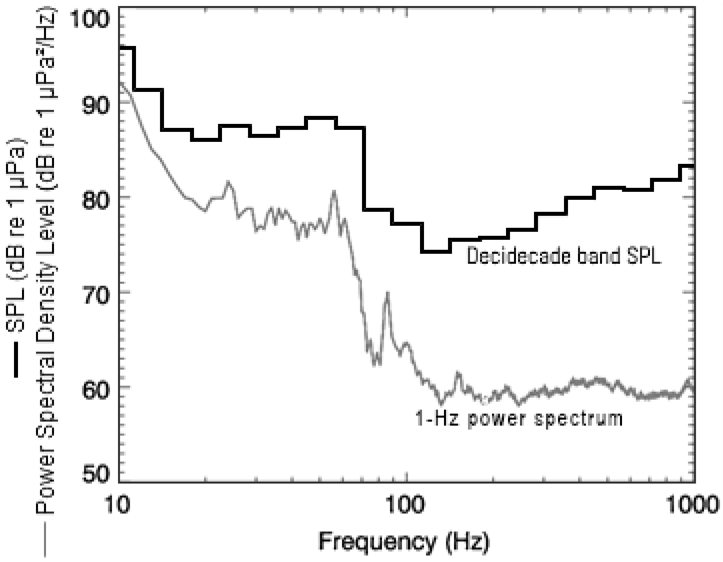

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the power spectrum.

A.3. Marine Mammal Noise Effect Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggest that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for auditory injury, impairment, and disturbance. The following sections summarise the recent development of thresholds; however, this field remains an active research topic.

A.3.1. Injury and Hearing Sensitivity Changes

In recognition of shortcomings of the SPL-only based auditory injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual auditory injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for humans; see Appendix A.4). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower PTS and TTS values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 $\mu Pa^2 \cdot s$. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced the Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 $\mu Pa^2 \cdot s$.

As of present, a definitive approach is still not apparent. There is consensus in the research community that an SEL-based method is preferable, either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes auditory injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018 (NMFS 2018). Southall et al. (2019) revisited the interim criteria published in 2007. All noise exposure criteria in NMFS (2018) and Southall et al. (2019) are identical (for impulsive and non-impulsive sounds); however, the mid-frequency cetaceans from NMFS (2018) are classified as high-frequency cetaceans in Southall et al.

(2019), and high-frequency cetaceans from NMFS (2018) are classified as very-high-frequency cetaceans in Southall et al. (2019).

A.3.2. Behavioural Response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

NMFS currently uses step function (all-or-none) threshold of 120 dB re 1 µPa SPL (unweighted) for non-impulsive sounds to assess and regulate noise-induced behavioural impacts on marine mammals (NOAA 2019). The 120 dB re 1 µPa threshold is associated with continuous sources and was derived based on studies examining behavioural responses to drilling and dredging (NOAA 2018), referring to Malme et al. (1983), Malme et al. (1984), and Malme et al. (1986), which were considered in Southall et al. (2007). Malme et al. (1986) found that playback of drillship noise did not produce clear evidence of disturbance or avoidance for levels below 110 dB re 1 µPa (SPL), possible avoidance occurred for exposure levels approaching 119 dB re 1 µPa. Malme et al. (1984) determined that measurable reactions usually consisted of rather subtle short-term changes in speed and/or heading of the whale(s) under observation. It has been shown that both received level and proximity of the sound source is a contributing factor in eliciting behavioural reactions in humpback whales (Dunlop et al. 2017, Dunlop et al. 2018).

A.4. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal’s sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.4.1. Marine Mammal Frequency Weighting Functions

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \tag{A-8}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA’s technical guidance that assesses acoustic impacts on marine mammals (NMFS 2018), and in the latest guidance by Southall (2019). The updates did not affect the content related to either the definitions of frequency-weighting functions or the threshold values. Table A-1 lists the frequency-weighting parameters for each hearing group relevant to this assessment, and Figure A-3 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by Southall et al. (2019).

Hearing group	a	b	flo (Hz)	fhi (kHz)	*K* (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
High-frequency cetaceans (most dolphins, plus sperm, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
Very-high-frequency cetaceans (true porpoises, *Kogia*, river dolphins, *Cephalorhynchus* spp., *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36

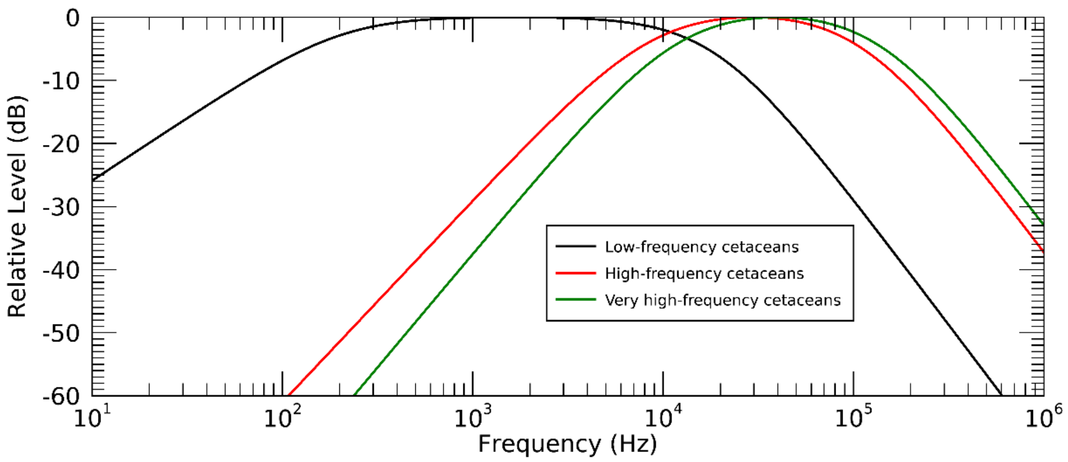

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by Southall et al. (2019).

Appendix B. Methods and Parameters

B.1. Environmental Parameters

B.1.1. Bathymetry

Water depth data for much of the modelling site were provided by Woodside Energy Ltd. This dataset comprised: bathymetry of Rankin Bank at 2 m resolution; bathymetry of swathes around the Greater Western Flank, also at 2 m resolution; and a wider area bathymetry around the site at a resolution of 25 m. The bathymetry was supplemented with additional data from the Australian Bathymetry and Topography Grid (Whiteway 2009), this dataset provides bathymetry at a resolution of 9 arc-seconds (equivalent to 0.0025° and equating to approximately 278 m × 262 m resolution). Figure B-1 shows the resultant data used for modelling.

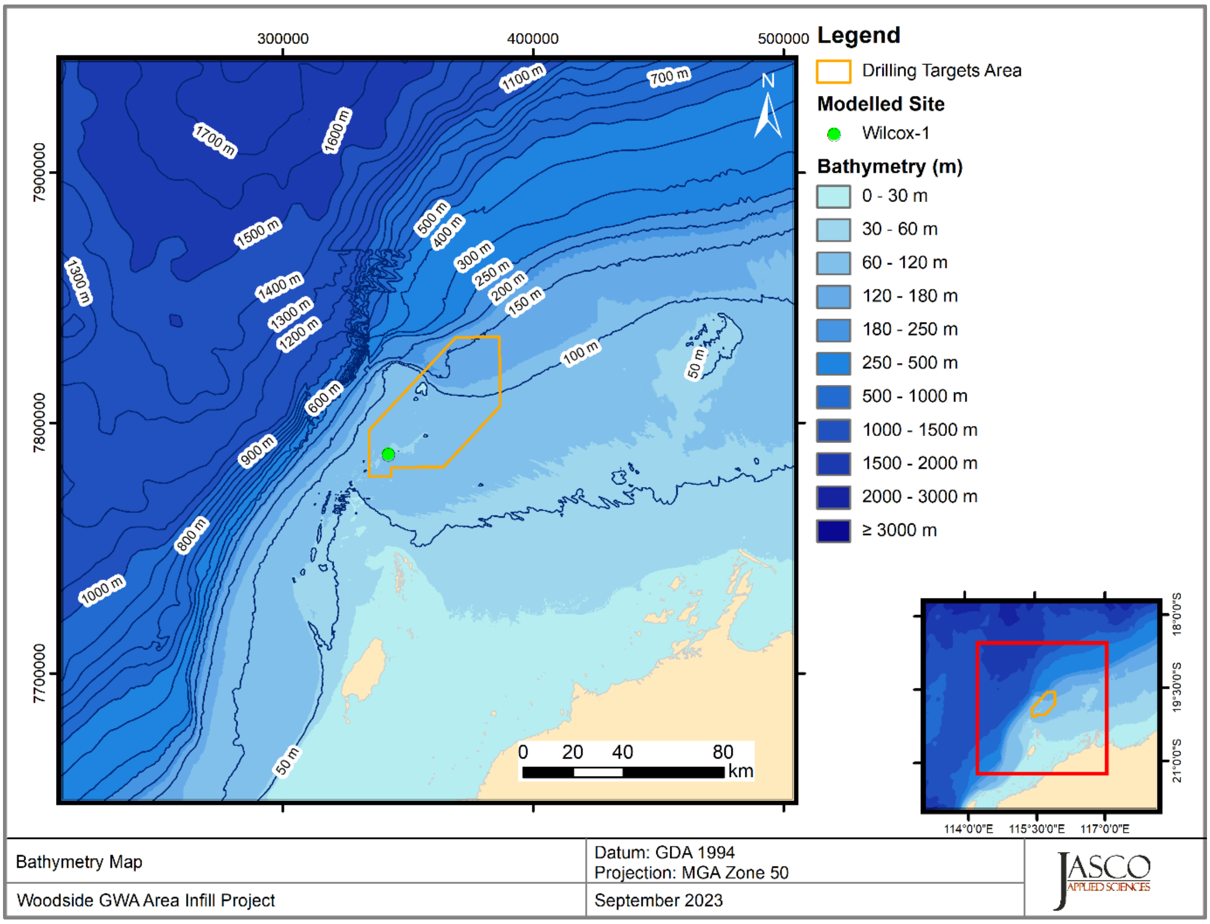

Figure B-1. Bathymetry of the region and the piling locations.

The datasets were combined to form a single bathymetric grid resampled at 50 m for the purposes of the acoustic modelling, the extents of which forms a box 125 km × 125 km centred on the modelling site.

B.1.2. Sound Speed Profile

The speed of sound in sea water is a function of temperature, salinity, and pressure (depth) (Coppens 1981). Sound speed profiles were obtained from the US Navy's Generalized Digital Environmental

Model (GDEM; NAVO 2003). Considering the greater area around the proposed MODU installation area and deep waters, the sound speed profiles were assumed to be representative of typical propagation conditions annually. Monthly average profiles to 200 m, and a September average profile to 1800 m, are shown in Figure B-2. September was selected for conservative purposes and to align with previousmodelling conducted for Woodside. These profiles were assumed to be representative of the entire area for modelling purposes.

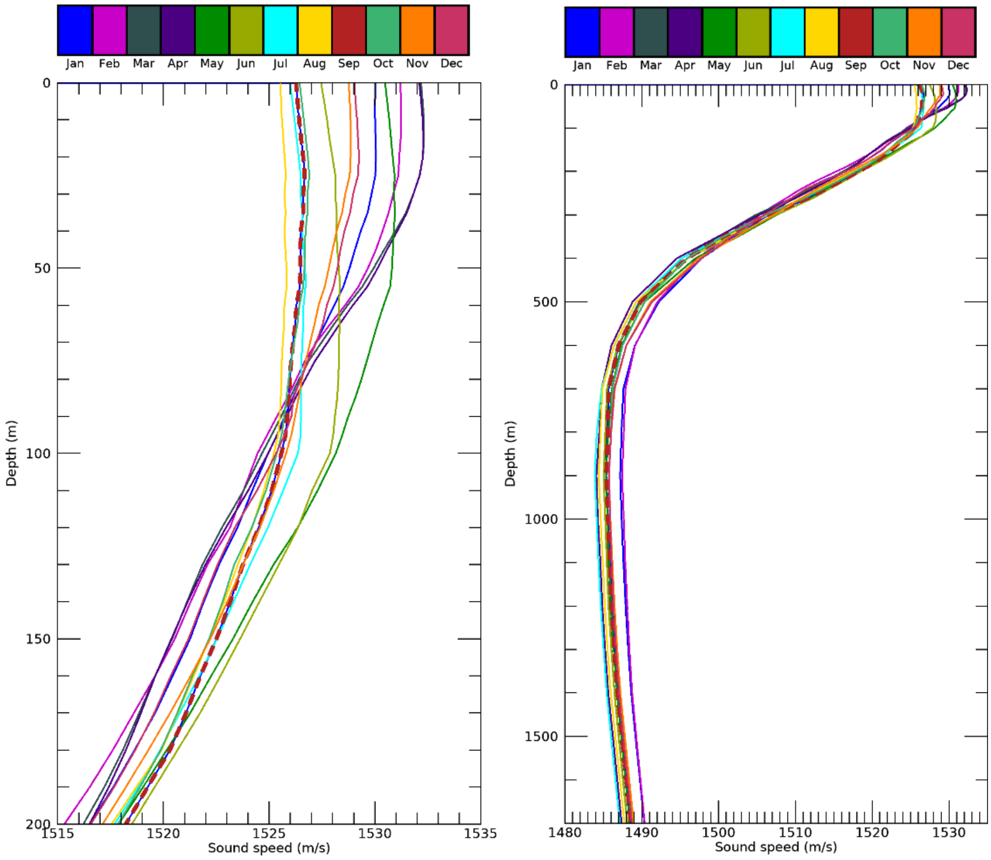

Figure B-2. Monthly average modelling sound speed profiles to 200 m and September average profile to 1700 m Profiles are calculated from temperature and salinity profiles from Generalized Digital Environmental Model V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

B.1.3. Geoacoustics

In shallow water environments where there is increased interaction with the seafloor, the properties of the substrate have a large influence over the resulting propagating sound. The geoacoustic model used in this work is based on the geological conditions sourced from borehole data previously supplied by Woodside. The required parameters for modelling sound propagation are the density (ρ), compressional-wave speed, (c_p), shear-wave speed (c_s), compressional-wave attenuation (α_p), and shear-wave attenuation (α_s). These properties have been estimated from the lithology supplied and based on average parameters for the sediment type and depth below the sea floor (Hamilton 1980, Duncan and Gavrilov 2012) and are shown in Table B-1.

Table B-1. Geoacoustic profile for the Woodside GWA Area Infill modelled site.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–26	Silty carbonate sand to interbedded sandy carbonated mud and sand	1.78	1523–1674	0.05–0.67	180	0.10
26–42	Carbonated sandy silt to muddy, sandy carbonate silt/silty mud	1.80	1685–1716	0.68–0.79		
42–72	Carbonate silty sand with occasional poorly cemented calcarenite layers	1.78	1704–1745	0.77–0.91		
72–108	Silty sandy poorly cemented calcarenite	2.32–2.37	2121–2181	0.32–0.33		
108–188	High strength calcarenite zone, locally sandy	2.87–2.96	2781–2909	0.53–0.55		

B.2. Sound Propagation Models

B.2.1. Propagation Loss

The propagation of sound through the environment was modelled by predicting the acoustic propagation loss—a measure, in decibels, of the decrease in sound level between a source and a receiver some distance away. Geometric spreading of acoustic waves is the predominant way by which propagation loss occurs. Propagation loss also happens when the sound is absorbed and scattered by the seawater, and absorbed scattered, and reflected at the water surface and within the seabed. Propagation loss depends on the acoustic properties of the ocean and seabed; its value changes with frequency.

If the acoustic energy source level (ESL), expressed in dB re 1 $\mu Pa^2 \cdot s\ m^2$, and propagation loss (PL), in units of dB, at a given frequency are known, then the received level (RL) at a receiver location can be calculated in dB re 1 $\mu Pa^2 \cdot s$ by:

$$\mathrm{RL} = \mathrm{SL} - \mathrm{PL}. \tag{B-1}$$

B.2.2. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). While other models may be more accurate for steep-angle propagation in high-shear environment, MONM is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 10 Hz to 1 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies > 1 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

MONM computes acoustic fields in three dimensions by modelling propagation loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure B-3).

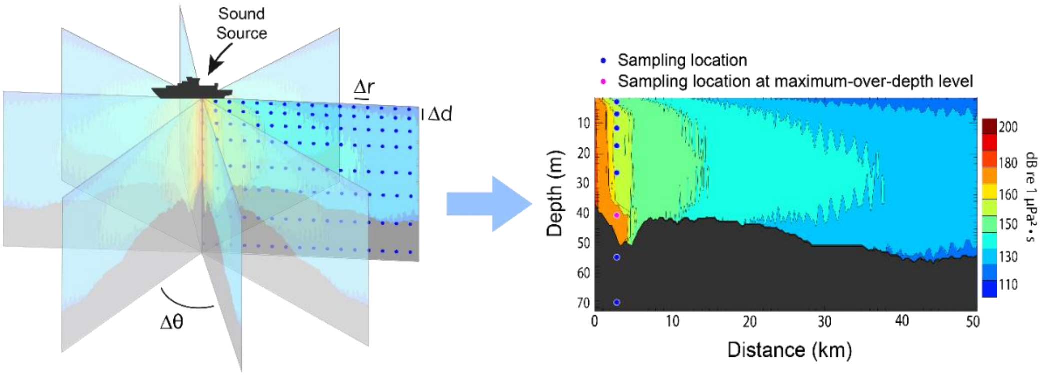

Figure B-3. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic propagation loss at the centre frequencies of decidecade bands. Sufficiently many decidecade frequency-bands, starting at 10 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the propagation loss is modelled within each of the N vertical planes as a function of depth and range from the source. The decidecade received per-second SEL are computed by subtracting the band propagation loss values from the directional source level in that frequency band. Composite broadband received per-second SEL are then computed by summing the received decidecade levels.

The received 1-s SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-second SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-second SEL. These maximum-over-depth per-second SEL are presented as colour contours around the source.

B.3. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure B-4).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure B-4(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure B-4(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

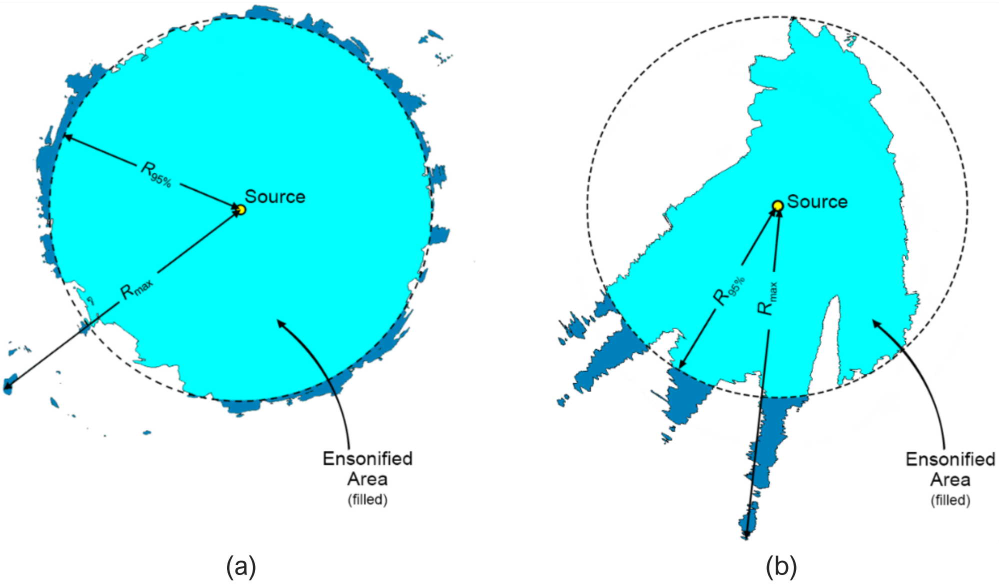

Figure B-4. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

B.4. Model Validation Information

Predictions from JASCO's propagation models (MONM, FWRAM, and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities that have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

APPENDIX F ACOUSTIC MODELLING FOR IMPACT PILE DRIVING

Woodside GWA Area Infill Development OPP

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

JASCO Applied Sciences (Australia) Pty Ltd

22 September 2023

Authors:

Emma Ozanich
Alina M. Muellenmeister
Matthew W. Koessler
Craig R. McPherson

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Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences (JASCO) performed a modelling study of underwater sound levels associated with the Woodside Energy Ltd. (Woodside) GWA Area Infill Development OPP in the region of Rankin Bank. The modelling study considers installation of one subsea pile within a 24-hour period at two possible locations.

The study predicted ranges to acoustic thresholds that may result in injury to, or behavioural disturbance of marine fauna. The corresponding thresholds used in this study represented the best available science for behavioural response/disturbance, temporary threshold shift (TTS), and permanent threshold shift (PTS) or injury depending upon the fauna group. The fauna considered included marine mammals, sea turtles, and fish, including fish larvae and eggs.

The modelling methodology was to characterise sound from pile driving at specific locations and then determine how the resultant sound travels considering the environmental properties that influence the propagation of underwater sound. The modelling considered dynamics of impact pile driving and range-dependent environmental properties. It was assumed that any of the activities could be performed at any time during the year, therefore a conservative season for the sound speed profile was considered.

Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p); zero-to-peak pressure levels (PK, L_{pk}); and either single-strike (i.e., per-strike) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria and noise sources. In this report, the duration period for accumulated SEL is defined as a 24-hour period over which sound energy is integrated; the level is specified with the abbreviation SEL_{24h}.

SEL_{24h} is a cumulative metric that reflects the dosimetric effect of noise levels within 24 hours, based on the assumption that a receiver (e.g., an animal) is consistently exposed to such noise levels at a fixed position. More realistically, marine animals would not stay in the same location for 24 hours (especially in the absence of location-specific habitat) but rather a shorter period, depending on the animal's behaviour and the source's proximity. Therefore, a reported radius for the SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be impaired, but rather that an animal could be exposed to the sound level associated with impairment (either PTS or TTS) if it remained at that location for 24 hours.

A realistic representation of the potential exposures for migrating pygmy blue whales (*Balaenoptera musculus brevicauda*) was undertaken using animal movement modelling ('animat modelling'). While acoustic modelling inherently assumes static animals, the JASCO Animal Simulation Model Including Noise Exposure (JASMINE) combines modelled sound fields with realistic animal movements to predict how animals might be impacted through sound exposure. JASMINE provides a framework for understanding and predicting sound exposure for species of interest and for calculating ranges to relevant regulatory thresholds. The distribution of distances to the source of simulated animals ('animats') predicted to be exposed to sound levels above relevant thresholds was used to calculate the horizontal distance that includes 95% of the distances that exceeded a given threshold ($ER_{95\%}$). Within the $ER_{95\%}$, there is generally some proportion of animats that do not exceed the threshold criteria. This occurs for several reasons, including the spatial and temporal characteristics of the sound field and the way in which the animats are exposed to the sound field over time, both vertically and horizontally. The probability that an animat within the $ER_{95\%}$ was exposed above threshold was also computed (P_{exp}) to provide additional context.

Two sets of animat simulations were conducted. Simulations with animats restricted to the pygmy blue whale migratory Biologically Important Area (BIA) provide an understanding of how animats will be exposed given the location and environment-specific context in which they are most likely to occur. Simulations in which the animats are seeded in an unrestricted manner allow for the calculation of exposure range across the entire project area. These ranges may then be interpreted to determine buffer zones around the BIA for different project options and scenarios. The unrestricted seeding approach is informative in cases where there is very little or no overlap between the BIA and the planned operational area, as is the case for the pile driving associated with the GWA Area Infill Development OPP. The closest distance between the BIA and the potential pile locations is approximately 27 km.

The animat modelling was included in the scope of work to provide context to possible exposures to migrating pygmy blue whales over an entire day. The distances to isopleths associated with the effect thresholds for PTS and TTS are more realistic than those from the static sound fields as they consider potential animal movements during migration, passing through the operational region.

A summary of the acoustic modelling results for piling operations is presented in Table 1, and a summary of the animal movement modelling results is presented in Table 2.

Acoustic Modelling – Piling Operations:

- Auditory injury to cetaceans from sound exposure level metrics: accumulated SEL over single-pile driving time, weighted to account for cetacean species-group hearing sensitivity, exceeded thresholds for auditory injury (permanent threshold shift, PTS) within 2.43 km from Wilcox-1 and 3.11 km from Yodel South for low-frequency cetaceans, 60 m from Wilcox-1 and 50 m from Yodel South for high-frequency cetaceans, and 1.61 km from Wilcox-1 and 1.87 km from Yodel South for very-high-frequency cetaceans.
- EPBC Act Policy Statement 2.1 criterion: single strike SEL exceeded the threshold of 160 dB re 1 $\mu Pa^2 \cdot s$ within 1.05 km of Wilcox-1 and 1.31 km of Yodel South.
- Behavioural effects in cetaceans that result from SPL: the noise from piling strikes exceeded the 160 dB re 1 µPa SPL threshold for behavioural effects within maximum distances of 4.79 km of Wilcox-1 and 5.78 km of Yodel South.
- Based on accumulated SEL metrics, fish could sustain acoustic injury (including both mortal and recoverable injuries) within 250 m of Wilcox-1 and 330 m of Yodel South for fishes with a swim bladder, and within 20 m of Wilcox-1 and 50 m of Yodel South for fishes without a swim bladder. Fish could experience TTS within 2.43 km or 3.53 km of the pile driving operations at Wilcox-1 or Yodel South.

Accumulated SELs were calculated based on an estimated 2108 blows over a 1.13 hour period for the 1200 kJ hammer.

Table 1. *Piling Operations:* Maximum (R_{max}) horizontal distances (in km) to relevant thresholds for marine fauna.

Hearing group	Threshold Type	Metric	Threshold	Wilcox-1	Yodel South
				R_{max} (km)	R_{max} (km)
Low frequency cetaceans	PTS [a]	$L_{E,24h}$	183	2.43	3.11
	TTS [a]	$L_{E,24h}$	168	16.0	22.6
High frequency cetaceans	PTS [a]	$L_{E,24h}$	185	0.06	0.05
	TTS [a]	$L_{E,24h}$	170	0.36	0.41
Very high-frequency cetaceans	PTS [a]	$L_{E,24h}$	155	1.61	1.87
	TTS [a]	$L_{E,24h}$	140	8.88	10.6
All Marine Mammal Groups	Behavioural Response [b]	L_p	160	4.79	5.78
Fish without swim bladder	Mortality and Potential mortal injury [c]	$L_{E,24h}$	219	–	0.03
	Recoverable injury [c]	$L_{E,24h}$	216	0.02	0.05
	TTS [c]	$L_{E,24h}$	186	2.43	3.53
	Recoverable injury [c]	L_{pk}	213	0.03	0.05
Fish with swim bladder not involved in hearing	Mortality and Potential mortal injury [c]	$L_{E,24h}$	210	0.05	0.09
	Recoverable injury [c]	$L_{E,24h}$	203	0.25	0.33
	TTS [c]	$L_{E,24h}$	186	2.43	3.53
	Recoverable injury [c]	L_{pk}	207	0.06	0.10
Fish with swim bladder involved in hearing	Mortality and Potential mortal injury [c]	$L_{E,24h}$	207	0.15	0.20
	Recoverable injury [c]	$L_{E,24h}$	203	0.25	0.33
	TTS [c]	$L_{E,24h}$	186	2.43	3.53
	Recoverable injury [c]	L_{pk}	207	0.06	0.10
Sea turtles	PTS [d]	$L_{E,24h}$	204	0.19	0.25
	TTS [d]	$L_{E,24h}$	189	1.41	1.73
	Behavioural disturbance [e]	L_p	166	2.15	2.45
	Behavioural response [e]	L_p	175	0.58	0.77

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).
L_{pk}= unweighted peak sound pressure level (dB re 1 µPa)
L_p= unweighted sound pressure level (dB re 1 µPa)
L_E= sound exposure level for single strike (dB re 1 µPa^2 s)
$L_{E,24h}$= sound exposure level over 24 hours (dB re 1 µPa^2 s), unweighted for fish and frequency weighted for all other groups
[a] Southall et al. (2019) criteria for marine fauna
[b] NOAA (2019) recommended unweighted behavioural threshold for marine mammals
[c] Popper et al. (2014)
[d] Finneran et al. (2017)
[e] McCauley et al. (2000)

Pygmy blue whales – Animat results

- The exposure ranges predicted using animat modelling are more realistic, due to the incorporation of species-specific realistic movements, rather than conservative approach of calculating ranges using the maximum-over-depth sound fields and receivers which are stationary for 24 hours. This is because the exposure ranges account for animats sampling the sound field vertically and horizontally based on species-specific diving and movement parameters.
- In general, exposure ranges from animal movement modelling for PTS and TTS criteria (Southall et al. 2019) are typically shorter than those predicted using acoustic propagation modelling because of the shorter time (‘dwell time’) to accumulate sound energy of the moving animats. The maximum exposure ranges ($ER_{95\%}$) to PTS and TTS thresholds were 0.77 and 8.98 km, respectively, with probabilities of an animat within the $ER_{95\%}$ being exposed above the PTS and TTS thresholds of 81 and 76%, respectively.

- Exposure ranges ($ER_{95\%}$) for single exposure metrics, such as the SPL behavioural response criteria, are typically comparable to the predicted acoustic ranges. In this study, exposure ranges are generally very similar or slightly lower than the R_{max} acoustic ranges.
- Both pile driving scenarios resulted in exposures above the SPL behavioural response threshold. The maximum $ER_{95\%}$ to the threshold was 4.16 km with a corresponding probability of an animat within the $ER_{95\%}$ being exposed above the threshold of 86%.
- The closest distance between the migratory pygmy blue whale migration BIA and the potential pile driving locations is approximately 27 km. Because of this, none of the restricted animat seeding scenarios resulted in exposures above threshold.

Table 2. Summary of animat simulation results for PTS, TTS, and SPL behavioural response criteria for pygmy blue whales (unrestricted seeding simulation). Maximum exposure ranges show $ER_{95\%}$ first and probability of exposure of animats travelling within the $ER_{95\%}$ in parentheses.

Pile Location	Species	Behavioural response (SPL)[4]	TTS (SEL_{24h})[3]	PTS (SEL_{24h})[3]
		160[2]	168[1]	183[1]
Wilcox-1	Pygmy blue whale	4.10 (67%)	6.36 (64%)	0.59 (68%)
Yodel South		4.16 (86%)	8.98 (76%)	0.77 (81%)

[1] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
[2] SPL (L_p; dB re 1 µPa)
[3] Southall et al. (2019) criteria for marine fauna.
[4] NOAA (2019) unweighted behavioural threshold for marine mammals.

1. Introduction

Woodside Energy Ltd. (Woodside) plans to develop the gas supply capabilities to the North West Shelf Project's Goodwyn Alpha (GWA) platform with a subsea tieback from hydrocarbon fields in the vicinity. This development project is called the GWA Area Infill Development OPP and proposes several production wells in multiple drill centres tied back to GWA by a subsea pipeline. The wells may be drilled by a moored mobile offshore drilling unit (MODU) and the mooring points may require piling. The exact requirements have not been finalised, and certain assumptions about the piling have been made.

Submerged banks and shoals in the region, namely Rankin Bank and Wilcox Shoal, have been identified as environmentally sensitive habitats that could be affected by piling noise. The area contains hard and soft coral species, sponges, and other filter feeders. This report will therefore consider the potential impacts from underwater noise generated by the piling activities on particular fauna that inhabit these environmentally sensitive habitats, as well as marine mammals in general.

Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p); zero-to-peak pressure levels (PK, L_{pk}), and either single-strike (i.e., per-strike) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria and noise sources. In this report, the duration period for SEL accumulation is defined as a 24-hour period over which sound energy is integrated; the level is specified with the abbreviation SEL_{24h}.

The acoustic modelling results were also used in as inputs to animal movement modelling simulations to predict the distance at which pygmy blue whales (*Balaenoptera musculus brevicauda*) are expected to be exposed above threshold criteria for PTS, TTS, and may be subject to a behavioural response. Sound exposure distribution estimates are determined by moving large numbers of simulated animals (animats) through a modelled time-evolving sound field, computed using specialised sound source and sound propagation models. This approach provides the most realistic prediction of the maximum expected SPL and SEL for comparison against the relevant thresholds and criteria.

Section 1 outlines the specific details of modelling study. Section 2 details the metrics used to represent underwater acoustic fields and the associated effect criteria considered. Section 3 details the methodology for predicting the source levels and modelling the sound propagation, including source levels and environmental parameters required by the propagation models. Section 3.3 presents the results, which are then discussed in Section 5.

1.1. Modelling Scenarios

Two nominal piling locations were selected for estimating the impact of piling noise on marine fauna: Wilcox-1 and Yodel South. The two locations were selected to represent the geographical extent of possible construction sites and to consider the effect of local bathymetry on the acoustic propagation. Full waveform acoustic modelling (Appendix C.3) was used in this report to estimate the noise impact on marine fauna.

These locations are detailed in Table 3 and indicated graphically in Figure 1.

Table 3. Locations of the piling activities in MGA coordinates (Datum GDA94, MGA Zone 50).

Designation	Scenarios	GDA94 MGA Zone 50		Water depth (m)
		X (m)	Y (m)	
Wilcox-1	1	341 889	7 787 654	72.0
Yodel South	2	366 544	7 813 565	112.7

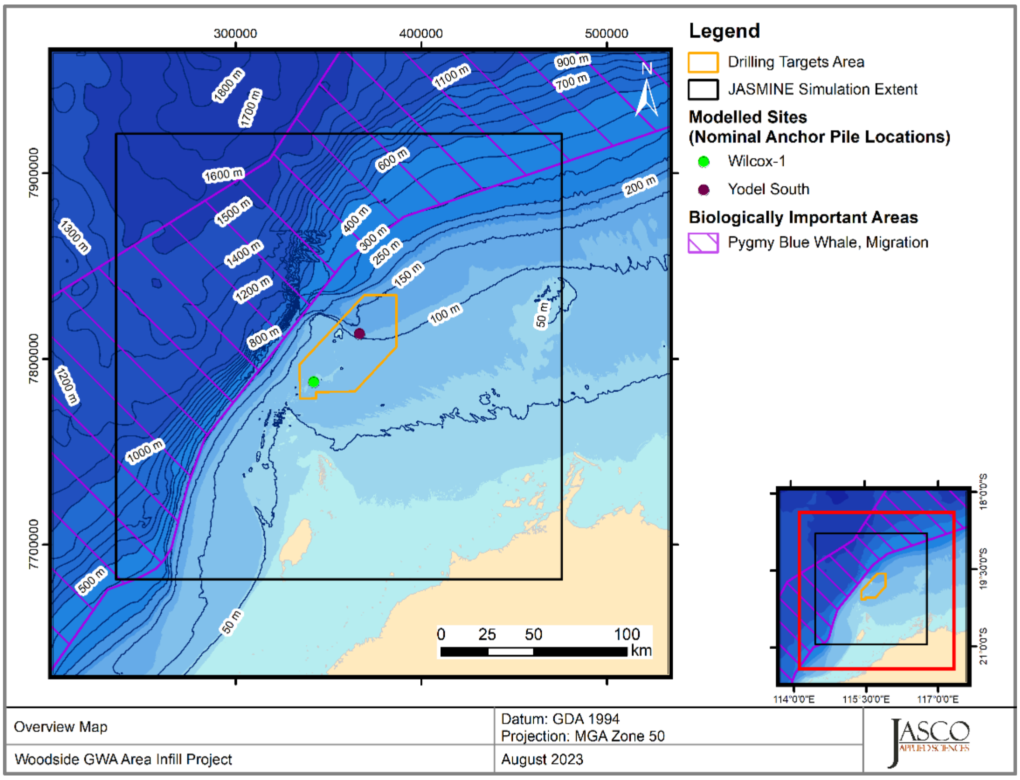

Figure 1. Locations of the sites Wilcox-1 and Yodel South, used to estimate the acoustic impact of pile driving on marine fauna.

One hammer and pile combination were modelled at two locations, with the same pile drivability used for both locations. A hammer energy of 1200 kJ, pile diameter of 2.18 m, and pile length of 32 m was used. The pile is expected to be driven into the sediment using a sub-sea hammer.

The total noise exposure (SEL) for each scenario depends on the total number of hammer blows required to drive the pile. A driveability analysis, conducted by Woodside prior to this study, estimated that it would take approximately 3600 blows (2 hours driving at 30 blows per minute) to drive the piles 30 m into the substrate with a 600 kJ hammer. While Woodside did not conduct a driveability analysis for the 1200 kJ hammer; however, using JASCO's pile model, it was estimated that the 1200 kJ hammer would displace the pile 1.7 times as far as the 600 kJ hammer, assuming the same sediment resistance. Based on this calculation, the 1200 kJ hammer would reduce the total number of blows by 41% (i.e., 2108 blows), compared to the 600 kJ hammer. The estimated total driving time for the 1200 kJ hammer would therefore be 1 hour and ten minutes.

2. Noise Effect Criteria

To assess the potential effects of a sound–producing activity, it is necessary to first establish exposure criteria (thresholds) for which sound levels may be expected to have a negative effect on animals. Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL–based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that investigate the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

The perceived loudness of sound, especially impulsive noise such as from pile driving, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a “per-strike” assessment or over 24 h. The acoustic metrics in this report reflect the ISO standard for acoustic terminology, ISO/DIS 18405:2017 (2017).

The following thresholds and guidelines for this study were chosen because they represent the best available science, and sound levels presented in literature for fauna with no defined thresholds:

1. Marine mammals:
    a. Peak pressure levels (PK; L_{pk}) and frequency–weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Southall et al. (2019) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals for impulsive sources.
    b. Marine mammal behavioural thresholds based on the current interim U.S. National Oceanic and Atmospheric Administration (NOAA) (2019) unweighted criterion for marine mammals of 160 dB re 1 µPa (SPL; L_p) for impulsive sound sources.
2. Fish, fish eggs, and larvae:
    a. Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).
3. Sea turtles:
    a. Frequency–weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of PTS and TTS in turtles for non–impulsive and impulsive sound sources.
    b. Sea turtle behavioural response threshold of 166 dB re 1 µPa (SPL; L_p) for impulsive noise, along with a sound level associated with behavioural disturbance 175 dB re 1 µPa (SPL; L_p) (McCauley et al. 2000).

For additional context, the distance to the unweighted per-pulse SEL of 160 dB re 1 µPa^2·s (L_E) from the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA 2008), is reported.

The following sections (Section 2.1 along with Appendices A.3 and A.4), expand on the thresholds, guidelines and sound levels for all marine fauna.

2.1. Impulsive Noise

Impact pile driving activities have been assessed as impulsive noise source as consistent with the considered thresholds and guidelines.

2.1.1. Marine Mammals

The criteria applied in this study to assess possible effects of impulsive noise sources on marine mammals are summarised Table 4; cetaceans were identified as the hearing group requiring assessment. Details on thresholds related to auditory threshold shifts or hearing loss and behavioural response are provided in Appendix A.3, with frequency weighting explained in detail in Appendix A.4. Of particular note, whilst the newly published Southall et al. (2021) provides recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals. The criteria from the current interim U.S. National Oceanic and Atmospheric Administration (NOAA) (2019) has been applied.

Table 4. Acoustic effects of impulsive noise on marine mammals: Unweighted SPL, SEL_{24h}, and PK thresholds.

Hearing group	NOAA (2019)	Southall et al. (2019)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)
Low–Frequency (LF) cetaceans	160	183	219	168	213
High–frequency (HF) cetaceans		185	230	170	224
Very–High–frequency (VHF) cetaceans		155	202	140	196

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS or TTS onset.
L_p= unweighted sound pressure level (dB re 1 µPa).
L_{pk}= unweighted peak sound pressure level (dB re 1 µPa).
$L_{E,24h}$= sound exposure level over 24 hours (dB re 1 µPa^2 s).

2.1.2. Fish, Sea turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Sea Turtles was formed to continue developing noise exposure criteria for fish and sea turtles, work begun by a NOAA panel two years earlier. The Working Group developed guidelines with specific thresholds for different levels of effects for several species groups (Popper et al. 2014). The guidelines define quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death,
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma, and
- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. However, as these depend upon activity–based subjective ranges, these effects are not addressed in this report and are included in Tables 5 for completeness only. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure depends on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Sea turtles, fish eggs, and fish larvae are considered separately.

Impulsive noise from pile driving is assessed in this study based on the relevant effects thresholds from Popper et al. (2014) listed in Table 5. In general, whether an impulsive sound adversely effects fish behaviour depends on the species, the state of the individual exposed, and other factors.

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

Table 5. Criteria for pile driving noise exposure for fish, adapted from Popper et al. (2014).

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

L_{pk}= unweighted peak sound pressure level (dB re 1 µPa).
$L_{E,24h}$= sound exposure level over 24 hours (dB re 1 µPa^2 s), unweighted for fish.
All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.
Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. Popper et al. (2014) suggested thresholds for onset of mortal injury (including PTS) and mortality for sea turtles and, in absence of taxon–specific information, adopted the levels for fish that do not hear well (suggesting that this likely would be conservative for sea turtles). Finneran et al. (2017) in turn presented revised thresholds for sea turtle injury and hearing impairment (TTS and PTS). Their rationale is that sea turtles have best sensitivity at low frequencies and are known to have poor auditory sensitivity (Bartol and Ketten 2006, Dow Piniak et al. 2012). Accordingly, TTS and PTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al. 2014).

McCauley et al. (2000) observed the behavioural response of caged sea turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the sea turtles increased their swimming activity, and above

175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy et al. 2017) acknowledges the 166 dB re 1 µPa SPL reported (McCauley et al. 2000) as the level that may result in a behavioural response to marine turtles. The 175 dB re 1 µPa level from McCauley et al. (2000) is recommended as a criterion for behavioural disturbance; these thresholds are shown in Table 6.

Table 6. Acoustic effects of impulsive noise on sea turtles: Unweighted sound pressure level (SPL), 24-hour sound exposure level (SEL_{24h}), and peak pressure (PK) thresholds

Effect type	Criterion	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Behavioural response	McCauley et al. (2000)	166	NA	
Behavioural disturbance		175		
PTS onset thresholds* (received level)	Finneran et al. (2017)	NA	204	232
TTS onset thresholds* (received level)			189	226

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS and TTS onset.

L_p= unweighted sound pressure level (dB re 1 µPa).

L_{pk}= unweighted peak sound pressure level (dB re 1 µPa).

$L_{E,24h}$= sound exposure level over 24 hours (dB re 1 µPa² s).

3. Methods

3.1. Per-strike Modelling

When driven with impact hammers, piles deform, creating a stress wave that travels down the pile and radiates sound into the surrounding air, water, and seabed. This sound may be received as a direct transmission from the sound source to biological receivers (such as marine mammals, sea turtles, and fish) through the water or as the result of reflected paths from the surface or re-radiated into the water from the seabed (Figure 2). Sound transmission depends on many environmental parameters, such as the sound speeds in water and substrates; sound production parameters of the pile and how it is driven, including the pile material, size (length, diameter, and thickness) and the type and energy of the hammer.

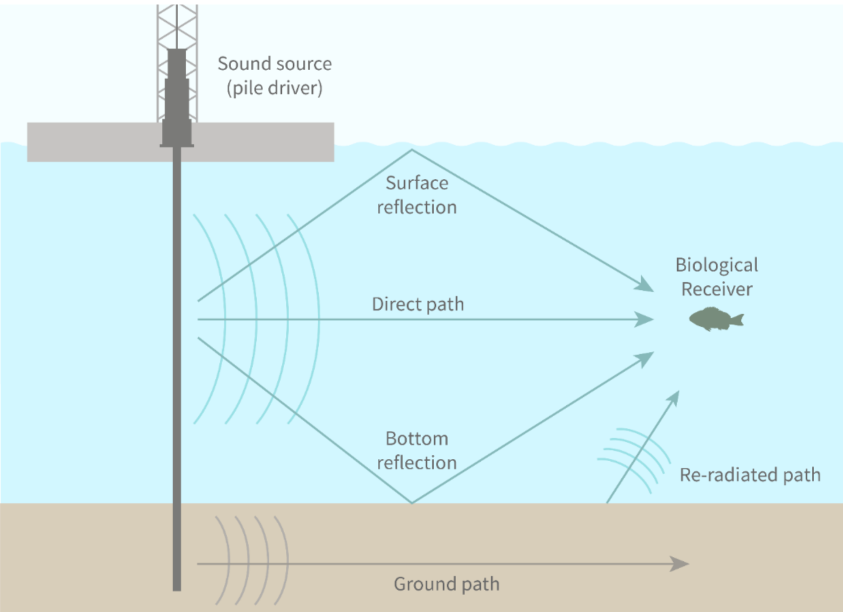

Figure 2. Sound propagation paths associated with pile driving (adapted from Buehler et al. 2015).

To predict the acoustic field from the pile driving, JASCO's Pile Driving Source Model (PDSM; Appendix B), a physical model of pile vibration and near-field sound radiation (MacGillivray 2014), was used in conjunction with the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010) to predict source levels associated with impact pile driving activities. Piles are modelled as a vertical installation using a finite-difference structural model of pile vibration based on thin-shell theory. The sound radiating from the pile itself was simulated using a vertical array of discrete point sources.GRLWEAP 2010 was used to compute the force at the top of each pile assuming direct contact between the representative hammers, helmets, and piles (i.e., no cushioning material). The construction plan calls for the piles to be driven using two different models of hydraulic impact hammer (Table 7). The hammer used for the acoustic modelling is selected in bold.

Table 7. Modelled pile driving hammers.

Hammer model	Maximum energy (kJ)	Ram weight (t)	Hammer weight (t)	Max blow rate (per min)	Modelled blow rate (per min)
IHC S–600	600	30	64	42	31
IHC S–1200	**1200**	**60**	**140**	**38**	**31**

Forcing functions for the two hammers were modelled assuming that driving was carried out using the maximum recommended hammer energy (Figure 3). The forcing functions serve as inputs to JASCO's pile driving source model (PDSM), which was used to estimate equivalent acoustic source characteristics detailed in Appendix B.1.2.

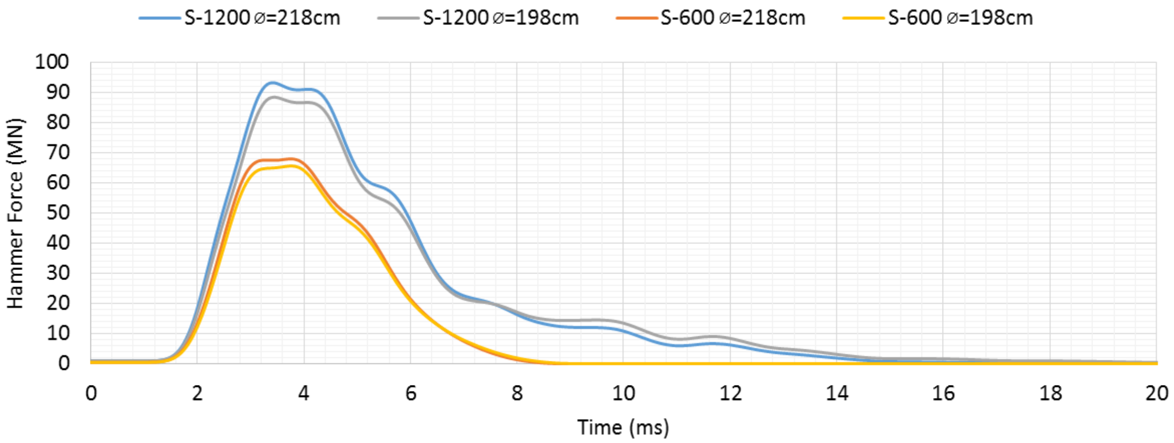

Figure 3. Modelled forcing functions versus time for the IHC S600 and IHC S1200 hydraulic impact hammers for 1.98 m and 2.18 m diameter piles. The IHC S1200 hammer with 2.18 diameter pile was used for this modelling.

JASCO's FWRAM (FWRAM, Appendix C.3) propagation model was used to combine the outputs of the source model with spatial and temporal environmental factors (e.g., location, oceanographic conditions, and seabed type) to get time-domain representations of the sound signals in the environment and estimate sound field levels. This model is used to estimate the energy distribution per frequency (source spectrum) at a close distance from the source (10 m) from 10 Hz to 1024 Hz. In addition, an empirical extrapolation was applied to these results to extend the frequency range up to 25 kHz and a 20 dB/decade decay rate was applied to match acoustic measurements of impact pile driving of similarly-sized piles (Illingworth & Rodkin 2007, Matuschek and Betke 2009). Examples of decidecade band levels are provided in Section 4.1.1. Appendix A.1 describes the sound level metrics in further detail.

To produce maps of received sound level distributions and to calculate distances to specified sound level thresholds, the maximum-over-depth level is calculated at each modelled easting and northing position within the considered region. The radial grids of maximum-over-depth levels are then resampled (by linear triangulation) to produce a regular Cartesian grid with a cell size of 20 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields (Appendix C.4).

3.2. Accumulated SEL Modelling for Pile Driving

The modelling approach outlined in Sections 3.1 provides per-strike SEL for three stages of pile driving (i.e., three penetration depths). Because a single pile will be driven per day and the piling noise level far exceeds any background, the corresponding sound exposure level can be denoted as SEL_{24h} even though the effective period of accumulation is the estimated time for fully driving a single pile. The accumulated SEL over a single pile, or the SEL_{24h}, depends on the total number of strikes to drive the pile to the target penetration depth.

Total driving time was estimated assuming continuous piling at a rate of approximately 0.517 strikes/second (31 strikes/minute) for the IHC S1200. As per the pile design, likely hammer and installation approach, the number of strikes required for the driving of the pile were estimated using the provided penetration depth and estimated penetration rate. The SEL_{24h} was computed by adjusting the single-strike SEL by 10*log$_{10}$(N), where N is the total number of strikes. A summary of the total number of strikes per penetration depth and over the entire pile is provided in Table 8.

Table 8. Total number of strikes and driving time.Strikes were broken down into stages corresponding to the three modelled penetrations for the IHC S1200 hammer. Pile specifications are shown in Table 7.

Pile Type	Hammer	Full penetration depth (m)	Modelled penetration depth (m)	Penetration range for accumulated SEL (m)	Number of strikes	Average Penetration rate (mm/strike)	Total number of strikes	Time for full penetration (hr)
Anchor pile	IHC S1200	30	2	2	140	14.2	2108	1.13
			16	16	984	14.2		
			30	30	984	14.2		

3.3. Animal Movement and Exposure Modelling

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats to sound arising from the two pile driving scenarios (Section 1.1). JASMINE integrates the predicted sound field with biologically meaningful movement rules for each marine mammal species (pygmy blue whales for the current analysis) that results in an exposure history for each animat in the model. An overview of the exposure modelling process using JASMINE is shown in Figure 4.

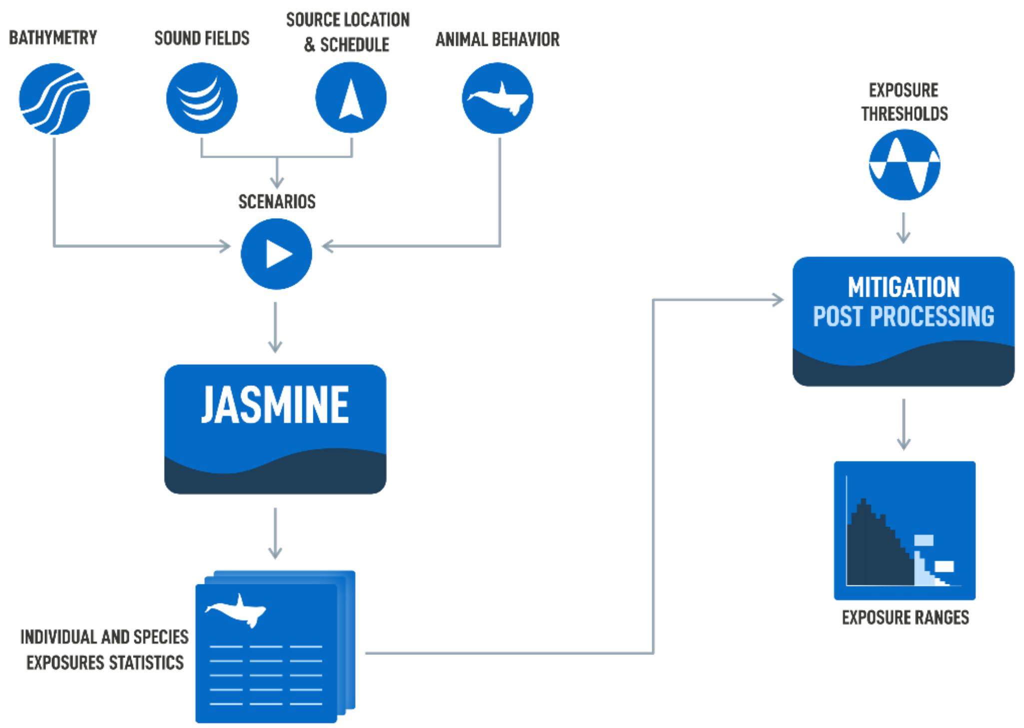

Figure 4. Exposure modelling process overview.

In JASMINE, the sound received by the animats is determined by the proposed piling activities. As illustrated in Figure 5, animats are programmed to behave like the marine animals that may be present in an area. The parameters used for forecasting realistic behaviours (e.g., diving and foraging depth, swim speed, surface times) are determined and interpreted from marine mammal studies (e.g., tagging studies) where available, or reasonably extrapolated from related or comparable species. For cumulative metrics, an individual animat's sound exposure levels are summed over a 24 h duration to determine its total received energy, and then compared to the relevant threshold criteria. For single-exposure metrics, the maximum exposure is evaluated against threshold criteria for each 24 h period. For additional information on JASMINE, see Appendix D.

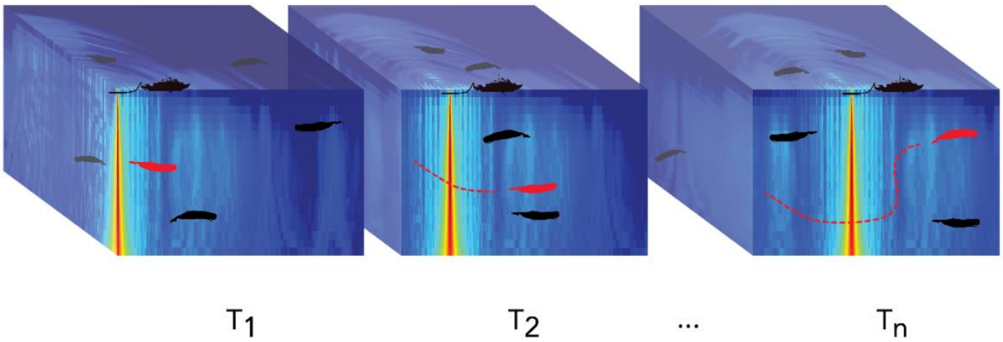

Figure 5. Depiction of animats in a moving sound field. Example animat (red) shown moving with each time step (T_n). The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

The exposure criteria for impulsive sounds (described in Section 2.1) were used to determine the number of animats that exceeded thresholds. To generate statistically reliable probability density functions, model simulations were run with animat sampling densities of 4 animats/km^2. Due to insufficient density data availability, the modelling results are not related to real-world density estimates for pygmy blue whales within the BIA. To evaluate PTS, TTS and behavioural response, exposure results were obtained using detailed behavioural information for migrating pygmy blue whales (described in Section 3.3.2). The simulation was run for a representative period of 24 h to coincide with the acoustic modelling effort. Animal movements and exposures were modelled for the two pile driving locations. Both scenarios were run for migrating pygmy blue whales restricted to their migratory BIAs as well as unrestricted.

Figure 6 shows an example animat track (generated for information purposes only and not related to the results presented in this report) with associated received levels from a stationary point source. The top panel displays the animat track relative to the point source, and the bottom panel displays the accumulation of SEL_{24h} for TTS and PTS criteria. At approximately 50 seconds, the animat is exposed so that the TTS threshold is exceeded, and at approximately 700 seconds the animat is exposed so that the PTS threshold is exceeded.

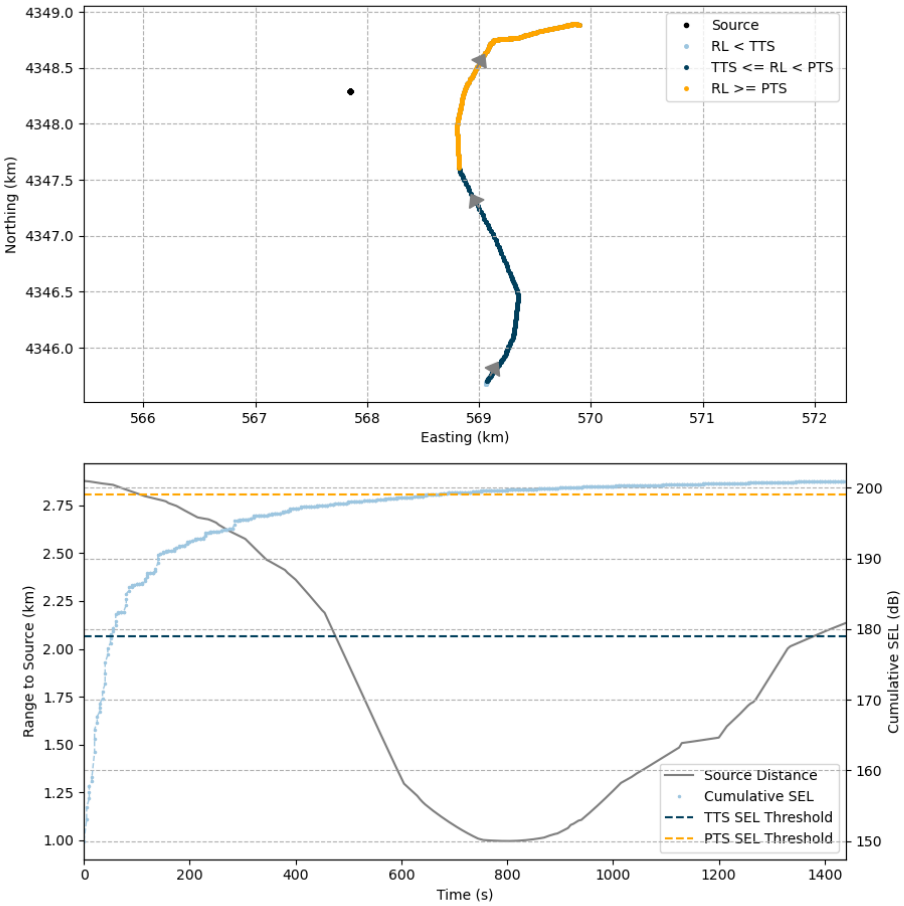

Figure 6. Animat track from an example simulation showing northward movement over a 1400 s duration. The upper panel shows a plan view of both a stationary point source and a foraging animat. Animat steps are coloured to indicate whether the accumulated sound energy at that point has exceeded either TTS or PTS threshold criteria. The lower panel shows horizontal distance in kilometres to the source (grey line; left y-axis) and cumulative 24-h SEL ($L_{E,24h}$, dB re 1 µPa²·s; right y-axis) as a function of time. Note that this example does not use data from the current study.

3.3.1. Exposure-based Radial Distance Estimation

The results from the animal movement and exposure modelling provided a way to estimate radial distances to effect thresholds. The distance to the closest point of approach (CPA) for each of the animats was recorded. The $ER_{95\%}$ (95% Exposure Range) is the horizontal distance that includes 95% of the animat CPAs that exceeded a given effect threshold (Figure 7). Within the $ER_{95\%}$, there is generally some proportion of animats that do not exceed threshold criteria. This occurs for several reasons, including the spatial and temporal characteristics of the sound field and the way in which animats sample the sound field over time, both vertically and horizontally. The sound field varies as a function of range, depth, and azimuth based on a variety of factors such as bathymetry, sound speed profile, and geoacoustic parameters. The way the animats sample the sound field depends upon species-typical swimming and diving characteristics (e.g., swim speed, dive depth, surface intervals, and reversals). Furthermore, even within a particular species definition, these characteristics vary with behavioral state (e.g., feeding, migrating). As this results in some animats not exceeding threshold criteria even within the $ER_{95\%}$, the probability that an animat within that distance was exposed above threshold within the $ER_{95\%}$ was also computed (P_{exp}) to provide additional context.

Acoustic ranges are reported for both $R_{95\%}$ and R_{max}, however, exposure ranges are reported for $ER_{95\%}$ only since, statistically, ER_{max} is not defined. JASMINE is a Monte Carlo simulation, and the results are probabilistic in nature. This is in contrast with acoustic modelling, where there is a specific maximum isopleth range for a given source/environment setup.

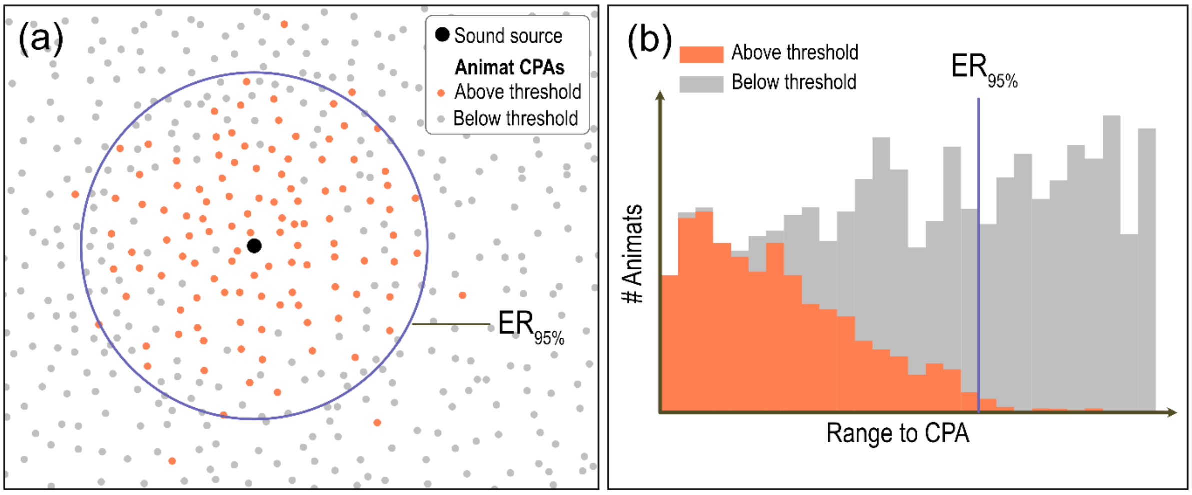

Figure 7. Example distribution of animat closest points of approach (CPAs). Panel (a) shows the horizontal distribution of animats near a sound source. Panel (b) shows the distribution of distances to animat CPAs. The 95% exposure range ($ER_{95\%}$) is indicated in both panels.

3.3.2. Pygmy Blue Whale Behaviour

The two pile driving locations are in proximity to the migration BIA for pygmy blue whales, therefore migratory behaviour was the only behavioural profile considered. Detailed information on pygmy blue whales was derived from a range of sources that used multi-sensor tags to record fine-scale dive and movement behaviour (Owen et al. 2016, AIMS unpublished data 2021), as well as satellite tags to record travel speed (Thums and Ferreira 2021).

Multi-sensor tags typically record the depth of an animal along with various movement parameters such as swim speed and their body's orientation. Owen et al. (2016) equipped a sub-adult pygmy blue whale with a multi-sensor tag off Western Australia. They identified dives for the tagged animal as migratory, feeding, or exploratory (i.e., no lunges recorded which would indicate feeding). Pygmy blue whales in the simulation area are presumed to be migrating, and so feeding was not included in the model. Exploratory dives were considered to be part of migratory behaviour, and so the two dive types were modelled together such that the animats were migrating 95% of the time and engaged in exploratory dives 5% of the time (Owen et al. 2016).

Using data from Owen et al. (2016), the approximate length of a bout of exploratory dives could be determined, as well as the average (± SD) depth of this dive type. The speed of travel for both dive behaviours was calculated from data presented in Thums and Ferreira (2021), who analysed data from satellite tags deployed on pygmy blue whales in the Northwest Marine Region. All remaining parameters were calculated from two multi-sensor tags deployed on pygmy blue whales off Western Australia (AIMS unpublished data 2021).

The behaviour of migrating pygmy blue whales was modelled to reflect animats transiting through the modelling area on a 230° track for the southward migration. This represents the animals migrating along the west coast of Australia to their breeding grounds in Indonesia (Double et al. 2014, Thums and Ferreira 2021). However, Warren et al. (2022) showed that during southward migration whales appeared to travel through Rankin Bank, and move into the deeper water of the migratory BIA to the WSW on a 270° track. Therefore, animal movement modelling considered an additional scenario with pygmy blue whales travelling through the modelling area on a 270° track in an unrestricted manner.

4. Results

For the results and tables presented below where a dash is used in place of a horizontal distance, these thresholds may or may not be reached due to the discreetly sampled radial increments of the modelled sound fields. A dash therefore is an indication that effect levels for the associated metric may only be reached within a very close proximity to a given source.

4.1. Pile Driving

The maximum-over-depth sound fields for the modelled pile driving scenarios are presented below in two formats: as tables of distances to sound levels (Section 4.1.2) and, where the distances are long enough, as contour maps showing the directivity and range to various sound levels (Section 4.1.3).

4.1.1. Received Levels at 10 m

Since piles are distributed and directional sources, they cannot be accurately approximated by a point source with corresponding source levels. It is possible to compare the maximum modelled levels at short distances from the piles. Figure 8 shows the decidecade–band levels for the receiver with the highest SEL at a horizontal range of 10 m, for each of the three modelled penetration depths.

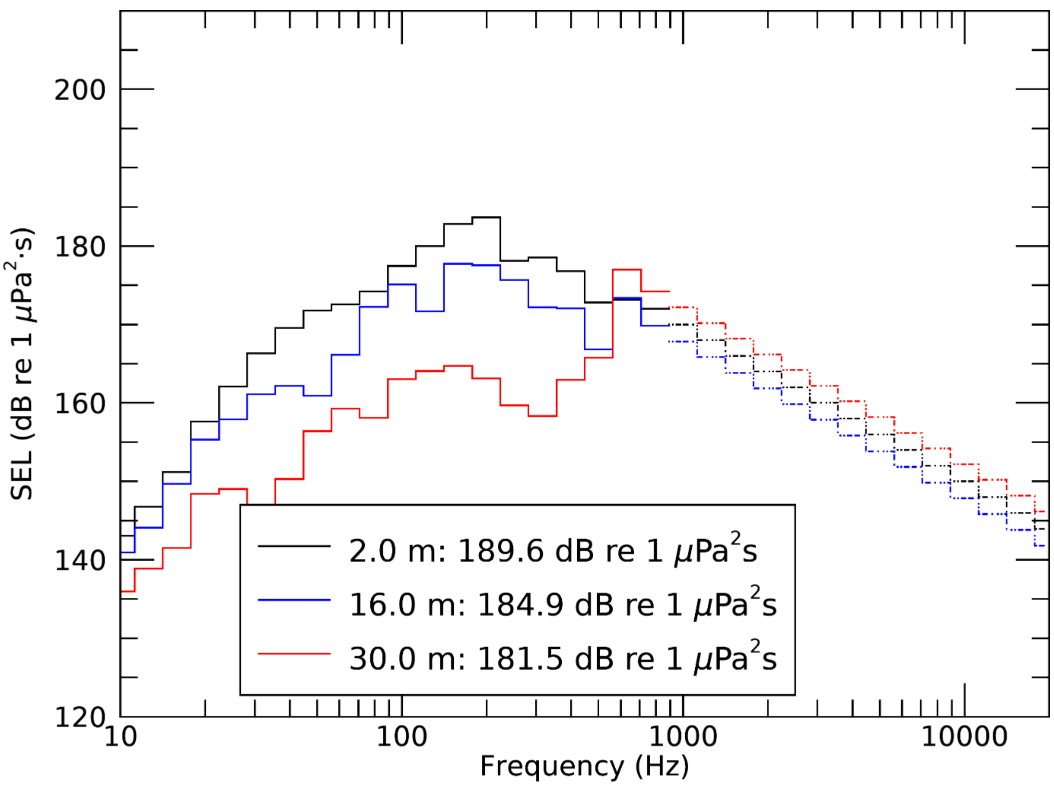

Figure 8. *Wilcox-1*: Decidecade–band levels for the receiver with highest SEL at 10 m horizontal range for impact pile driving using the IHC S1200 hammer, after high–frequency extrapolation (dashes indicate extrapolated portion of the spectrum above 1000 Hz). Legend items indicate the modelled pile penetration and the broadband SEL in dB re 1 μPa²·s.

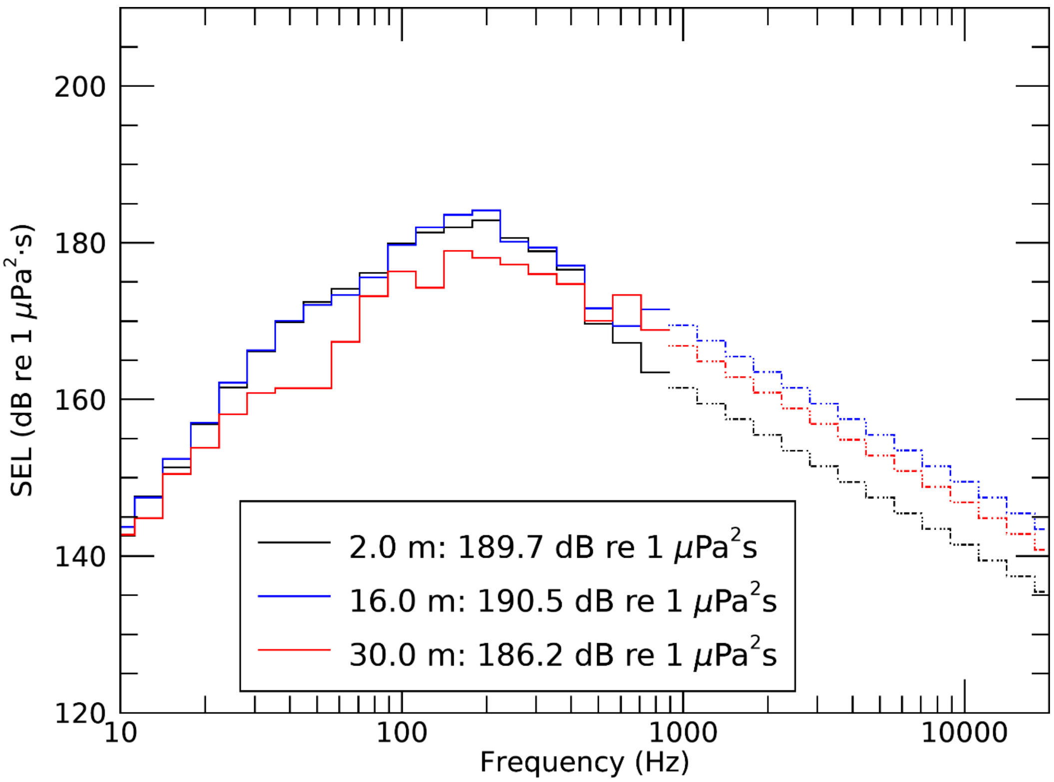

Figure 9. *Yodel South*: Decidecade–band levels for the receiver with highest SEL at 10 m horizontal range for impact pile driving using the IHC S1200 hammer, after high–frequency extrapolation (dashes indicate extrapolated portion of the spectrum above 1000 Hz). Legend items indicate the modelled pile penetration and the broadband SEL in dB re 1 μPa²·s.

4.1.2. Tabulated Results

This section presents the per-strike sound fields in terms of maximum-over-depth SPL, SEL, and PK. The different metrics are presented for the following reasons:

- SPL sound fields (Table 9 and Table 10) were used to determine the distances to marine mammal and turtle behavioural thresholds (see Section 2.1).
- SEL sound fields (Table 11 and Table 12) are used as inputs into the 24 h SEL scenario.
- PK metrics within the water column (Table 13 and Table 14) are relevant to thresholds and guidelines for marine mammals, sea turtles, fish, fish eggs and larvae (see Section 2.1).

Frequency-weighted SEL_{24h} sound fields were used to estimate the maximum distance and the area to marine mammals and turtle PTS and TTS thresholds (listed in Table 15 and Table 16), and to estimate maximum distance and the area to injury and TTS guidelines for fish (Table 17 and Table 18). Distances are reported as R_{max} and $R_{95\%}$ as described in Appendix C.4.

Table 9. *Wilcox-1: modelled maximum–over–depth per–strike SPL isopleths*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from each pile and for each penetration depth.

SPL (L_p; dB re 1 µPa)	Penetration depth (m)					
	2.0		16.0		30.0	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
200	0.02	0.02	–	–	–	–
190	0.05	0.05	0.03	0.03	0.02	0.02
180	0.44	0.42	0.23	0.22	0.09	0.08
175[1]	0.58	0.54	0.51	0.47	0.39	0.37
170	1.23	1.10	0.96	0.90	0.49	0.47
166[2]	2.15	2.00	1.81	1.66	0.73	0.67
160[3]	4.79	4.45	4.37	3.95	1.49	1.36
150	15.6	14.3	14.8	12.8	4.67	4.14
140	39.3	34.8	36.1	32.1	12.3	10.5
130	98.1	64.6	98.0	60.4	30.1	26.3

[1] Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000).
[2] Threshold for turtle behavioural response to impulsive noise (McCauley et al. 2000).
[3] Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 10. *Yodel South: modelled maximum–over–depth per–strike SPL isopleths*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from each pile and for each penetration depth.

SPL (L_p; dB re 1 µPa)	Penetration depth (m)					
	2.0		16.0		30.0	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
200	–	–	–	–	–	–
190	0.10	0.10	0.06	0.06	0.03	0.03
180	0.29	0.28	0.26	0.25	0.23	0.22
175[1]	0.77	0.74	0.70	0.68	0.39	0.38
170	1.42	1.29	1.08	0.94	0.81	0.79
166[2]	2.45	2.25	1.88	1.74	1.46	1.40
160[3]	5.78	5.25	4.81	4.46	4.13	3.82
150	16.3	14.2	15.8	14.2	15.2	13.9
140	47.7	40.4	48.5	39.8	46.1	37.9
130	92.8	83.4	93.7	82.7	90.6	78.5

[1] Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000).
[2] Threshold for turtle behavioural response to impulsive noise (McCauley et al. 2000).
[3] Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 11. *Wilcox-1: modelled maximum–over–depth per–strike SEL isopleths*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from each pile and for each penetration depth.

Per–strike SEL (L_E; dB re 1 µPa²·s)	Penetration depth (m)					
	2.0		16.0		30.0	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
190	–	–	–	–	–	–
180	0.06	0.06	0.03	0.03	0.02	0.02
170	0.47	0.44	0.27	0.25	0.12	0.12
160†	1.05	0.99	0.83	0.75	0.47	0.44
150	1.45	1.33	1.16	1.04	0.61	0.53
140	5.50	5.07	4.94	4.52	1.63	1.49
130	17.6	16.2	16.3	14.3	5.13	4.59

† Low power zone assessment criteria DEWHA (2008).
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 12. *Yodel South: modelled maximum–over–depth per–strike SEL isopleths*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from each pile and for each penetration depth.

Per–strike SEL (L_E; dB re 1 µPa²·s)	Penetration depth (m)					
	2.0		16.0		30.0	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
190	–	–	0.02	0.02	–	–
180	0.11	0.11	0.06	0.06	0.05	0.05
170	0.33	0.31	0.30	0.29	0.26	0.25
160†	1.31	1.15	0.87	0.83	0.74	0.72
150	1.55	1.43	1.32	1.13	0.94	0.91
140	6.68	6.03	5.84	5.21	5.02	4.59
130	19.7	17.9	18.5	16.6	17.7	16.0

† Low power zone assessment criteria DEWHA (2008).
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 13. *Wilcox-1*: Maximum (R_{max}) horizontal distances (in km) from the pile to modelled maximum-over-depth peak pressure level (PK) thresholds based on Southall et al. (2019) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for sea turtles, for relevant modelled site with water depth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Penetration Depth (m)		
		2.0	16.0	30.0
		R_{max} (km)	R_{max} (km)	R_{max} (km)
PTS				
LF cetaceans	219	–	–	–
HF cetaceans	230	–	–	–
VHF cetaceans	202	0.13	0.06	0.03
Sea turtles	232	–	–	–
TTS				
LF cetaceans	213	0.03	–	0.03
HF cetaceans	224	–	–	–
VHF cetaceans	196	0.47	0.40	0.10
Sea turtles	226	–	–	–
Fish				
Fish I (also applied to sharks)	213	0.03	–	–
Fish II, III Fish eggs, and larvae	207	0.06	0.03	0.02

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 14. *Yodel South*: Maximum (R_{max}) horizontal distances (in km) from the pile to modelled maximum-over-depth peak pressure level (PK) thresholds based on Southall et al. (2019) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for sea turtles, for relevant modelled site with water depth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Penetration Depth (m)		
		2.0	16.0	30.0
		R_{max} (km)	R_{max} (km)	R_{max} (km)
PTS				
LF cetaceans	219	–	–	–
HF cetaceans	230	–	–	–
VHF cetaceans	202	0.14	0.12	0.11
Sea turtles	232	–	–	–
TTS				
LF cetaceans	213	0.05	0.03	0.02
HF cetaceans	224	–	–	–
VHF cetaceans	196	0.37	0.36	0.31
Sea turtles	226	–	–	–
Fish				
Fish I (also applied to sharks)	213	0.05	0.03	0.02
Fish II, III Fish eggs, and larvae	207	0.10	0.06	0.04

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 15. *Wilcox-1:* Maximum-over-depth distances (in km) to frequency-weighted 24 h sound exposure level (SEL_{24h}) based PTS and TTS for marine mammals (Southall et al. 2019) and sea turtles (Finneran et al. 2017) considering the driving of the entire pile.

Fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Anchor pile	
		R_{max} (km)	Area (km²)
PTS			
LF cetaceans	183	2.43	16.0
HF cetaceans	185	0.06	0.01
VHF cetaceans	155	1.61	6.97
Sea turtles	204	0.19	0.08
TTS			
LF cetaceans	168	16.0	613
HF cetaceans	170	0.36	0.39
VHF cetaceans	140	8.88	171
Sea turtles	189	1.41	5.46

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 16. *Yodel South:* Maximum-over-depth distances (in km) to frequency-weighted 24 h sound exposure level (SEL_{24h}) based PTS and TTS for marine mammals (Southall et al. 2019) and sea turtles (Finneran et al. 2017) considering the driving of the entire pile.

Fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Anchor pile	
		R_{max} (km)	Area (km²)
PTS			
LF cetaceans	183	3.11	25.7
HF cetaceans	185	0.05	0.01
VHF cetaceans	155	1.87	7.60
Sea turtles	204	0.25	0.20
TTS			
LF cetaceans	168	22.6	1090
HF cetaceans	170	0.41	0.50
VHF cetaceans	140	10.6	254
Sea turtles	189	1.73	8.80

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 17. *Wilcox-1:* Distances to 24 h sound exposure level (SEL_{24h}) based fish criteria in the water column.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Anchor pile	
		R_{max} (km)	Area (km²)
Fish I	219	–	–
Fish II, fish eggs and fish larvae	210	0.05	0.01
Fish III	207	0.15	0.02
Recoverable injury			
Fish I	216	–	–
Fish II, III	203	0.25	0.19
Temporary threshold shift (TTS)			
Fish I, II, III	186	2.43	17.4

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 18. *Yodel South:* Distances to 24 h sound exposure level (SEL_{24h}) based fish criteria in the water column.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Anchor pile	
		R_{max} (km)	Area (km²)
Fish I	219	–	–
Fish II, fish eggs and fish larvae	210	0.09	0.02
Fish III	207	0.20	0.11
Recoverable injury			
Fish I	216	0.05	0.01
Fish II, III	203	0.33	0.34
Temporary threshold shift (TTS)			
Fish I, II, III	186	3.53	35.3

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

4.1.3. Sound Field Maps and Plots

Maps of the per strike sound fields are presented as maximum-over-depth sound level contour maps in Figures 10–15 and as vertical slice plots in Figure 16–21 for selected azimuths. Accumulated SEL_{24h} maps are shown in Figures 22–25 for selected weightings.

4.1.3.1. SPL Sound Level Contour Maps

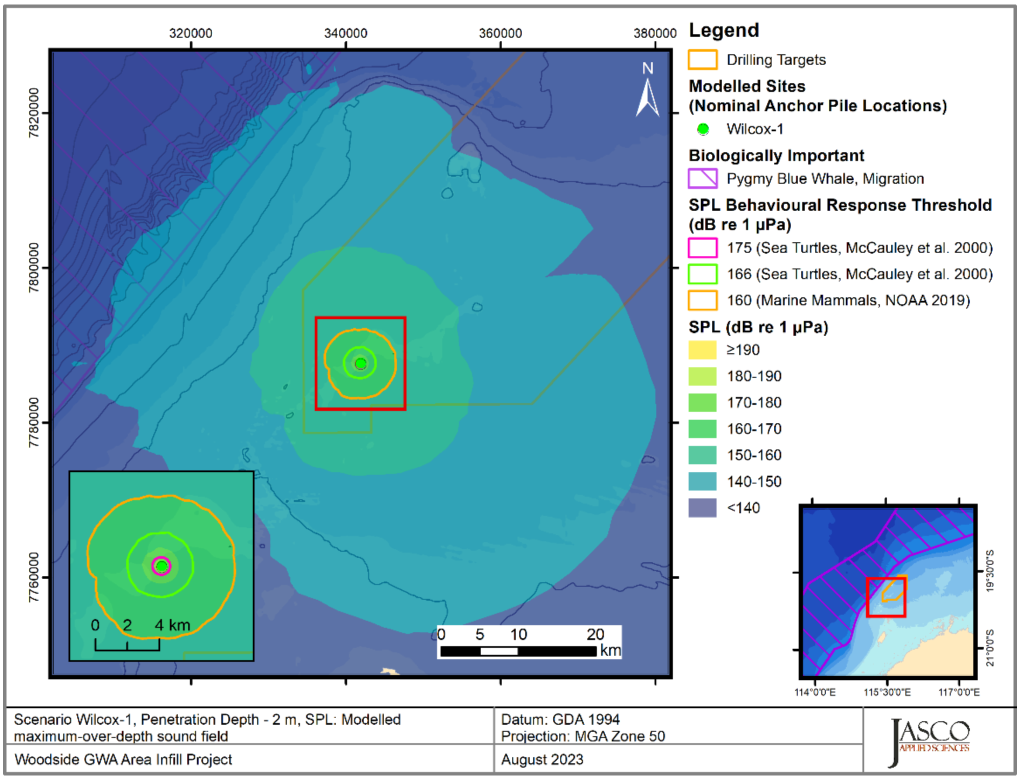

Figure 10. *Wilcox-1, Pile penetration depth – 2 m*, SPL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural thresholds for marine mammals and sea turtles.

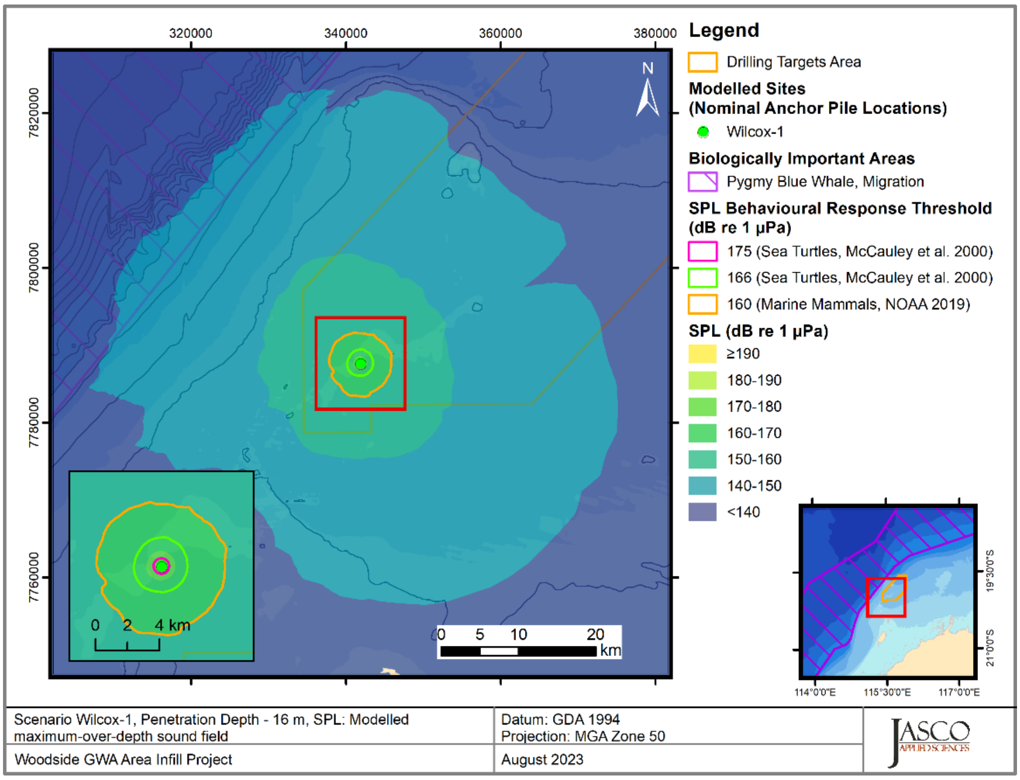

Figure 11. *Wilcox-1, Pile penetration depth – 16 m*, SPL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural thresholds for marine mammals and sea turtles.

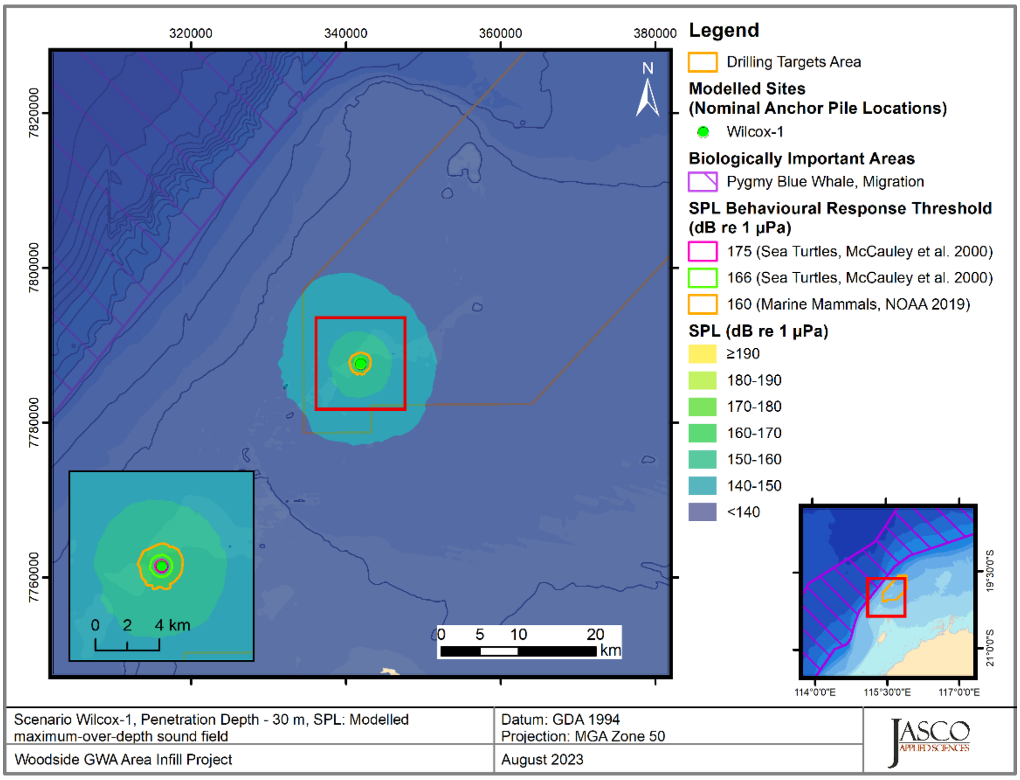

Figure 12. *Wilcox-1, Pile penetration depth – 30 m*, SPL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural thresholds for marine mammals and sea turtles.

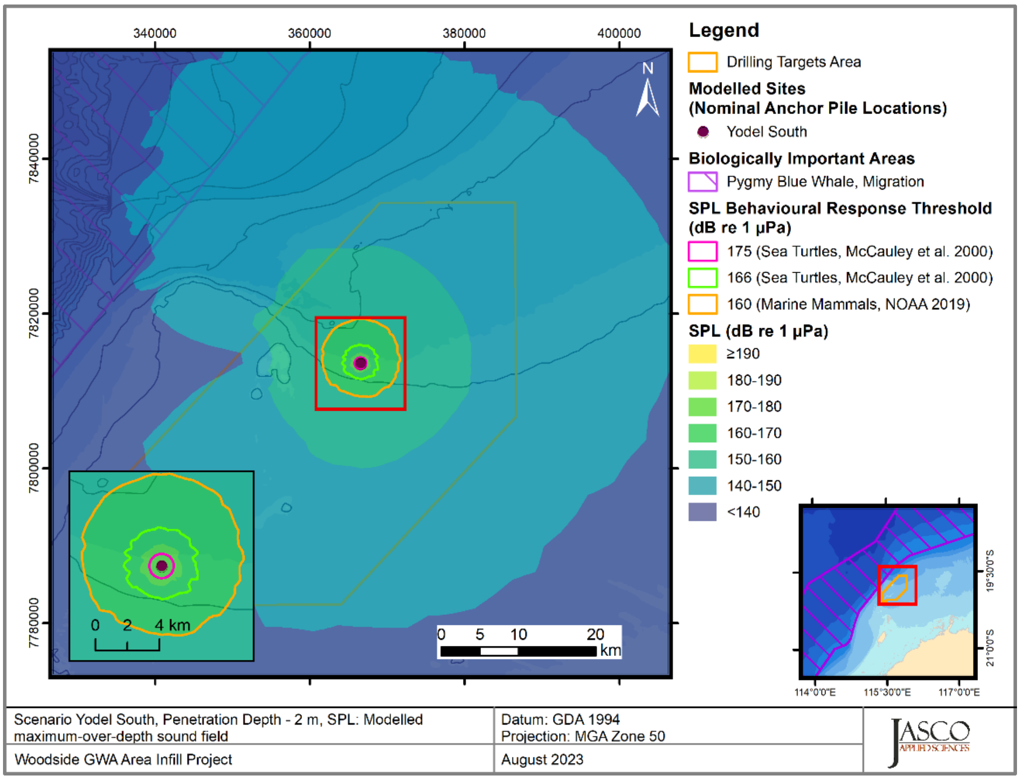

Figure 13. *Yodel South, Pile penetration depth – 2 m,* SPL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural thresholds for marine mammals and sea turtles.

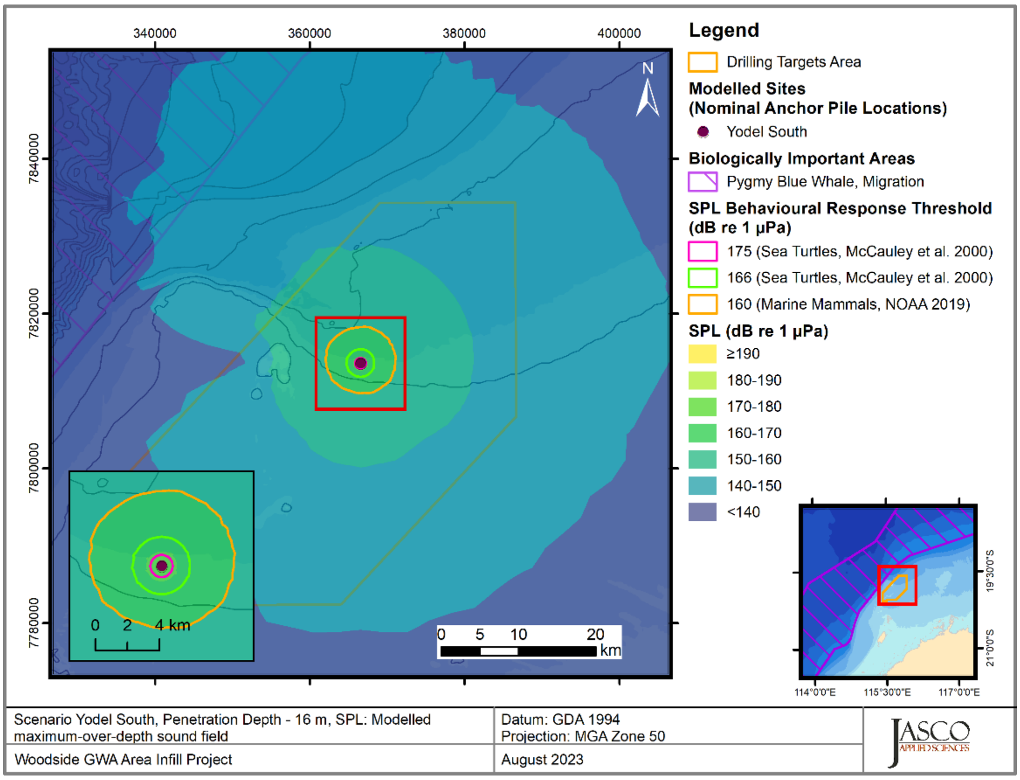

Figure 14. *Yodel South, Pile penetration depth –16 m*, SPL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural thresholds for marine mammals and sea turtles.

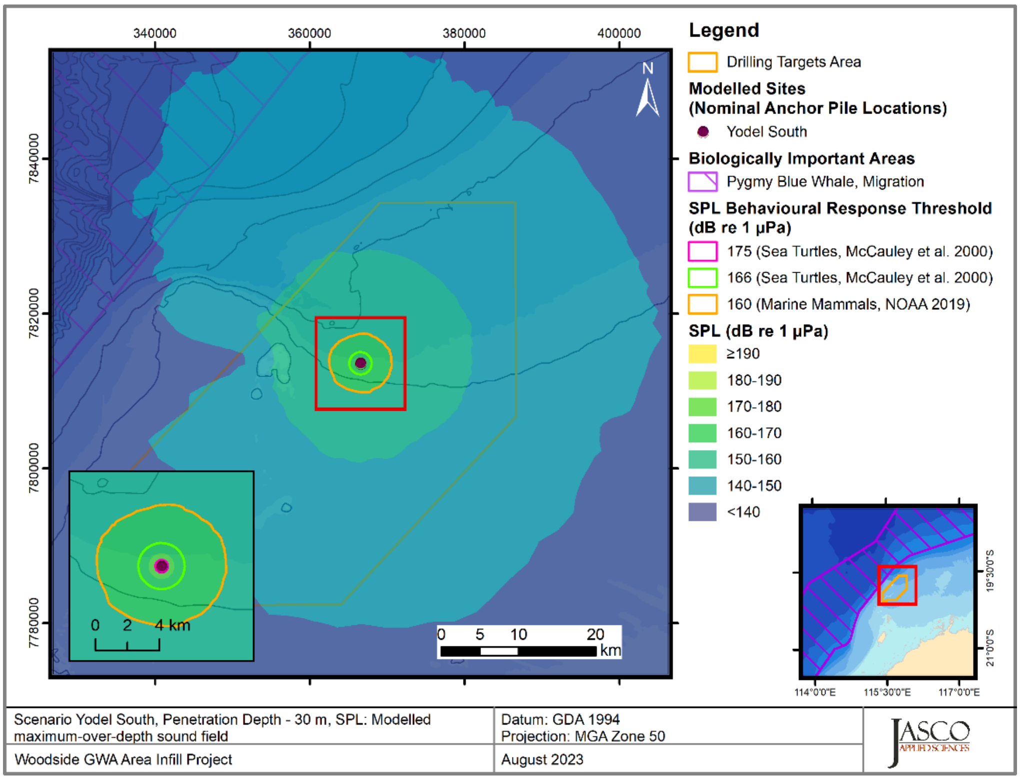

Figure 15. *Yodel South, Pile penetration depth – 30 m*, SPL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural thresholds for marine mammals and sea turtles.

4.1.3.2. SPL Per-strike Vertical Slice Plots

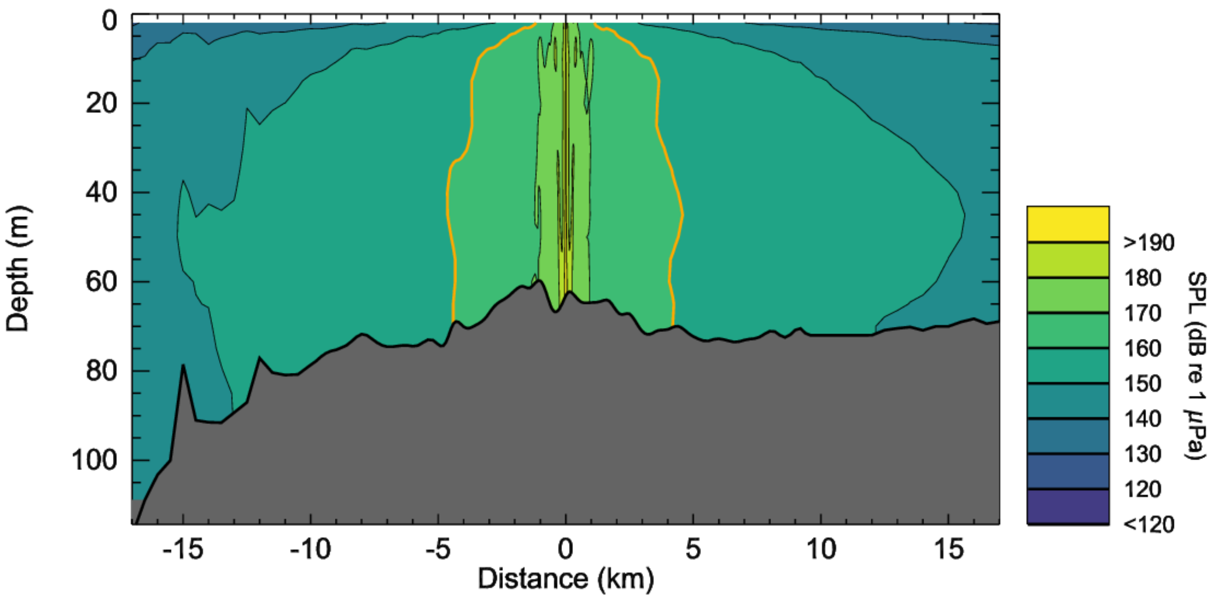

Figure 16. *Wilcox-1, Pile penetration depth – 2 m, SPL*: Vertical slice plot showing variations with depth and distance from the pile for the first penetration depth. The seabed is shown as dark grey. The orange contour indicates the marine mammal behavioural threshold for impulsive sound sources (NOAA 2019). Cross sections are along the 45°/225° transect.

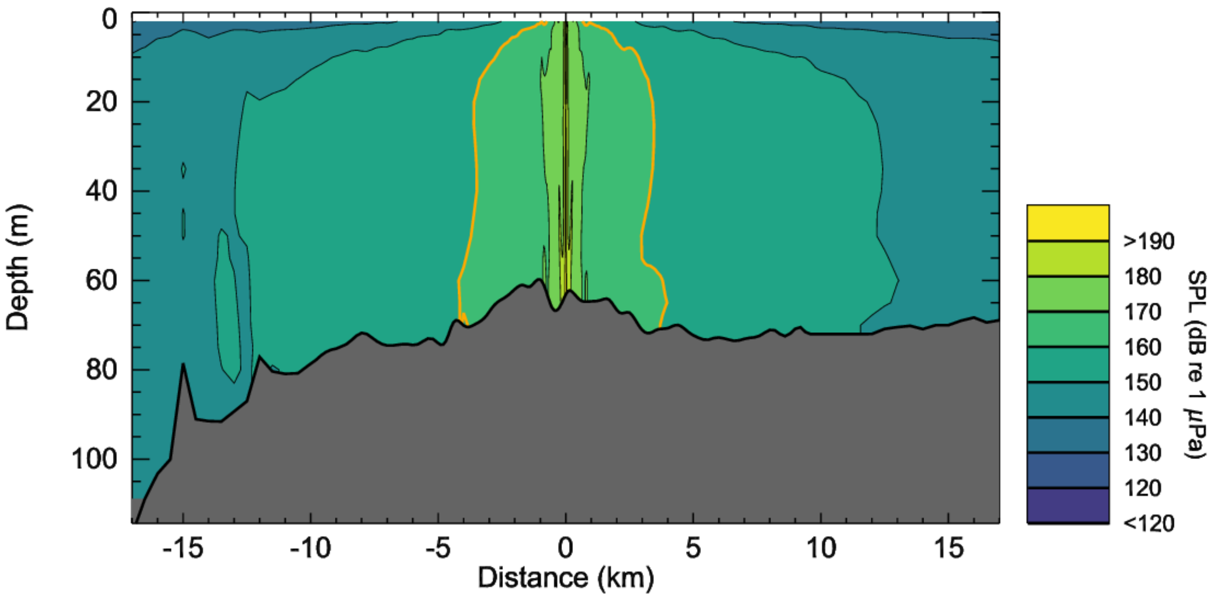

Figure 17. *Wilcox-1, Pile penetration depth – 16 m, SPL*: Vertical slice plot showing variations with depth and distance from the pile for the second penetration depth. The seabed is shown as dark grey. The orange contour indicates the marine mammal behavioural threshold for impulsive sound sources (NOAA 2019). Cross sections are along the 135°/315° transect.

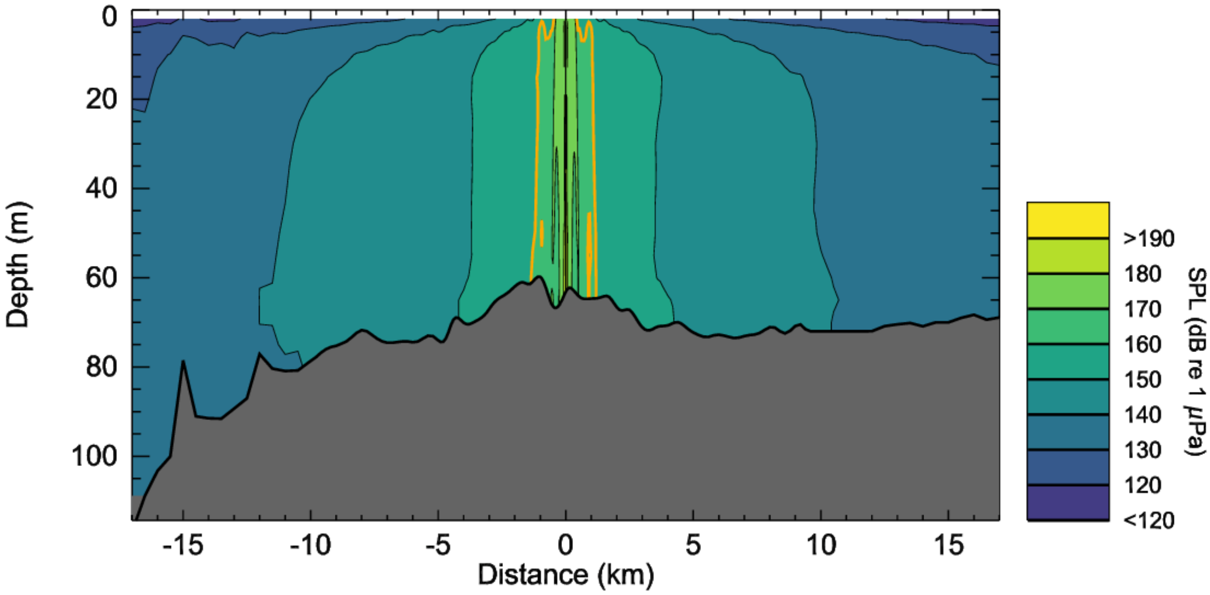

Figure 18. *Wilcox-1, Pile penetration depth – 30 m, SPL*: Vertical slice plot showing variations with depth and distance from the pile for the third penetration depth. The seabed is shown as dark grey. The orange contour indicates the marine mammal behavioural threshold for impulsive sound sources (NOAA 2019). Cross sections are along the 135°/315° transect.

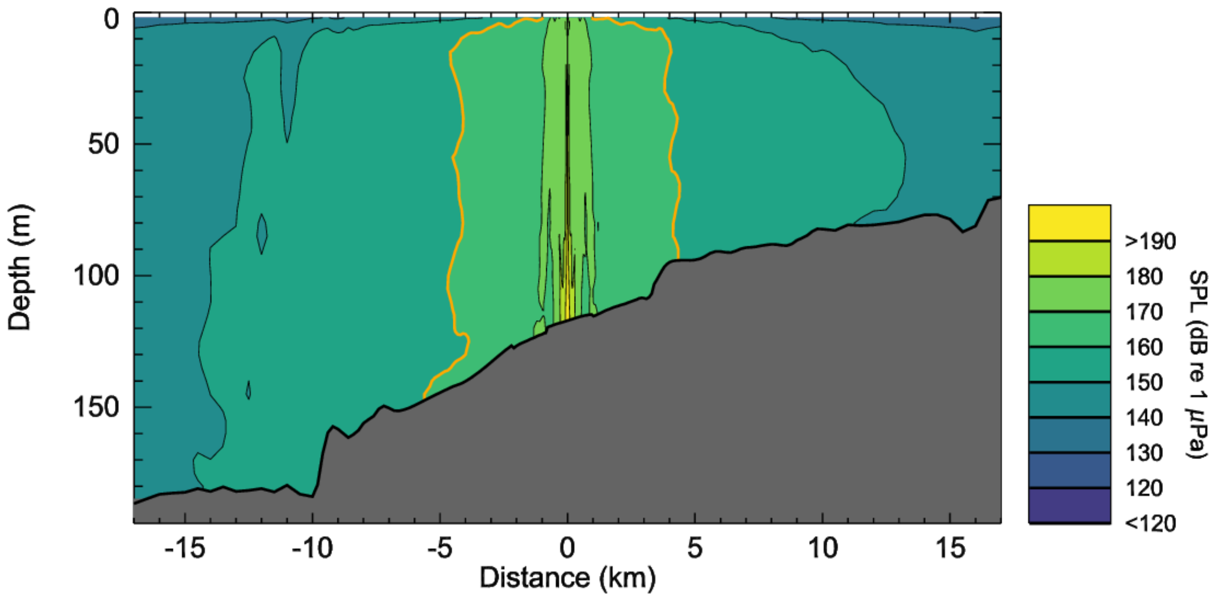

Figure 19. *Yodel South, Pile penetration depth – 2 m, SPL*: Vertical slice plot showing variations with depth and distance from the pile for the first penetration depth. The seabed is shown as dark grey. The orange contour indicates the marine mammal behavioural threshold for impulsive sound sources (NOAA 2019). Cross sections are along the 135°/315° transect.

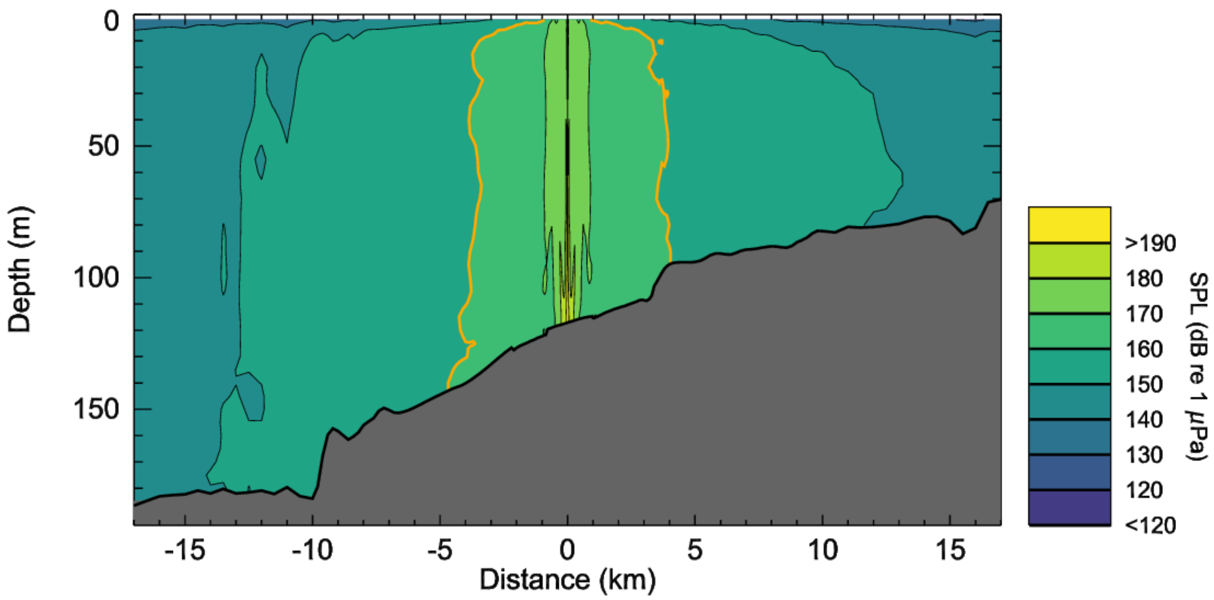

Figure 20. *Yodel South, Pile penetration depth – 16 m, SPL*: Vertical slice plot showing variations with depth and distance from the pile for the second penetration depth. The seabed is shown as dark grey. The orange contour indicates the marine mammal behavioural threshold for impulsive sound sources (NOAA 2019). Cross sections are along the 135°/315° transect.

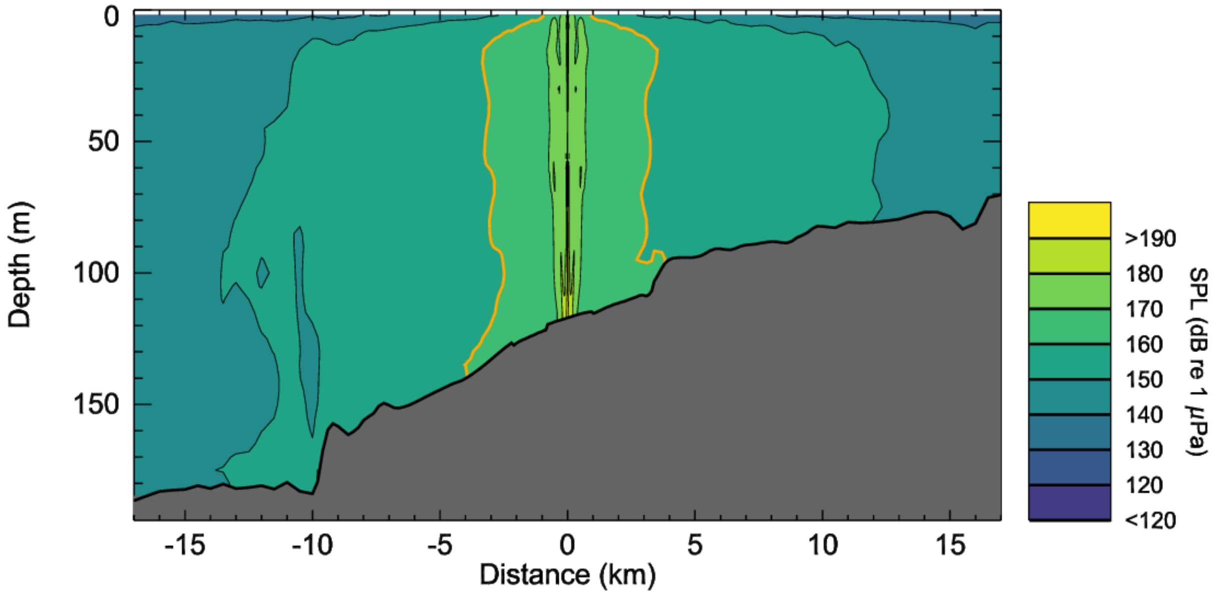

Figure 21. *Yodel South, Pile penetration depth – 30 m, SPL*: Vertical slice plot showing variations with depth and distance from the pile for the third penetration depth. The seabed is shown as dark grey. The orange contour indicates the marine mammal behavioural threshold for impulsive sound sources (NOAA 2019). Cross sections are along the 135°/315° transect.

4.1.3.3. Accumulated SEL_{24h} Sound Level Contour Maps

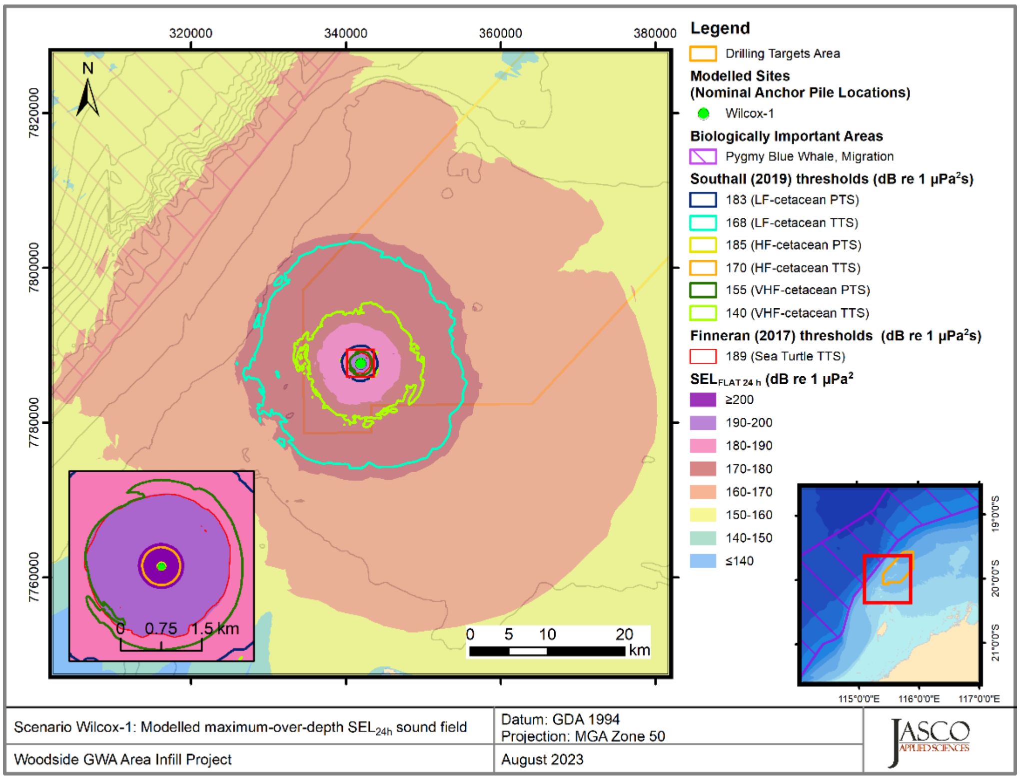

Figure 22. *Wilcox-1*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for cetaceans and sea turtles. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Table 15 for threshold distances.

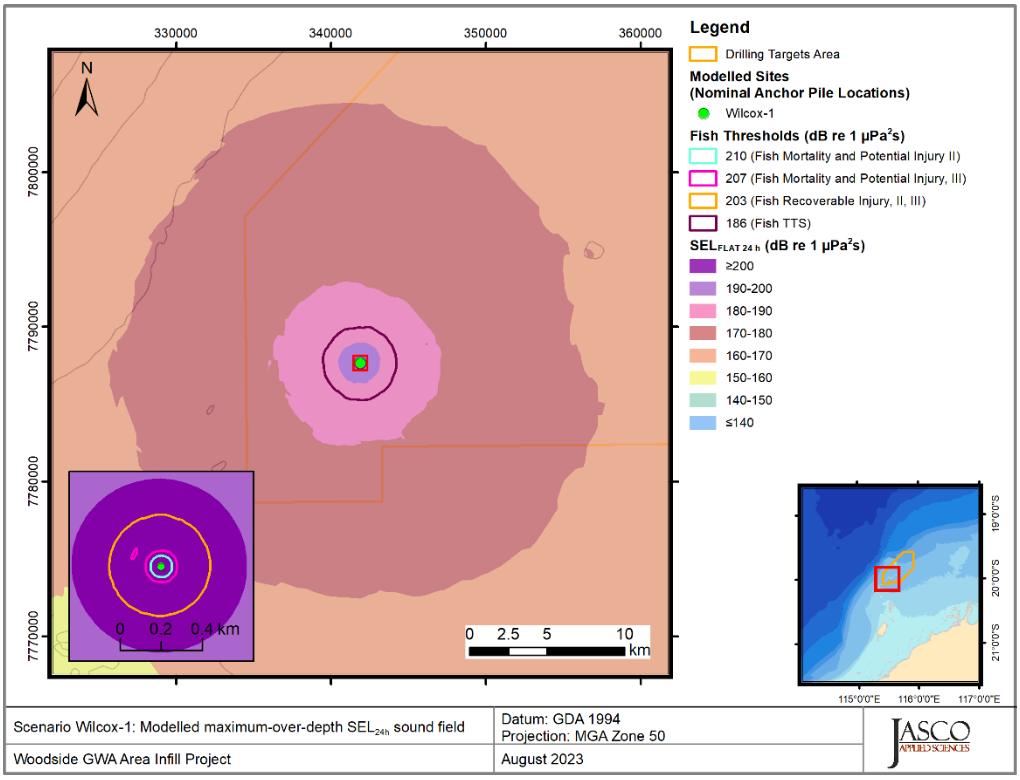

Figure 23. *Wilcox-1*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths relevant to fish injury and TTS. Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Table 17 for threshold distances.

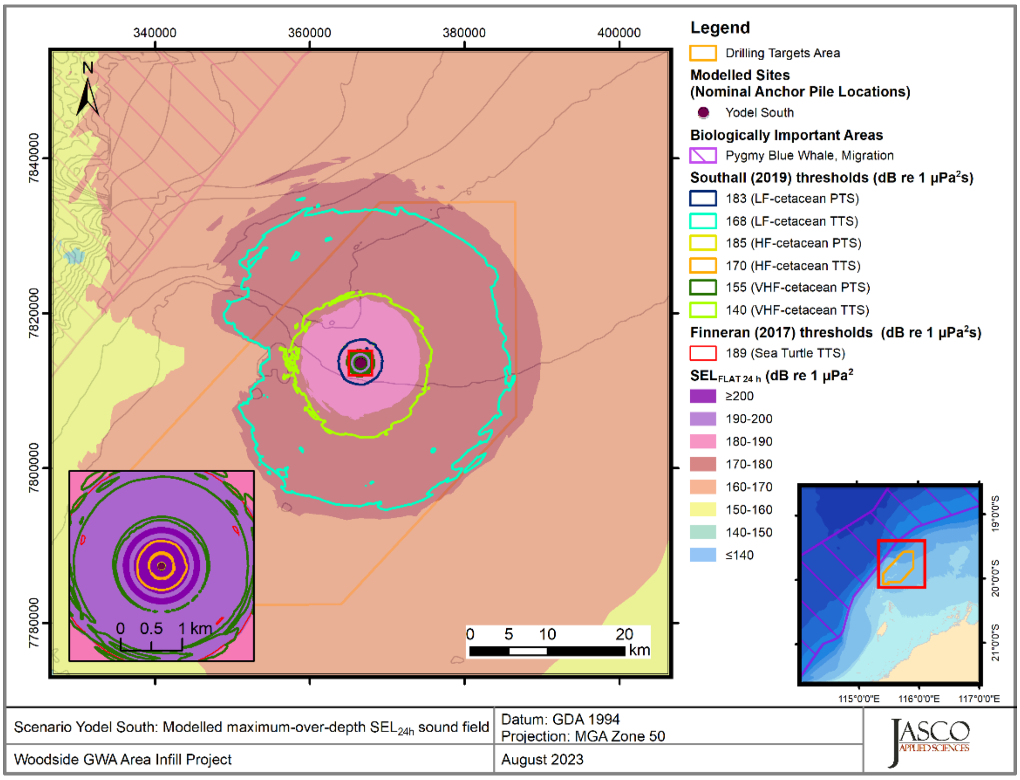

Figure 24. *Yodel South*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for cetaceans and sea turtles. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Table 16 for threshold distances.

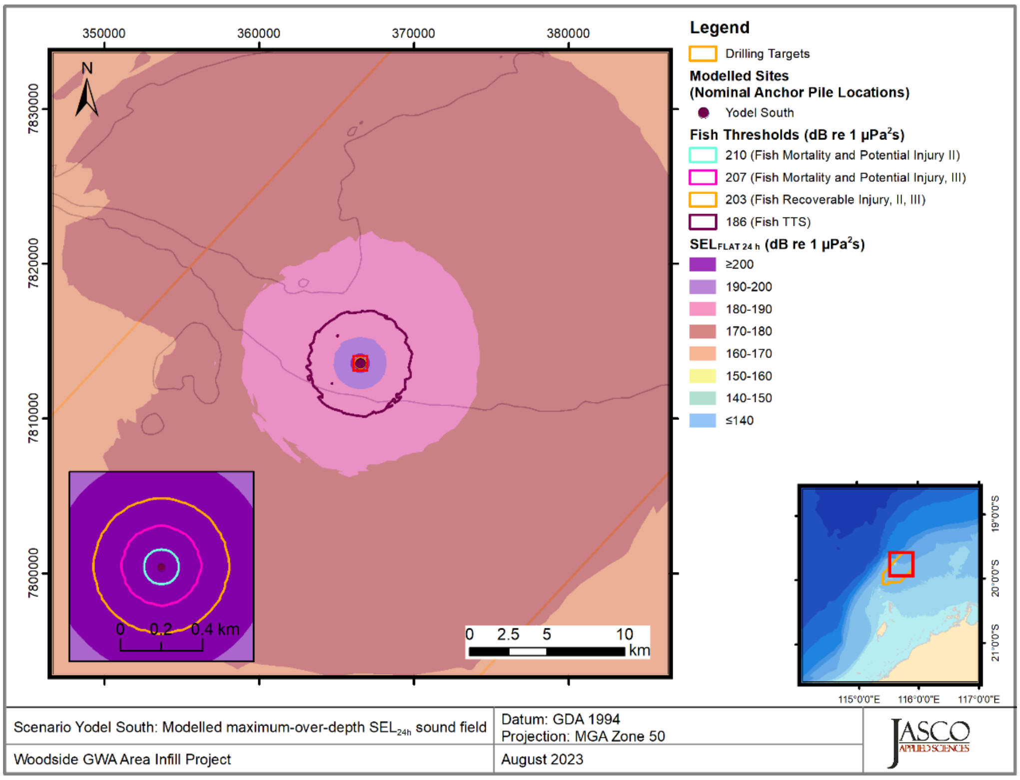

Figure 25. *Yodel South*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths relevant to fish injury and TTS. Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Table 18 for threshold distances.

4.2. Animal Movement Exposure Ranges

A summary of radial distances to exposure thresholds for migrating pygmy blue whales, along with the probability of exposure for both pile driving scenarios (see Table 3) are included in below. Tables 19 and 20 show results for scenarios with animats unrestricted and restricted to the BIA, respectively, for pygmy blue whales. Results include $ER_{95\%}$ exposure ranges calculated for the 160 dB SPL behavioural response threshold and SEL_{24h} thresholds for both TTS and PTS, and the probability of an animat being exposed above the threshold within the $ER_{95\%}$.

Section 4.2.1 shows histograms of CPA ranges to SEL_{24h} PTS, TTS, and the behavioural response threshold for pygmy blue whale animats not restricted to the BIA. Please note that no pygmy blue whale animats were exposed above threshold for the BIA-restricted scenarios and therefore, no histograms of CPA ranges are presented for these cases.

Table 19. Summary of animat simulation results for pygmy blue whales with animats not restricted to the BIA. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided.

Threshold	Pygmy blue whales, 230° migration				Pygmy blue whales, 270° migration			
	Wilcox-1		Yodel South		Wilcox-1		Yodel South	
Description	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
PTS (SEL_{24h})[1]	0.59	68	0.72	77	0.53	75	0.77	81
TTS (SEL_{24h})[2]	6.36	64	8.98	76	6.29	66	8.86	77
Behavioural response (SPL)[3]	4.04	64	4.04	87	4.10	67	4.16	86

[1] LF-weighted SEL_{24h} (183 dB re 1 µPa²·s) (Southall et al.)
[2] LF-weighted SEL_{24h} (168 dB re 1 µPa²·s) (Southall et al.)
[3] SPL (160 dB re 1 µPa) (NOAA (2019))

Table 20. Summary of animat simulation results for pygmy blue whales with animats restricted to the BIA. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided. Dashes indicate no animats were exposed above threshold.

Threshold	Pygmy blue whales, 230° migration			
	Wilcox-1		Yodel South	
Description	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
PTS (SEL_{24h})[1]	–	–	–	–
TTS (SEL_{24h})[2]	–	–	–	–
Behavioural response (SPL)[3]	–	–	–	–

[1] LF-weighted SEL_{24h} (183 dB re 1 µPa²·s) (Southall et al.)
[2] LF-weighted SEL_{24h} (168 dB re 1 µPa²·s) (Southall et al.)
[3] SPL (160 dB re 1 µPa) (NOAA (2019))

4.2.1. Exposure Range Histograms

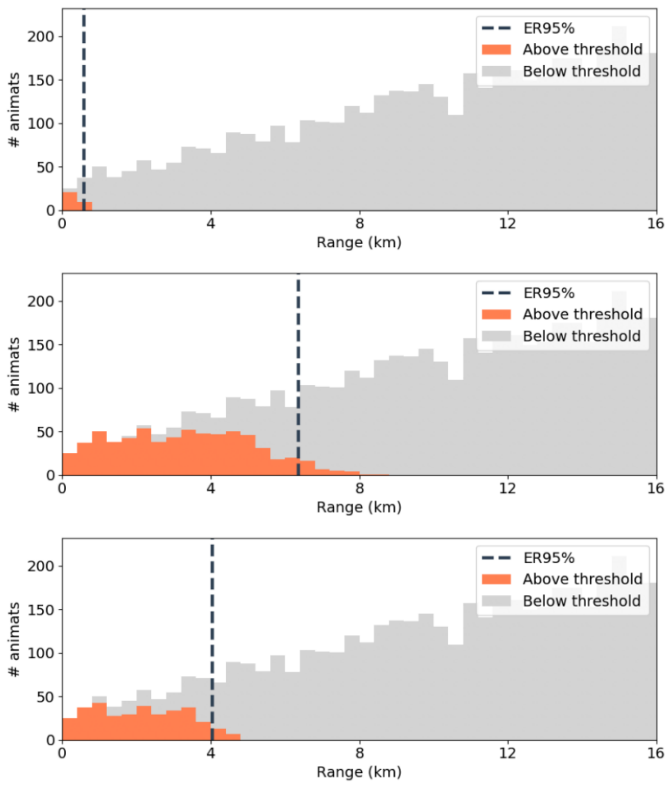

Figure 26. *Wilcox-1, 230° south-bound migrating animats, unrestricted seeding*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel), SEL_{24h} TTS threshold (middle panel), SPL behavioural threshold (bottom panel). Bar colours indicate whether the animats exceeded the threshold.

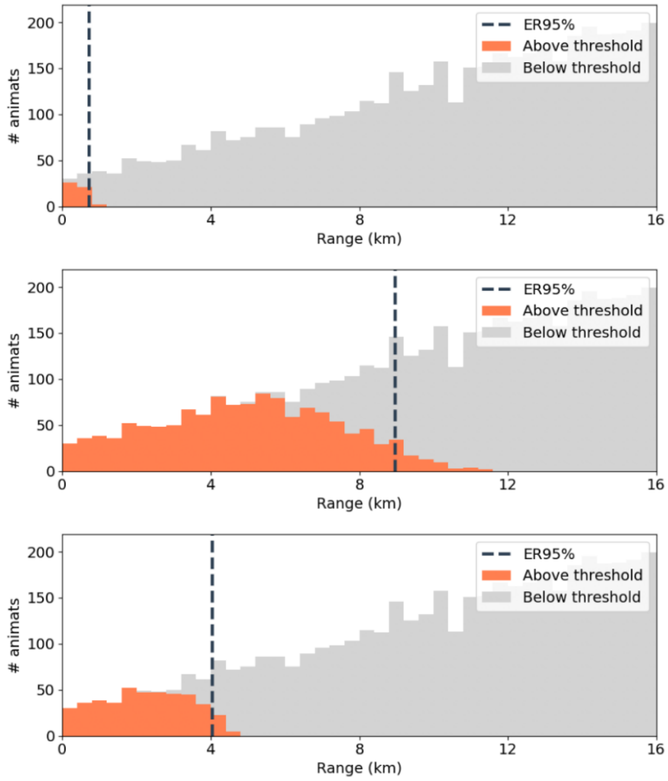

Figure 27. *Yodel South, 230° south-bound migrating animats, unrestricted seeding*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel), SEL_{24h} TTS threshold (middle panel), SPL behavioural threshold (bottom panel). Bar colours indicate whether the animats exceeded the threshold.

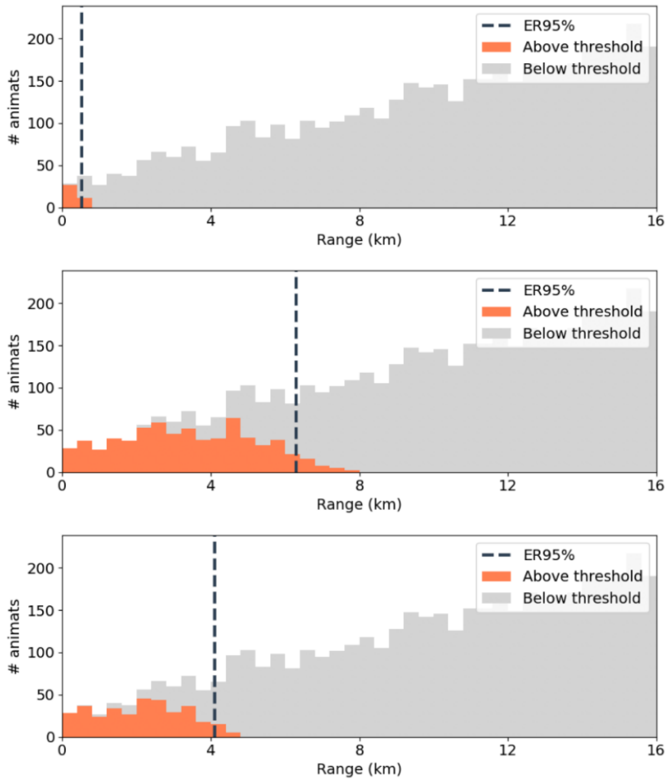

Figure 28. *Wilcox-1, 270° south-bound migrating animats, unrestricted seeding*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel), SEL_{24h} TTS threshold (middle panel), SPL behavioural threshold (bottom panel). Bar colours indicate whether the animats exceeded the threshold.

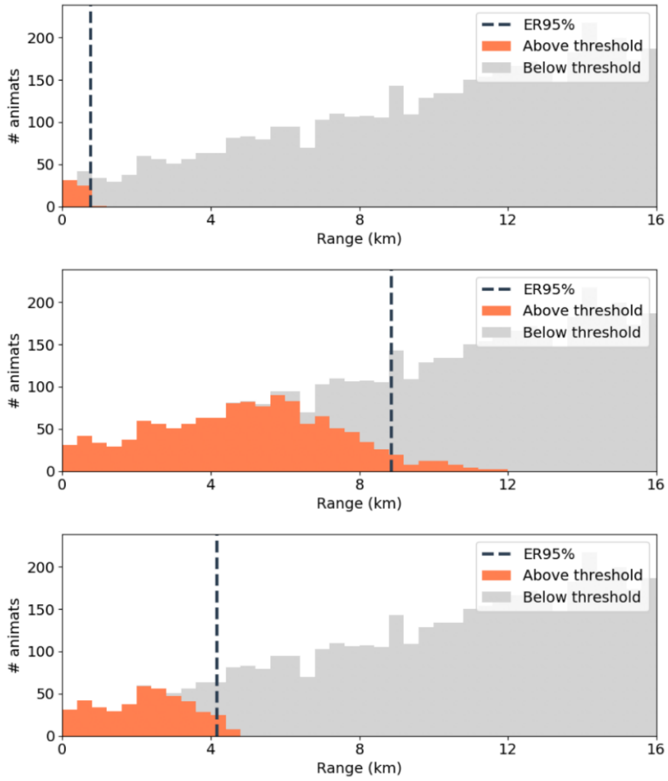

Figure 29. *Yodel South, 270° south-bound migrating animats, unrestricted seeding*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel), SEL_{24h} TTS threshold (middle panel), SPL behavioural threshold (bottom panel). Bar colours indicate whether the animats exceeded the threshold.

5. Discussion and Conclusion

Underwater sound levels associated with key construction activities for potential pile driving activities planned by Woodside within the vicinity of Rankin Bank on the NWS were considered in this study. This study specifically predicted underwater sound levels associated with impact driving of subsea MODU anchor piles at sites Wilcox-1 and Yodel South.

The underwater sound field was modelled at two sites for pile driving for single impact hammer and single pile design, which have been selected to assess the largest impact potential on marine fauna in this region. Most acoustic energy from the sound sources considered is output of lower frequencies, in the tens to hundreds of hertz.

A September yearly average sound speed profile (Appendix C.1.2) was selected to as part of the approach to estimate distances to received sound level thresholds. Modelling also accounted for site-specific bathymetric variations (Appendix C.1.1) and local geoacoustic properties (Appendix C.1.3). The sound speed profile was primarily downwards refracting until about 900 m water depth. Near the sea surface, a slightly upward refracting layer was present and extends to about ~25 m water depth. The profile had a minimum sound speed at the sound channel axis at about 900 m. For shallower depths the sound speed increased due to increasing temperature, and below 900 m the sound speed also increased but a relatively gradual rate 900 m due to increasing pressure.

The modelled site encompassed water depths near 100 m across one defined geological area with a single representative water column profile. The bathymetry within survey area varied very gradually within the vicinity of the modelling sites but grew steeper within about 30 – 60 km toward the north/northwest of the modelling site, respectively. The majority of the modelled area was shallower than 1000 m depth, although the maximum depth in the modelling area was 1592 m. Reflections from the seabed combined with the increasing slope towards deeper waters lead to longer ranges towards the north.

The combination of low-frequency content from the piling sound with the water depths within the survey area resulted in the sound field substantially interacting with the seabed. The maximum-over-depth sound footprint maps and vertical slice plots (Section 4.1.3) assist in demonstrating the influence of the bathymetry, sound speed profile and seabed composition on the sound field.

The footprint maps and cross-sections in Section 4.1.3 show that the propagation at Wilcox-1 and Yodel South is approximately axisymmetric, with a small bathymetric feature reducing propagation to the west of the Yodel South site. The vertical slice plots demonstrate that although acoustic energy propagates further into deeper water away from the shelf, the thresholds considered are not long enough to reach the shelf break and are restricted to shallower depths. The rate of loss in shallower shelf water is primarily dependent on the magnitude of the water depth change, the bathymetric gradient and the geoacoustic properties of the seabed (Jensen et al. 2011). These parameters have been incorporated into the acoustic models to provide a realistic estimate of the received levels.

5.1. Pile Driving

This study predicted underwater sound levels associated with impact driving of subsea piles at sites Wilcox-1 and Yodel South. The pile driving scenario is based on approximated and likely designs and installation approaches.

The underwater sound field was modelled for a 32 m long pile with a 2.18 m diameter with 76 mm wall thickness. The anchor piles will be driven a total of 30.0 m into the seabed. The broadband sound energy at 10 m for each penetration depth ranged from 181.5 to 189.6 dB re 1 $\mu Pa^2 \cdot s$ at Wilcox-1 and 186.2 to 189.7 dB re 1 $\mu Pa^2 \cdot s$ at Yodel South with the maximum sound energy concentrated in the frequency range 100 to 400 Hz (see Figure 8 and Figure 9). Levels from the pile at the 2.0 m penetration depth had the highest energy.

When the hammer strikes the pile, noise propagates into the water as a downward Mach cone (see Appendix B-1). A portion of the energy from the strike is also reflected at the pile bottom, generating an upward Mach cone. This cycle of downward propagation, reflection, and upward propagation occurs multiple times per strike. At close range from the pile, noise levels are determined by the summation of Mach cones, which might add constructively (i.e., their summation results in a total wave with higher amplitude than the original ones) or destructively (i.e., wavefronts can cancel each other, resulting in lower amplitudes). The way in which Mach cones combine with each other is strongly dependent on their frequency content, which is determined by the hammer forcing function and the pile dimensions.

Due to the relation between the speed of sound in steel (~5000 m/s) relative to the speed of sound in the water (~1525 m/s at the depth of the pile), the Mach cone propagates away from the pile and impinges the seabed at an angle of ~17°. As shown in Figure 16, the Mach cone corresponding to the shallowest pile penetration, when the longest portion of the pile is exposed to the water column, introduces substantial energy that propagates through the water column, compared to the deepest pile penetration for the anchor pile scenario, for which substrate sound propagation tends to dominate near the pile. Correspondingly, the distances to per-strike isopleths are generally farthest when most of the pile is in the water column, and distances are shortest at the end of piling when most of the pile is buried in the sediment.

For criteria based on SEL_{24h} metrics, the ranges above must be considered in context of the duration of operations. One pile will be driven per day; therefore, the corresponding sound level is denoted as SEL_{24h}. The estimated time for driving a single pile was 1.13 h (Table 8). The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within the driving period and assumes that an animal is consistently exposed to such noise levels at a fixed position. The radii that correspond to SEL_{24h} typically represent an unlikely worst-case scenario for SEL-based exposure since. More realistically, marine fauna (mammals, sea turtles or fish) would not stay in the same location or at the same range for an extended period. Therefore, a reported radius associated with the accumulated SEL criteria does not mean that any animal travelling within this radius of the source will be injured, but rather that it could be injured if it remained in that range for the entire period of driving. While it may be nominally feasible to install more than one pile per day, this scenario would need to be considered in the modelling.

A summary of distances to relevant acoustic thresholds for pile driving are shown in Table 21.

Table 21. *Piling Operations:* Maximum (R_{max}) horizontal distances (in km) to relevant thresholds for marine fauna.

Hearing group	Threshold Type	Metric	Threshold	Wilcox-1	Yodel South
				R_{max} (km)	R_{max} (km)
Low frequency cetaceans	PTS [a]	$L_{E,24h}$	183	2.43	3.11
	TTS [a]	$L_{E,24h}$	168	16.0	22.6
High frequency cetaceans	PTS [a]	$L_{E,24h}$	185	0.06	0.05
	TTS [a]	$L_{E,24h}$	170	0.36	0.41
Very high-frequency cetaceans	PTS [a]	$L_{E,24h}$	155	1.61	1.87
	TTS [a]	$L_{E,24h}$	140	8.88	10.6
All Marine Mammal Groups	Behavioural Response [b]	L_p	160	4.79	5.78
Fish without swim bladder	Mortality and Potential mortal injury [c]	$L_{E,24h}$	219	–	0.03
	Recoverable injury [c]	$L_{E,24h}$	216	0.02	0.05
	TTS [c]	$L_{E,24h}$	186	2.43	3.53
	Recoverable injury [c]	L_{pk}	213	0.03	0.05
Fish with swim bladder not involved in hearing	Mortality and Potential mortal injury [c]	$L_{E,24h}$	210	0.05	0.09
	Recoverable injury [c]	$L_{E,24h}$	203	0.25	0.33
	TTS [c]	$L_{E,24h}$	186	2.43	3.53
	Recoverable injury [c]	L_{pk}	207	0.06	0.10
Fish with swim bladder involved in hearing	Mortality and Potential mortal injury [c]	$L_{E,24h}$	207	0.15	0.20
	Recoverable injury [c]	$L_{E,24h}$	203	0.25	0.33
	TTS [c]	$L_{E,24h}$	186	2.43	3.53
	Recoverable injury [c]	L_{pk}	207	0.06	0.10
Sea turtles	PTS [d]	$L_{E,24h}$	204	0.19	0.25
	TTS [d]	$L_{E,24h}$	189	1.41	1.73
	Behavioural disturbance [e]	L_p	166	2.15	2.45
	Behavioural response [e]	L_p	175	0.58	0.77

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).
L_{pk}= unweighted peak sound pressure level (dB re 1 µPa)
L_p= unweighted sound pressure level (dB re 1 µPa)
L_E= sound exposure level for single strike (dB re 1 µPa^2 s)
$L_{E,24h}$= sound exposure level over 24 hours (dB re 1 µPa^2 s), unweighted for fish and frequency weighted for all other groups
[a] Southall et al. (2019) criteria for marine fauna
[b] NOAA (2019) recommended unweighted behavioural threshold for marine mammals
[c] Popper et al. (2014)
[d] Finneran et al. (2017)
[e] McCauley et al. (2000)

5.2. Animal Movement Modelling

The estimated sound fields produced by source and propagation models for the planned Woodside GWA Area Infill Development OPP were incorporated into an animat sound exposure model for migrating pygmy blue whales to estimate the radial distance within which 95% of the exposure exceedances occur ($ER_{95\%}$), along with the probability that an animat with the closest point of approach within that distance would be exposed above the relevant threshold (P_{exp}).

For the exposure analysis, restricted seeding and unrestricted seeding were considered for pygmy blue whales with two different migration directions considered.

The closest distance between the migratory pygmy blue whale BIA and the potential pile driving locations is approximately 27 km. Because of this, none of the restricted animat seeding scenarios resulted in exposures above threshold.

Sections 5.2.1 and 5.2.2 summarise the PTS, TTS, and behavioural exposure range results, with the tabulated results summarised in Table 22.

Table 22. Summary of animat simulation results for PTS, TTS and SPL behavioural response criteria for pygmy blue whales. Maximum exposure ranges show $ER_{95\%}$ first and probability of exposure of animats travelling within the $ER_{95\%}$ in parentheses.

Pile Location	Species	Behavioural response (SPL)[4]	TTS (SEL_{24h})[3]	PTS (SEL_{24h})[3]
		160[2]	168[1]	183[1]
Wilcox-1	Pygmy blue whale	4.10 km (67%)	6.36 km (64%)	0.59 km (68%)
Yodel South		4.16 km (86%)	8.98 km (76%)	0.77 km (81%)

[1] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
[2] SPL (L_p; dB re 1 µPa)
[3] Southall et al. (2019) criteria for marine fauna.
[4] NOAA (2019) unweighted behavioural threshold for marine mammals.

5.2.1. Behavioural Effects

Exposure ranges for single exposure metrics, such as the SPL behavioural response criteria, are typically comparable to the predicted acoustic ranges. Acoustic ranges are conservatively calculated using the maximum-over-depth sound fields while exposure ranges account for animats sampling the sound field vertically based on species-specific diving parameters, so exposure ranges are often slightly lower than acoustic ranges.

Considering pile driving at Wilcox-1, the maximum $ER_{95\%}$ to the behavioural threshold is 4.10 km with a probability of exposure of animats travelling within the $ER_{95\%}$ of 67%. This is 0.69 km less than the maximum R_{max} from the acoustic modelling and is a more realistic measure as it accounts for the distribution of the sound within the water column and how the pygmy blue whales interact with it. The maximum $ER_{95\%}$ to the behavioural threshold at Yodel South is 4.16 km with a probability of exposure of animats travelling within the $ER_{95\%}$ of 86%.

Due to the main lobe of acoustic energy remaining constant as depth increases, the animat determined exposure ranges were very similar to the static acoustic ranges for both pile driving scenarios, as expected based on the vertical distribution of the sound field. Migrating pygmy blue whales are expected to spend most of their time in a behavioural mode where most dives reach less than 20 m in depth. Figure 30 shows a vertical slice beginning at the source location and extending towards deeper water at an azimuth of 40°. This plot shows how migrating pygmy blue whales sample the upper portion of the water column, which does not differ much from the remaining water column, and results in exposure ranges that are very similar to acoustic ranges at this location.

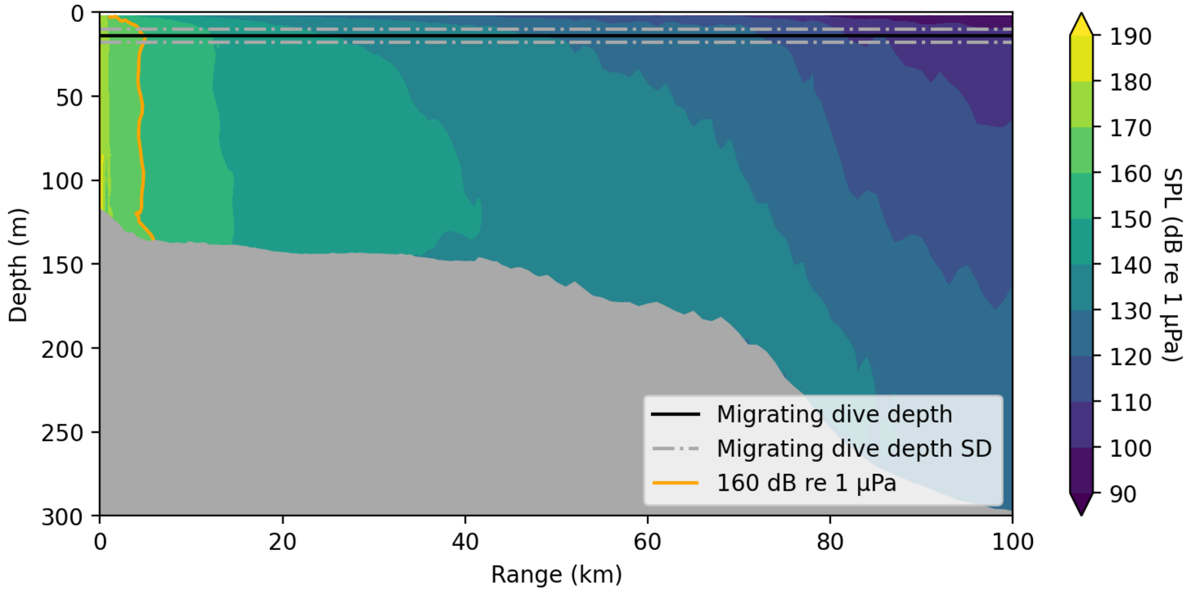

Figure 30. *Yodel South, Pile penetration depth – 2 m:* Example SPL vertical from the pile driving location at an azimuth of 40°. The 160 dB re 1 µPa behavioural response threshold is highlighted in red, and the migrating pygmy blue whale dive depth (mean and one standard deviation) is indicated by horizontal lines.

5.2.2. PTS and TTS

Exposure ranges from animal movement modelling for PTS and TTS criteria are typically shorter than those predicted using acoustic propagation modelling because of the generally shorter time (‘dwell time’) to accumulate sound energy of the moving animats.

In this analysis, the maximum $ER_{95\%}$ for PTS and TTS considering pile driving at the Wilcox-1 location was 0.59 and 6.36 km, respectively, with corresponding exposure probabilities for animats travelling within that range of 68 and 64%. At Yodel South, the maximum $ER_{95\%}$ for PTS and TTS to 0.77 and 8.98 km with corresponding exposure probabilities for animats travelling within that range of 81 and 76%, indicating that some, but not all, animats exposed within the 95th percentile range were exposed above threshold. This is because animats can move in and out of the modelling range as well as their vertical position in the water column, thus potentially limiting the length of time they are within the exposure radius. For example, an animat might approach within the predicted exposure range but if they are traveling more quickly on average than other animats, they may not accumulate as much exposure, or they may be spending more time at depths with quieter sound levels.
While the difference in exposure ranges between the two pile driving locations is likely due to their depth differences, the difference in exposure ranges between the migration directions is only minor.

The animat modelling was included in the scope of work to provide context to possible exposures to migrating pygmy blue whales over an entire day. The distances to isopleths associated with the effect thresholds for PTS and TTS, are more realistic than those from the static sound fields as they consider potential animal movements during migration, passing through the operational region.

Glossary

Unless otherwise stated in an entry, these definitions are consistent with ISO 18405 (2017).

1/3-octave

One third of an octave. *Note*: A 1/3-octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec).

1/3-octave-band

Frequency band whose bandwidth is one 1/3-octave. *Note*: The bandwidth of a 1/3-octave-band increases with increasing centre frequency.

90 % energy time window

The time interval over which the cumulative energy rises from 5 to 95 % of the total pulse energy. This interval contains 90 % of the total pulse energy. Used to compute the 90 % sound pressure level. Unit: second (s). Symbol: T_{90}.

90 % sound pressure level (90 % SPL)

The sound pressure level calculated over the 90 % energy time window of a pulse. Unit: decibel (dB).

absorption

The conversion of sound energy to heat energy. Specifically, the reduction of sound pressure amplitude due to particle motion energy converting to heat in the propagation medium.

acoustic impedance

The ratio of the sound pressure in a medium to the volume flow rate of the medium through a specified surface due to the sound wave. It is a measure of how well sound propagates through a particular medium.

acoustic noise

Sound that interferes with an acoustic process.

acoustic self-noise

Sound at a receiver caused by the deployment, operation, or recovery of a specified receiver, and its associated platform (ISO 18405:2017).

ambient sound

Sound that would be present in the absence of a specified activity (ISO 18405:2017). Usually a composite of sound from many sources near and far, e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium. Attenuation depends on frequency—higher frequency sounds are attenuated faster than lower frequency sounds.

auditory frequency weighting

The process of applying an auditory frequency-weighting function. An example for marine mammals are the auditory frequency-weighting functions published by Southall et al. (2007).

auditory frequency-weighting function

Frequency-weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.

azimuth

A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also known as bearing.

background noise

Combination of ambient sound, acoustic self-noise, and, where applicable, sonar reverberation (ISO 18405:2017) that is detected, measured, or recorded with a signal.

bandwidth

A range within a continuous band of frequencies. Unit: hertz (Hz).

broadband level

The total level measured over a specified frequency range. If the frequency range is unspecified, the term refers to the entire measured frequency range.

cavitation

A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean

Member of the order Cetacea. Cetaceans are aquatic mammals and include whales, dolphins, and porpoises.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called a longitudinal wave. In seismology/geophysics, it's called a primary wave or P-wave. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

conductivity-temperature-depth (CTD)

Measurement data of the ocean's conductivity, temperature, and depth; used to compute sound speed profiles and salinity.

continuous sound

A sound whose sound pressure level remains above the background noise during the observation period and may gradually vary in intensity with time, e.g., sound from a marine vessel.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006). For example, one decade up from 1000 Hz is 10,000 Hz, and one decade down is 100 Hz.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Especially suited to quantify variables with a large dynamic range.

decidecade

One tenth of a decade. Approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct), and for this reason sometimes referred to as a 1/3-octave.

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

energy source level

A property of a sound source equal to the sound exposure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2 s$.

ensonified

Exposed to sound.

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

Fourier transform, Fourier synthesis

A mathematical technique which, although it has varied applications, is referenced in a physical data acquisition context as a method used in the process of deriving a spectrum estimate from time-series data (or the reverse process, termed the inverse Fourier transform). A computationally efficient numerical algorithm for computing the Fourier transform is known as the fast Fourier transform (FFT).

frequency

The rate of oscillation of a periodic function measured in cycles per unit time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency-weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function (ISO 18405:2017). For sound of a given frequency, the frequency-weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency-weighting function*: compensatory frequency-weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency-weighting function*: frequency-weighting function describing the sensitivity of an acoustic recording system, which typically consists of a hydrophone, one or more amplifiers, and an analog-to-digital converter.

functional hearing group

Category of animal species when classified according to their hearing sensitivity, hearing anatomy, and susceptibility to sound. For marine mammals, initial groupings were proposed by Southall et al. (2007), and revised groupings are developed as new research/data becomes available. Revised groupings proposed by Southall et al. (2019) include low-frequency cetaceans, high-frequency cetaceans, very high-frequency cetaceans, phocid carnivores in water, other carnivores in water, and sirenians. See auditory frequency-weighting functions, which are often applied to these groups.

Example hearing groups for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

geoacoustic

Relating to the acoustic properties of the seabed.

harmonic

A sinusoidal sound component that has a frequency that is an integer multiple of the frequency of a sound to which it is related. For a sound with a fundamental frequency of f, the harmonics have frequencies of $2f$, $3f$, $4f$, etc.

hearing threshold

For a given species or functional hearing group, the sound level for a given signal that is barely audible (i.e., that would be barely audible for a given individual in the presence of specified background noise during a specific percentage of experimental trials).

hertz (Hz)

Unit of frequency defined as one cycle per second. Often expressed in multiples such as kilohertz (1 kHz = 1000 Hz).

high-frequency (HF) cetaceans

See functional hearing group. *Note*: The mid- and high-frequency cetaceans groups proposed by Southall et al. (2007) were renamed high- and very-high-frequency cetaceans, respectively, by Southall et al. (2019).

hydrophone

An underwater transducer. A passive electronic device for recording or listening to underwater sound.

hydrostatic pressure

The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

intermittent sound

A sound whose level abruptly drops below the background noise level multiple times during an observation period.

impulsive sound

Qualitative term meaning sounds that are typically transient, brief (less than 1 s), broadband, with rapid rise time and rapid decay. They can occur in repetition or as a single event. Sources of impulsive sound include, among others, explosives, seismic airguns, and impact pile drivers.

isopleth

A line drawn on a map through all points having the same value of some specified quantity (e.g., sound pressure level isopleth).

knot (kn)

Unit of vessel speed equal to 1 nautical mile per hour.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. For example, a value of sound pressure level with reference to 1 μPa^2 can be written in the form x dB re 1 μPa^2.

low-frequency (LF) cetaceans

See functional hearing group.

manual analysis

Human examination of acoustic data via visual review of spectrograms and/or aural inspection of data.

masking

Obscuring of sounds of interest by other sounds at similar frequencies.

median

The 50th percentile of a statistical distribution.

mid-frequency (MF) cetaceans

See functional hearing group. *Note*: The mid-frequency cetaceans group proposed by Southall et al. (2007) was renamed high-frequency cetaceans by Southall et al. (2019).

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point source (monopole). Often used to quantify source levels of vessels or industrial operations from measurements. See also radiated noise level.

multiple linear regression

A statistical method that seeks to explain the response of a dependent variable using multiple explanatory variables.

M-weighting

A set of auditory frequency-weighting functions proposed by Southall et al. (2007).

mysticete

Member of the Mysticeti, a suborder of cetaceans. Also known as baleen whales, mysticetes have baleen plates (rather than teeth) that they use to filter food from water (or from sediment as for grey whales). This group includes rorquals (Balaenopteridae, such as blue, fin, humpback, and minke whales), right and bowhead whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

N percent exceedance level

The sound level exceeded N % of the time during a specified time interval. See also percentile level.

non-impulsive sound

Sound that is not an impulsive sound. Not necessarily a continuous sound.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete

Member of Odontoceti, a suborder of cetaceans. These whales, dolphins, and porpoises have teeth (rather than baleen plates). Their skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

other marine carnivores in water (OCW)

See functional hearing group.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of backscattered sound (which are negligible for most ocean-acoustic propagation problems), simplifying the computation of propagation loss.

peak sound pressure level (PK), zero-to-peak sound pressure level

The level (L_{pk}) of the squared maximum magnitude of the sound pressure (p_{pk}^2) in a stated frequency band and time window. Defined as $L_{\mathrm{pk}} = 10log_{10}(p_{\mathrm{pk}}^2/p_0^2) = 20log_{10}(p_{pk}/p_0)$. Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2.

peak-to-peak sound pressure

The difference between the maximum and minimum sound pressure over a specified frequency band and time window. Unit: pascal (Pa).

percentile level

The sound level not exceeded *N* % of the time during a specified time interval. The *N*th percentile level is equal to the (100−*N*) % exceedance level. See also N percent exceedance level.

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. Considered auditory injury. Compare with temporary threshold shift.

point source

A source that radiates sound as if from a single point.

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, $\mathrm{PL}(x) = \mathrm{SL} - L(x)$. Unit: decibel (dB).

radiated noise level (RNL)

A source level that has been calculated assuming sound pressure decays geometrically with distance from the source, with no influence of the sea-surface or seabed. Often used to quantify source levels of vessels or industrial operations from measurements. See also monopole source level.

received level

The level of a given field variable measured (or that would be measured) at a given location.

reference value

Standard value of a quantity used for calculating underwater sound level. The reference value depends on the quantity for which the level is being calculated:

Quantity	Reference value
Sound pressure	$p_0{}^2$ = 1 μPa^2 or p_0 = 1 μPa
Sound exposure	E_0 = 1 μPa^2 s
Sound particle displacement	$\delta_0{}^2$ = 1 pm^2
Sound particle velocity	$u_0{}^2$ = 1 nm^2/s^2
Sound particle acceleration	$a_0{}^2$ = 1 μm^2/s^4

shear wave

A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called a secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium. In common meaning, a form of energy that propagates through media (e.g., water, air, ground) as pressure waves.

sound exposure

Time integral of squared sound pressure over a stated time interval in a stated frequency band. The time interval can be a specified time duration (e.g., 24 h) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: pascal squared second (Pa^2 s). Symbol: E.

sound exposure level (SEL)

The level (L_E) of the sound exposure (E) in a stated frequency band and time window: $L_E = 10\log_{10}(E/E_0)$ (ISO 18405:2017). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 μPa^2 s.

sound exposure spectral density

Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ISO 18405:2017). Unit: pascal squared second per hertz (Pa^2 s/Hz).

sound field

Region containing sound waves.

sound intensity

Product of the sound pressure and the sound particle velocity (ISO 18405:2017). The magnitude of the sound intensity is the sound energy flowing through a unit area perpendicular to the direction of propagation per unit time. Unit: watt per metre squared (W/m^2). Symbol: I.

sound particle acceleration

The rate of change of sound particle velocity. Unit: metre per second squared (m/s^2). Symbol: a.

sound particle velocity

The velocity of a particle in a material moving back and forth in the direction of the pressure wave. Unit: metre per second (m/s). Symbol: u.

sound pressure

The contribution to total pressure caused by the action of sound (ISO 18405:2017). Unit: pascal (Pa). Symbol: p.

sound pressure level (SPL), rms sound pressure level

The level (L_p) of the time-mean-square sound pressure (p^2_{rms}) in a stated frequency band and time window: $L_p = 10\log_{10}(p^2_{\mathrm{rms}}/p^2_0) = 20\log_{10}(p_{rms}/p_0)$, where rms is the abbreviation for root-mean-square. Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 µPa^2. SPL can also be expressed in terms of the root-mean-square (rms) with a reference value of p_0 = 1 µPa. The two definitions are equivalent.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

A property of a sound source equal to the sound pressure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 µPa^2 m^2.

spectrum

Distribution of acoustic signal content over frequency, where the signal's content is represented by its power, energy, mean-square sound pressure, or sound exposure.

surface duct

The upper portion of a water column within which the gradient of the sound speed profile causes sound to refract upward and therefore reflect repeatedly off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity caused by noise exposure. Compare with permanent threshold shift.

thermocline

A depth interval near the ocean surface that experiences larger temperature gradients than the layers above and below it due to warming or cooling by heat conduction from the atmosphere and by warming from the sun.

unweighted

Term indicating that no frequency-weighting function is applied.

very high-frequency (VHF) cetaceans

See functional hearing group.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Acoustic Metrics

This section describes in detail the acoustic metrics, impact criteria, and frequency weighting relevant to the modelling study.

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (ANSI 2013, e.g., ISO 2017).

The sound pressure level (SPL or L_p; dB re 1 μPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10 \log_{10}\left(\frac{1}{T}\int_T g(t)\, p^2(t)\, dt / p_0^2\right) \text{ dB} \tag{A-1}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function.

The sound exposure level (SEL or L_E; dB re 1 μPa^2·s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10 \log_{10}\left(\int_T p^2(t)\, dt / T_0 p_0^2\right) \text{ dB} \tag{A-2}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right) \text{ dB}\,. \tag{A-3}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.4). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should also be specified.

A.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3 octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_{\mathrm{c}}(i)$, is defined as:

$$f_{\mathrm{c}}(i) = 10^{\frac{i}{10}}\ \mathrm{kHz} \tag{A-4}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{\mathrm{lo},i} = 10^{\frac{-1}{20}} f_{\mathrm{c}}(i) \quad \text{and} \quad f_{\mathrm{hi},i} = 10^{\frac{1}{20}} f_{\mathrm{c}}(i) \tag{A-5}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band 10 ($f_c(10)$ = 10 Hz) to band 44 ($f_{\mathrm{c}}(44)$ = 25 kHz).

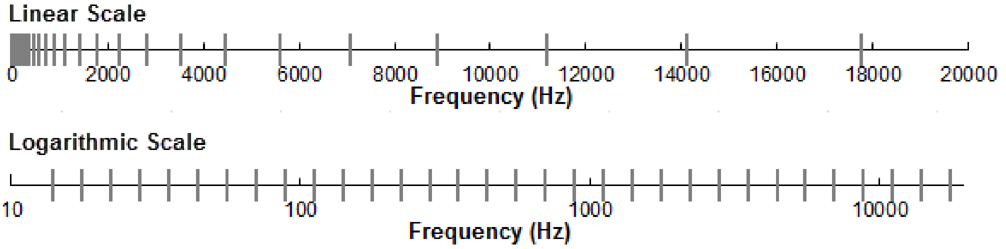

Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\mathrm{lo},i}$ and $f_{\mathrm{hi},i}$:

$$L_{p,i} = 10\, log_{10} \int_{f_{\mathrm{lo},i}}^{f_{\mathrm{hi},i}} S(f)\, \mathrm{d}f\ \ \mathrm{dB} \tag{A-6}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_i 10^{\frac{L_{p,i}}{10}}\ \mathrm{dB} \tag{A-7}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient sound signal. Because the decidecade bands are wider than 1 Hz, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

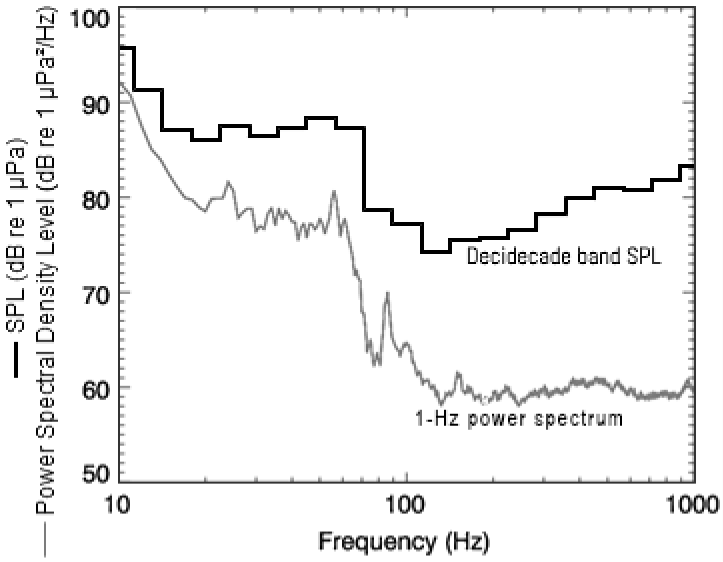

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the power spectrum.

A.3. Marine Mammal Impact Criteria – Impulsive

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.3.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 μPa^2·s. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 μPa^2·s.

As of present, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; with the criteria defined in NMFS (2018). The latest criteria are from Southall et al. (2019) which is applied in this report.

A.3.2. Behavioural response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

For impulsive noise, NMFS currently uses step function thresholds of 160 dB re 1 μPa SPL (unweighted) to assess and regulate noise-induced behavioural impacts for marine mammals (NOAA 2018, NOAA 2019). The threshold for impulsive sound is derived from the High-Energy Seismic Survey (HESS) panel (HESS 1999) report that, in turn, is based on the responses of migrating mysticete whales to airgun sounds (Malme et al. 1984). The HESS team recognised that behavioural responses to sound may occur at lower levels, but significant responses were only likely to occur above a SPL of 140 dB re 1 μPa. Southall et al. (2007) found varying responses for most marine mammals between a SPL of 140 and 180 dB re 1 μPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions.

A.4. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.4.1. Marine Mammal Frequency Weighting Functions

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \tag{A-8}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses acoustic impacts on marine mammals (NMFS 2018), and in the latest guidance by Southall (2019). The updates did not affect the content related to either the definitions of frequency-weighting functions or the threshold values, however, the terminology for mid- and high-frequency cetaceans was changed to high- and very high-frequency cetaceans. Table A-1 lists the frequency-weighting parameters for each hearing group relevant to this assessment, and Figure A-3 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by Southall et al. (2019).

Hearing group	a	b	flo (Hz)	fhi (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
High-frequency cetaceans (most dolphins, plus sperm, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
Very-high-frequency cetaceans (true porpoises, *Kogia*, river dolphins, *Cephalorhynchus* spp., *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36

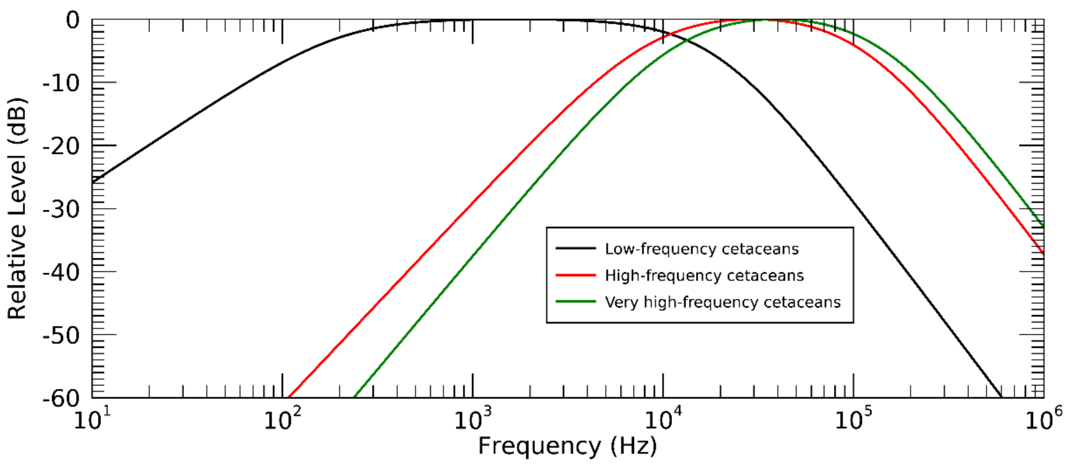

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by Southall et al. (2019).

Appendix B. Acoustic Source Model

B.1. Acoustic Source Model – Pile Driving

B.1.1. Source Properties

For most projects involving pile driving, there is potential for direct transmission from the sound source to biological receivers, and there are reflected sound paths from the water's surface and bottom that may be perceived by marine fauna. Normally, ground-radiated sound is dominated by low frequencies that cannot propagate efficiently through shallow water. When pile driving is the sound source, there is the potential for substrate-borne sound caused by the hammer's action on the pile to be re-radiated back into the water where it may reach a biological receiver. For pile driving, energy transmission through water depends on the following factors (Christopherson and Lundberg 2013):

1. Direct contact between the pile and the water
2. The depth of the water column
3. The size of the pile
4. The type of hammer
5. The hammer energy
6. The addition of re-radiation of substrate-borne sound

The way sound propagates in water is affected by obstructions (barges, breakwater walls, other piles, etc.) and the bathymetric characteristics (Buehler et al. 2015). Figure B-1 illustrates these basic propagation concepts.

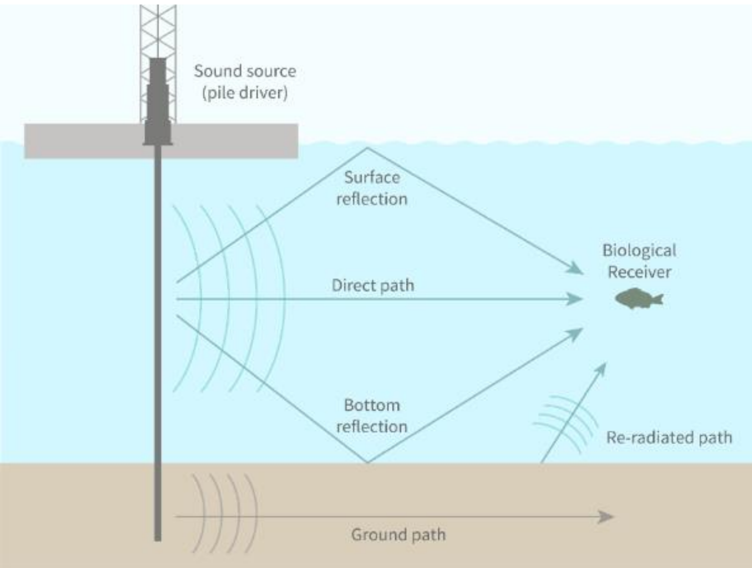

Figure B-1 Underwater sound propagation paths associated with pile driving (Buehler et al. 2015).

B.1.2. Source Model

A physical model of pile vibration and near-field sound radiation is used to calculate source levels of piles. The physical model employed in this study computes the underwater vibration and sound radiation of a pile by solving the theoretical equations of motion for axial and radial vibrations of a cylindrical shell. These equations of motion are solved subject to boundary conditions, which describe the forcing function of the hammer at the top of the pile and the soil resistance at the base of the pile, as shown in Figure B-2. Damping of the pile vibration due to radiation loading is computed for Mach waves emanating from the pile wall. The equations of motion are discretised using the finite difference (FD) method and are solved on a discrete time and depth mesh.

To model the sound emissions from the piles, the force of the pile driving hammers also had to be modelled. The force at the top of each pile was computed using the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010), which includes a large database of simulated hammers—both impact and vibratory—based on the manufacturer's specifications. The forcing functions from GRLWEAP were used as inputs to the FD model to compute the resulting pile vibrations.

The sound radiating from the pile itself is simulated using a vertical array of discrete point sources. The point sources are centred on the pile axis. Their amplitudes are derived using an inverse technique, such that their collective particle velocity, calculated using a near-field wave-number integration model, matches the particle velocity in the water at the pile wall. The sound field propagating away from the vertical source array is then calculated using a time-domain acoustic propagation model (FWRAM, Appendix C.3). MacGillivray (2014) describes the theory behind the physical model in more detail.

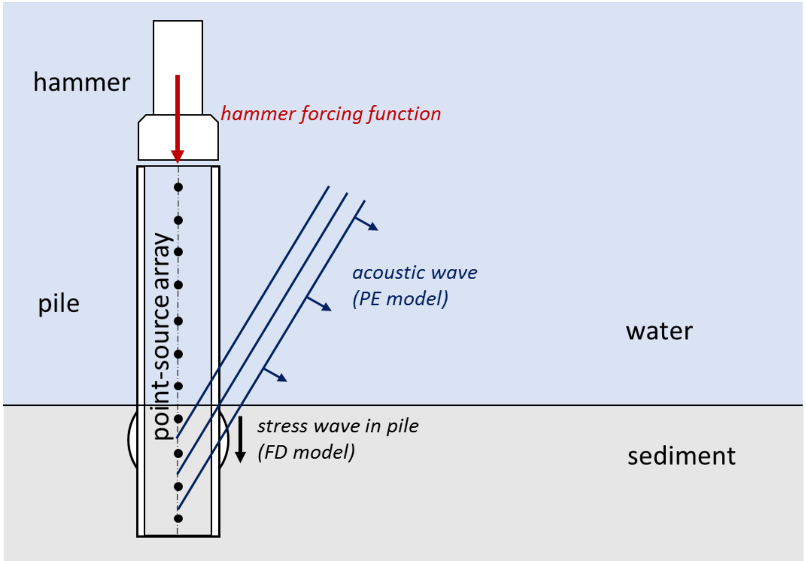

Figure B-2. Physical model geometry for impact driving of a cylindrical pile(vertical cross-section). The hammer forcing function is used with the finite difference (FD) model to compute the stress wave vibration in the pile. A vertical array of point sources is used with the parabolic equation (PE) model to compute the acoustic waves that the pile wall radiates.

Appendix C. Sound Propagation Models

C.1. Environmental Parameters

C.1.1. Bathymetry

Water depth data for much of the modelling site were provided by Woodside Energy Ltd. This dataset comprised: bathymetry of Rankin Bank at 2 m resolution; bathymetry of swathes around the Greater Western Flank, also at 2 m resolution; and a wider area bathymetry around the site at a resolution of 25 m. The bathymetry was supplemented with additional data from the Australian Bathymetry and Topography Grid (Whiteway 2009), this dataset provides bathymetry at a resolution of 9 arc-seconds (equivalent to 0.0025° and equating to approximately 278 m × 262 m resolution). Figure C-1 shows the resultant data used for modelling.

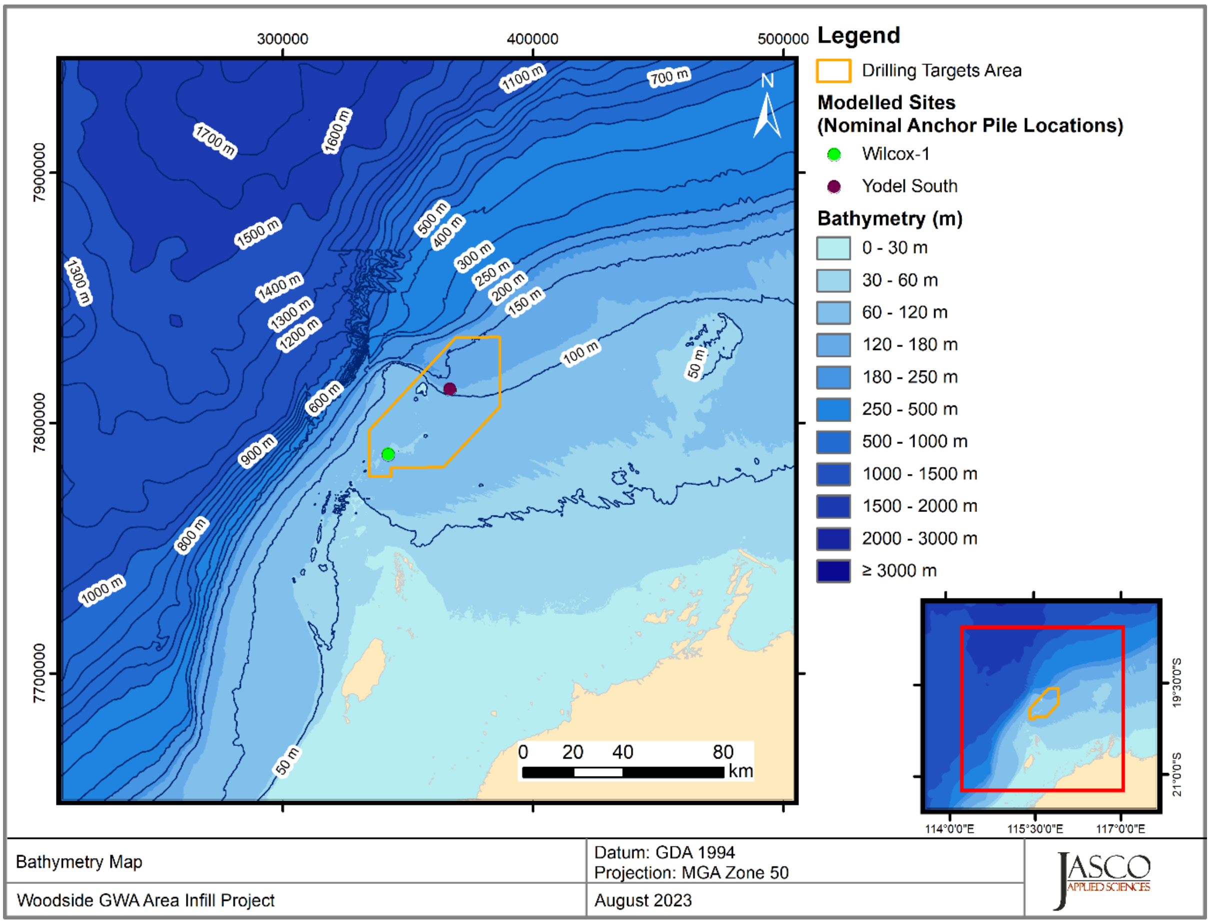

Figure C-1. Bathymetry of the region and the piling locations.

The datasets were combined to form a single bathymetric grid resampled at 50 m for the purposes of the acoustic modelling, the extents of which forms a box 125 km × 125 km centred on the modelling site.

C.1.2. Sound Speed Profile

The speed of sound in sea water is a function of temperature, salinity, and pressure (depth) (Coppens 1981). Sound speed profiles were obtained from the US Navy's Generalized Digital Environmental

Model (GDEM; NAVO 2003). Considering the greater area around the proposed MODU installation area and deep waters, the sound speed profiles were assumed to be representative of typical propagation conditions annually. Monthly average profiles to 200 m, and a September average profile to 1800 m, are shown in Figure C-2. September was selected for conservative purposes and to align with previous pile driving modelling conducted for Woodside. These profiles were assumed to be representative of the entire area for modelling purposes.

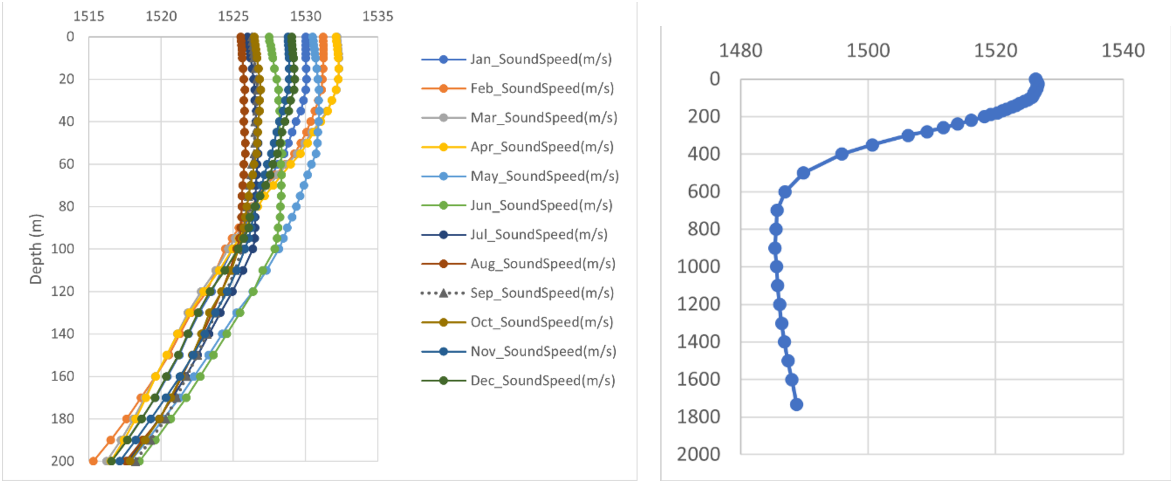

Figure C-2. Monthly average modelling sound speed profiles to 200 m and September average profile to 1800 m Profiles are calculated from temperature and salinity profiles from Generalized Digital Environmental Model V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

C.1.3. Geoacoustics

In shallow water environments where there is increased interaction with the seafloor, the properties of the substrate have a large influence over the resulting propagating sound. The geoacoustic model used in this work is based on the geological conditions sourced from borehole data previously supplied by Woodside. The required parameters for modelling sound propagation are the density (ρ), compressional-wave speed, (c_p), shear-wave speed (c_s), compressional-wave attenuation (α_p), and shear-wave attenuation (α_s). These properties have been estimated from the lithology supplied and based on average parameters for the sediment type and depth below the sea floor (Hamilton 1980, Duncan and Gavrilov 2012) and are shown in Table C-1. Although full compression-wave speed and attenuation profiles are included in the modelling, only the surface shear-wave properties are utilised by FWRAM.

Table C-1. Geoacoustic profile for the Woodside GWA Area Infill modelled sites.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–26	Silty carbonate sand to interbedded sandy carbonated mud and sand	1.78	1523–1674	0.05–0.67	180	0.10
26–42	Carbonated sandy silt to muddy, sandy carbonate silt/silty mud	1.80	1685–1716	0.68–0.79		
42–72	Carbonate silty sand with occasional poorly cemented calcarenite layers	1.78	1704–1745	0.77–0.91		
72–108	Silty sandy poorly cemented calcarenite	2.32–2.37	2121–2181	0.32–0.33		
108–188	High strength calcarenite zone, locally sandy	2.87–2.96	2781–2909	0.53–0.55		

C.2. Propagation Loss

The propagation of sound through the environment can be modelled by predicting the acoustic propagation loss—a measure, in decibels, of the decrease in sound level between a source and a receiver some distance away. Geometric spreading of acoustic waves is the predominant way by which propagation loss occurs. Propagation loss also happens when the sound is absorbed and scattered by the seawater, and absorbed scattered, and reflected at the water surface and within the seabed. Propagation loss depends on the acoustic properties of the ocean and seabed; its value changes with frequency.

If the acoustic energy source level ($L_{S,E}$), expressed in dB re 1 µPa²m²s, and energy propagation loss (PL_E), in units of dB, at a given frequency are known, then the received level ($L_{E,p}$) at a receiver location can be calculated in dB re 1 µPa²s by:

$$L_{E,p}(\theta, r) = L_{S,E}(\theta) - PL_E(\theta, r), \tag{C-1}$$

where θ defines the specific direction, and r is the range of the receiver from the source.

C.3. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from impact pile driving, time-domain representations of the pressure waves generated in the water are required for calculating SPL and peak pressure level. Furthermore, the pile must be represented as a distributed source to accurately characterize vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on a wide-angle parabolic equation (PE) algorithm. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seabed geoacoustic profile). FWRAM computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Synthetic pressure waveforms were modeled over the frequency range 10–1024 Hz, inside a 1 s window (e.g. Figure C-3). The synthetic pressure waveforms were post-processed, after applying a travel time correction, to calculate standard SPL and SEL metrics versus range and depth from the source.

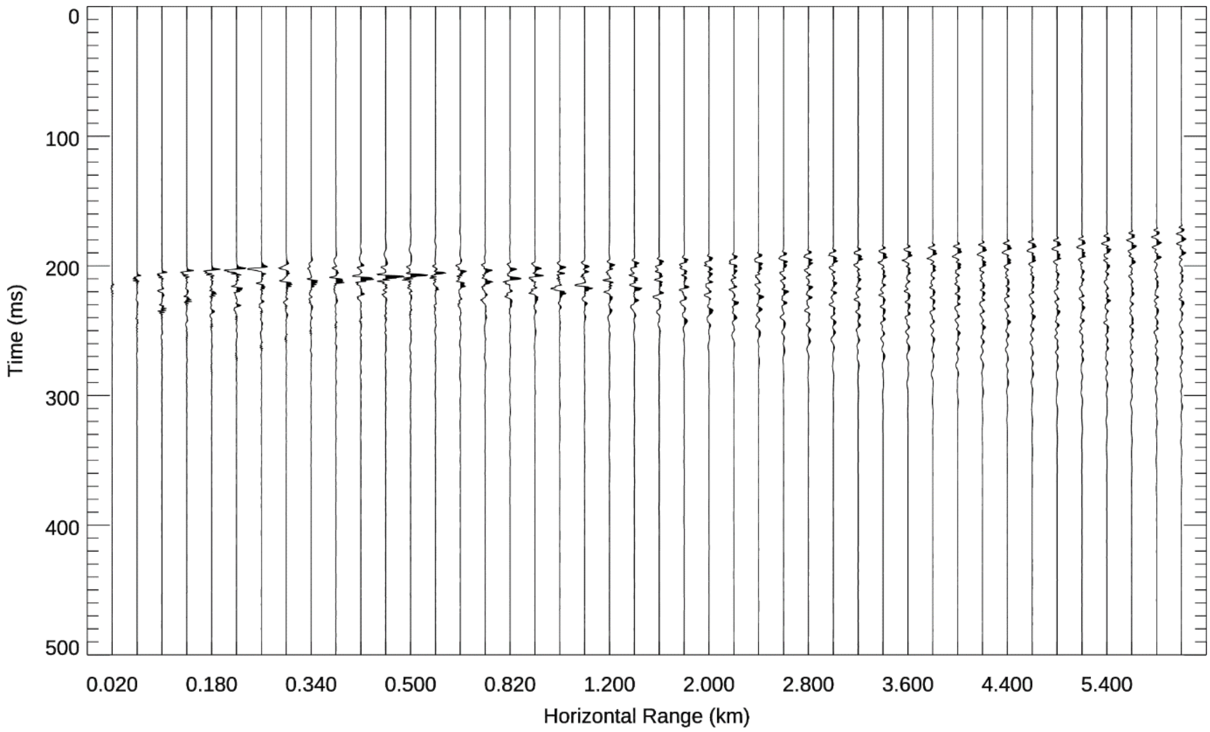

Figure C-3. Example of synthetic pressure waveforms computed by FWRAM at multiple range offsets for 30 m embedment at site Wilcox-1. Receiver depth is 35 m and the amplitudes of the pressure traces have been normalised for display purposes.

Full-waveform modelling was also used to calculate SPL. The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Impulses typically lengthen in duration as they propagate away from their source, due to waveguide dispersion effects associated with seafloor and surface reflections. The changes in pulse length, and therefore the considered time window, affect the numeric computation of SPL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms), as implemented in Martin et al. (2017b).

C.4. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure C-4).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure C-4(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure C-4(b), on the other hand,

$R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

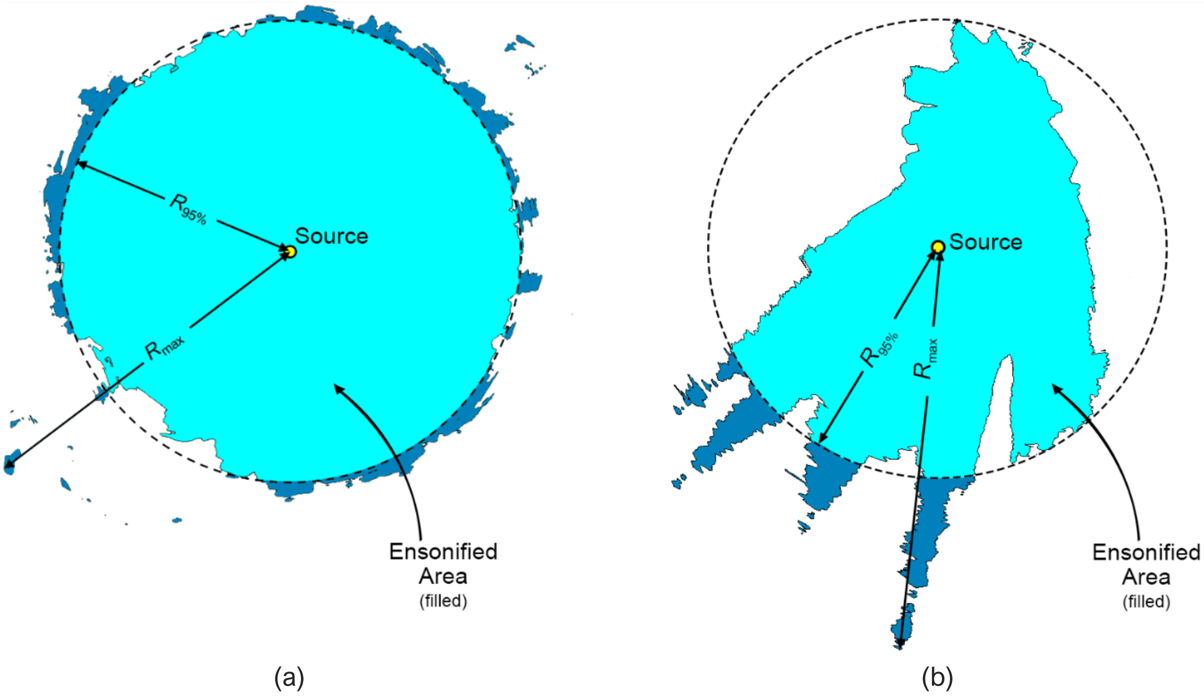

Figure C-4. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

C.5. Model Validation Information

Predictions from JASCO's propagation models (MONM, FWRAM, and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities that have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

Appendix D. Animal Movement and Exposure Modelling

Animal movement and exposure modelling considers the movement of both sound sources and animals over time. Acoustic source and propagation modelling are used to generate 3-D sound fields that vary as a function of distance to source, depth, and azimuth. Sound sources are modelled at representative sites and the resulting sound fields are assigned to source locations using the minimum Euclidean distance. The sound received by an animal at any given time depends on its location relative to the source. Because the true locations of the animals within the sound fields are unknown, realistic animal movements are simulated using repeated random sampling of various behavioural parameters. The Monte Carlo method of simulating many animals within the operations area is used to estimate the sound exposure history of the population of simulated animals (animats).

Monte Carlo methods provide a heuristic approach for determining the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. The probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. The greater the number of random samples, in this case the more simulated animats, the better the approximation of the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2). Higher densities provide a finer PDF estimate resolution but require more computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The animat density is typically much higher than the real-world density to ensure good representation of the PDF. The resulting PDF is scaled using real-world density when this information is available.

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behaviour. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behaviour model (3MB, Houser 2006) and used to predict the exposure of animats to sound arising from the anthropogenic activities. Animats are programmed to behave like the species likely to be present in the survey area. The parameters used for forecasting realistic behaviours (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's modelled sound exposure levels are summed over the total simulation duration to determine its total received energy, and then compared to the assumed threshold criteria.

JASMINE uses the same animal movement algorithms as 3MB (Houser, 2006), but has been extended to be directly compatible with JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM) acoustic field predictions, for inclusion of source tracks, and importantly for animats to change behavioural states based on time and space dependent modelled variables such as received levels for aversion behaviour, although aversion was not considered in this study.

D.1. Animal Movement Parameters

JASMINE uses previously measured behaviour to forecast behaviour in new situations and locations. The parameters used for forecasting realistic behaviour are determined (and interpreted) from marine species studies (e.g., tagging studies). Each parameter in the model is described as a probability distribution. When limited or no information is available for a species parameter, a Gaussian or uniform distribution may be chosen for that parameter. For the Gaussian distribution, the user determines the mean and standard deviation of the distribution from which parameter values are drawn. For the uniform distribution, the user determines the maximum and minimum distribution from which parameter values are drawn. When detailed information about the movement and behaviour of a species are available, a user-created distribution vector, including cumulative transition probabilities, may be used (referred to here as a vector model; Houser 2006). Different sets of parameters can be defined for different behaviour states. The probability of an animat starting out in or transitioning into a given behaviour state can in turn be defined in terms of the animat's current behavioural state, depth, and the time of day. In addition, each travel parameter and behavioural state has a termination function that governs how long the parameter value or overall behavioural state persists in simulation.

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below.

Travel sub-models

- **Direction**– determines an animat's choice of direction in the horizontal plane. Sub-models are available for determining the heading of animats, allowing for movement to range from strongly biased to undirected. A random walk model can be used for behaviours with no directional preference, such as feeding and playing. In a random walk, all bearings are equally likely at each parameter transition time step. A correlated random walk can be used to smooth the changes in bearing by using the current heading as the mean of the distribution from which to draw the next heading. An additional variant of the correlated random walk is available that includes a directional bias for use in situations where animals have a preferred absolute direction, such as migration. A user-defined vector of directional probabilities can also be input to control animat heading. For more detailed discussion of these parameters, see Houser (2006) and Houser and Cross (1999).
- **Travel rate**–defines an animat's rate of travel in the horizontal plane. When combined with vertical speed and dive depth, the dive profile of the animat is produced.

Dive sub-models

- **Ascent rate**–defines an animat's rate of travel in the vertical plane during the ascent portion of a dive.
- **Descent rate**–defines an animat's rate of travel in the vertical plane during the descent portion of a dive.
- **Depth**–defines an animat's maximum dive depth.
- **Reversals**–determines whether multiple vertical excursions occur once an animat reaches the maximum dive depth. This behaviour is used to emulate the foraging behaviour of some marine mammal species at depth. Reversal-specific ascent and descent rates may be specified.
- **Surface interval**–determines the duration an animat spends at, or near, the surface before diving again.

D.2. Exposure Integration Time

The interval over which acoustic exposure (L_E) should be integrated and maximal exposure (L_p) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 h baseline accumulation period, but state that there may be situations where this is not appropriate (e.g., a high-level source and confined population). Resetting the integration after 24 h can lead to overestimating the number of individual animals exposed because individuals can be counted multiple times during an operation. The type of animal movement engine used in this study simulates realistic movement using swimming behaviour collected over relatively short periods (hours to days) and does not include large-scale movement such as migratory circulation patterns. For this study, a representative 24-hour period was simulated.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that could approach the source during an operation is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited. In the simulation, every animat that reaches a border is replaced by another animat entering at the opposing border—e.g., an animat crossing the northern border of the simulation is replaced by one entering the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition. The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

D.3. Seeding Density and Scaling

Seeding density refers to the spatial sample rate, in units of animats/km^2, used in the simulation. It is not related to the real-world animal density, but rather is a model parameter that controls the how samples are drawn from the model space. The minimum required seeding density for any given project depends on several factors such as bathymetry, source characteristics, and the behavioural profile of the animats, with the main constraint being computation time and resources. Seeding density is adjusted as needed based on model conditions specific to a project or project area.

In the present study, the exposure criteria for impulsive sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 4 animat/km^2 over the entire simulation area. Due to insufficient density data availability, the modelling results are not related to real-world density estimates for pygmy blue whales within the BIAs.

APPENDIX G MARINE DISPERSION MODELLING FOR A HYDROTEST DISCHARGE

WOODSIDE NWS INFILL OPP: MARINE DISPERSION MODELLING FOR HYDROTEST

Report

MAW1261J.000
Rev 3
29 November 2023

Contents

Tables

Figures

EXECUTIVE SUMMARY

Background

The Goodwyn Area (GWA) Infill Development planned by Woodside Energy Ltd (Woodside) will comprise of multiple development opportunities designed to fill ullage at the GWA Platform as the producing NWS fields decline. The opportunity is currently at an early stage of project engineering and consists of a subsea tie-back to the GWA Platform. Well fluids will undergo processing at the GWA platform before being exported to the Karratha Gas Plant for final processing prior to export to domestic and international markets.

The GWA Infill Development will also include a multi-well tie-back from the Wilcox prosect, via a 25 km long pipeline to the Lady-Nora Pemberton pipe-line end termination (PLET) facility. The Wilcox prospect is located within the boundary of the Montebello Marine Park Multiple Use Zone however will be drilled outside the marine park.

To support the preparation of environmental approvals documentation, RPS was commissioned by Woodside to undertake a detailed marine dispersion modelling study of a proposed hydrotest discharge in the vicinity of the Wilcox well.

The principal aim of the study was to quantify the likely extents of the near-field and far-field mixing zones based on the required dilution levels for biocide in the hydrotest discharge. This will indicate whether concentrations of this contaminant are still likely to be above stated threshold levels at the limits of the mixing zones (i.e., are not predicted to be diluted below the relevant threshold).

To accurately determine the dilution of the hydrotest discharge and the total potential area of influence, the effect of near-field mixing needs to be considered first, followed by an investigation of the far-field mixing performance. Different modelling approaches are required for calculating near-field and far-field dilutions due to the differing hydrodynamic scales.

Summary of Modelling Results

Near-Field Modelling

The key observations were as follows:

- Modelling indicated that irrespective of season, the plume will travel the furthest (282.4 m) from the discharge location during high current speeds, with average dilution levels of 1:896-1:1,214 predicted at the end of the near-field zone.
- Under low and medium current speeds, the maximum distance for the source becomes progressively less (104.7 m and 150.7 m, respectively) due to decreasing current strength.
- Average dilution levels at the end of the near-field zone under low and medium currents are predicted to be 1:484-1:607 and 1:661-1:899, respectively.
- Under all current conditions, the plume is predicted to attach to the seabed (Coandă attachment) and remain near the seabed.
- In the assessed seasons, indicative safe dilution levels of 1:10,000 are not achieved within the near-field.

Far-Field Modelling

The far-field modelling expands on the near-field work by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume back to the discharge location. In this case, concentrations near the discharge point can be increased due to the discharge plume mixing with the remnant plume from an earlier time. This may be a potential source of episodic increases in pollutant concentrations in the receiving waters.

A stochastic modelling procedure was applied in the far-field modelling to sample a representative set of conditions that could affect the distribution of constituents. This approach involves multiple simulations (50 per season for a total of 150) of the specified discharge scenario, with each simulation being carried out under a randomly selected period of currents.

The key observations were as follows:

- Near-field and far-field modelling are used to describe different processes and scales of effect, and therefore the far-field modelling results will not necessarily correspond to the outcomes at the end of the near-field mixing zone for any given discharge scenario.
- The far-field results included episodes of pooling of the discharge plume under slack currents, which caused lower dilutions (higher concentrations) further from the discharge location when the pooled plume was advected away. Episodes of recirculation – where the effluent plume moved back under the discharge at some later time due to the oscillatory nature of the tide – were also observed, compounding the pooling effect, and further lowering the dilution values.
- The predictions of the far-field modelling are considered conservative due to the conservative nature of the dispersion coefficients derived from the nearfield plume characteristics. This means the far-field outcomes reflect a potential overestimation of contaminant concentrations and a corresponding underestimation of dilution levels.
- Lower concentrations (resulting from higher dilution) are generally predicted to occur during stronger currents. Localised zones (patches) of higher concentrations are expected to occur during the turning of the tide or during periods of weak drift currents.
- At the 95th percentile the field of effect of the plume with less than 10,000 dilutions relative to the source is predicted to extend up to 491 m during winter, with predominant plume travel being west-northwest to east-southeast throughout the year.
- At the higher percentile (99th) the maximum distance increases to 3,023 m during the transitional period. These calculations assume that no processes other than dilution would reduce the source concentration of biocide over time.
- An area of exposure defined by the relevant dilution contour is predicted to reach a maximum of 0.03-0.07 km^2 and 2.51-2.74 km^2 at the 95th percentile and 99th percentile, respectively.
- The overall plume footprint was observed to predominantly drift in a west-northwest and/or east-southeast throughout direction throughout the year.
- At the 95th percentile and 99th percentile the field of effect of the plume with less than 10,000 dilutions relative to the source is predicted to extend up to 491 m and 3,023 m throughout the year.
- An area of coverage of 0.08 km^2 and 3.57 km^2 is predicted for the dilutions out to a maximum of 1:10,000 at the 95th percentile and 99th percentile, respectively.

1 INTRODUCTION

1.1 Background

The Goodwyn Area Infill Development planned by Woodside Energy Ltd (Woodside) will comprise of multiple development opportunities designed to fill ullage at the GWA Platform as the producing NWS fields decline. The opportunity is currently at an early stage of project engineering and consists of a subsea tie-back to the GWA Platform. Well fluids will undergo processing at the GWA platform before being exported to the Karratha Gas Plant for final processing prior to export to domestic and international markets.

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The principal aim of the study was to quantify the likely extents of the near-field and far-field mixing zones based on the required dilution levels for biocide in the hydrotest discharge. This will indicate whether concentrations of this contaminant are still likely to be above stated threshold levels at the limits of the mixing zones (i.e., are not predicted to be diluted below the relevant threshold).

To accurately determine the dilution of the hydrotest discharge and the total potential area of influence, the effect of near-field mixing needs to be considered first, followed by an investigation of the far-field mixing performance. Different modelling approaches are required for calculating near-field and far-field dilutions due to the differing hydrodynamic scales.

The regional context of the discharge location for the assessed scenario is shown in Figure 1.1. The details of the scenario assessed in this study are summarised in Table 1.1.

The potential area that may be influenced by the hydrotest discharge stream was assessed for three distinct seasons: (i) summer (December to February); (ii) the transitional periods (March and September to November); and (iii) winter (April to August). An annualised aggregation of outcomes was also assembled.

Table 1.1 Location of the Wilcox well used as the release site for the hydrotest dispersion modelling assessment.

Release site	Latitude (°S)	Longitude (°E)	Water depth (m)
Wilcox	19° 59' 53.8"	115° 29' 38.4"	74

1.2 Scope of Work

The physical mixing of the hydrotest plumes was first investigated for the near-field mixing zone. The limits of the near-field mixing zone are defined by the area where the levels of mixing and dilution are controlled by a plume’s initial jet momentum and the buoyancy flux, resulting from density differences between the plume and the receiving water. When the plume encounters a boundary such as the water surface, near-field mixing is complete. At this point, the plume is considered to enter the far-field mixing zone.

The scope of the modelling included the following components:

1. Collation of suitable water current, temperature and salinity conditions expected at the nominated location for use as forcing data in the dilution models. Conditions at the discharge depth and the vertical profile are important. Data will be drawn from the models previously validated and generated for Woodside.
2. Derivation of statistical distributions for the current speed and direction for use in the near-field modelling. Analyses will include percentile distributions and development of current roses. This analysis is important to ensure that current data samples applied in the dispersion model are statistically representative.

3. Establishment of a near-field discharge model for the outlined scenario, running sensitivity and production cases to estimate the near-field behaviour of the plume and establish likely levels of dilution in this region. Outcomes from the near-field modelling will include estimates of the width, shape and orientation of the plumes and resulting contaminant concentrations and dilutions for the hydrotest discharge at a range of incident current speeds.
4. Establishment of a far-field model encompassing the required location and surrounding area.
5. Undertaking of a stochastic modelling assessment of far-field fate. The far-field modelling will be conducted in a stochastic manner, as it accounts for the natural variability at the site by taking replicate time series samples of current data that are drawn randomly from a longer time series.
6. Statistical analysis of the outcomes of all replicate simulations from the far-field modelling to estimate the concentration envelopes and percentile concentration distributions over time.

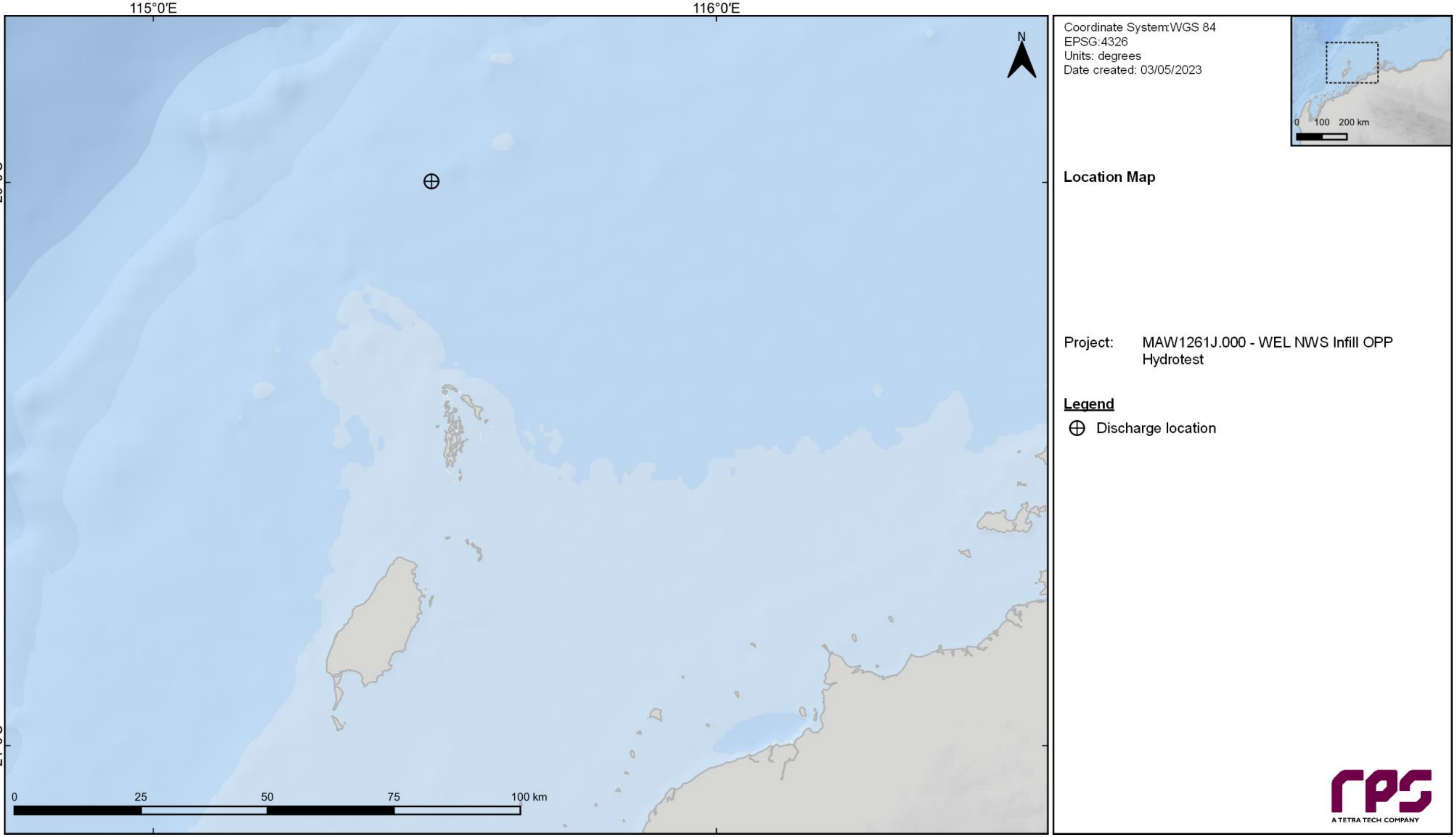


Figure 1.1 **Location of the proposed Wilcox well on the North West Shelf off the northern coast of Western Australia.**

2 MODELLING METHODOLOGY

2.1 Near-Field Modelling

2.1.1 Overview

Numerical modelling was applied to quantify the area of influence of hydrotest discharges, in terms of the distribution of the maximum contaminant concentrations that might occur with distance from the source given defined discharge configurations, source concentrations, and the range of metocean conditions that affect the discharge location.

The dispersion of the hydrotest discharge will depend, initially, on the geometry and hydrodynamics of the discharges themselves, where the induced momentum and buoyancy effects dominate over background processes. This region is generally referred to as the near-field zone and is characterised by variations over short time and space scales. As the discharges mix with the ambient waters, the momentum and buoyancy signatures are eroded, and the background – or ambient – processes become dominant.

The shape and orientation of the discharged water plumes, and hence the distribution and dilution rate of the plume, will vary significantly with natural variation in prevailing water currents. Therefore, to best calculate the likely outcomes of the discharges, it is necessary to simulate discharge under a statistically representative range of current speeds representative of the Wilcox well location.

2.1.2 Description of Near-Field Model: CORMIX

The near-field mixing and dispersion of the outfall was simulated using the three-dimensional flow model, CORMIX. CORMIX is a mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones. CORMIX contains a series of elements for the analysis and design of single or multi-port discharges. Discharges may be submerged or above surface, buoyant or denser than receiving water, and the receiving water may be stratified or unstratified. The emphasis of the model is the influence of the geometry and dilution characteristics on the initial mixing zone (Doneker & Jirka, 1990; Jirka et al., 1991). CORMIX is widely applied worldwide and has been validated in many independent studies (http://www.cormix.info/validations.php).

CORMIX is a collection of analytic solutions to simplified forms of the mathematical equations describing transport and dispersion of waterborne constituents. The simplifications come about through a range of assumptions about the source configuration, source characteristics (discharge and buoyancy) and the ambient environment. These assumptions effectively limit the domain within which the analytic solutions apply. For the typical outfall source flow, two main zones can be defined as described in Table 2.1.

Although CORMIX does calculate far-field dispersion, the assumptions of the algorithms limit application to homogeneous environments with no eddies in the ambient flow and little recirculation. For this reason, the CORMIX component of the calculations for this study was limited to the near-field zone.

Table 2.1 CORMIX mixing zones.

Zone	Description
Near-field	Jet characteristics, momentum flux, buoyancy flux and outfall geometry influence the plume's trajectory and mixing.
Far-field	Ambient conditions control the plume's trajectory and dilution due to density current buoyant spreading and ambient turbulence.

CORMIX specifies the average dilution or bulk dilution (flux averaged) as 1.7 times the centreline dilution. The centreline is defined by the points of maximum concentration (maximum temperature, minimum dilution, etc.) at each vertical section along the longitudinal axis. Accordingly, centreline depth is defined as the depth of the maximum concentration point (maximum temperature, minimum dilution) along the longitudinal axis.

2.1.3 Setup of Near-Field Model

2.1.3.1 Discharge Characteristics

The PW discharge characteristics for hydrotest scenario is summarised in Table 2.2. The hydrotest is discharged from a 2-inch diameter pipe oriented horizontally near seabed (~73 m below the water surface) at the Wilcox well location. The flow was assumed to come through a single outlet at a rate of 130 m^3/hr at an ambient temperature and salinity. The assumed temperature and salinity off the discharge is summarised in Table 2.2.

The total volume of the hydrotest water from the discharge was assumed as 2,000 m^3. Based on the engineering definitions available at the time of commissioning of the dispersion modelling study, it is anticipated that the dewatering operations will take approximately 15 hours (Scenario 1).

Concentrations of the constituents of interest (biocide) within the discharge is described in Table 2.3, along with the required dilution factor to reach the defined threshold concentration.

Table 2.2 Summary of hydrotest discharge characteristics assumed for near-field modelling.

Parameter	Scenario 1
Flow rate (m^3/hr)	130
Volume (m^3)	2,000
Location	Wilcox well
Duration (hours)	15
Outlet pipe internal diameter (m) [in]	0.05 [2”]
Number of ports	1
Outlet pipe orientation	Horizontal
Discharge depth (m)	~73
Discharge density (kg/m^3)	Ambient (seawater)
Discharge temperature (°C)	Ambient (seawater)
Discharge salinity (ppt)	Ambient (seawater)
Biocide concentration (ppm)	600

Table 2.3 Constituent of interest within the hydrotest discharges and criteria for analysis of exposure.

Constituent	Source concentration (ppm)	Threshold concentration (ppm)	Required dilution factor
Biocide	600	0.06	10,000

2.1.3.2 Ambient Environmental Conditions

Inputs of ambient environmental conditions to the CORMIX model included a vertical profile of temperature and salinity, along with constant current speeds and general direction (per simulation). The temperature and salinity profiles are required to accurately account for the relative buoyancy of the diluting plume, while the current speeds control the intensity of initial mixing and the deflection of the hydrotest plume. These inputs are described in the following sections.

2.1.3.2.1 Ambient Temperature and Salinity

Temperature and salinity data applied to the near-field modelling was sourced from the World Ocean Atlas 2013 (WOA13) database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration, NOAA) and its co-located World Data Center for Oceanography (Levitus *et al.*, 2013).

Table 2.4 and Table 2.5 show the average seasonal water temperature and salinity levels, respectively, at varying depths from 0 m to 70 m. This data can be considered representative of conditions at the discharge location.

The seasonal temperature profiles exhibit a reasonably consistent reduction in temperature with increasing depth. Salinity levels are generally most consistent with depth and indicate a vertically well-mixed water body (34.8-35.1 practical salinity unit, PSU), irrespective of season or depth.

Table 2.4 Average seasonal temperature levels adjacent to the discharge location.

Depth (m)	Temperature (°C)			
	Summer	Winter	Transitional	Annualised
0	27.9	26.8	26.7	27.0
10	27.8	26.8	26.8	27.0
20	27.7	26.7	26.5	26.9
35	27.4	26.7	26.0	26.6
45	26.8	26.5	25.6	26.3
70	24.9	25.5	24.7	25.1

Table 2.5 Average seasonal salinity levels adjacent to the discharge location.

Depth (m)	Salinity (PSU)			
	Summer	Winter	Transitional	Annualised
0	35.0	35.1	34.8	35.0
10	35.0	35.1	34.8	35.0
20	35.0	35.1	34.8	35.0
35	35.0	35.1	34.8	35.0
45	34.9	35.1	34.8	34.9
70	34.9	35.0	34.9	34.9

2.1.3.2.2 Ambient Current

Ocean current data was sourced from a ten-year hindcast data set of combined large-scale ocean (BRAN) and tidal currents (Figure 2.1 to Figure 2.4). The data was statistically analysed to determine the 5th, 50th and 95th percentile current speeds. These statistical current speeds can be considered representative of the range of seasonal conditions at the drilling location.

Table 2.6 to Table 2.8 present the steady-state, unidirectional current speeds at varying depths used as input to the near-field model as forcing for each discharge case and season were calculated as:

- 5th percentile (weak current speed).
- 50th percentile (median current speed).
- 95th percentile (strong current speed).

Table 2.6 Calculations for ambient current conditions adjacent to the proposed discharge location during summer.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.061	0.245	0.534
12.5	0.063	0.246	0.531
22.7	0.066	0.247	0.529
34.2	0.069	0.249	0.530
48.5	0.072	0.254	0.536
75.2	0.058	0.228	0.523

Table 2.7 Calculations for ambient current conditions adjacent to the proposed discharge location during winter.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.070	0.260	0.548
12.5	0.070	0.257	0.540
22.7	0.069	0.255	0.536
34.2	0.067	0.253	0.536
48.5	0.065	0.251	0.537
75.2	0.057	0.232	0.528

Table 2.8 Calculations for ambient current conditions adjacent to the proposed discharge location during transitional periods.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.067	0.254	0.555
12.5	0.070	0.254	0.552
22.7	0.071	0.254	0.551
34.2	0.071	0.256	0.551
48.5	0.074	0.260	0.556
75.2	0.060	0.235	0.553

Table 2.9 Calculations for ambient current conditions adjacent to the proposed discharge location throughout the annualised period.

Depth (m)	5^{th} percentile (weak) current speed (m/s)	50^{th} percentile (median) current speed (m/s)	95^{th} percentile (strong) current speed (m/s)
2.5	0.067	0.254	0.547
12.5	0.068	0.253	0.542
22.7	0.069	0.253	0.539
34.2	0.069	0.253	0.540
48.5	0.070	0.254	0.544
75.2	0.058	0.232	0.535

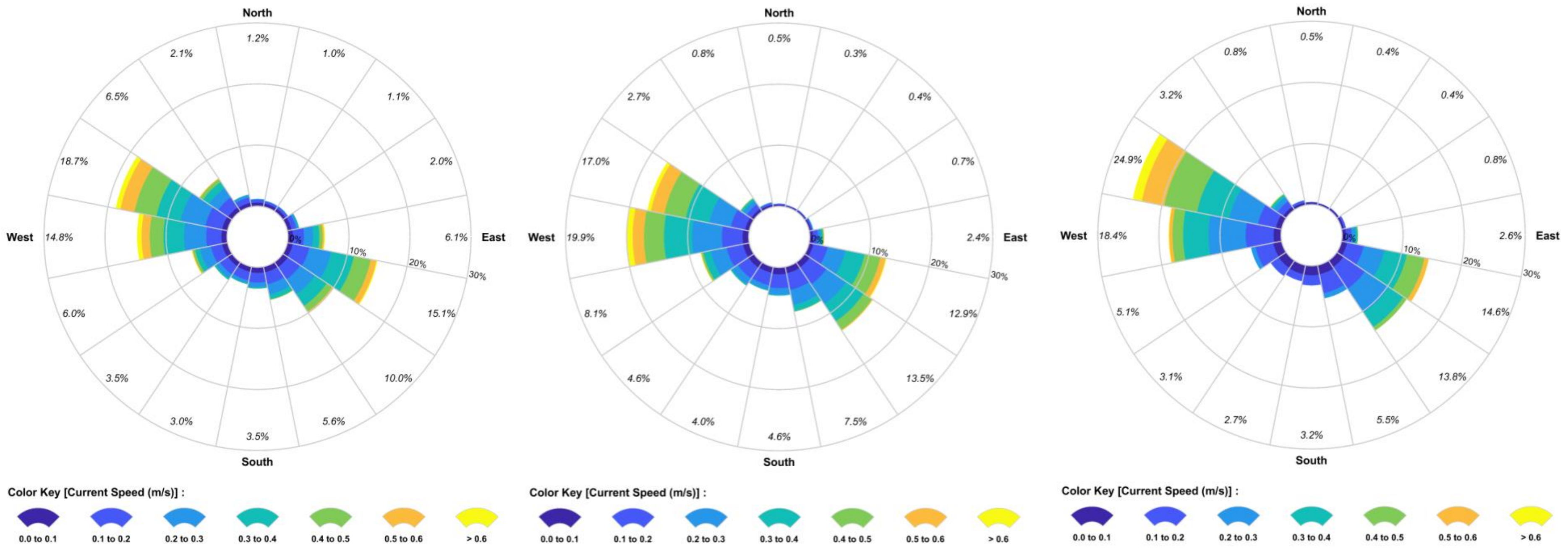


Figure 2.1 Summer current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

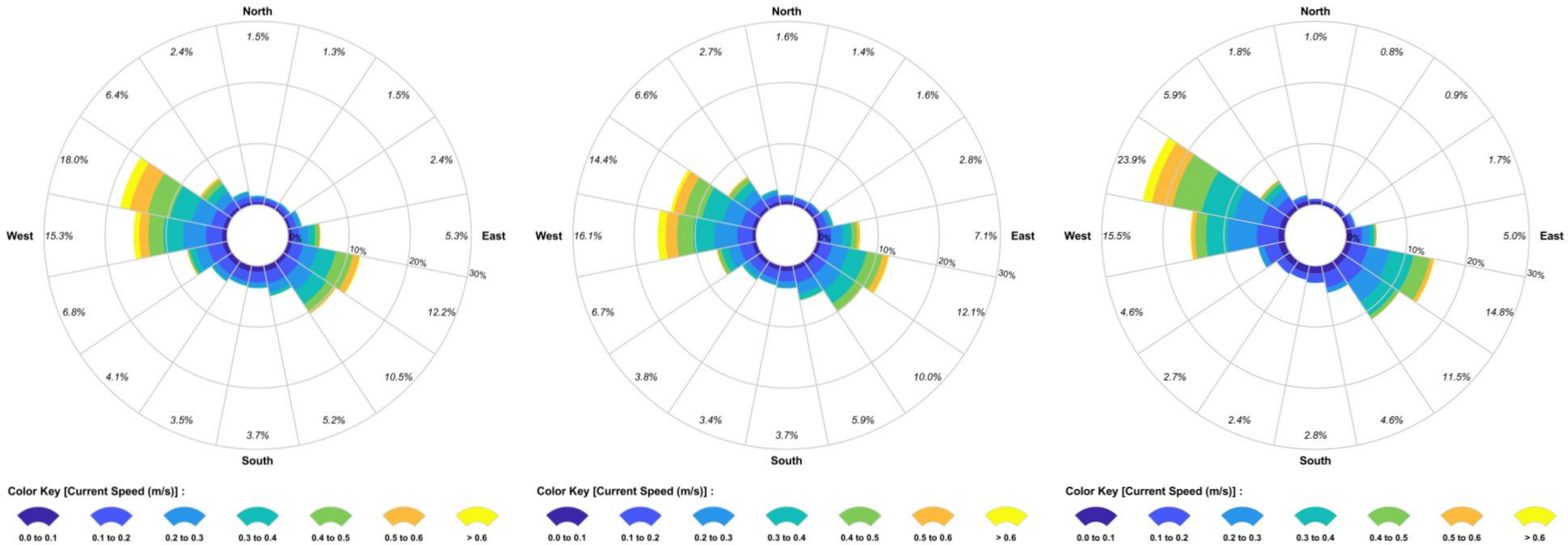


Figure 2.2 Winter current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

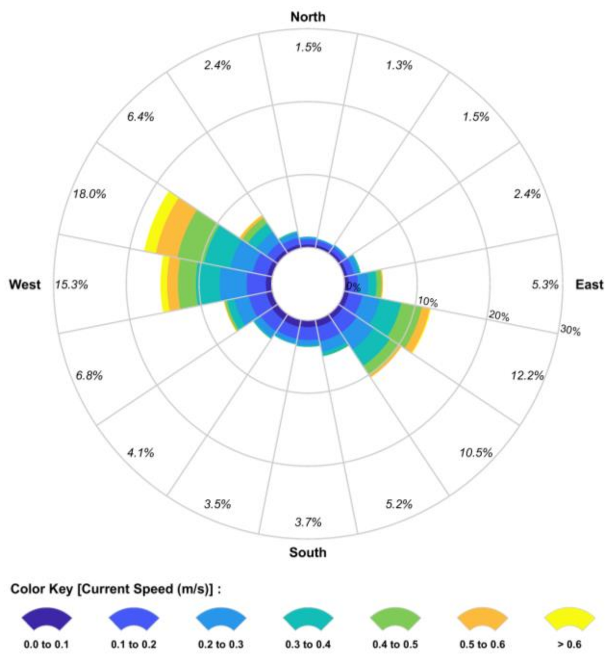


Figure 2.3 Transitional current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

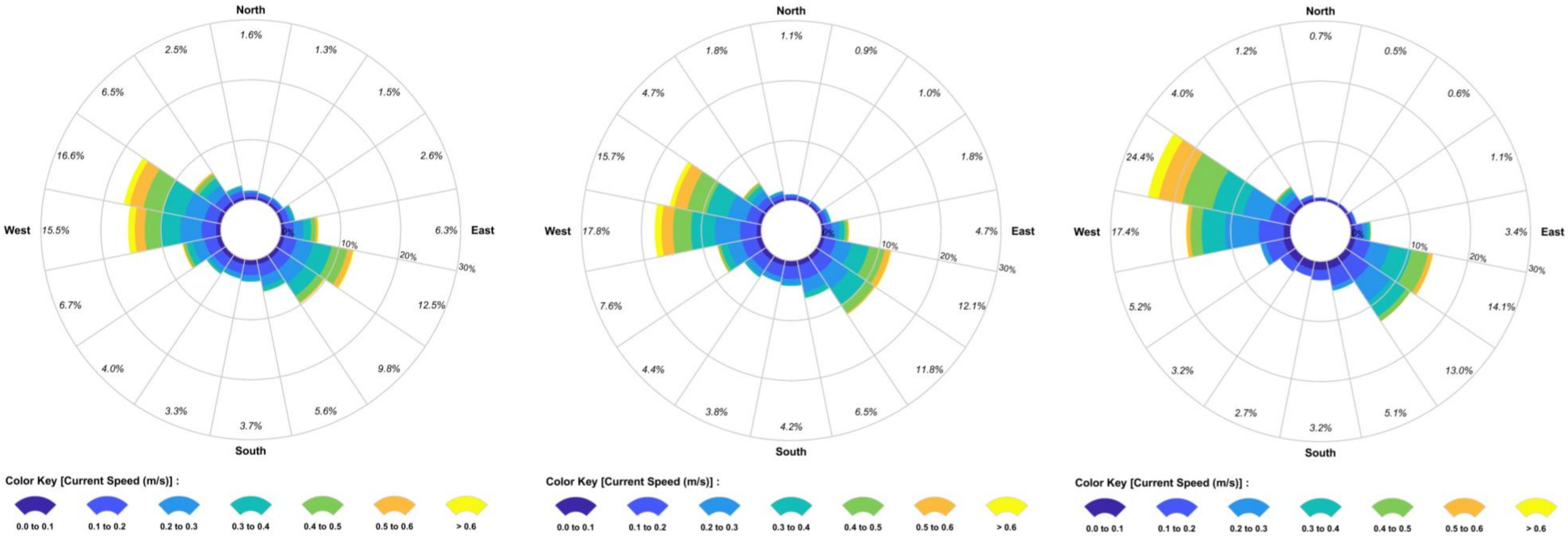


Figure 2.4 **Annualised current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.**

2.2 Far-Field Modelling

2.2.1 Overview

The far-field modelling expands on the near-field work by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume back to the discharge location to be assessed. In this case, concentrations near the discharge point can be increased due to the discharge plume mixing with the remnant plume from an earlier time. This may be a potential source of episodic increases in constituent concentrations in the receiving waters.

2.2.2 Description of Far-Field Model: CHEMMAP

The mixing and dispersion of the discharges was predicted using the three-dimensional discharge and plume behaviour model, CHEMMAP (French-McCay & Isaji, 2004; French-McCay *et al.*, 2006).

CHEMMAP predicts the movement and fate of a wide variety of chemical products, including floating, sinking, soluble/insoluble chemicals and product mixtures (French-McCay & Isaji, 2004). CHEMMAP incorporates many important chemical modelling components, including transport and spreading of floating chemicals; transport of dissolved or particulate chemicals in three dimensions; evaporation or volatilisation of chemicals at the surface; dissolution; re-suspension; sedimentation; and degradation of chemicals in air, water, and sediments (French-McCay *et al.*, 2006).

The most important inputs associated with the chemical model are the physical properties relating to the released chemical. The properties used to predict the fate and transport of each chemical include density, vapour pressure, water solubility, environmental degradation rates, adsorbed/dissolved partitioning coefficients (K_{OW}, K_{OC}), viscosity and surface tension (French-McCay *et al.*, 2006). CHEMMAP contains its own chemical database and the information found within this database is compiled from published literature sources (French-McCay & Payne, 2008).

The transport algorithm within CHEMMAP depends heavily on the precision of the input current data (French-McCay & Whittier, 2004). The model uses a Lagrangian three-dimensional transport model to predict the movement of the chemical in the water column, on the surface and in the air (French-McCay & Whittier, 2004).

For each time step, the model calculates the phase transfer percentages and changes the state of proportions of the spilled chemical (French-McCay & Isaji, 2004). This may mean that a chemical changes from a substance floating on the surface to a gas or is dissolved into the water column. The evaporation algorithm used in the CHEMMAP model has been tested by comparison to experimental data from Kawamura & Mackay (1987) and French-McCay & Whittier (2004).

2.2.3 Stochastic Modelling

A stochastic modelling procedure was applied in the far-field modelling to sample a representative set of conditions that could affect the distribution of constituents. This approach involves multiple (50) simulations of a given discharge scenario and season, with each simulation being carried out under a randomly selected period of currents. This methodology ensures that the calculated movement and fate of each discharge is representative of the range of prevailing currents at the discharge location. Once the stochastic modelling is complete, all simulations are statistically analysed to develop the distribution of outcomes based on time and event.

The stochastic simulations are jointly processed as an aggregated set for each season. This is done by building a time series of maximum contaminant concentrations, at any depth in the water column within each model grid cell, for all time steps of all replicate simulations. The resultant time series at each grid cell is a representation of the stochastic outcomes, and this is statistically analysed to allow percentile data (representing the percentage of time that concentrations occur) to be generated. The resultant percentile concentration contours, and the initial source concentration of the discharge, are used to determine the dilution contours for each percentile.

To calculate the tabulated results of dilutions at distances from the source location, all grid cells at the specified radial distances (e.g. 100 m), including a buffer zone of 10 m either side (e.g. every grid cell in the 90-110 m range), are interrogated. The minimum dilution is calculated as the lowest value in any individual non-zero grid cell within the defined range, including the buffer zone. The average dilution is calculated as the average value across all non-zero grid cells within the defined range, including the buffer zone. This is done for all defined radial distances from the source location for each percentile.

2.2.4 Setup of Far-Field Model

2.2.4.1 Discharge Characteristics

The CHEMMAP model simulated the discharge into a time-varying current field with the initial dilution set by the near-field results described in Section 3.1.

The hydrotest discharge scenario was modelled as single discharge over 15 hours using 50 simulations for each season. Once the simulations were complete the cumulative results based on the biocide concentration were reported on a seasonal and annualised basis: (i) summer (December to February); (ii) transitional (March and September to November), (iii) winter (April to August) and annual (January to December). The scenario was thus grouped this way for results to be presented as dilutions.

The hydrotest discharge characteristics are summarised in Table 2.10.

Table 2.10 Summary of far-field hydrotest discharge modelling assumptions.

Parameter	Scenario 1
Hindcast modelling period	2006-2015
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August) Annual
Flow rate (m^3/hr)	130
Discharge volume (m^3)	2,000
Discharge duration (hours)	15
Discharge depth (m)	~73
Discharge salinity (ppt)	Ambient
Discharge temperature (°C)	Ambient
Number of simulations	150 (50 per season)
Simulated discharge type	Continuous

2.2.4.2 Mixing Parameters

Horizontal and vertical dispersion coefficients are used in dispersion modelling to represent the mixing and diffusion processes caused by turbulence, which are sub-grid processes at the scale of the hydrodynamic data that drives transport of material. The dispersion coefficients are expressed in units of rate of area of change (m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations. Increasing the vertical dispersion coefficient spreads the discharge further across the vertical layers.

The horizontal turbulent diffusion of the plume is dependent on the hydrodynamic conditions (i.e. wind, wave, and current) and the physical scale of the plume compared to the scales of the oceanic processes that disperse the plume. For a plume of approximately 10-100 m width, dispersion occurs primarily through small-scale horizontal swirling motions and vertical mixing, with a horizontal dispersion rate of the order of 0.1 m^2/s. As the plume grows to a scale of 1-10 km, it begins to be subject to mesoscale eddies and the horizontal dispersion rate increases to the order of a few to tens of m^2/s. At even larger scales, the plume would be larger than the mesoscale eddies and eddy mixing becomes the dominant mechanism, with a rate of horizontal dispersion of 100-1,000 m^2/s.

For this project, with an open ocean environment and length scales of 10 m to 1 km, a horizontal diffusion rate of 0.25 m^2/s was applied. A value of 0.10 cm^2/s was set for the vertical dispersion coefficient to account for the influence of turbulence within the water column, as well as wave-induced turbulence. These values are based on previous experience and informed by studies by Copeland (1996).

2.2.4.3 Grid Configuration

CHEMMAP uses a three-dimensional grid to represent the geographic region under study (water depth and bathymetric profiles). Due to the rapid mixing and small-scale effect of the effluent discharge, it was necessary to use a fine grid with a resolution of 20 m x 20 m to track the movement and fate of the discharge plume. The extent of the grid region measured approximately 20 km (longitude or x-axis) by 20 km (latitude or y-axis), which was subdivided horizontally into 1,000 x 1,000 cells. The vertical resolution was set to 2 m.

2.2.4.4 Approach to Coupling with Near-Field Model Outputs

Near-field modelling considers dispersion and movement of plumes due to physical processes that occur over smaller time and space scales (metres and minutes, respectively) than were important to this study (tens of kilometres and tens of minutes to hours or days) and only considers steady state conditions (fixed discharge and current).

To assess the far-field behaviour of the discharge plume over the longer term and over a wider area, CHEMMAP was applied to simulate the trajectory and fate of the discharge using the initial calculations of the near-field model. The CHEMMAP model operates over a coarser grid to calculate the dynamics of the discharge material and resulting seabed concentrations and bottom thicknesses over the wider region, accounting for changing current field. Discharge details may also change over time.

Due to the different time and space scales involved, it is necessary to carefully couple the output from the near-field as input to the far-field model to maintain mass balance.

The coupling method employed by RPS involved translating the modelling results of the near-field (CORMIX) simulations into spatially varying and ambient condition dependent input (sources) for input into the far-field model (CHEMMAP). The RPS methodology is designed to be partially dynamic (one-way coupling).

The coupling involved:

1. Running the near-field model (CORMIX) under steady-state discharge configurations (Table 2.6 to Table 2.9) under a range of ambient current speeds (5th, 25th, 50th, 75th and 95th percentile) for each season (summer, winter and transitional) to define the range of geometries and distributions of the plume that should result after all near-field processes have completed.
2. Using these calculations for mass distributions to define input concentrations and locations within the grid of the far-field model (in the vertical and horizontal), that vary with the prevailing current speed and direction at the discharge point, ensuring that the initial mass is conserved, without any initial convective descent.
3. Running sensitivity tests to determine the appropriate horizontal and vertical grid scales to apply to the CHEMMAP model (to avoid over-dilution of the input concentration) along with the most appropriate mixing parameters (horizontal and vertical dispersion) to avoid over or under-dispersion.

2.2.5 Regional Ocean Currents

2.2.5.1 Background

The area of interest for this study is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf. While the mass flow is generally towards the south-west, year-round, the internal gyres generate local currents in all directions. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. Further south of the project area, the

Leeuwin Current becomes the dominant large-scale current system, flowing poleward down the pressure gradient along the Western Australian coastline and past Cape Leeuwin.

Offshore regions with water depths exceeding 100-200 m experience significant large-scale drift currents. These drift currents can be relatively strong (1-2 knots) and complex, manifesting as a series of eddies, meandering currents, and connecting flows. These offshore drift currents also tend to persist longer (days to weeks) than tidal current flows (hours between reversals) and thus will have greater influence upon the net trajectory of plumes over time scales exceeding a few hours.

Wind shear on the water surface also generates local-scale currents that can persist for extended periods (hours to days) and result in long trajectories. Persistent winds along the mainland coast can induce Ekman transport, where surface waters move offshore and facilitate upwelling events in which cold nutrient-rich waters from the deep Indian Ocean are brought to the surface. However, due to the opposing transport of warm tropical waters by the Leeuwin Current, large-scale persistent upwelling along the Western Australian coast is suppressed. Therefore, upwelling events are sporadic, short-term and localised to areas of the coastline where the continental shelf narrows, including the area around the Capes and the Ningaloo coast (IMOS, 2014). This process is seasonal/transient and affected by the strength of the Leeuwin Current, with minimal upwelling in times with strong Leeuwin Current flow.

The current-induced transport of plumes can be variably affected by combinations of tidal, wind-induced, and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to rigorously understand patterns of potential transport from a given discharge location.

To appropriately allow for temporal and spatial variation in the current field, dispersion modelling requires the current speed and direction over a spatial grid covering the potential migration trajectories of plumes. As long-term measured current data is not available for simultaneous periods over a network of locations covering the offshore areas relevant to this study, the analysis relied upon hindcasts of the circulation generated through numerical modelling by internationally recognised organisations.

A composite modelled ocean current data product was derived by combining predictions of mesoscale circulation currents, available at daily resolution from global ocean models, with predictions of the hourly tidal currents generated by the RPS HYDROMAP model. By combining a drift current model with a tidal model, the influences of inter-annual and seasonal drift patterns, and the more regular variations in tide, were depicted, ensuring nearshore and offshore hydrodynamic processes were represented.

2.2.5.2 Mesoscale Circulation Model

2.2.5.2.1 Description of Mesoscale Model: BRAN

Representation of the drift currents that affect the area were available from the output of the BRAN (Oke *et al.*, 2013, 2009, 2008; Schiller *et al.*, 2008) ocean model, which is sponsored by the Australian Government through the Commonwealth Bureau of Meteorology (BoM), Royal Australian Navy and CSIRO. BRAN is a data-assimilative, three-dimensional ocean model that has been run as a hindcast for many periods and is now used for ocean forecasting (Schiller *et al.*, 2008).

BRAN routinely assimilates sea level anomaly data, tide gauge data, sea surface temperature and in situ temperature and salinity measurements (Oke *et al.*, 2009). Comparisons of BRAN hindcast outputs to satellite and independent in situ observations found that BRAN was reliably representing the broad-scale ocean circulation, the mesoscale surface eddy field, and shelf circulation around Australia (Oke *et al.*, 2008; Schiller *et al.*, 2008). Additionally, reanalysis of past periods using the BRAN model has been shown to realistically represent upwelling events, in particular along the Bonney Coast of South Australia, a region of frequent wind-driven upwellings (Oke *et al.*, 2009).

The BRAN predictions for drift currents are produced at a horizontal spatial resolution of approximately 0.1° over the region, at a frequency of once per day, averaged over the 24-hour period. Hence, the BRAN model data provides estimates of mesoscale circulation with horizontal resolution suitable to resolve eddies of a few tens of kilometres' diameter, as well as connecting stream currents of similar spatial scale. Drift currents that are represented over the inner shelf waters in the BRAN data are principally attributable to wind induced drift.

There are several versions of the BRAN database available. A notable BRAN simulation spans the period of January 1994 to August 2016. From this database, three-dimensional data representing horizontal water movement at discrete depths was extracted for all points in the model domain for the years 2006-2015 (inclusive). The data was assumed to be a suitably representative sample of the current conditions over the study area for future years.

Although this data should represent effects of upwelling and downwelling processes on horizontal transport at a given depth, the data does not explicitly represent vertical currents between horizontal layers. This was considered reasonable because vertical currents associated with episodic upwelling and downwelling events are relatively small in magnitude (3-30 cm/s; Kämpf *et al.*, 2004) compared to horizontal currents represented in the tidal and non-tidal current data (0.5-2 m/s), and considering allowances for dispersion rates in the horizontal (0.1-50 m/s) and vertical (1-10 cm/s) planes.

2.2.5.2.2 Mesoscale Currents at the Discharge Location

The data for the scenario indicates that higher average current speeds are characteristic of the April to June period, with the highest average speeds (0.20 m/s) occurring near the release site in June (Figure 2.5). Lower average current speeds are more common during the January to March period, with the lowest average speeds (0.11 m/s) occurring near release site in October. Current directions near the discharge site are predominately westerly across the year.

The extracted current data near the discharge location provides an insight into the expected initial behaviour of plumes due to the drift currents alone. Plumes moving beyond the release sites, particularly towards the coast, would be subject to considerable variation in the drift current regime.

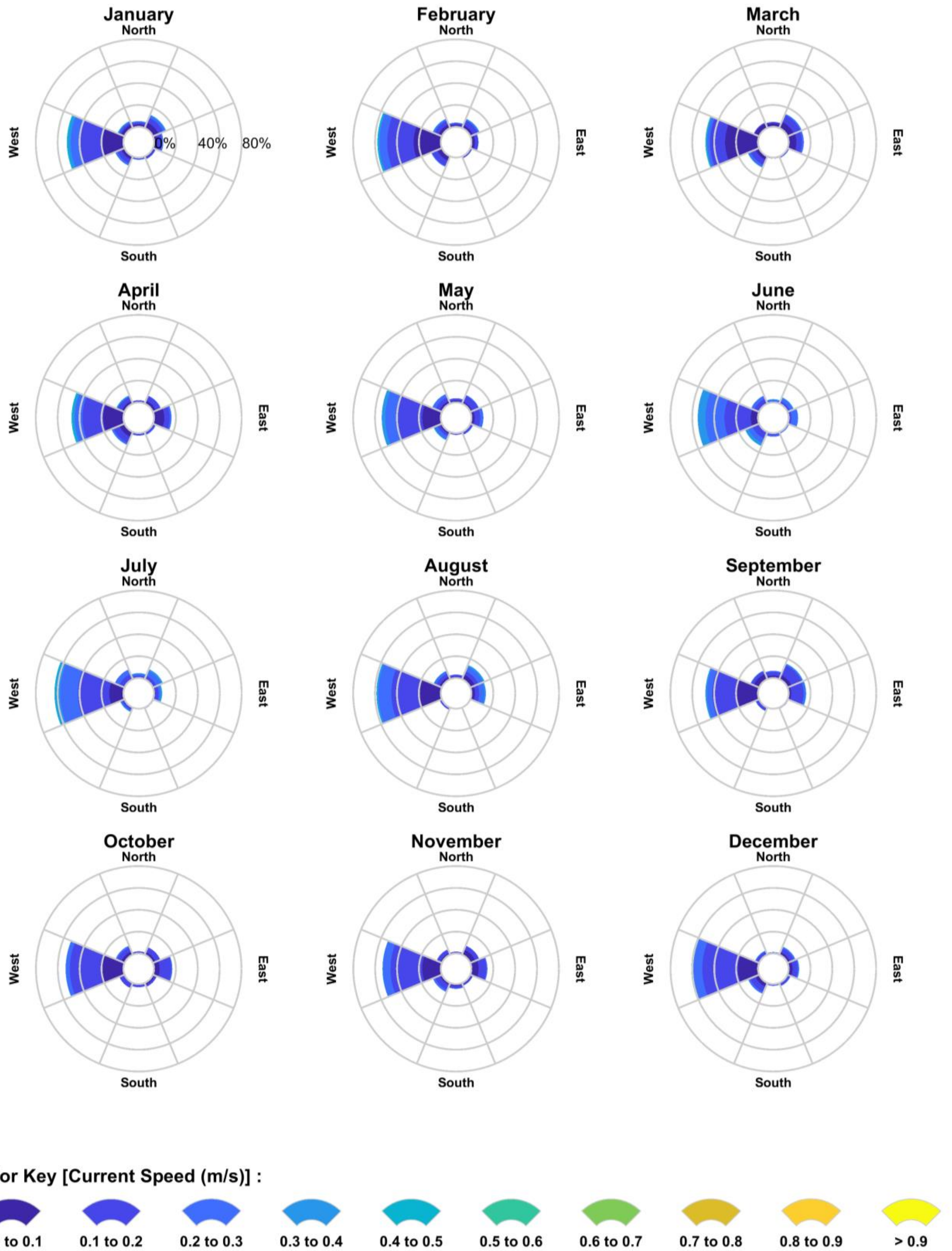


Figure 2.5 **Monthly current distribution (2006-2015, inclusive) derived from the BRAN database near to the discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.**

2.2.5.3 Tidal Circulation

2.2.5.3.1 Description of Tidal Model: HYDROMAP

As the BRAN model does not include tidal forcing, and because the data is only available at a daily frequency, a tidal model was developed for the study region using RPS' three-dimensional hydrodynamic model, HYDROMAP.

The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 30 years (Isaji and Spaulding, 1986, 1984; Isaji *et al.*, 2001; Zigic *et al.*, 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the National Marine Oil Spill Contingency Plan for the Australian Maritime Safety Authority (AMSA, 2002).

HYDROMAP simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction. The model employs a sophisticated dynamically nested-gridding strategy, supporting up to six levels of spatial resolution within a single domain. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

The numerical solution methodology of HYDROMAP follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon & Spaulding (1987). A more detailed presentation of the model can be found in Isaji & Spaulding (1984).

2.2.5.3.2 Tidal Domain Setup

A HYDROMAP model was established over a domain that extended approximately 3,300 km east-west by 3,100 km north-south over the eastern Indian Ocean. The grid extends beyond Eucla in the south and beyond Bathurst Island in the north (Figure 2.6).

Approximately 98,600 cells were used to define the region, with four layers of sub-gridding applied to provide variable resolution throughout the domain. The resolution at the primary level was 15 km. The finer levels were defined by subdividing these cells into 4, 16 and 64 cells, resulting in resolutions of 7.5 km, 3.75 km, and 1.88 km.

The finer grids were allocated in a stepwise fashion to areas where higher resolution of circulation patterns was required to resolve flows through channels, around shorelines or over more complex bathymetry. Figure 2.7 shows a zoomed subset of the hydrodynamic model grid in the North West Shelf region, showing the finer resolution grids surrounding the numerous shoals, islands, and complex areas of the mainland coastline.

Bathymetric data used to define the three-dimensional shape of the study domain was extracted from the Geoscience Australia 250 m resolution bathymetry database (Whiteway, 2009) and the CMAP electronic chart database, supplemented where necessary with manual digitisation of chart data supplied by the Australian Hydrographic Office. Depths in the domain ranged from shallow intertidal areas through to approximately 7,200 m.

2.2.5.3.3 Tidal Boundary Conditions

Ocean boundary data for the HYDROMAP model was obtained from the TOPEX/Poseidon global tidal database (TPXO7.2) of satellite-measured altimetry data, which provided estimates of tidal amplitudes and phases for the eight dominant tidal constituents (designated as K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1) at a horizontal scale of approximately 0.25°. Using the tidal data, sea surface heights are firstly calculated along the open boundaries at each time step in the model.

The TOPEX/Poseidon satellite data is produced, and quality controlled by the US National Atmospheric and Space Agency (NASA). The satellites, equipped with two highly accurate altimeters capable of taking sea level measurements accurate to less than ±5 cm, measured oceanic surface elevations (and the resultant tides) for over 13 years (1992-2005). In total, these satellites carried out more than 62,000 orbits of the planet. The TOPEX/Poseidon tidal data has been widely used amongst the oceanographic community, being the subject of more than 2,100 research publications. As such, the TOPEX/Poseidon tidal data is considered suitably accurate for this study.

2.2.5.3.4 Tidal Elevation Validation

For the purpose of verification of the tidal predictions, the model output was compared against independent predictions of tides using the XTide database (Flater, 1998). The XTide database contains harmonic tidal constituents derived from measured water level data at locations around the world. Overall, there are more than 120 tidal stations within the HYDROMAP model domain; however, some of these are in areas that are not sufficiently resolved by this large-scale ocean model. More than 80 stations along the coastline were suitable for comparisons of the model performance with the observed data. These stations covered the mid-to-northwest regions of the Western Australian coastline, encompassing the locales of the marine discharges considered in this study

For the purposes of brevity and clarity, a selected representative subset of the available tidal station validation data is presented here.

Water level time series for the selected subset of ten stations are shown in Figure 2.8 and Figure 2.9 for a one-month period (January 2018). All comparisons show that the model produces a very good match to the known tidal behaviour for a wide range of tidal amplitudes and clearly represents the varying diurnal and semi-diurnal nature of the tidal signal.

The model skill was further evaluated through a comparison of the predicted and observed tidal constituents, derived from an analysis of model-predicted time series at each of the tidal station locations. Scatter plots of the observed and modelled amplitude (top) and phase (bottom) of the five dominant tidal constituents (S_2, M_2, N_2, K_1 and O_1) for all relevant stations within the model domain (>80) are presented in Figure 2.10. The red line on each plot shows the 1:1 line, which would indicate a perfect match between the modelled and observed data. Note that the data is generally closely aligned to the 1:1 line demonstrating the high quality of the model performance.

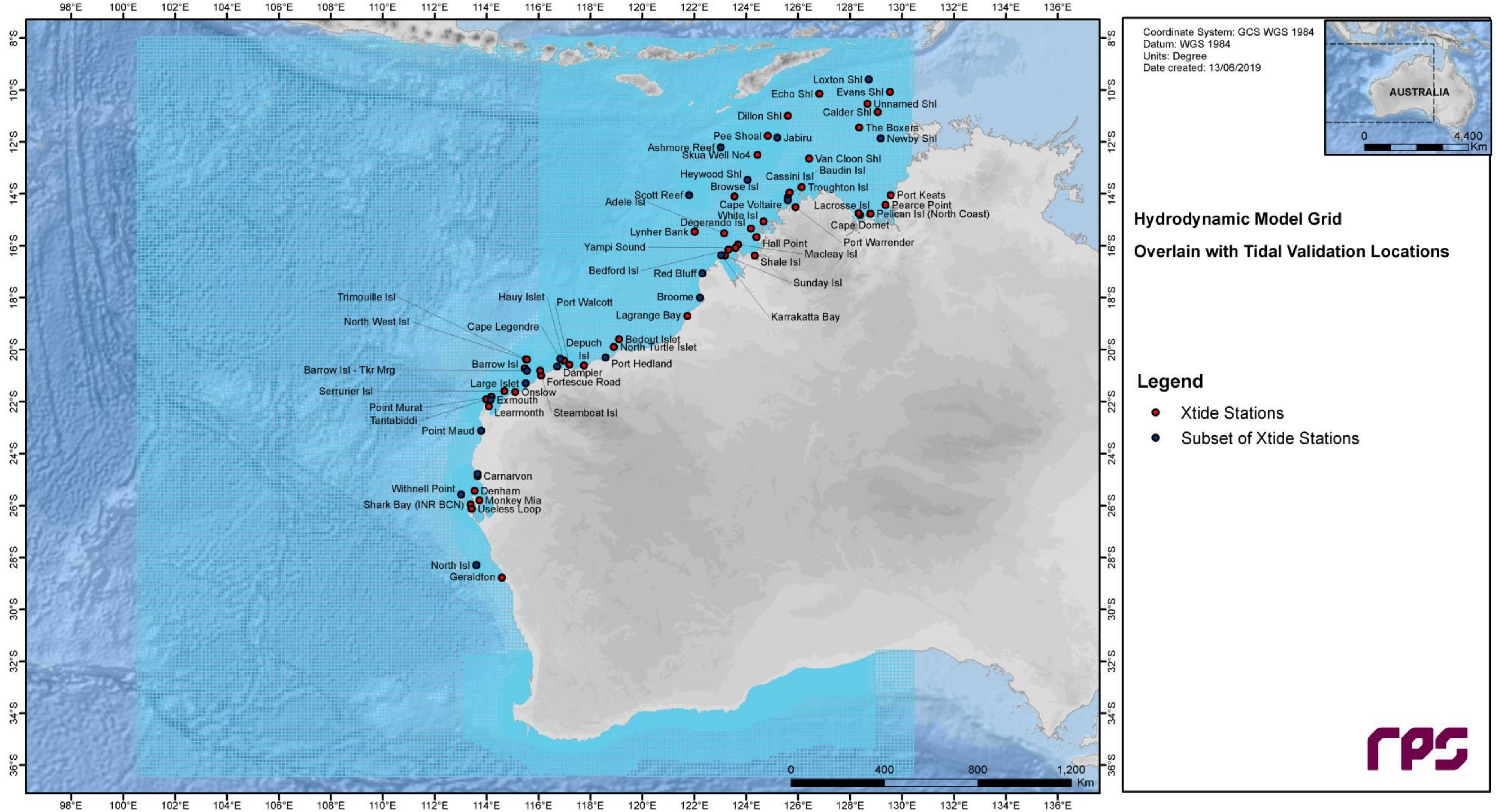


Figure 2.6 **Hydrodynamic model grid (blue wire mesh) used to generate the tidal currents, showing the full domain in context with the continental land mass and the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.**

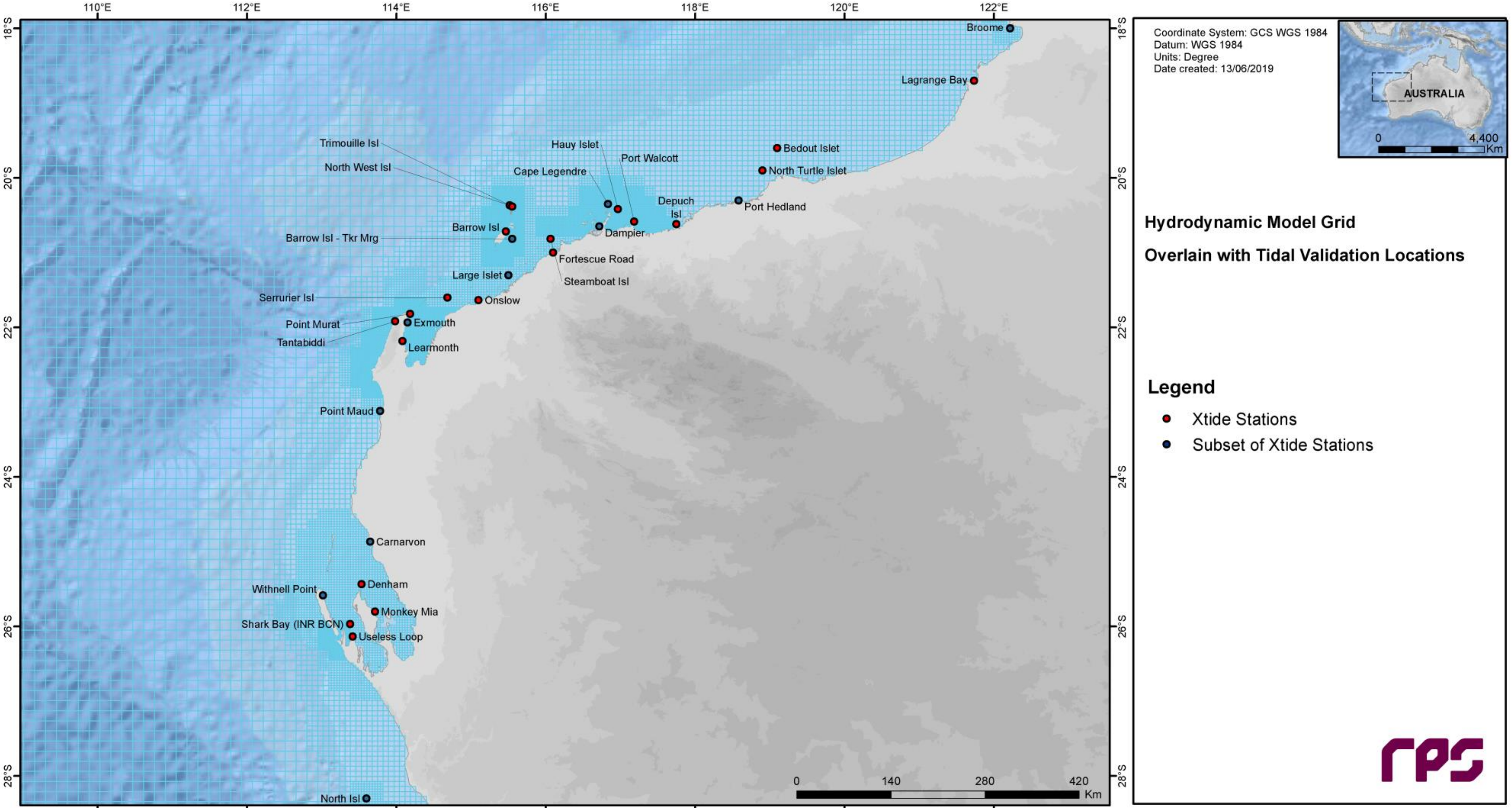


Figure 2.7 Zoomed subset of the hydrodynamic model grid (blue wire mesh) for the North West Shelf area, showing the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.

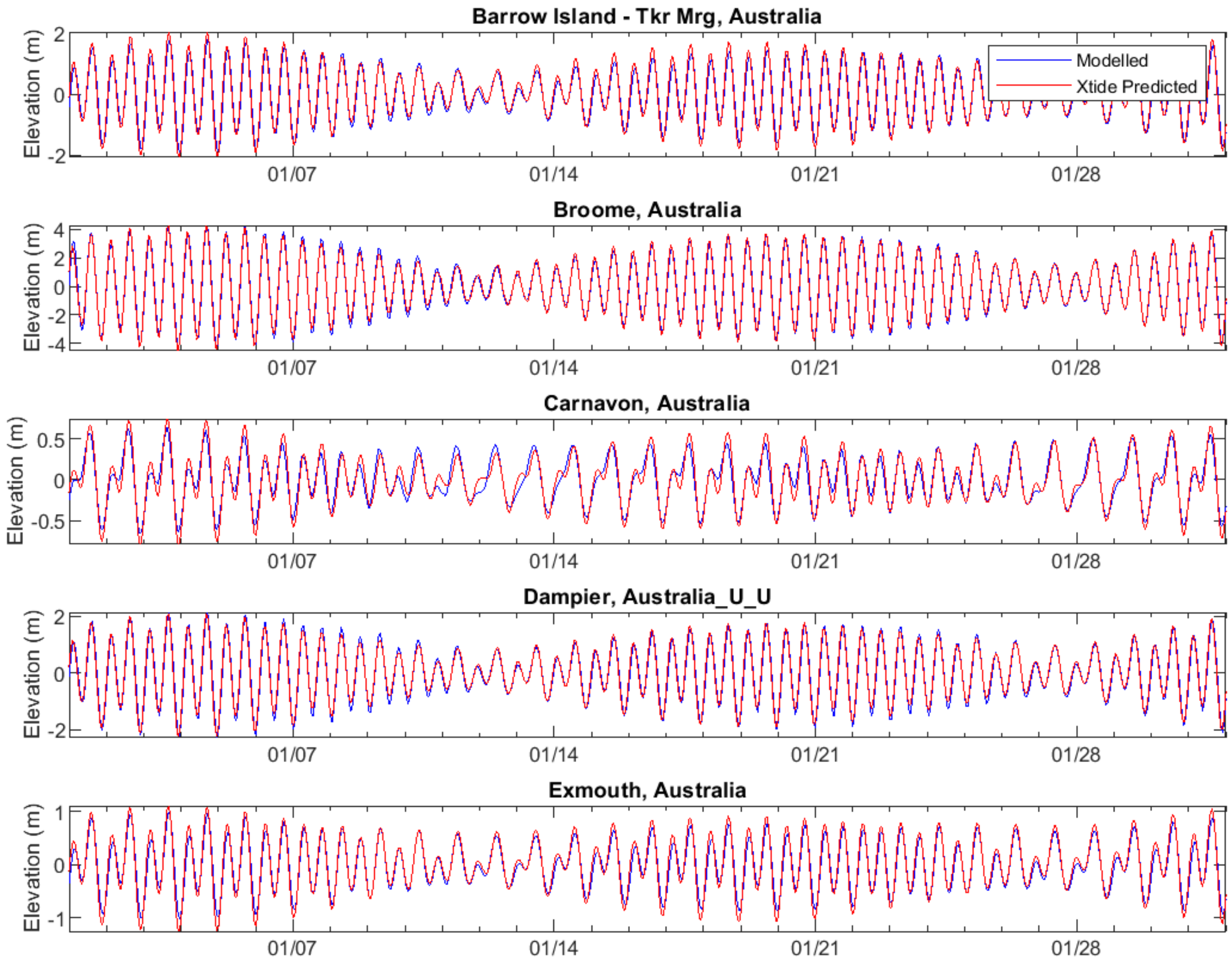


Figure 2.8 Comparisons between the predicted (blue line) and XTide predicted (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.

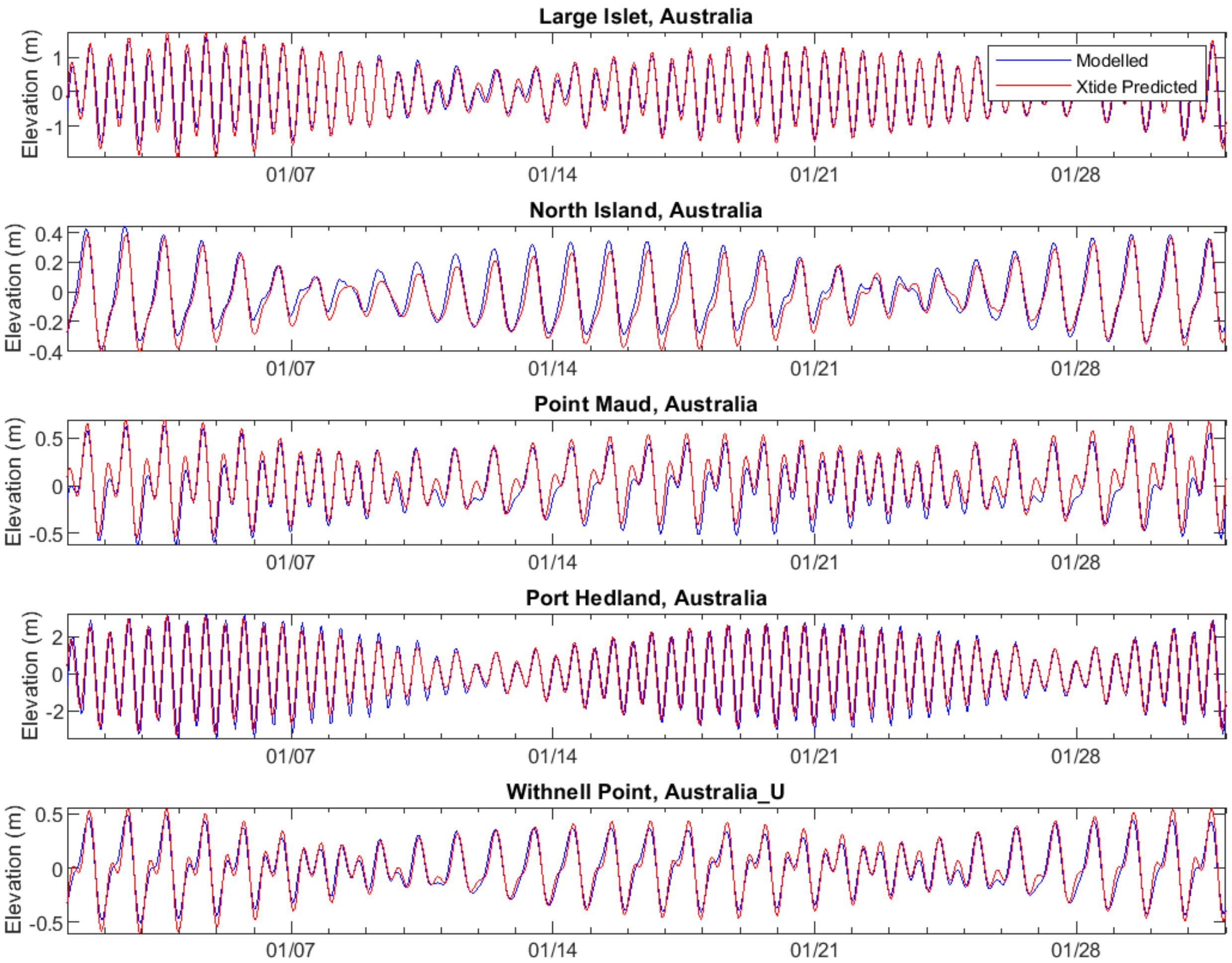
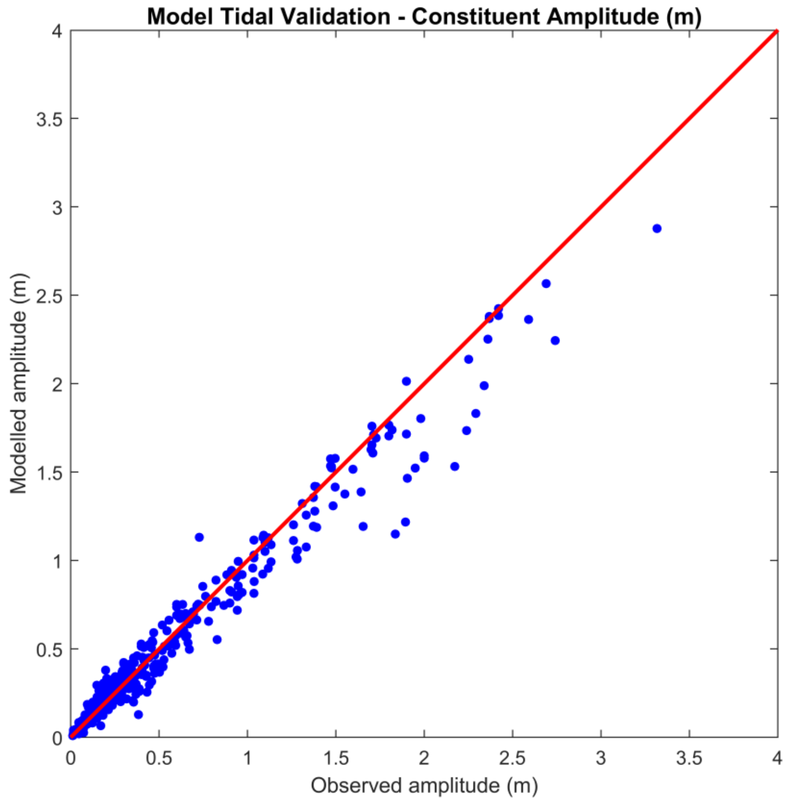


Figure 2.9 Comparisons between the predicted (blue line) and XTide predicted (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.



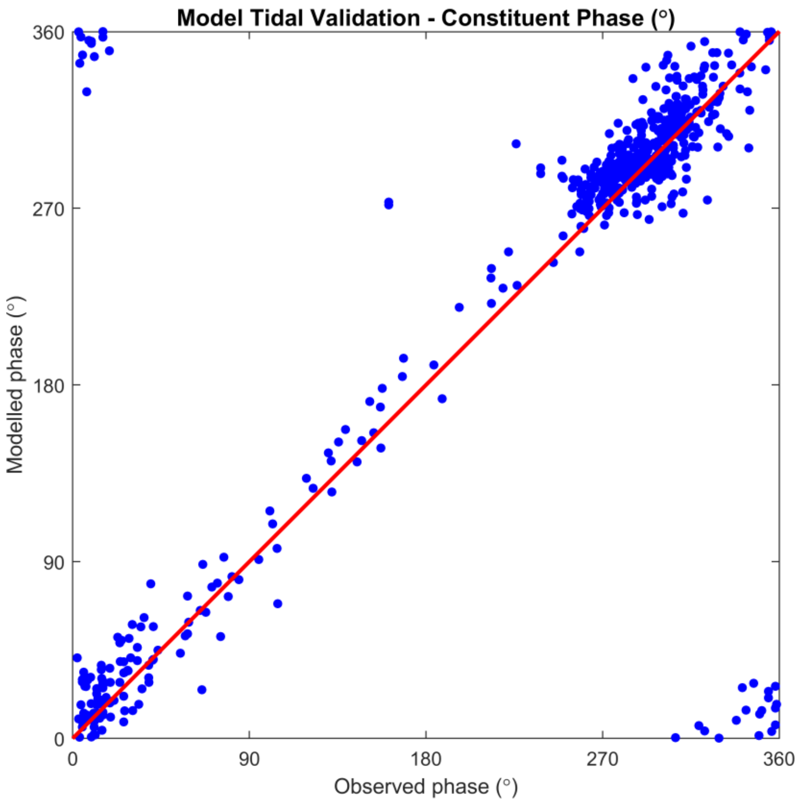


Figure 2.10 Comparisons between modelled and observed tidal constituent amplitudes (top) and phases (bottom) at all relevant stations (>80) in the HYDROMAP model domain. The red line indicates a 1:1 correlation between the modelled and observed data.

2.2.5.3.5 Tidal Currents at the Discharge Location

The monthly distributions of current speeds and directions for the HYDROMAP data point closest to the discharge location are displayed in Figure 2.11. Note that the convention for defining current direction is the direction *towards* which the current flows.

The data indicates cyclical tidal flow directions along a southeast-northwest axis at the modelled discharge site for the scenarios. The extracted current data near the discharge location provides an insight into the expected initial behaviour of plumes due to the tidal currents alone. Plumes moving beyond the release sites, particularly towards the coast, would be subject to considerable variation in the tidal current regime.

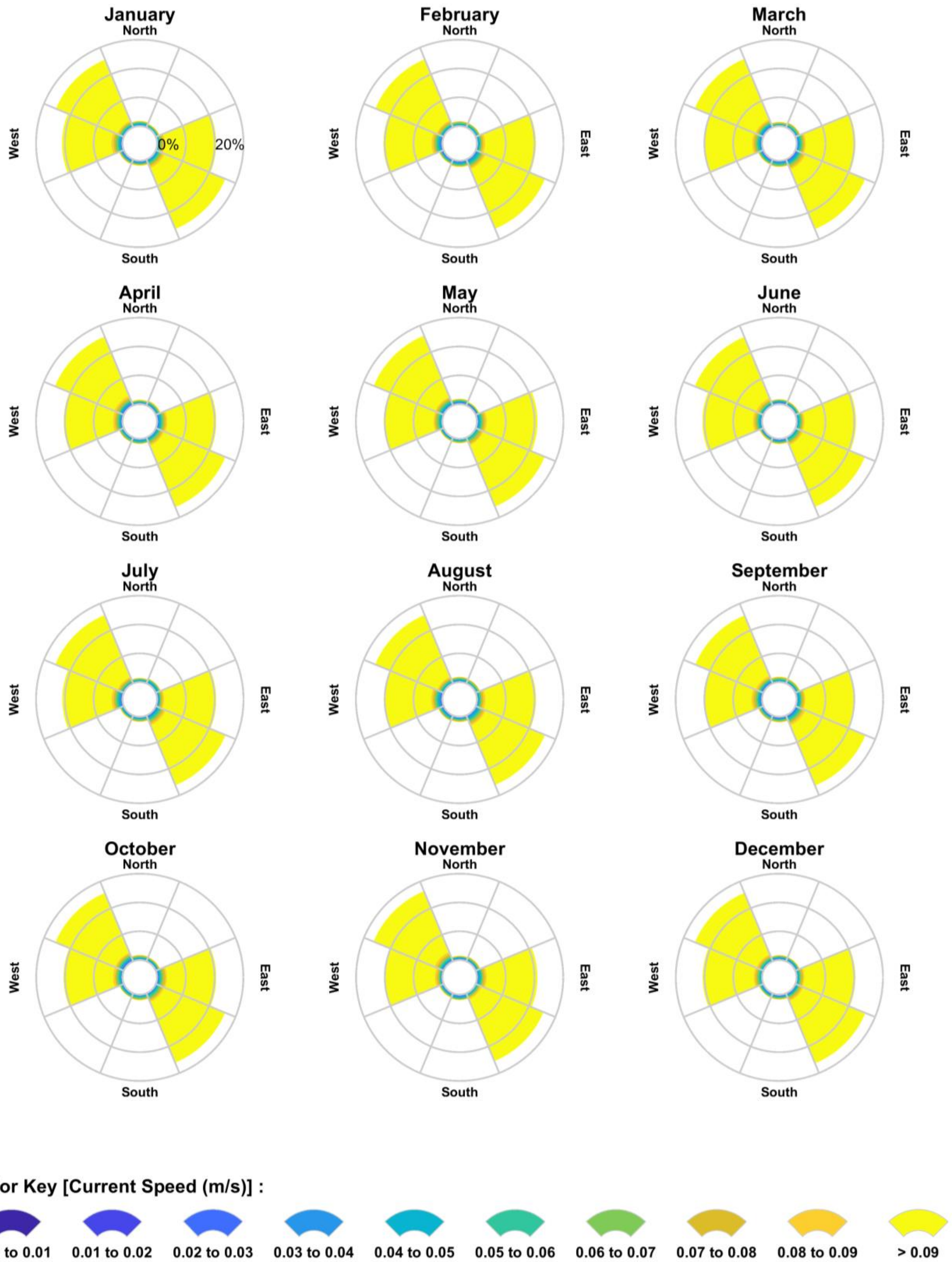


Figure 2.11 Monthly current distribution (2006-2015, inclusive) derived from the HYDROMAP database near to the discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

3 MODELLING RESULTS

3.1 Near-Field Modelling

3.1.1 Scenario 1: Discharge of 2,000 m^3 of Hydrotest Water

3.1.1.1 Overview

Conceptual plots of the near-field plume under low, medium, and high current speeds during summer, transitional and winter seasons are shown in Figure 3.1 to Figure 3.12. Table 3.1 presents a summary of the predicted near-field plume characteristics under varying current conditions.

Modelling indicated that irrespective of season, the plume will travel the furthest (282.4 m) from the discharge location during high current speeds, with average dilution levels of 1:896-1:1,214 predicted at the end of the near-field zone. Under low and medium current speeds, the maximum distance for the source becomes progressively less (104.7 m and 150.7 m, respectively) due to decreasing current strength. Average dilution levels at the end of the near-field zone under low and medium currents are predicted to be 1:484-1:607 and 1:661-1:899, respectively. Under all current conditions, the plume is predicted to attach to the seabed (Coandă attachment) and remain near the seabed.

In the assessed seasons, indicative safe dilution levels of 1:10,000 are not achieved within the near-field (Table 3.1).

It should be noted that, as the near-field modelling assumes constant currents, it does not account for any time-varying local circulation processes that may cause discharge plumes to pool or recirculate. As such, the levels of dilution predicted here may in some cases be over-predictions and the results should not be considered conservative. Generally, it is difficult to estimate the level of conservatism of near-field results due to the potential variations in seasonal and inter-annual environmental conditions from one location to another.

3.1.1.2 Results – Table

Table 3.1 Summary of the near-field plume characteristics and associated levels of dilution for varying current conditions. Dilution rates highlighted in red indicate that safe dilution of the overall discharge is not achieved during the near-field stage.

Season	Current percentile	Current strength	Distance from source (m)	Plume width (m)	Centreline dilution	Average dilution
Summer	5th	Low	87.2	18.8	285	484
	50th	Medium	101.7	11.1	389	661
	95th	High	179.6	8.5	527	896
Transitional	5th	Low	90.4	19.1	302	513
	50th	Medium	115.0	11.4	428	728
	95th	High	213.3	8.7	585	995
Winter	5th	Low	104.7	21.2	358	607
	50th	Medium	150.7	12.8	529	899
	95th	High	282.4	9.9	714	1,214

3.1.1.3 Results – Figures

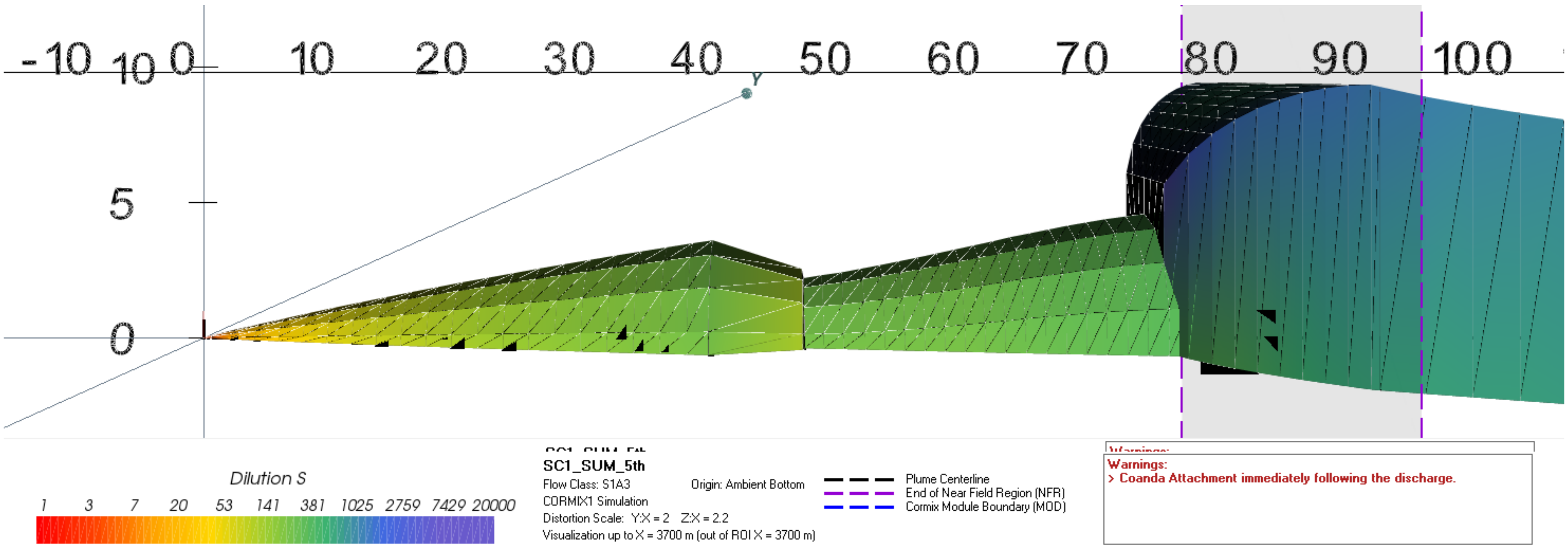


Figure 3.1 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during summer conditions under low ambient currents.

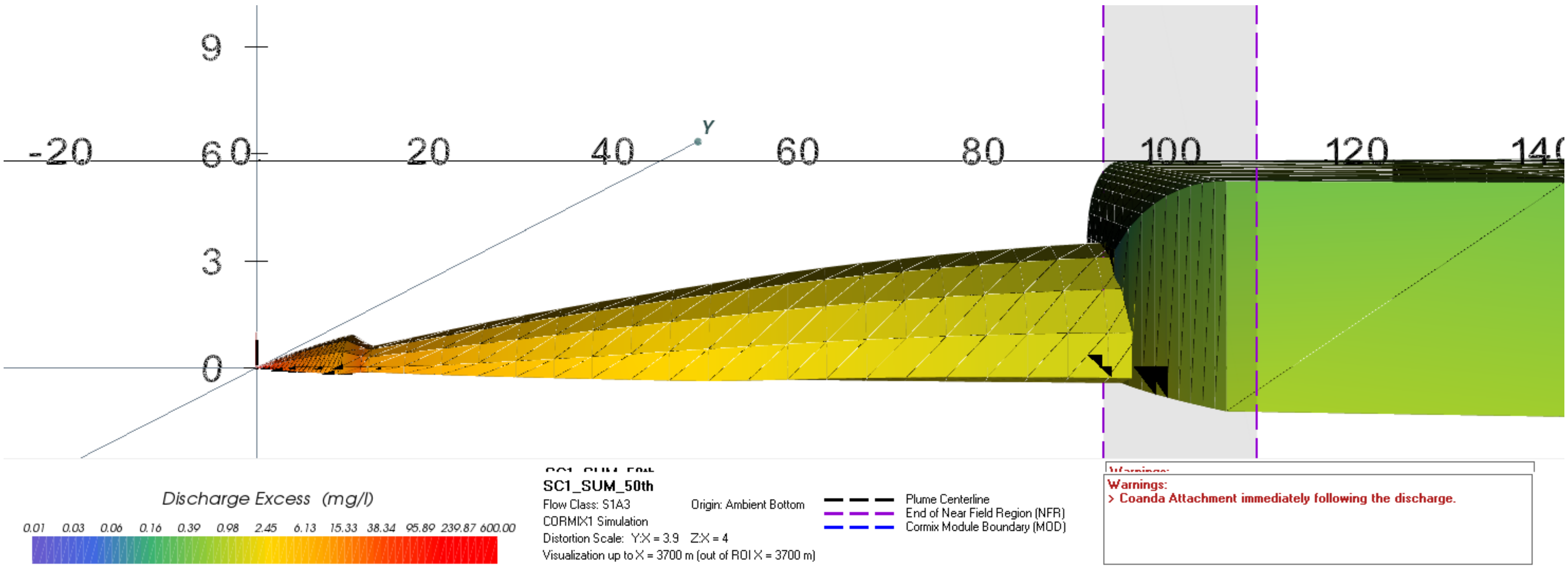


Figure 3.2 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during summer conditions under medium ambient currents.

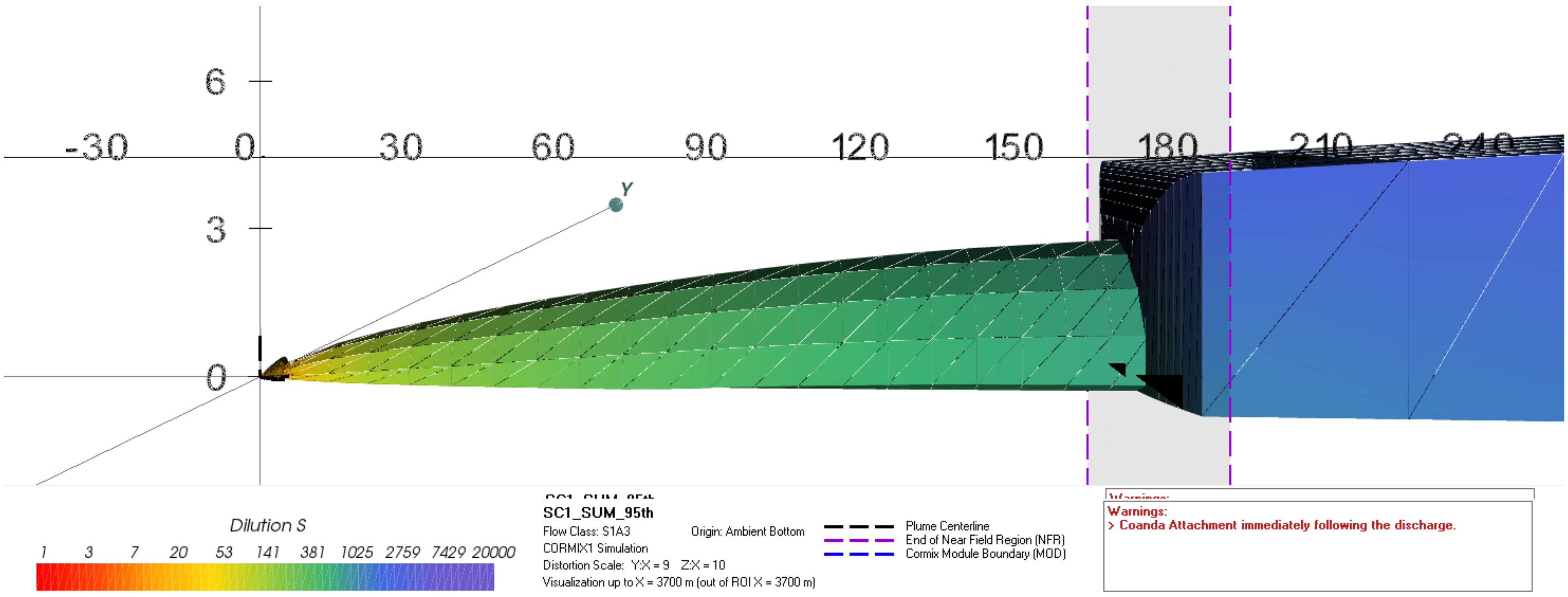


Figure 3.3 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during summer conditions under high ambient currents.

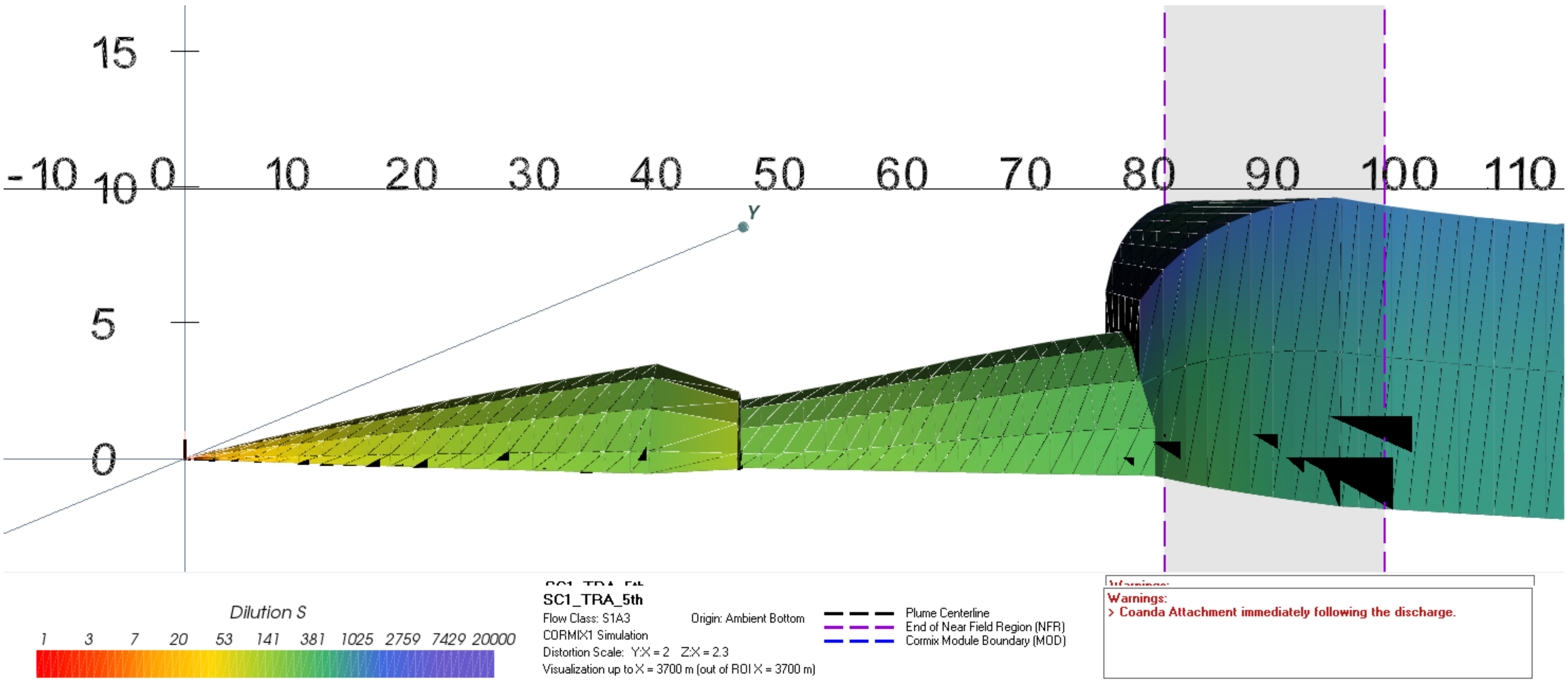


Figure 3.4 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during transitional conditions under low ambient currents.

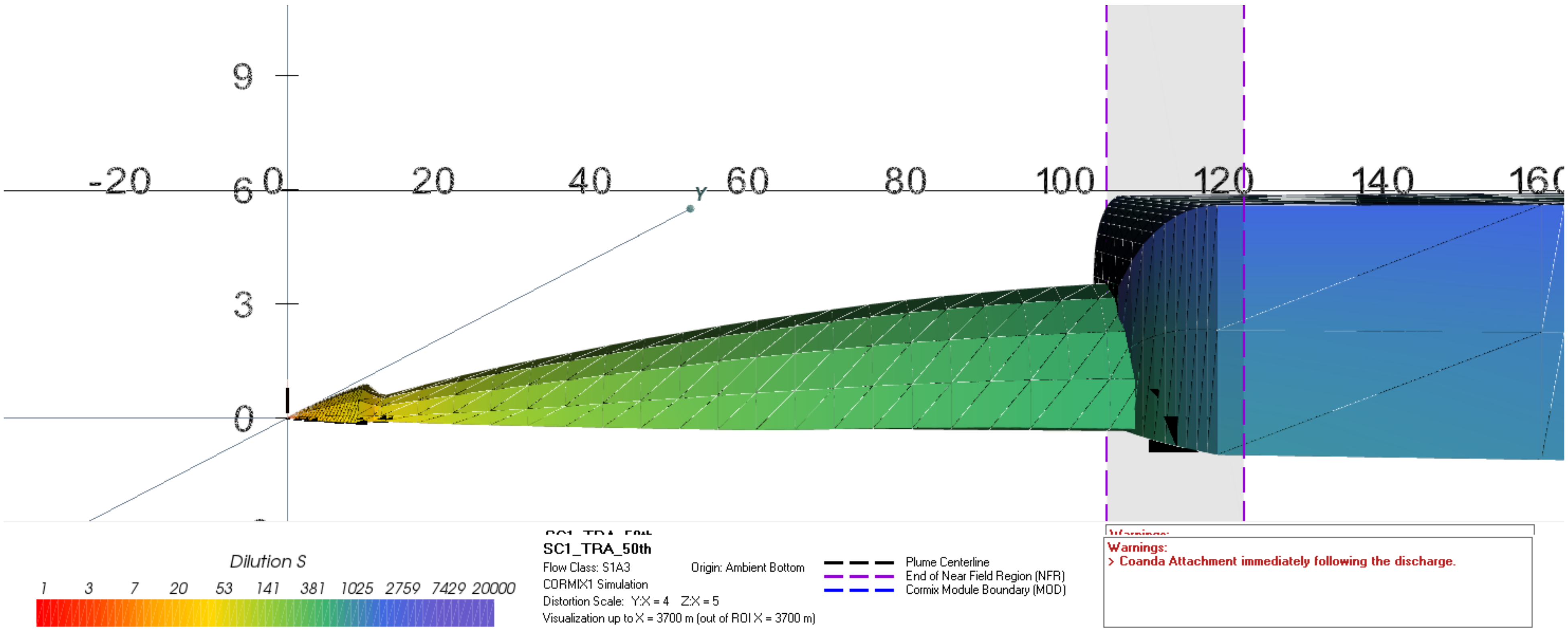


Figure 3.5 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during transitional conditions under medium ambient currents.

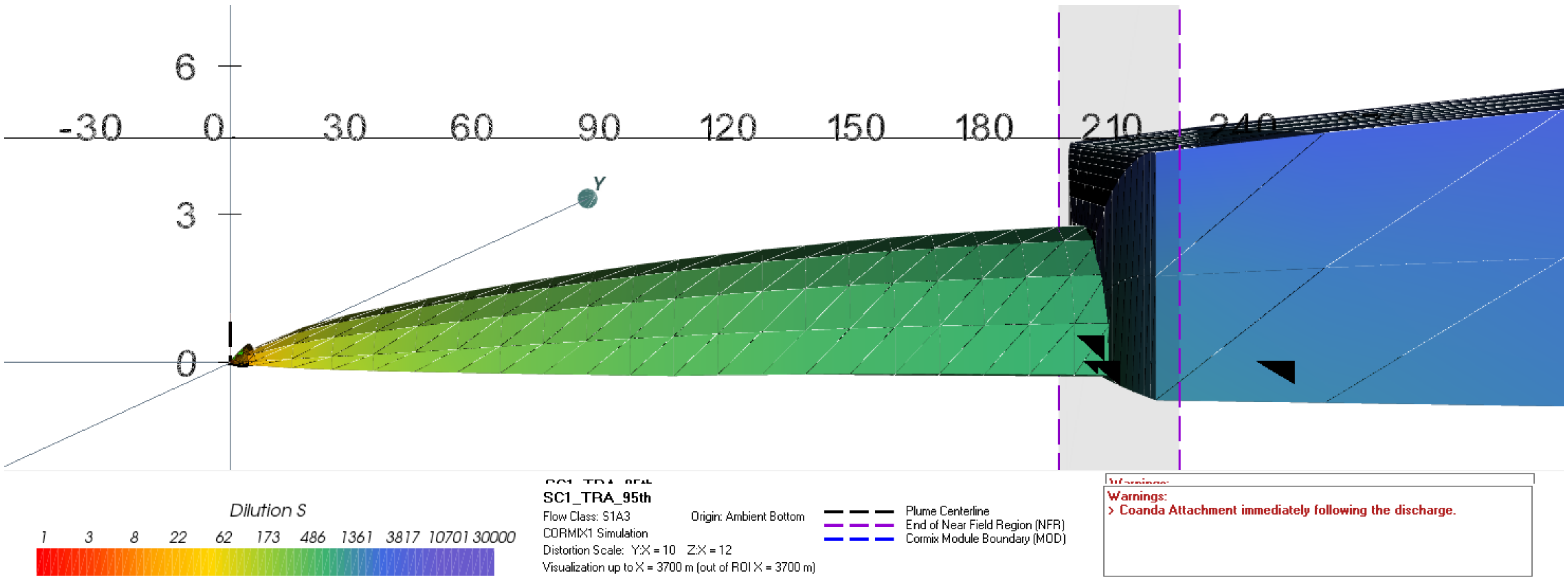


Figure 3.6 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during transitional conditions under high ambient currents.

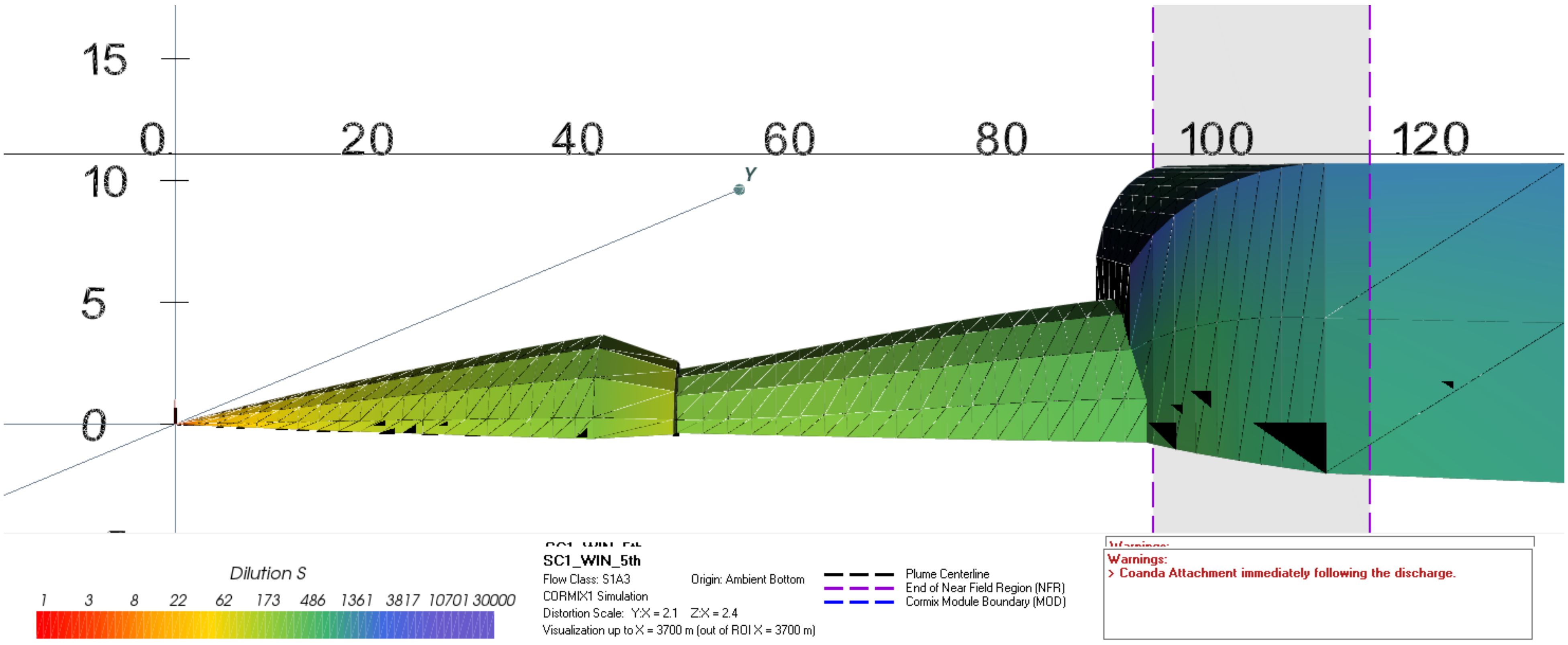


Figure 3.7 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during winter conditions under low ambient currents.

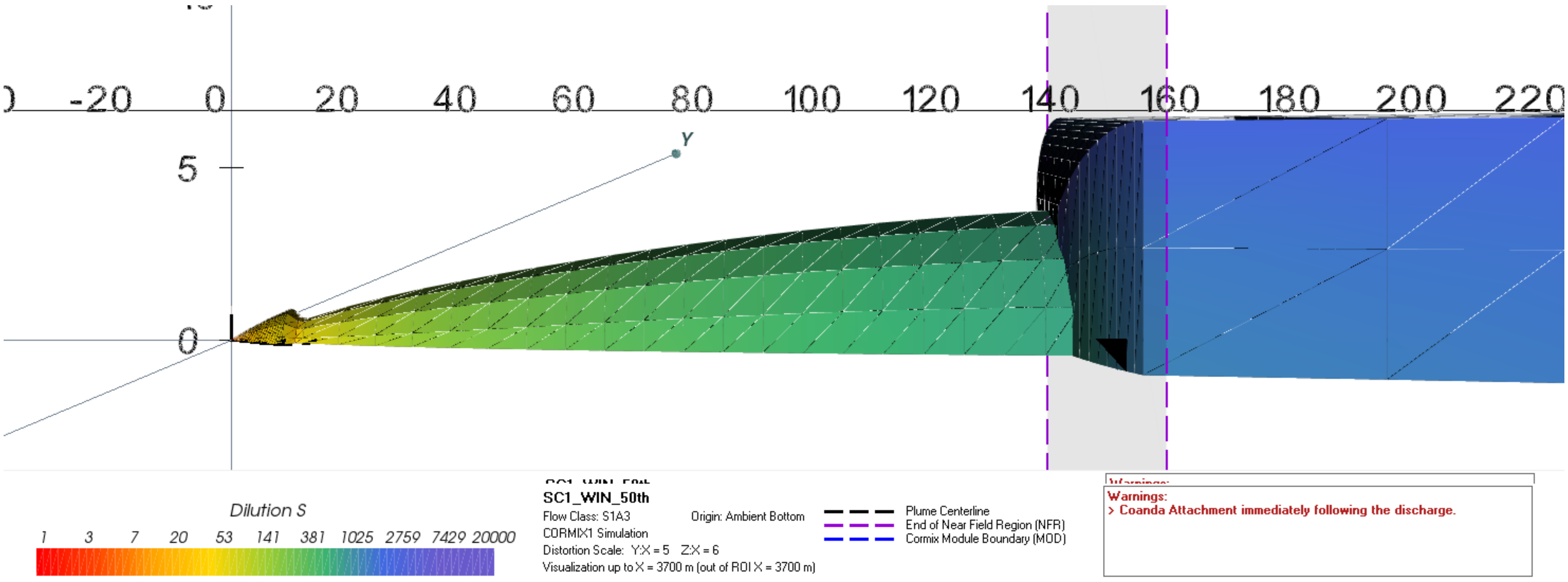


Figure 3.8 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during winter conditions under medium ambient currents.

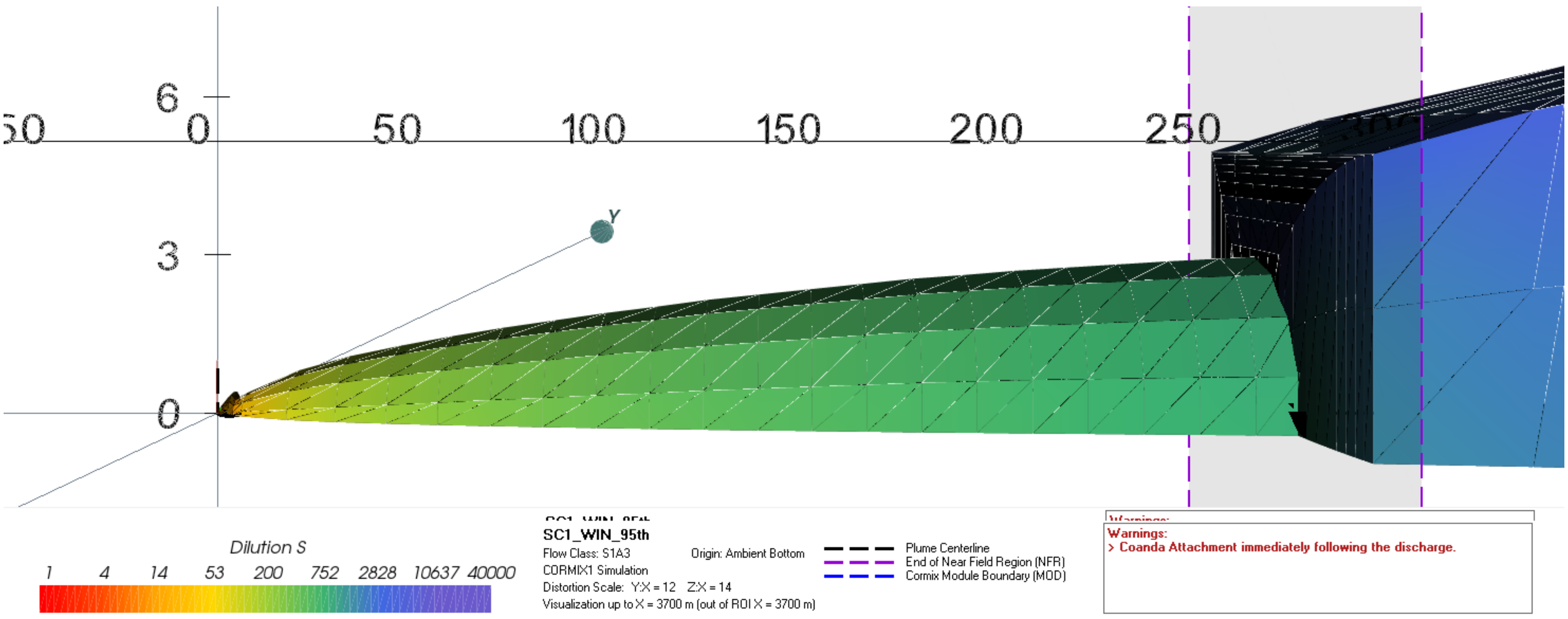


Figure 3.9 Near-field plume profile for a hydrotest discharge rate of 130 m³/hour during winter conditions under high ambient currents.

3.2 Far-Field Modelling

3.2.1 Overview

It is important to note that near-field and far-field modelling are used to describe different processes and scales of effect, and therefore the far-field modelling results will not necessarily correspond to the outcomes at the end of the near-field mixing zone for any given discharge scenario. The far-field results included episodes of pooling of the discharge plume under weak currents, which caused lower dilutions (higher concentrations) further from the discharge location when the pooled plume was advected away. Episodes of recirculation – where the plume moved back under the discharge at some later time due to the oscillatory nature of the tide – were also observed, compounding the pooling effect, and further lowering the dilution values.

3.2.2 Interpretation of Percentile Dilution contours

For each of the modelled discharge cases, the results for all simulations were combined and a statistical analysis performed to produce percentile contours of dilution. In the following sections, outcomes based on 95th and 99th percentile dilution contours are presented.

Calculation of 95th and 99th percentile statistics is a common approach to assessing the impact of dispersing plumes and captures the variability in outcomes, for all but the most ephemeral and extreme forcing conditions, in the data set under consideration. Impact assessment criteria for water quality are often defined using similar statistical indicators.

Note that the percentile figures do not represent the location of a plume at any point in time; they are a statistical and spatial summary of the percentage of time that dilution values occur across all replicate simulations and time steps. For example, if the 95th percentile minimum dilution at a particular location in the model domain is predicted as a value of 100, this means that for 95% of the time the dilution level will be higher than 100 and for only 5% of the time the dilution level will be lower than 100.

Dilution contours are calculated from the ratios of dispersing constituent concentrations in the receiving waters to the initial concentration of the constituent in the discharge. Note that this assumes the background concentration of the constituent in the receiving waters is zero and there is no significant biodegradation of the discharged constituent over the short duration of the dispersion process.

Table 3.2 summarises the initial concentrations of biocide, as specified, and the equivalent dispersed concentrations required to yield specific dilution levels (1:100, 1:200, 1:300 and 1:10,000). These concentrations may be useful to consider when interpreting the contour plots of percentile dilutions.

Table 3.2 Initial concentrations of biocide and equivalent concentrations at example dilution levels.

Biocide parameter	Biocide concentration (ppm)
Initial concentration in discharge	600
Initial concentration in receiving waters	0
Concentration at 1:100 dilution	6
Concentration at 1:200 dilution	3
Concentration at 1:300 dilution	2
Concentration at 1:10,000 dilution	0.06

3.2.3 Seasonal Analysis

3.2.3.1 Summary

The model outputs over the ten-year hindcast period (2006-2015) were combined and analysed on a seasonal basis (summer, transitional and winter). This approach assists with identifying the potential exposure to surrounding sensitive receptors whilst considering inter-annual variability in ocean current conditions.

Table 3.3 summarises the average and minimum dilution achieved at specific radial distances from the discharge location for each season and percentile.

Table 3.4 summarises the maximum distance for the discharge to achieve 1:10,000 dilution for each season and percentile. At the 95th percentile the field of effect of the plume with less than 10,000 dilutions relative to the source is predicted to extend up to 491 m during winter (Table 3.4), with predominant plume travel being west-northwest to east-southeast throughout the year (Figure 3.10 to Figure 3.15). At the higher percentile (99th) the maximum distance increases to 3,023 m during the transitional period. These calculations assume that no processes other than dilution would reduce the source concentration of biocide over time.

Table 3.5 provides a summary of the total area of coverage for the 1:10,000 dilution contour for each percentile. An area of exposure defined by the relevant dilution contour is predicted to reach a maximum of 0.03-0.07 km^2 and 2.51-2.74 km^2 at the 95th percentile and 99th percentile, respectively (Table 3.5).

3.2.3.2 Scenario 1: Discharge of 2,000 m^3 of Hydrotest Water

Table 3.3 Average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location in each season for Scenario 1.

Distance (m)	Summer				Transitional				Winter			
	95th percentile		99th percentile		95th percentile		99th percentile		95th percentile		99th percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
20	9,552	57	269	49	11,387	57	314	50	5,087	57	261	49
40	12,227	38	330	34	13,066	39	394	34	7,359	38	336	34
60	19,210	4,298	432	313	19,761	3,958	514	369	14,925	1,466	439	315
80	29,486	3,452	550	357	38,220	3,488	686	375	25,613	1,071	628	344
100	35,240	2,885	704	425	51,816	2,705	939	412	34,126	877	896	378
200	85,369	5,093	2,177	752	72,234	6,135	3,071	664	73,916	2,467	3,097	715
300	106,778	13,100	4,171	995	82,889	9,375	5,863	1,002	89,795	3,300	5,912	974
400	114,090	20,134	6,133	1,190	81,378	10,381	8,213	1,138	105,491	6,397	7,687	1,203
500	119,929	30,000	8,139	1,515	87,940	15,873	10,571	1,471	108,532	9,375	9,624	1,451
600	125,617	37,500	9,937	1,750	97,017	20,134	13,035	1,606	118,432	13,636	11,568	1,792
700	131,621	50,000	11,608	2,101	93,332	30,000	14,744	1,974	126,010	16,667	12,926	2,064
800	139,278	75,000	13,484	2,308	97,747	30,000	16,101	2,239	119,984	21,429	14,778	2,355
900	143,375	75,000	14,755	2,758	109,169	37,500	18,260	2,500	114,795	25,000	16,684	2,830
1,000	156,240	75,000	16,396	3,081	115,974	37,500	21,127	2,885	124,772	30,000	19,058	3,019
1,100	160,256	150,000	17,629	3,356	125,987	50,000	24,171	3,213	122,139	37,500	21,191	3,283
1,200	158,851	150,000	17,923	3,750	137,697	50,000	25,254	3,659	114,994	37,500	23,807	3,686
1,300	157,051	150,000	19,163	4,286	144,237	50,000	25,815	3,750	116,870	50,000	26,962	4,324
1,400	157,432	150,000	20,932	4,688	136,948	75,000	26,320	3,908	121,667	50,000	29,125	4,324
1,500	154,104	150,000	22,897	5,000	146,131	75,000	26,796	4,839	115,778	50,000	32,610	4,839
1,600	157,576	150,000	25,115	5,172	153,289	75,000	27,224	5,357	118,893	50,000	36,198	5,357
1,700	164,785	150,000	26,563	5,556	148,463	75,000	28,589	5,556	129,630	50,000	37,540	5,620
1,800	151,890	150,000	28,769	6,250	148,605	75,000	32,280	5,620	129,802	75,000	39,240	6,075
1,900	157,483	150,000	31,517	6,916	148,133	75,000	35,580	6,075	129,693	75,000	42,509	6,818
2,000	160,680	150,000	35,647	7,250	151,722	75,000	39,334	6,818	129,072	75,000	44,266	7,500

Distance (m)	Summer				Transitional				Winter			
	95th percentile		99th percentile		95th percentile		99th percentile		95th percentile		99th percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
2,100	163,095	150,000	38,693	7,866	147,761	75,000	46,195	6,916	131,106	75,000	47,384	7,895
2,200	164,966	150,000	43,652	8,333	149,682	75,000	50,663	6,818	127,962	75,000	49,174	8,333
2,300	152,428	150,000	45,648	8,824	150,827	75,000	54,223	7,618	131,158	75,000	51,009	8,824
2,400	165,714	150,000	48,556	9,375	151,358	150,000	60,205	7,143	134,167	75,000	52,347	9,375
2,500	156,719	150,000	50,507	10,000	150,000	150,000	58,822	7,895	133,677	75,000	54,454	9,375
2,600	154,606	150,000	53,584	10,000	151,329	150,000	53,742	8,479	135,676	75,000	58,493	9,430
2,700	161,399	150,000	56,854	10,000	151,338	150,000	57,103	8,026	129,202	75,000	66,808	9,560
2,800	163,509	150,000	58,794	10,714	152,494	150,000	60,087	8,333	130,128	75,000	77,497	9,954
2,900	163,725	150,000	56,459	10,714	150,000	150,000	59,598	8,987	133,887	75,000	82,706	10,714
3,000	159,375	150,000	51,393	11,538	150,000	150,000	60,931	9,158	134,459	75,000	86,789	11,538
3,100	156,286	150,000	52,894	12,500	151,153	150,000	62,781	10,957	138,305	75,000	90,624	10,957
3,200	150,991	150,000	52,457	12,831	150,000	150,000	63,232	10,714	138,427	75,000	87,900	11,538
3,300	154,052	150,000	53,009	13,181	150,000	150,000	64,115	11,538	139,819	75,000	90,926	11,820
3,400	162,644	150,000	53,098	14,032	151,139	150,000	67,252	11,820	143,396	75,000	91,943	12,831
3,500	162,297	150,000	53,289	15,000	150,000	150,000	71,361	12,500	144,208	75,000	90,533	12,831
3,600	158,943	150,000	54,429	14,032	154,339	150,000	76,048	12,500	143,992	75,000	91,457	13,636
3,700	162,911	150,000	57,590	13,636	152,072	150,000	79,106	11,538	144,205	75,000	90,130	13,636
3,800	157,218	150,000	57,462	15,000	153,143	150,000	86,493	12,500	148,100	75,000	90,290	14,032
3,900	158,730	150,000	58,341	15,480	154,097	150,000	90,228	12,500	150,000	150,000	91,947	14,032
4,000	157,514	150,000	59,598	16,667	155,978	150,000	95,619	12,831	153,216	150,000	94,982	13,636

Table 3.4 Maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Scenario 1, with and without application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution	
		No median applied	Rolling 48-hour median applied
95th	Summer	225	-
	Transitional	365	-
	Winter	491	-
99th	Summer	2,584	-
	Transitional	3,023	-
	Winter	2,802	-

Table 3.5 Total area of coverage for 1:10,000 dilution in each season for Scenario 1, with and without application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution	
		No median applied	Rolling 48-hour median applied
95th	Summer	0.03	-
	Transitional	0.03	-
	Winter	0.07	-
99th	Summer	2.51	-
	Transitional	2.67	-
	Winter	2.74	-

3.2.3.2.1 Summer

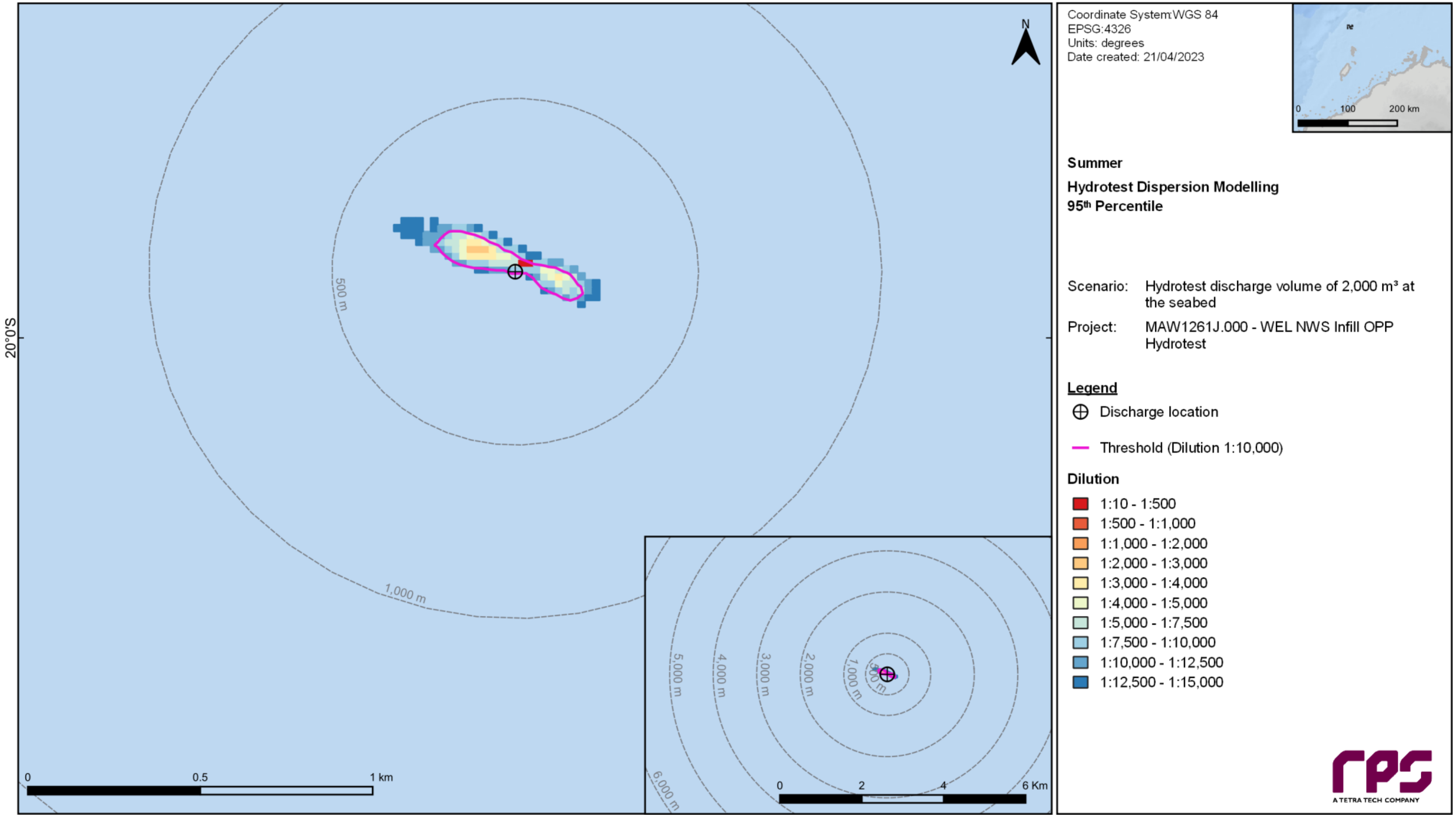


Figure 3.10 Predicted minimum dilutions at the 95th percentile under summer conditions for Scenario 1.

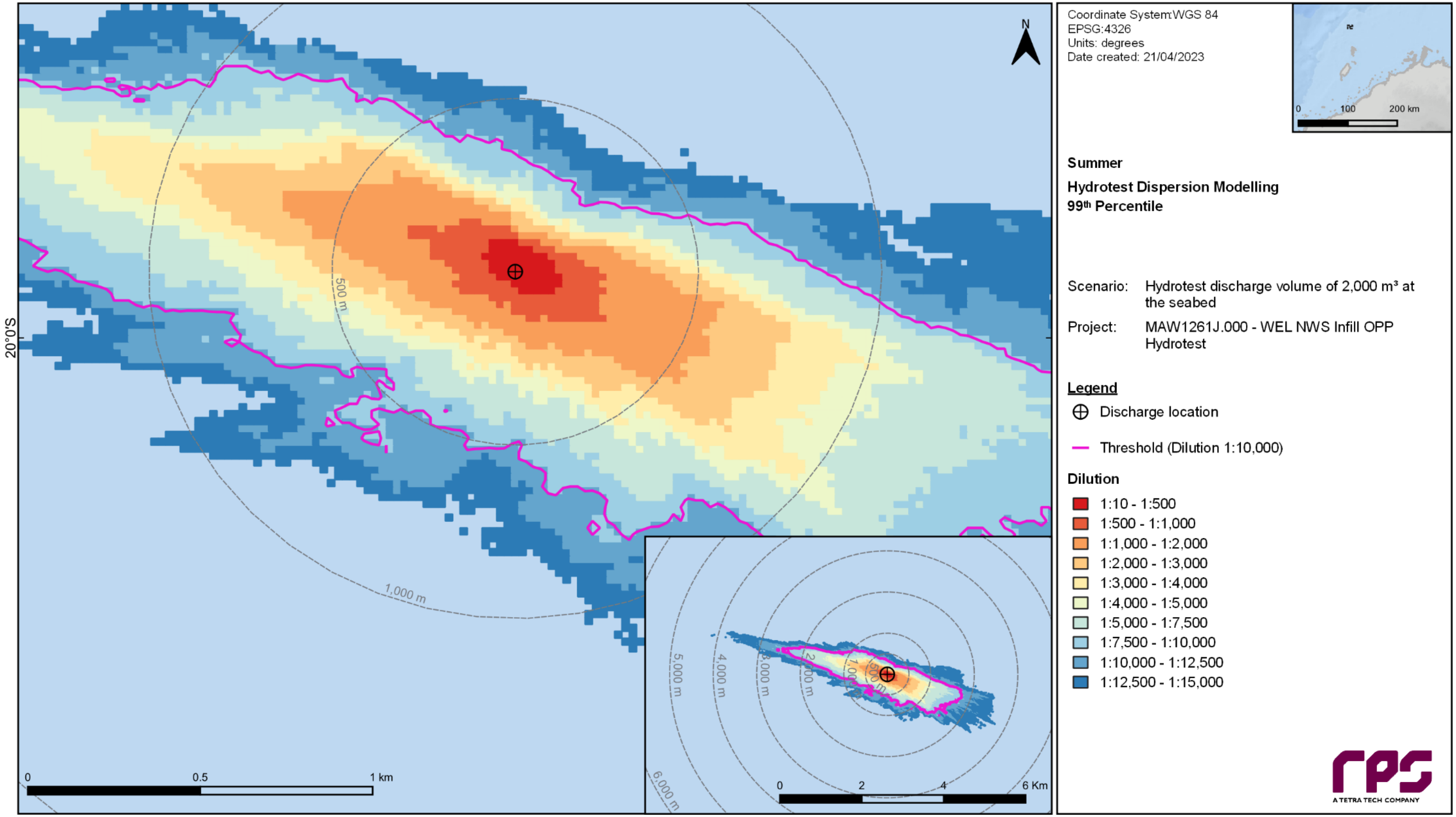


Figure 3.11 Predicted minimum dilutions at the 99th percentile under summer conditions for Scenario 1.

3.2.3.2.2 Transitional

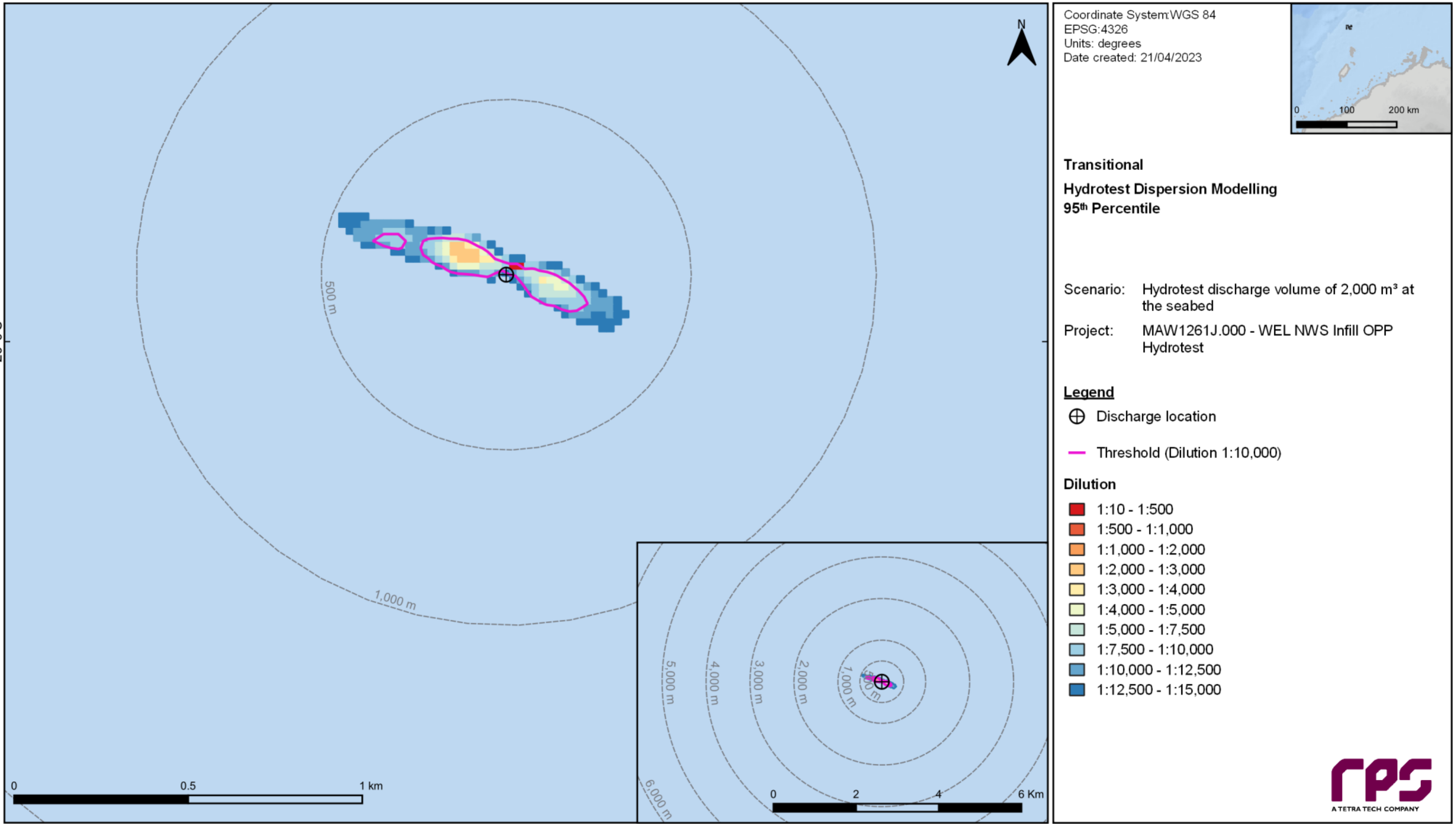


Figure 3.12 Predicted minimum dilutions at the 95th percentile under transitional conditions for Scenario 1.

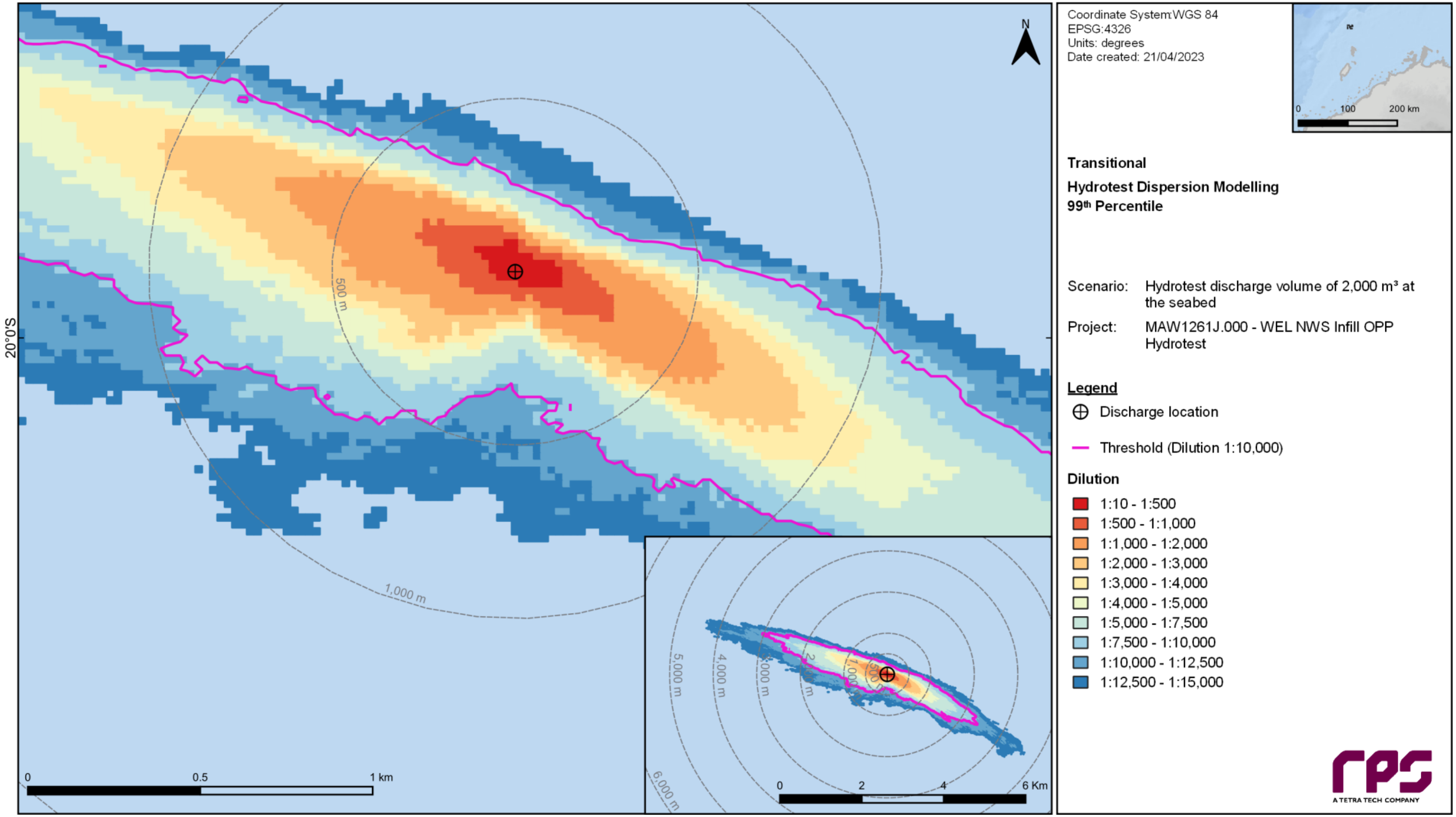


Figure 3.13 Predicted minimum dilutions at the 99th percentile under transitional conditions for Scenario 1.

3.2.3.2.3 Winter

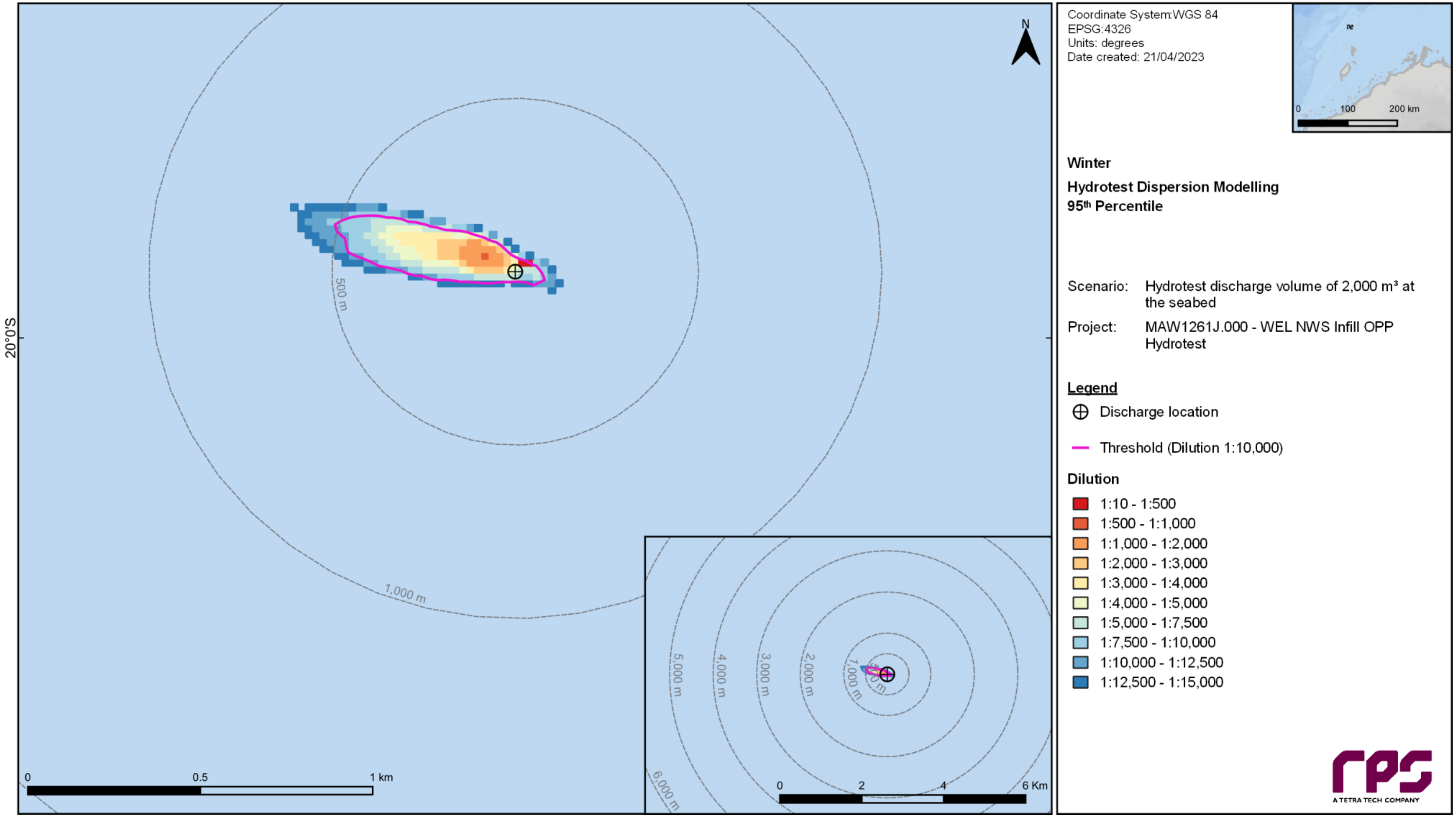


Figure 3.14 Predicted minimum dilutions at the 95th percentile under winter conditions for Scenario 1.

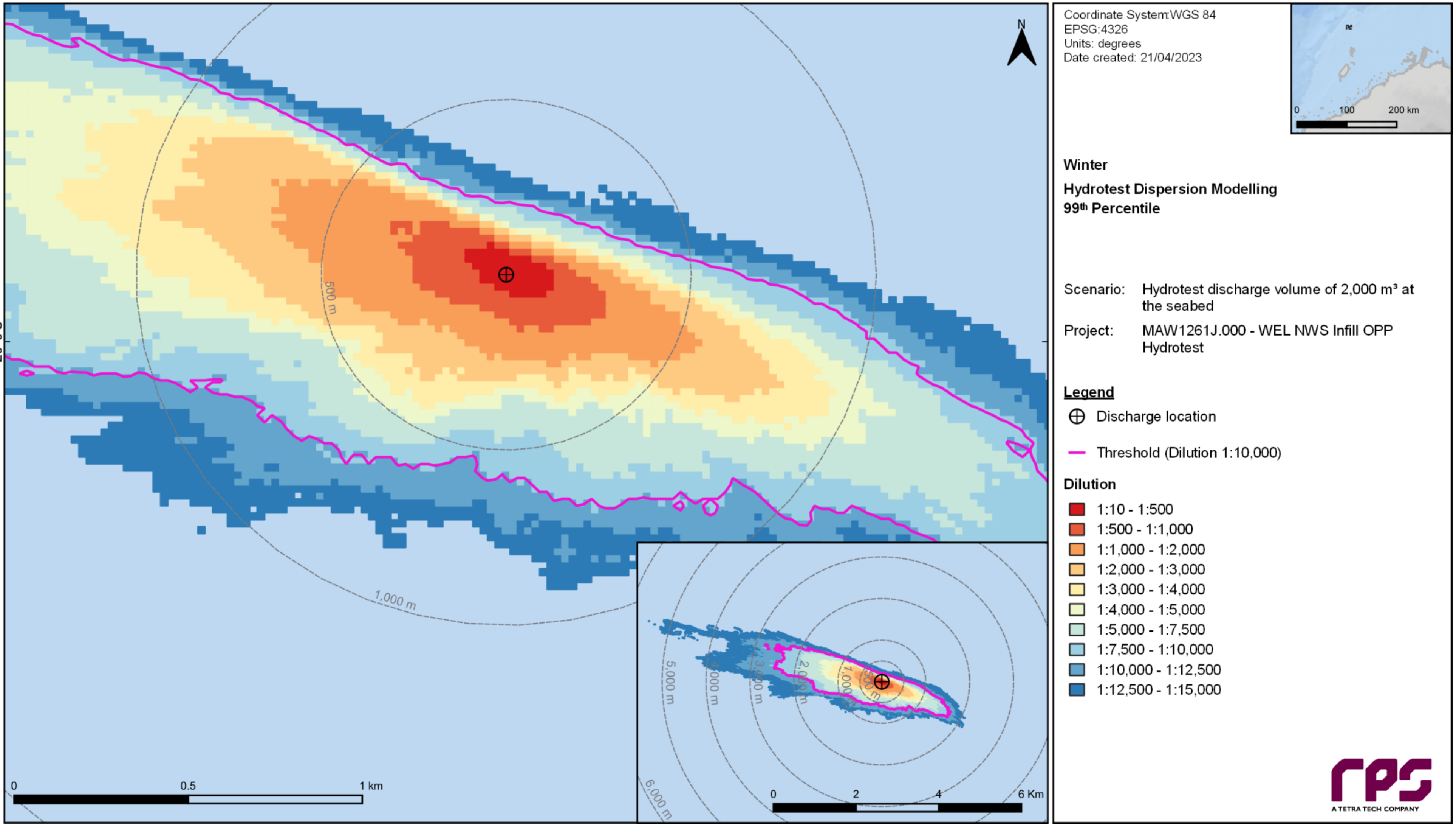


Figure 3.15 Predicted minimum dilutions at the 99th percentile under winter conditions for Scenario 1.

3.2.4 Annualised Analysis

3.2.4.1 Summary

Figure 3.16 and Figure 3.17 shows the 95th percentile and 99th percentile dilutions, respectively, for the annualised outcomes. The overall plume footprint was observed to predominantly drift in a west-northwest and/or east-southeast throughout direction throughout the year.

At the 95th percentile and 99th percentile the field of effect of the plume with less than 10,000 dilutions relative to the source is predicted to extend up to 491 m and 3,023 m throughout the year (Table 3.7). An area of coverage of 0.08 km^2 and 3.57 km^2 is predicted for the dilutions out to a maximum of 1:10,000 at the 95th percentile and 99th percentile, respectively (Table 3.8).

Table 3.6 shows the 95th percentile and 99th percentile dilution achieved at specified radial distances form the discharge location (20 m, 40 m, 60 m, 80 m, 100 m, and then every 100 m out to 4,000 m).

3.2.4.2 Scenario 1: Discharge of 2,000 m^3 of hydrotest water

Table 3.6 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location for Scenario 1.

Distance (m)	Annualised			
	95th percentile		99th percentile	
	Average	Minimum	Average	Minimum
20	5,087	57	255	49
40	7,264	38	320	34
60	12,128	1,466	409	313
80	20,322	1,071	521	344
100	27,948	877	659	378
200	66,364	2,467	2,014	664
300	82,631	3,300	3,780	974
400	96,886	6,397	5,461	1,138
500	103,317	9,375	7,286	1,451
600	109,070	13,636	9,279	1,606
700	115,641	16,667	10,984	1,974
800	124,432	21,429	12,713	2,239
900	125,931	25,000	13,738	2,500
1,000	130,756	30,000	14,942	2,885
1,100	129,472	37,500	16,139	3,213
1,200	133,143	37,500	16,504	3,659
1,300	138,267	50,000	17,520	3,750
1,400	139,149	50,000	18,893	3,908
1,500	141,959	50,000	20,610	4,839
1,600	143,677	50,000	22,210	5,172
1,700	146,116	50,000	22,892	5,556
1,800	142,482	75,000	24,792	5,620
1,900	143,966	75,000	27,153	6,075
2,000	145,363	75,000	29,126	6,818
2,100	148,143	75,000	31,318	6,916
2,200	145,919	75,000	33,570	6,818
2,300	144,081	75,000	34,928	7,618
2,400	150,223	75,000	35,849	7,143
2,500	145,527	75,000	37,214	7,895
2,600	145,011	75,000	38,540	8,479
2,700	144,660	75,000	40,318	8,026
2,800	146,326	75,000	43,864	8,333
2,900	144,298	75,000	46,222	8,987
3,000	146,003	75,000	50,219	9,158
3,100	146,155	75,000	54,029	10,957
3,200	145,178	75,000	57,312	10,714
3,300	146,881	75,000	62,070	11,538
3,400	151,234	75,000	63,635	11,820
3,500	150,372	75,000	63,644	12,500
3,600	151,625	75,000	64,256	12,500

Distance (m)	Annualised			
	95th percentile		99th percentile	
	Average	Minimum	Average	Minimum
3,700	148,861	75,000	65,451	11,538
3,800	150,631	75,000	67,494	12,500
3,900	151,503	150,000	67,695	12,500
4,000	152,331	150,000	69,142	12,831

Table 3.7 Annualised maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution for Scenario 1, with and without application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution	
		No median applied	Rolling 48-hour median applied
95th	Annual	491	-
99th		3,023	-

Table 3.8 Annualised total area of coverage for 1:10,000 dilution for Scenario 1, with and without application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution	
		No median applied	Rolling 48-hour median applied
95th	Annual	0.08	-
99th		3.57	-

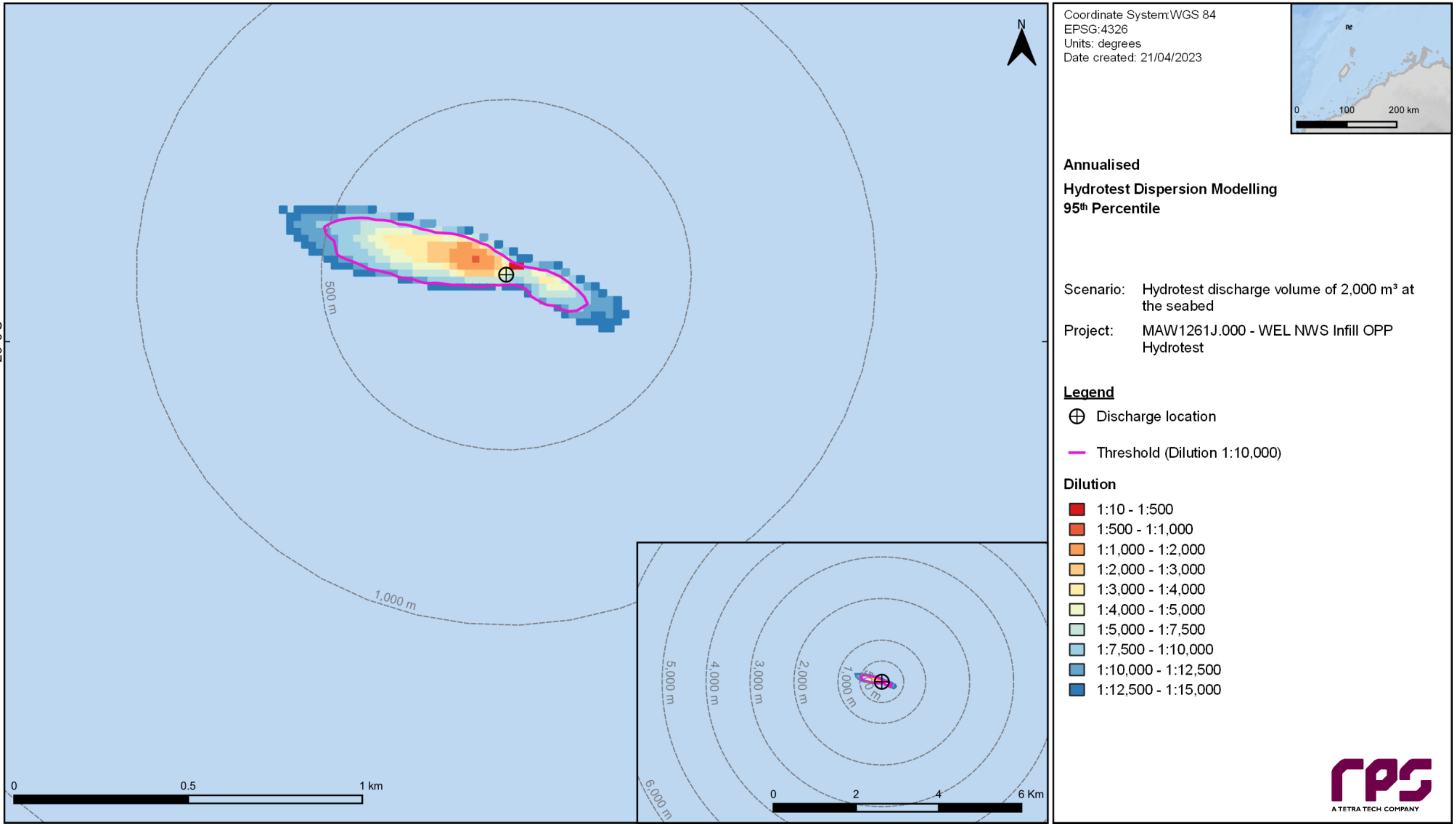


Figure 3.16 Predicted annualised minimum dilutions at the 95th percentile for Scenario 1.

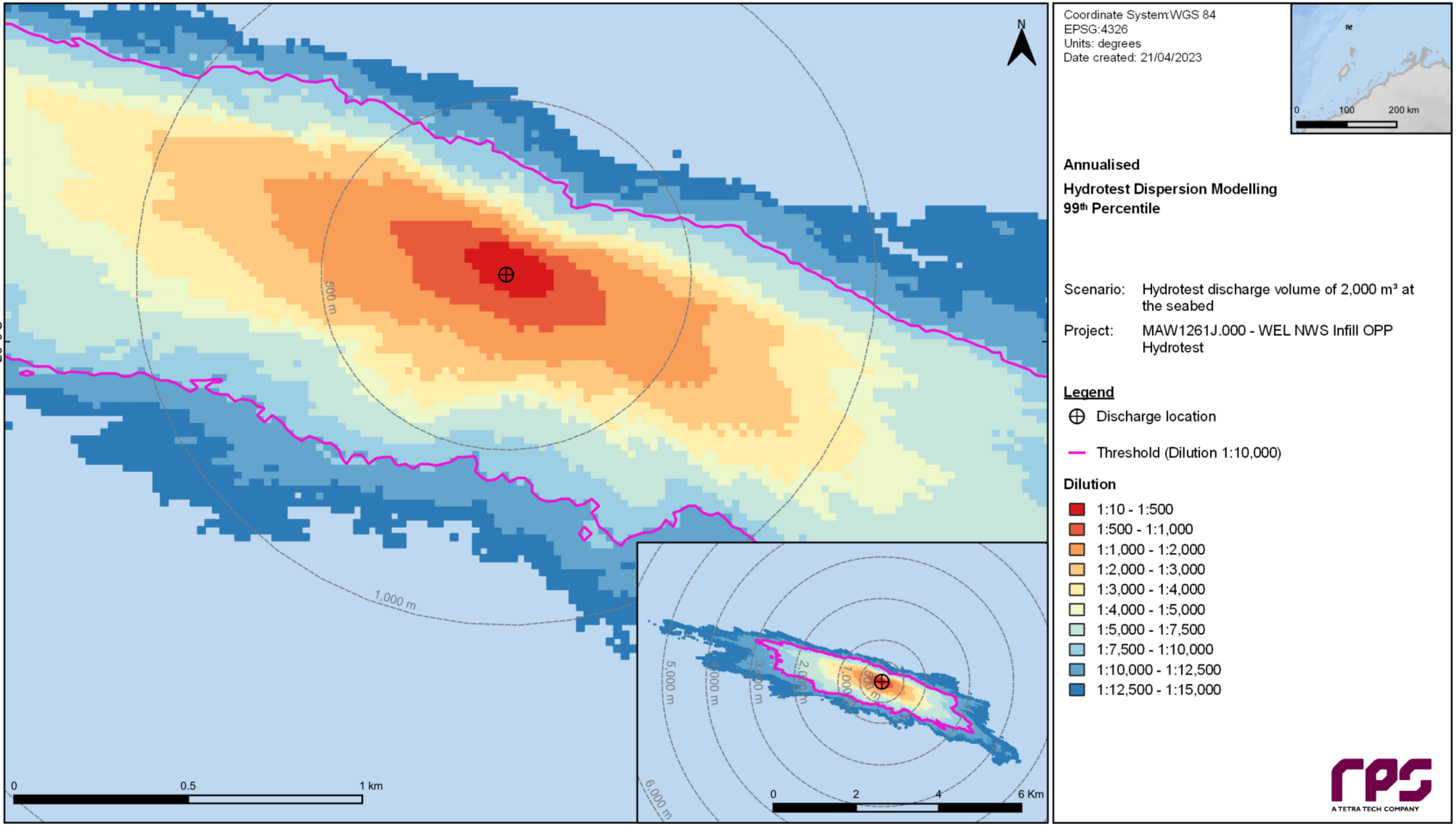


Figure 3.17 Predicted annualised minimum dilutions at the 99th percentile for Scenario 1.

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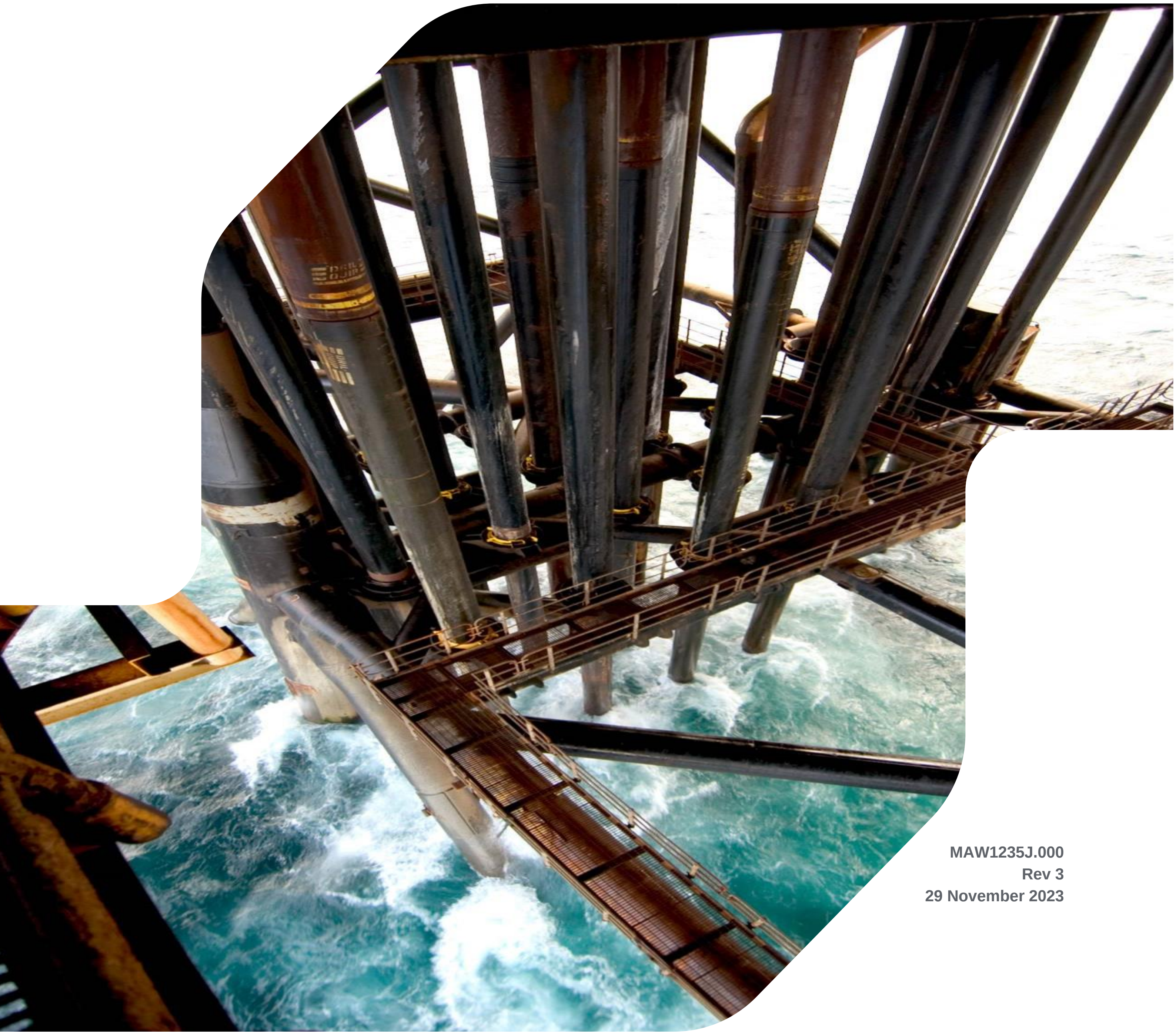
APPENDIX H MARINE DISPERSION MODELLING FOR DRILLING DISCHARGES

WOODSIDE NWS INFILL OPP: MARINE DISPERSION MODELLING FOR DRILLING DISCHARGES

Report



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Contents

Tables

Figures

EXECUTIVE SUMMARY

Background

RPS was commissioned by Woodside to undertake a detailed sediment dispersion modelling study that considered discharges of drill cuttings and drilling fluids to the marine environment during drilling of the Wilcox well for the Goodwyn Area (GWA) Infill Development.

The GWA Infill Development proposed by Woodside Energy Ltd (Woodside), will comprise of multiple development opportunities designed to fill ullage at the GWA Platform as the producing NWS fields decline. The opportunity is currently at an early stage of project engineering and consists of a subsea tie-backs to the GWA Platform. Well fluids will undergo processing at the GWA platform before being exported to the Karratha Gas Plant for final processing prior to export to domestic and international markets.

The GWA Infill Development will also include a multi-well tie-back from the Wilcox prosect, via a 25 km long pipeline to the Lady-Nora Pemberton pipe-line end termination (PLET) facility. The Wilcox prospect is located within the boundary of the Montebello Marine Park Multiple Use Zone however will be drilled outside the marine park.

The principal aims of the study were: to calculate the fate of discharged drill cuttings and unrecoverable drilling fluids; to quantify the likely area of coverage and levels of suspended sediments and bottom deposition (thickness and accumulated load); and to assess the risk exposure from drill cuttings and drilling fluids to any sensitive receptors within the Wilcox prospect.

To accurately determine the sediment discharge fate, the near-field discharge characteristics were assessed first, with the outcomes used to determine the starting state of simulations for the far-field assessment. Sensitivity testing was applied to the near-field modelling to calculate the influence of details such as discharge rate, discharge depth and relative density of the bulk discharge. The far-field modelling accounted for variation of the initial discharge, dilution, and depth distribution over time as the discharge rate and discharge management practices were varied.

Study Objectives

The main objectives of the study were to:

- Quantify the movement and fate of discharged drill cuttings and unrecoverable drilling fluids that would result from drilling activities in terms of extents of coverage and seabed deposition (thickness and concentration).
- Investigate the risk to submerged sensitive receptors posed by the discharges.

Summary of Modelling Results

Near-Field

Continuous Discharge

- Drill cuttings discharged during the 17.5” production casing section drilling operation will consist of relatively large particles (91.02%, ranging from 0.5-4 mm) that will have high fall velocities (7.3-25.4 cm/s).
- Drilling fluids will primarily be very fine silts and clay particles (65.7%, >3.9 µm) that will have extremely small fall velocities by comparison (<0.003 cm/s) and will be more subject to turbulent dispersion in the water column if they suspend from attachment to particles.
- Near-field simulation of continuous discharge of drill cuttings and drilling fluids indicated that the initial geometry and dilution of the discharge plume would be greatly affected by the prevailing current because the discharge rate (0.019 m/s) would be lower than the ambient velocity, which would result in

wake-flow conditions that are characterised by unsteady (patchy) plumes with high instantaneous concentrations at the point source.

- The near-field model calculated that there would be no discharge momentum to induce mixing.
- The plume would remain negatively buoyant relative to the receiving water (i.e., denser than the receiving water) and would sink subject to deflection by the prevailing current.
- The rate of deflection would decrease, and the plume would sink faster under slower current. Stronger current would deflect the sinking plume further from the source.
- The sinking plume would increase in diameter through entrainment of ambient water until either the plume achieves neutral buoyancy or sinks to the seabed.
- Under all current conditions the plume was arrested when the seafloor layer boundary was reached, and buoyancy reversal occurred in the bottom density current.
- The maximum horizontal distance before buoyancy reversal occurred was calculated to increase as a function of current speed. The maximum distance is calculated to increasing by an order of magnitude over speeds ranging from the 5^{th} to 95^{th} percentile.
- Dilutions under annualised conditions ranged from 7,176 to 86,679 dilutions, increasing with current speed (and hence also distance).

Dilute-and-Dump Discharge

- Near-field modelling of dilute-and-dump operations indicates that the discharge would have sufficient momentum to induce a velocity plume intruding into the receiving water and that the geometry and initial dilution of the plume would vary with the prevailing current speed.
- The plume movement would be dominated by momentum of the discharge jet that will be deflected by the ambient currents. The turbulence generated by the momentum of the jet would begin entraining ambient water, within metres of the source and within seconds to minutes of discharge.
- Once downward momentum is lost, the fate of the plume will depend upon the relative buoyancy as the dominating factor. The plume would remain negatively buoyant relative to the receiving water (i.e., denser than the receiving water) and would sink subject to deflection by the prevailing current.
- Under all current conditions the plume was arrested when the seafloor layer boundary was reached, and buoyancy reversal occurred in the bottom density current.
- The maximum horizontal distance before buoyancy reversal occurred was calculated to increase as a function of current speed. The maximum distance is calculated to increasing by an order of magnitude over speeds ranging from the 5^{th} to 95^{th} percentile.
- Dilutions under annualised conditions ranged from 4,828 to 60,381 dilutions, increasing with current speed (and hence also distance).

Pit Dump Discharge

- Near-field modelling of pit dump operations indicates that the discharge would have sufficient momentum to induce a velocity plume intruding into the receiving water and that the geometry and initial dilution of the plume would vary with the prevailing current speed.
- The plume movement would be dominated by momentum of the discharge jet that will be deflected by the ambient currents. The turbulence generated by the momentum of the jet would begin entraining ambient water, within metres of the source and within seconds to minutes of discharge.
- Once downward momentum is lost, the fate of the plume will depend upon the relative buoyancy as the dominating factor. The near-field model calculated that the plume would remain negatively buoyant relative to the receiving water (i.e., denser than the receiving water) and would sink subject to deflection by the prevailing current.
- Under all current conditions the plume was arrested when the seafloor layer boundary was reached, and buoyance reversal occurred in the bottom density current.

- The maximum horizontal distance before buoyance reversal occurred was calculated to increase as a function of current speed. The maximum distance is calculated to increasing by an order of magnitude over speeds ranging from the 5th to 95th percentile.
- Dilutions under annualised conditions ranged from 1,024 to 11,442 dilutions, increasing with current speed (and hence also distance).

Far-Field

Stochastic Analysis

- Local sedimentation will occur as a mound around the well site, with the major contribution by larger sediments (fine sand and larger) released by continuous discharges, while finer, slower sinking particles that represent a proportion of the sediment release by continuous discharge would disperse more widely with the prevailing current.
- The finer particles that make up the larger proportion of the dilute-and-dump and pit dump operations would also disperse widely with the prevailing current. Prevailing currents will be due to a combination of tidal and ocean drift currents.
- While the tidal currents are highly predictable and will follow an ellipse, with the main axis orientated west-north-west to east-south-east with reversal of the tide at approximately 6-hour intervals, the drift currents will be more variable and can persist over longer time scales.
- The thickness of the deposits generated by settling of these particles is calculated to decrease exponentially with distance from the drilling centre, with the maximum thickness calculated around the drilling centre. Relatively thin deposits were calculated for the deposition footprint.
- Most of the sediment released by continuous discharges will settle out over an elliptical area with a long axis aligned with the tidal currents.
- The potential for thin (0.1 mm) deposits of sediment to settle out at distances > 1,000 m is very low in all seasons at either the 95th or 99th percentile.
- Calculations for the distribution of suspended sediments released during drilling operations indicate that concentrations exceeding 10 mg/L might extend ~100-150 m from the source up to 5% of the time and ~2,000 m from the source up to 1% of the time.
- Concentrations exceeding 1 mg/L were calculated to extend ~10,000-12,000 m from the source up to 1% of the time.

1 INTRODUCTION

1.1 Background

The Goodwyn Area (GWA) Infill Development proposed by Woodside Energy Ltd (Woodside), will comprise of multiple development opportunities designed to fill ullage at the GWA Platform as the producing NWS fields decline. The opportunity is currently at an early stage of project engineering and consists of a subsea tie-backs to the GWA Platform. Well fluids will undergo processing at the GWA platform before being exported to the Karratha Gas Plant for final processing prior to export to domestic and international markets.

The GWA Infill Development will also include a multi-well tie-back from the Wilcox prosect, via a 25 km long pipeline to the Lady-Nora Pemberton pipe-line end termination (PLET) facility. The Wilcox prospect is located within the boundary of the Montebello Marine Park Multiple Use Zone however will be drilled outside the marine park.

To support the preparation of environmental approvals documentation, RPS was commissioned by Woodside to undertake a detailed sediment dispersion modelling study that considered discharges of drill cuttings and drilling fluids to the marine environment during drilling of a well (Wilcox) within permit WA-7R (near the Montebello Marine Park).

The principal aims of the study were: to calculate the fate of discharged drill cuttings and unrecoverable drilling fluids; to quantify the likely area of coverage and levels of suspended sediments and bottom deposition (thickness and accumulated load); and to assess the risk exposure from drill cuttings and drilling fluids to any sensitive receptors within the Wilcox prospect.

The regional context of the discharge location for the assessed scenario is shown in Figure 1.1. The details of the scenario assessed in this study are summarised in Table 1.1.

Table 1.1 Location of the Wilcox well used as the release site for the drill cuttings and drilling fluids dispersion modelling assessment.

Release site	Latitude (°S)	Longitude (°E)	Water depth (m)
Wilcox	19° 59' 53.8"	115° 29' 38.4"	70

1.2 Study Objectives

The main objectives of the study will be: (i) to quantify the movement and fate of discharged drill cuttings and unrecoverable drilling fluids that would result from drilling activities in terms of extents of coverage and seabed deposition (thickness and concentration); and (ii) to investigate the risk to submerged sensitive receptors posed by the discharges.

1.3 Scope of Work

The assessment of sediment discharge fate was undertaken as a two-step process:

1. Assessment of the fate of sediments on immediate discharge (near-field fate) due to the discharge velocity, depth and orientation of the discharge, and the bulk density of the discharge relative to the receiving water. The momentum and buoyancy of the discharge dominate the hydrodynamics over this space and time scale.
2. Assessment for subsequent transport, sinking and dispersion of sediment particles under the influence of water currents, dispersive forces, and the density profile of the water column. The characteristics of the sediment particles, including their density and size distribution, and background oceanographic processes are most important over this space and time scale.

The near-field discharge characteristics were assessed first, with the outcomes used to determine the starting state of simulations for the far-field assessment. Sensitivity testing was applied to the near-field modelling to calculate the influence of details such as discharge rate, discharge depth and relative density of the bulk discharge. The far-field modelling accounted for variation of the initial discharge, dilution, and depth distribution over time as the discharge rate and discharge management practices were varied.

The scope of the modelling was completed via the following sequence of tasks:

1. Collation of suitable water current, temperature and salinity conditions expected at the nominated location for use as forcing data in the near-field dilution model.
2. Derivation of statistical distributions for current speed and direction for use in the near-field modelling to represent the range of current speeds that would be possible during discharge.
3. Establishment of a near-field discharge model for the outlined scenario, running sensitivity and production cases to estimate the near-field behaviour of the plume and establish the likely dimensions, orientation, and dilution of the discharge plume in this region.
4. Establishment of a far-field model encompassing the required location and surrounding area, with forcing by water currents.
5. Stochastic modelling of the discharge under the optimum combination of control measures. This involved repeated simulation of the far-field fate of the sediment under a random sample of prevailing current conditions to account for natural variability around the discharge site.
6. Statistical analysis of the outcomes of all replicate simulations from the far-field modelling to estimate the potential concentration envelopes and the probability of individual outcomes for distributions of sediment on the seabed.
7. Technical reporting of all assumptions, inputs, methods, results, and conclusions.

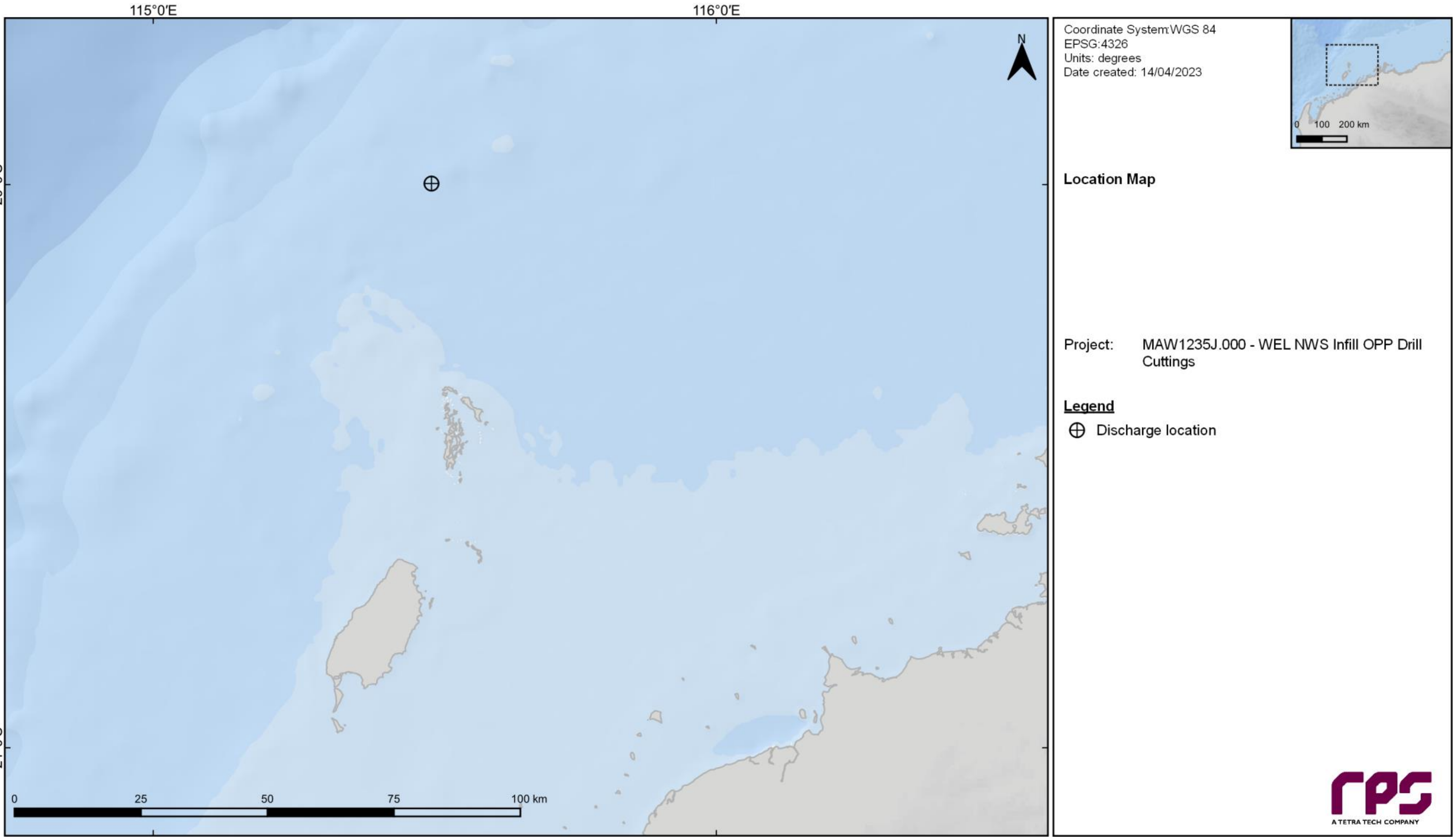


Figure 1.1 Location of the proposed Wilcox well on the North West Shelf off the northern coast of Western Australia.

2 MODELLING METHODS

2.1 Discharge Program Description and Model Operational Assumptions

2.1.1 Operation Description

During drilling, drill cuttings and drilling fluids containing sediment particles are discharged into the marine environment. Sources of these discharges can be summarised by separate activities:

- Continuous discharge of drill cuttings and retained fluids as drilling proceeds.
- Bulk discharge of water-based drilling fluids at the end of each hole section.
- Routine (approximately daily) discharge of a single mud pit (dilute-and-dump pit dumps).

The nature of these activities changes from top-hole sections to bottom-hole sections according to the strata being drilled, the fluids used for the sections, and the sizes of the holes. Variation in discharges also occurs during drilling of each section. It is assumed that batch drilling of wells does not occur and that each well section is drilled sequentially.

The top-hole sections (42” and 20”) of the Wilcox well will be drilled without a riser, which means drill cuttings and drilling fluids (WBM) will not be returned to the mobile offshore drilling unit (MODU). Top-hole sections will be drilled using a water-based drilling fluid composed of seawater and pre-hydrated bentonite that will be delivered as sweeps. The cuttings and drilling fluids will be discharged from the hole directly from seabed depth at the well site. Drill cuttings, and any drilling fluids that remain attached to the drill cuttings, will be discharged continuously during drilling of this section.

After each top-hole section is completed, the well annulus will be cemented. Once at the end of each section, some drilling fluid will be discharged continuously directly to the seabed at the well site. Once all top-hole sections are drilled and cemented, any remaining (unused) drilling fluid will be pit-dumped from the MODU.

The bottom-hole sections (17.5”, 13.5“, and 9-7/8“) of the Wilcox well will be drilled with a marine riser in place, which enables drill cuttings and drilling fluids to be circulated back to the MODU where the cuttings will be separated from the drilling fluid by the solids control equipment (SCE). The SCE uses shale shakers to remove coarse cuttings from the drilling fluid. After processing by the shale shakers, the recovered fluids are directed to centrifuges, which are used to remove fine solids (~4.5 to 6 µm). Where a non-WBM (NWBM) system is needed to drill a well section, the cuttings with NWBM drilling fluid will also pass through a cuttings dryer to achieve an oil-on-cuttings (OOC) discharge limit of ~6.5%, or less, as an average over well sections drilled with NWBM.

The cuttings (with either retained WBM fluids or NWBM fluids) will be discharged from the MODU discharge point during each of the bottom-hole sections. Cuttings with retained fluids will be discharged continuously over the drilling of the hole section. Dilute-and-dump operations to discharge diluted drilling fluids will also occur over a relatively short period of time (tens of minutes to hours, depending on the amount discharged) during drilling for each section. Unused WBM fluids will also be pit-dumped from the MODU discharge point after each of the 20”, 17.5”, 13.5“ and 9-7/8“ sections is completed. There will be no fluids discharged during cementing of the bottom-hole sections, as the riser will return all fluids to the MODU.

Dispersion modelling and analysis of the cuttings and fluids discharged during drilling was undertaken for one drill centre location, accounting for metocean conditions on a seasonal and annual basis. A summary of the volumes and durations of discharge events for this section is provided in Table 2.1. All volumes and durations were consistent with the information provided by WEL in the Scope of Work (SOW).

Table 2.1 Summary of the estimated volumes of discharged drill cuttings and unrecoverable mud solids for each well interval.

Well interval	Hole diameter (inches)	Discharge method	Cuttings volume discharged (m^3)	Drilling fluids			Discharge duration (hours)
				Type	Liquid volume discharged (bbl)	Solid volume discharged (m^3)	
42" conductors	42"	Cuttings and drilling fluids discharged directly to the seabed	64	Seawater and pre-hydrated bentonite sweeps	3,122	39.7	3.1
20" surface casing	20"	Cuttings and drilling fluids discharged directly to the seabed	44	Seawater and pre-hydrated bentonite sweeps	3,935	50.0	7.0
Pit dump (20" surface casing)	N/A	Drilling fluids discharged from drilling rig at 20 m	0	Seawater and pre-hydrated bentonite sweeps	1,000	12.7	1.4
17.5" Production Casing	17.5"	Cuttings and drilling fluids discharged from drilling rig at 20 m	302	WBM (seawater + barite and bentonite)	1,899.5	24.2	55.0
Dilute and dump (17.5" production casing)	N/A	Drilling fluids discharged from drilling rig at 20 m	0	WBM (seawater + barite and bentonite)	12,000	152.6 (15.3 per event)	12 per event (10 single events)
Pit dump (17.5" production casing	N/A	Drilling fluids discharged from drilling rig at 20 m	0	WBM (seawater + barite and bentonite)	4,000	50.9	7.2
13.5" production casing	13.5	Cuttings and drilling fluids discharged from drilling rig at 20 m	163	WBM (seawater + barite and bentonite)	1,025	13.0	67.2
Dilute and dump (13.5" production casing	N/A	Drilling fluids discharged from drilling rig at 20 m	0	WBM (seawater + barite and bentonite)	2,800	35.6 (8.9 per event)	12 per event (4 single events)
Pit dump (13.5" production casing)	N/A	Drilling fluids discharged from drilling rig at 20 m	0	WBM (seawater + barite and bentonite)	4,000	50.9	4.8
9-7/8" open hole	9-7/8"	Cuttings and drilling fluids discharged from drilling rig at 20 m	9	WBM (seawater + barite and bentonite)	56.6	0.7	59.5
Dilute and dump (9-7/8" open hole)	N/A	Drilling fluids discharged from drilling rig at 20 m	0	WBM (seawater + barite and bentonite)	60	0.8	12
Pit dump (9-7/8" open hole)	N/A	Drilling fluids discharged from drilling rig at 20 m	0	WBM (seawater + barite and bentonite)	3,620	46.0	4.8
		Totals	**582**	**-**	**37,518**	**477.2**	**10.4**

2.1.2 Drilling Discharge Inputs

The input data used to set up the dispersion model included:

- Volumes and discharge durations of the cuttings and unrecoverable drilling fluids.
- Particle size distributions (PSDs) measured during a recent drilling campaign and associated settling velocities.
- Bulk density of the released material.
- Temperature and salinity profiles of the receiving waters.
- The height of the discharge points relative to mean sea level.
- Current data to represent local physical forcing.

Table 2.2 provides a summary of the discharge configuration and the estimated volumes of drill cuttings and drilling fluids used as input into the discharge model.

Table 2.2 Key inputs to dispersion modelling for cuttings and unrecoverable solids in the drilling fluids to represent discharges during drilling of the Wilcox well.

Parameter	Wilcox well
Volume of drill cuttings discharged (m^3)	582
Volume of solids in drilling fluids discharged (m^3)	477.2
Volume of liquids in drilling fluids discharged (bbl)	37,518
Density of drill cuttings (kg/m^3)	2,600
Density of drilling solids in WBM (kg/m^3)	2,300
Discharge duration (days)	~20
Depth of discharges (m) for bottom-hole sections	20
Discharge pipe orientation	Vertical
Sea surface discharge pipe diameter (inches) [m]	18 [0.457 m]

WBM – Water based muds.

2.1.3 Geotechnical Information

Definition of the PSD of drill cuttings was based on samples collected by Woodside as part of the GWF-2 study and provided to RPS for use in the current study. A large proportion of the material sampled consisted of coarse material (>1,000 µm). The collected samples were sieved to separate the cuttings that were <250 µm into smaller fractions. The most critical geotechnical information required as input into the modelling is PSD data for this finer material. The resultant PSDs for each hole size have been redistributed to match the material size classes used in the CORMIX (see Section 2.3.2) and MUDMAP (see Section 2.4.2) models, as shown in Table 2.3.

Table 2.3 Particle size distribution of drill cuttings broken down into appropriate size classes.

Sediment grain size class	Size range (µm)	Proportion (%)	Fall velocity (cm/s)
Fine pebbles	>4,000	0.70	19.4
Very fine pebbles	>2,000	62.40	13.4
Very coarse sand	>1,000	33.40	8.9
Coarse sand	>500	1.80	5.3
Medium sand	>250	0.60	2.4
Fine sand	>125	0.20	0.77
Very fine sand	>62.5	0.10	0.20
Coarse silt	>31.3	0.10	0.05
Medium silt	>15.6	0.20	0.012
Fine silt	>7.81	0.20	0.003
Very fine silt	>3.91	0.30	0.0008
Clay	>1.95	0.00	0.0002

Definition of the PSD of solids in the drilling fluids was also based on samples collected and supplied by Woodside as part of the GWF-2 study and provided to RPS for use in the current study (Table 2.4). The PSD data indicates that most of the solids in the drilling fluids consist of very fine silt and clay (<4 µm).

Table 2.4 Particle size distribution of sediment in the drilling fluid broken down into appropriate size classes.

Sediment grain size class	Size range (µm)	Proportion (%)	Fall velocity (cm/s)
Fine pebbles	>4,000	0.90%	19.4
Fine silt	>7.81	3.10%	0.003
Very fine silt	>3.91	61.70%	0.0008
Clay	>1.95	34.30%	0.0002

2.2 Regional Ocean Currents

2.2.1 Background

The area of interest for this study is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf. While the mass flow is generally towards the south-west, year-round, the internal gyres generate local currents in all directions. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. Further south of the project area, the Leeuwin Current becomes the dominant large-scale current system, flowing poleward down the pressure gradient along the Western Australian coastline and past Cape Leeuwin.

Offshore regions with water depths exceeding 100-200 m experience significant large-scale drift currents. These drift currents can be relatively strong (1-2 knots) and complex, manifesting as a series of eddies, meandering currents, and connecting flows. These offshore drift currents also tend to persist longer (days to weeks) than tidal current flows (hours between reversals) and thus will have greater influence upon the net trajectory of plumes over time scales exceeding a few hours.

Wind shear on the water surface also generates local-scale currents that can persist for extended periods (hours to days) and result in long trajectories. Persistent winds along the mainland coast can induce Ekman transport, where surface waters move offshore and facilitate upwelling events in which cold nutrient-rich waters from the deep Indian Ocean are brought to the surface. However, due to the opposing transport of warm tropical waters by the Leeuwin Current, large-scale persistent upwelling along the Western Australian coast is suppressed. Therefore, upwelling events are sporadic, short-term and localised to areas of the coastline where the continental shelf narrows, including the area around the Capes and the Ningaloo coast (IMOS, 2014). This process is seasonal/transient and affected by the strength of the Leeuwin Current, with minimal upwelling in times with strong Leeuwin Current flow.

The current-induced transport of plumes can be variably affected by combinations of tidal, wind-induced, and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to rigorously understand patterns of potential transport from a given discharge location.

To appropriately allow for temporal and spatial variation in the current field, dispersion modelling requires the current speed and direction over a spatial grid covering the potential migration trajectories of plumes. As long-term measured current data is not available for simultaneous periods over a network of locations covering the offshore areas relevant to this study, the analysis relied upon hindcasts of the circulation generated through numerical modelling by internationally recognised organisations.

A composite modelled ocean current data product was derived by combining predictions of mesoscale circulation currents, available at daily resolution from global ocean models, with predictions of the hourly tidal currents generated by the RPS HYDROMAP model. By combining a drift current model with a tidal model, the influences of inter-annual and seasonal drift patterns, and the more regular variations in tide, were depicted, ensuring nearshore and offshore hydrodynamic processes were represented.

2.2.2 Mesoscale Circulation Model

2.2.2.1 Description of Mesoscale Model: BRAN

Representation of the drift currents that affect the area were available from the output of the BRAN (Oke *et al.*, 2013, 2009, 2008; Schiller *et al.*, 2008) ocean model, which is sponsored by the Australian Government through the Commonwealth Bureau of Meteorology (BoM), Royal Australian Navy and CSIRO. BRAN is a data-assimilative, three-dimensional ocean model that has been run as a hindcast for many periods and is now used for ocean forecasting (Schiller *et al.*, 2008).

BRAN routinely assimilates sea level anomaly data, tide gauge data, sea surface temperature and in situ temperature and salinity measurements (Oke *et al.*, 2009). Comparisons of BRAN hindcast outputs to satellite and independent in situ observations found that BRAN was reliably representing the broad-scale ocean circulation, the mesoscale surface eddy field, and shelf circulation around Australia (Oke *et al.*, 2008; Schiller *et al.*, 2008). Additionally, reanalysis of past periods using the BRAN model has been shown to realistically represent upwelling events, in particular along the Bonney Coast of South Australia, a region of frequent wind-driven upwellings (Oke *et al.*, 2009)

The BRAN predictions for drift currents are produced at a horizontal spatial resolution of approximately 0.1° over the region, at a frequency of once per day, averaged over the 24-hour period. Hence, the BRAN model data provides estimates of mesoscale circulation with horizontal resolution suitable to resolve eddies of a few tens of kilometres' diameter, as well as connecting stream currents of similar spatial scale. Drift currents that are represented over the inner shelf waters in the BRAN data are principally attributable to wind induced drift.

There are several versions of the BRAN database available. A notable BRAN simulation spans the period of January 1994 to August 2016. From this database, three-dimensional data representing horizontal water movement at discrete depths was extracted for all points in the model domain for the years 2006-2015 (inclusive). The data was assumed to be a suitably representative sample of the current conditions over the study area for future years.

Although this data should represent effects of upwelling and downwelling processes on horizontal transport at a given depth, the data does not explicitly represent vertical currents between horizontal layers. This was considered reasonable because vertical currents associated with episodic upwelling and downwelling events are relatively small in magnitude (3-30 cm/s; Kämpf *et al.*, 2004) compared to horizontal currents represented in the tidal and non-tidal current data (0.5-2 m/s), and considering allowances for dispersion rates in the horizontal (0.1-50 m/s) and vertical (1-10 cm/s) planes.

2.2.2.2 Mesoscale Currents at the Discharge Location

The data for the scenario indicates that higher average current speeds are characteristic of the April to June period, with the highest average speeds (0.20 m/s) occurring near the release site in June (Figure 2.1). Lower average current speeds are more common during the January to March period, with the lowest average speeds (0.11 m/s) occurring near release site in October. Current directions near the discharge site are predominately westerly across the year.

The extracted current data near the discharge location provides an insight into the expected initial behaviour of plumes due to the drift currents alone. Plumes moving beyond the release sites, particularly towards the coast, would be subject to considerable variation in the drift current regime.

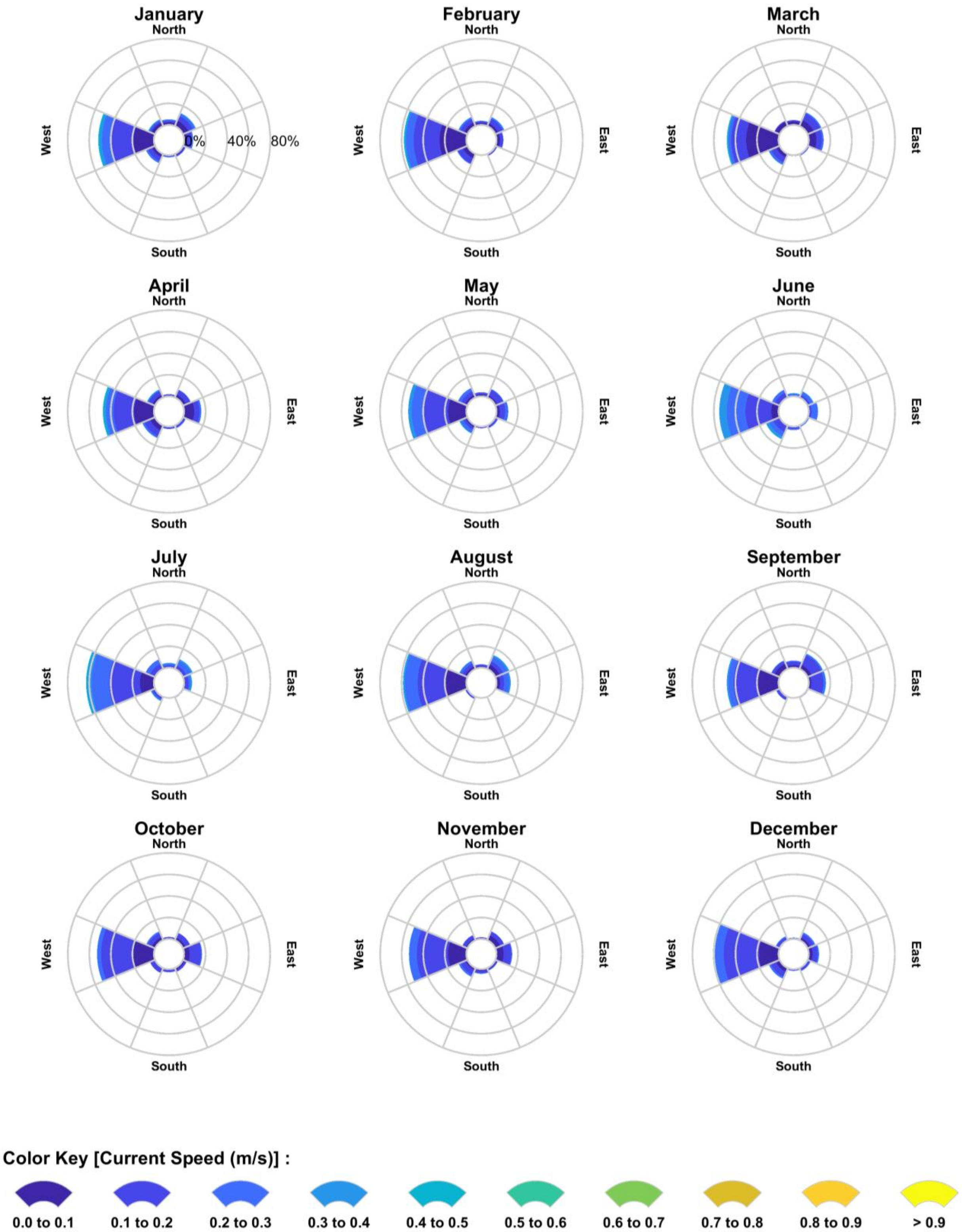


Figure 2.1 **Monthly current distribution (2006-2015, inclusive) derived from the BRAN database near to the discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.**

2.2.3 Tidal Circulation

2.2.3.1 Description of Tidal Model: HYDROMAP

As the BRAN model does not include tidal forcing, and because the data is only available at a daily frequency, a tidal model was developed for the study region using RPS' three-dimensional hydrodynamic model, HYDROMAP.

The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 30 years (Isaji and Spaulding, 1986, 1984; Isaji *et al.*, 2001; Zigic *et al.*, 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the National Marine Oil Spill Contingency Plan for the Australian Maritime Safety Authority (AMSA, 2002).

HYDROMAP simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction. The model employs a sophisticated dynamically nested-gridding strategy, supporting up to six levels of spatial resolution within a single domain. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

The numerical solution methodology of HYDROMAP follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon & Spaulding (1987). A more detailed presentation of the model can be found in Isaji & Spaulding (1984).

2.2.3.2 Tidal Domain Setup

A HYDROMAP model was established over a domain that extended approximately 3,300 km east-west by 3,100 km north-south over the eastern Indian Ocean. The grid extends beyond Eucla in the south and beyond Bathurst Island in the north (Figure 2.2).

Approximately 98,600 cells were used to define the region, with four layers of sub-gridding applied to provide variable resolution throughout the domain. The resolution at the primary level was 15 km. The finer levels were defined by subdividing these cells into 4, 16 and 64 cells, resulting in resolutions of 7.5 km, 3.75 km, and 1.88 km.

The finer grids were allocated in a stepwise fashion to areas where higher resolution of circulation patterns was required to resolve flows through channels, around shorelines or over more complex bathymetry. Figure 2.3 shows a zoomed subset of the hydrodynamic model grid in the North West Shelf region, showing the finer resolution grids surrounding the numerous shoals, islands, and complex areas of the mainland coastline.

Bathymetric data used to define the three-dimensional shape of the study domain was extracted from the Geoscience Australia 250 m resolution bathymetry database (Whiteway, 2009) and the CMAP electronic chart database, supplemented where necessary with manual digitisation of chart data supplied by the Australian Hydrographic Office. Depths in the domain ranged from shallow intertidal areas through to approximately 7,200 m.

2.2.3.3 Tidal Boundary Conditions

Ocean boundary data for the HYDROMAP model was obtained from the TOPEX/Poseidon global tidal database (TPXO7.2) of satellite-measured altimetry data, which provided estimates of tidal amplitudes and phases for the eight dominant tidal constituents (designated as K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1) at a horizontal scale of approximately 0.25°. Using the tidal data, sea surface heights are firstly calculated along the open boundaries at each time step in the model.

The TOPEX/Poseidon satellite data is produced, and quality controlled by the US National Atmospheric and Space Agency (NASA). The satellites, equipped with two highly accurate altimeters capable of taking sea level measurements accurate to less than ±5 cm, measured oceanic surface elevations (and the resultant tides) for over 13 years (1992-2005). In total, these satellites carried out more than 62,000 orbits of the planet. The TOPEX/Poseidon tidal data has been widely used amongst the oceanographic community, being the subject of more than 2,100 research publications. As such, the TOPEX/Poseidon tidal data is considered suitably accurate for this study.

2.2.3.4 Tidal Elevation Validation

For the purpose of verification of the tidal predictions, the model output was compared against independent predictions of tides using the XTide database (Flater, 1998). The XTide database contains harmonic tidal constituents derived from measured water level data at locations around the world. Overall, there are more than 120 tidal stations within the HYDROMAP model domain; however, some of these are in areas that are not sufficiently resolved by this large-scale ocean model. More than 80 stations along the coastline were suitable for comparisons of the model performance with the observed data. These stations covered the mid-to-northwest regions of the Western Australian coastline, encompassing the locales of the marine discharges considered in this study

For the purposes of brevity and clarity, a selected representative subset of the available tidal station validation data is presented here.

Water level time series for the selected subset of ten stations are shown in Figure 2.4 and Figure 2.5 for a one-month period (January 2018). All comparisons show that the model produces a very good match to the known tidal behaviour for a wide range of tidal amplitudes and clearly represents the varying diurnal and semi-diurnal nature of the tidal signal.

The model skill was further evaluated through a comparison of the predicted and observed tidal constituents, derived from an analysis of model-predicted time series at each of the tidal station locations. Scatter plots of the observed and modelled amplitude (top) and phase (bottom) of the five dominant tidal constituents (S_2, M_2, N_2, K_1 and O_1) for all relevant stations within the model domain (>80) are presented in Figure 2.6. The red line on each plot shows the 1:1 line, which would indicate a perfect match between the modelled and observed data. Note that the data is generally closely aligned to the 1:1 line demonstrating the high quality of the model performance.

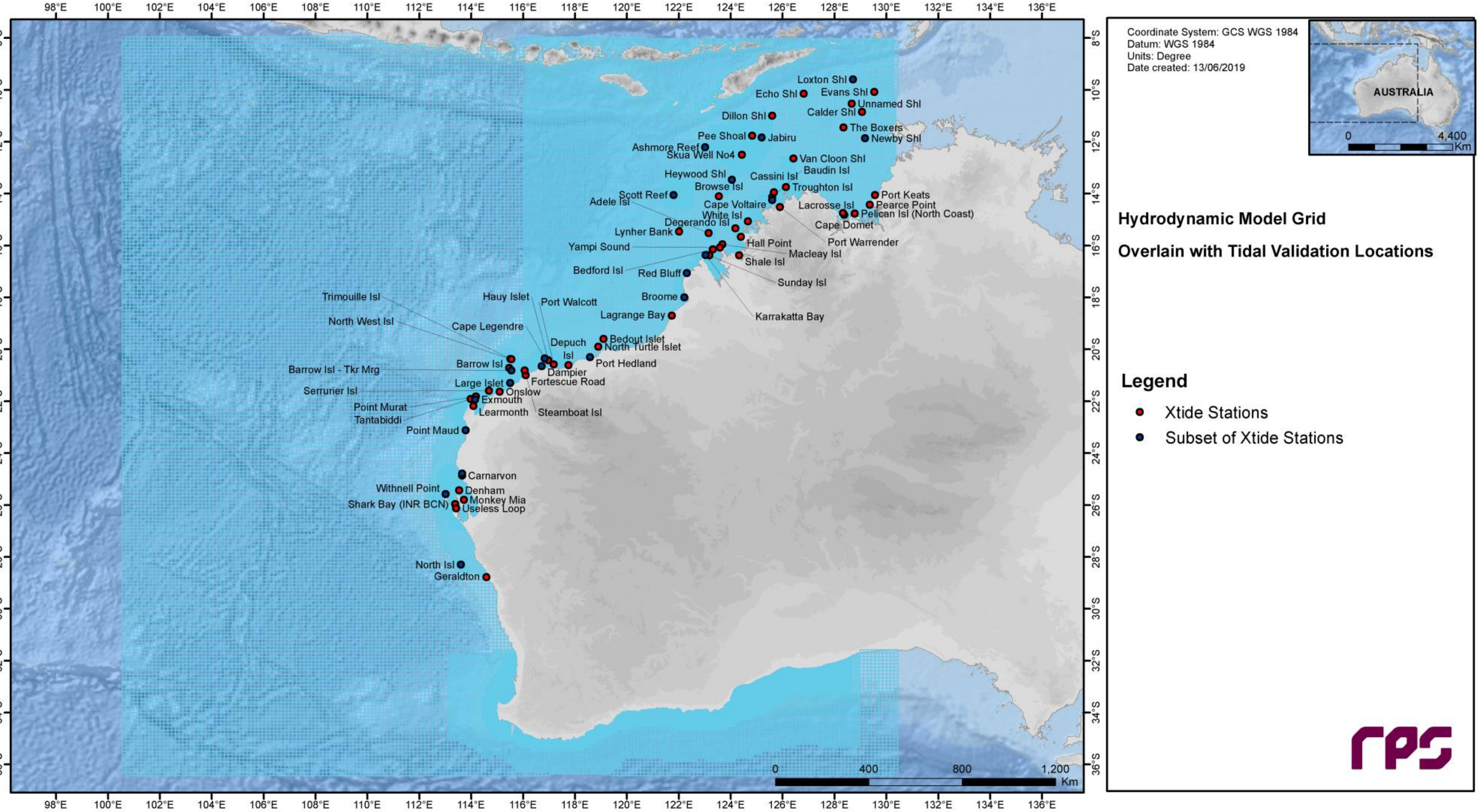


Figure 2.2 **Hydrodynamic model grid (blue wire mesh) used to generate the tidal currents, showing the full domain in context with the continental land mass and the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.**

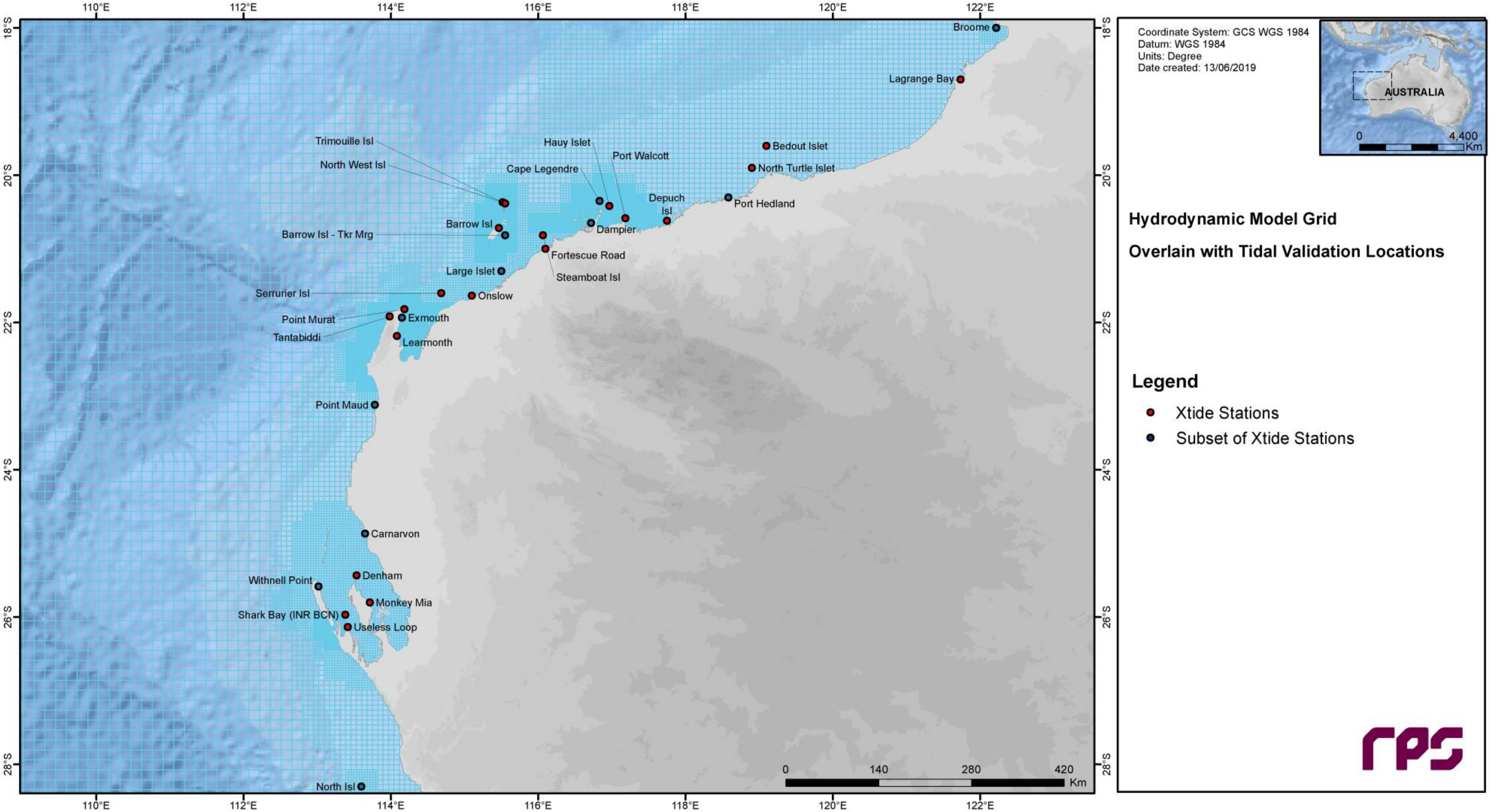


Figure 2.3 **Zoomed subset of the hydrodynamic model grid (blue wire mesh) for the North West Shelf area, showing the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.**

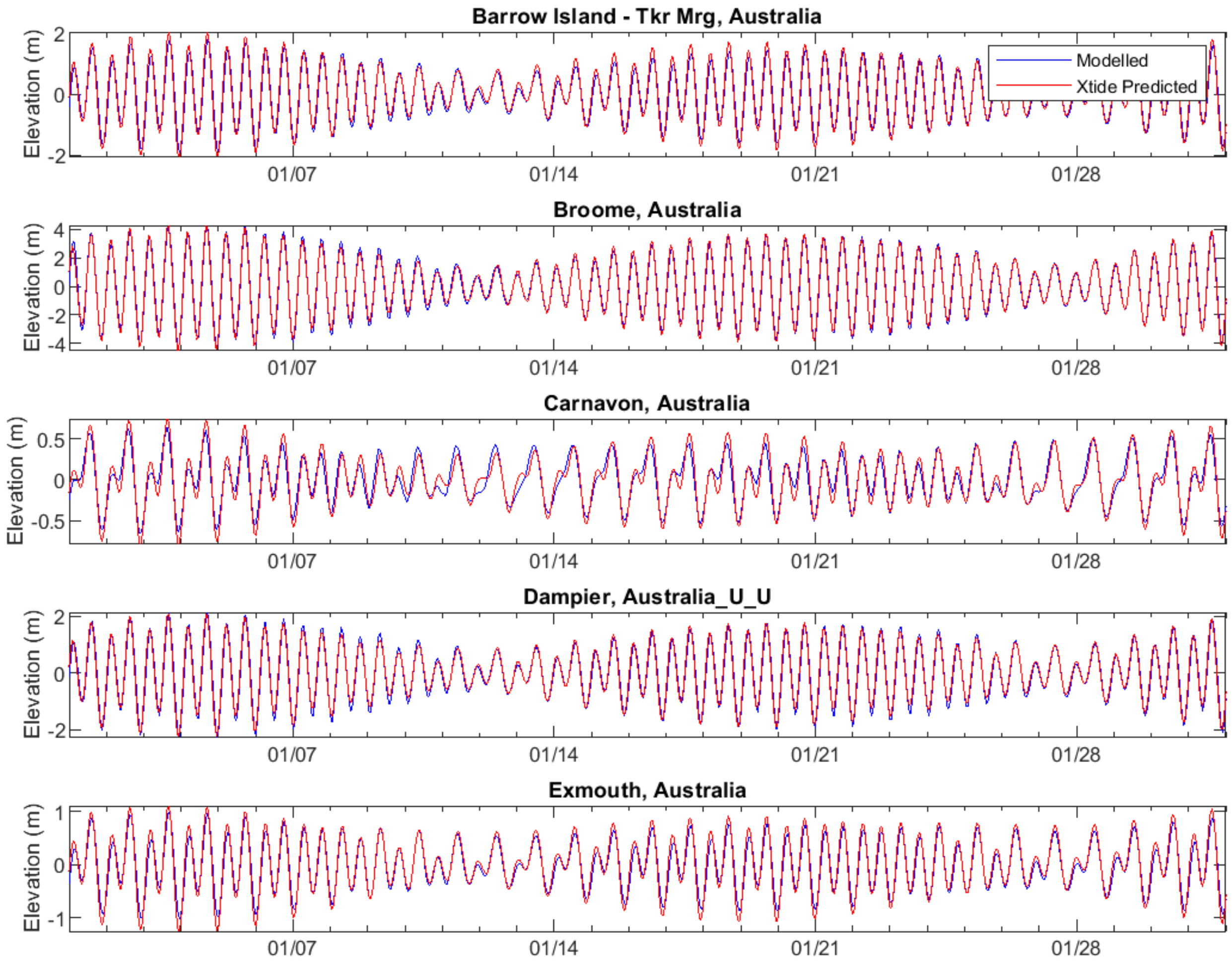


Figure 2.4 Comparisons between the predicted (blue line) and XTide predicted (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.

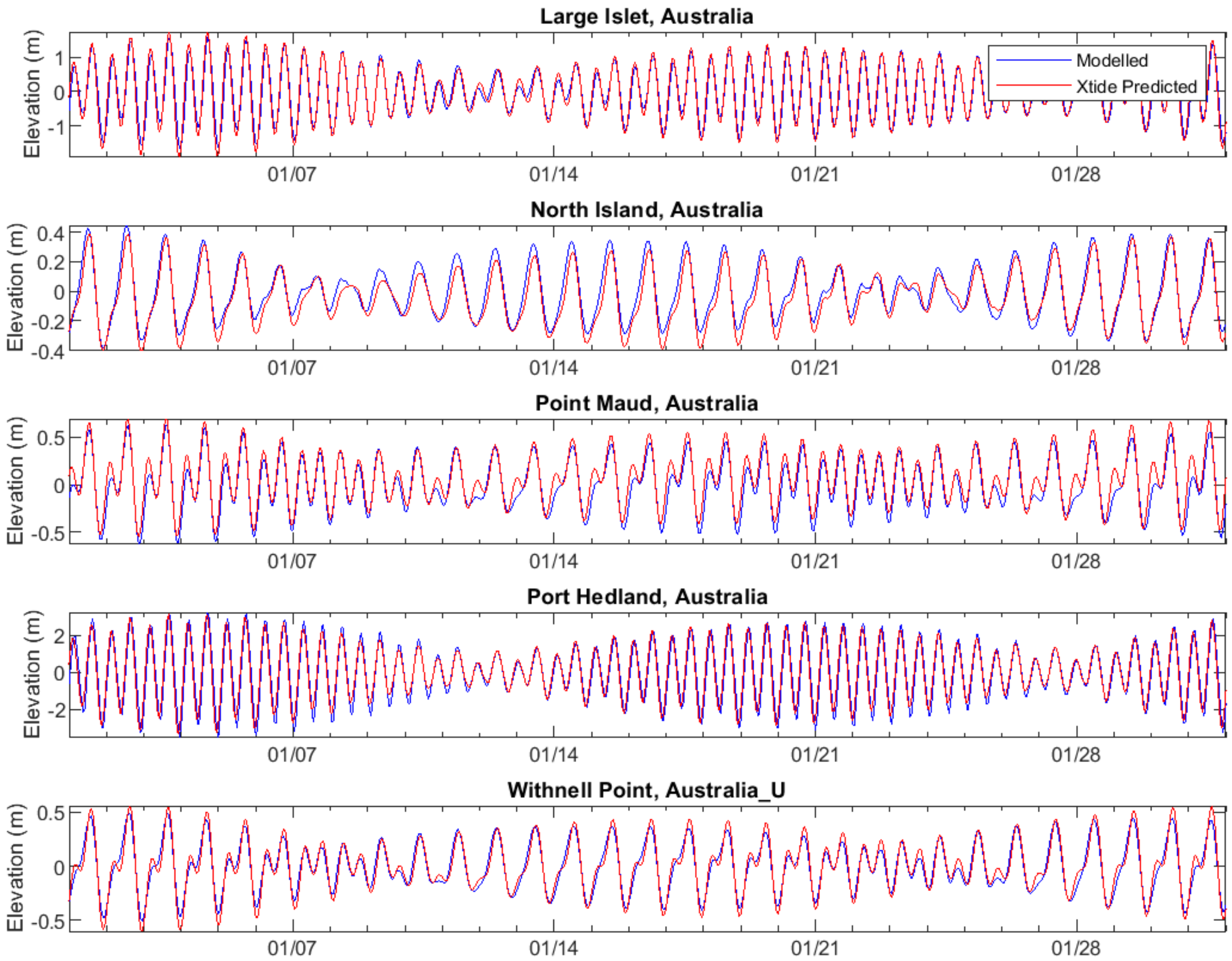
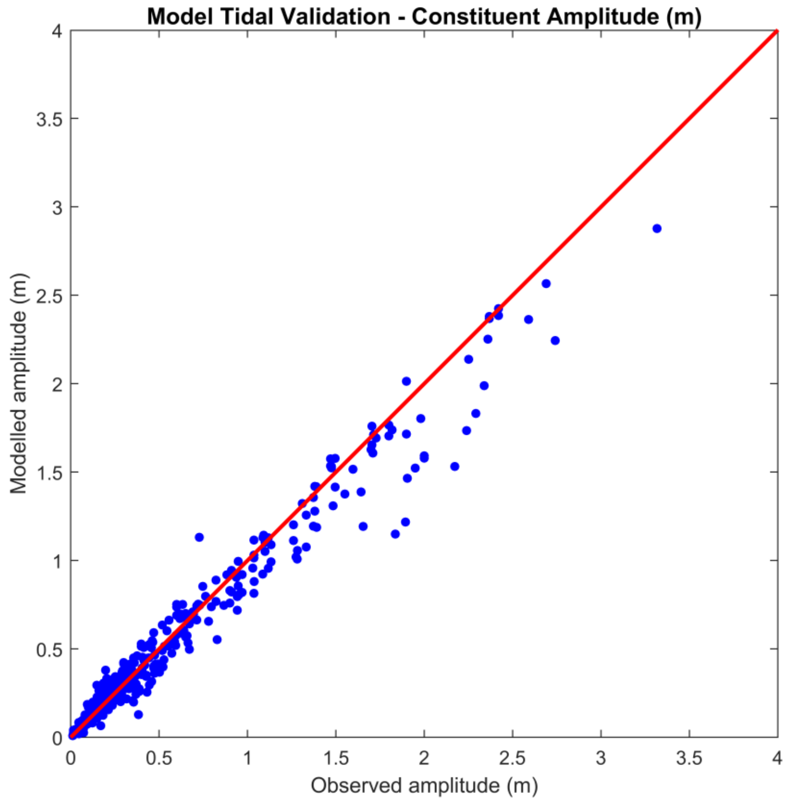


Figure 2.5 **Comparisons between the predicted (blue line) and XTide predicted (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.**



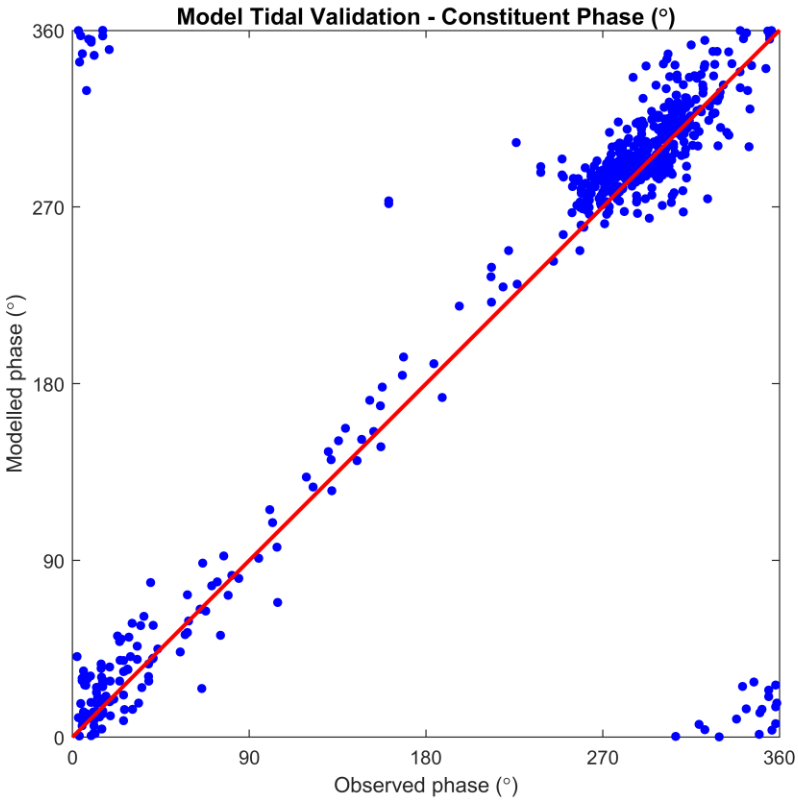


Figure 2.6 Comparisons between modelled and observed tidal constituent amplitudes (top) and phases (bottom) at all relevant stations (>80) in the HYDROMAP model domain. The red line indicates a 1:1 correlation between the modelled and observed data.

2.2.3.5 Tidal Currents at the Discharge Location

The monthly distributions of current speeds and directions for the HYDROMAP data point closest to the discharge location are displayed in Figure 2.7. Note that the convention for defining current direction is the direction *towards* which the current flows.

The data indicates cyclical tidal flow directions along a southeast-northwest axis at the modelled discharge site for the scenarios. The extracted current data near the discharge location provides an insight into the expected initial behaviour of plumes due to the tidal currents alone. Plumes moving beyond the release sites, particularly towards the coast, would be subject to considerable variation in the tidal current regime.

Figure 2.7 Monthly current distribution (2006-2015, inclusive) derived from the HYDROMAP database near to the discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

2.3 Near-Field Modelling

2.3.1 Overview

Numerical modelling was applied to quantify the area of influence of sediment plumes, in terms of the distribution of the maximum concentrations that might occur with distance from the source given defined discharge configurations, source concentrations, and the distribution of the metocean conditions affecting the discharge location.

The dispersion of the discharge will depend, initially, on the geometry and hydrodynamics of the discharges themselves, where the induced momentum and buoyancy effects dominate over background processes. This region is generally referred to as the near-field zone and is characterised by variations over short time and space scales. As the discharges mix with the ambient waters, the momentum and buoyancy signatures are eroded, and the background – or ambient – processes become dominant.

The shape and orientation of the discharged water plumes, and hence the distribution and dilution rate of the plumes, will vary over the wider spatial and times scales with natural variation in prevailing water currents. Therefore, to best calculate the likely outcomes of the discharges, it is necessary to simulate discharge under a statistically representative range of current speeds representative of the well location.

2.3.2 Description of Near-Field Model: CORMIX

The near-field mixing and dispersion of the discharge was simulated using the three-dimensional flow model, CORMIX. CORMIX is a mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones. CORMIX is widely applied worldwide and has been validated in many independent studies (http://www.cormix.info/validations.php).

CORMIX is a collection of analytic solutions to simplified forms of the mathematical equations describing transport and dispersion of water borne constituents. The simplifications come about through a range of assumptions about the source configuration, source characteristics (discharge and buoyancy) and the ambient environment. These assumptions effectively limit the domain within which the analytic solutions apply. For the typical discharge source flow, two main zones can be defined as described in Table 2-5.

CORMIX has four core hydrodynamic simulation models. These models are CORMIX1, CORMIX2, CORMIX3, and DHYDRO. CORMIX1 is used for single port diffusers submerged and/or above the water surface, CORMIX2 is for submerged multiport diffusers, and CORMIX3 simulates the buoyant surface discharges. DHYDRO solves brine and/or sediment discharges from a single port, multiport diffusers, or negatively buoyant surface discharge that can be orientated in any direction. In this study, DHYDRO was used for the near-field calculations. The emphasis of the DHYDRO model is the influence of the geometry and dilution characteristics on the initial mixing zone (Doneker & Jirka, 1990; Jirka *et al.*, 1991).

Although CORMIX does calculate far-field dispersion, the assumptions of the algorithms limit application to homogeneous environments with no eddies in the ambient flow and little recirculation. For this reason, the CORMIX component of the calculations for this study were limited to the near-field zone.

Table 2-5 CORMIX mixing zone definitions.

Zone	Description
Near-field	Jet characteristics, momentum flux, buoyancy flux and discharge geometry influence the plume's trajectory and mixing.
Far-field	Ambient conditions control the plume's trajectory and dilution due to density current buoyant spreading and ambient turbulence.

CORMIX specifies the average dilution or bulk dilution (flux-averaged) as 1.7 times the centreline dilution. The centreline is defined by the points of maximum concentration (maximum temperature, minimum dilution, etc.) at each vertical section along the longitudinal axis. Accordingly, centreline depth is defined as the depth of the maximum concentration point (maximum temperature, minimum dilution) along the longitudinal axis.

Figure 2.8 shows a conceptual diagram of the dispersion and fate of a buoyant discharge and an idealised representation of the discharge phases.

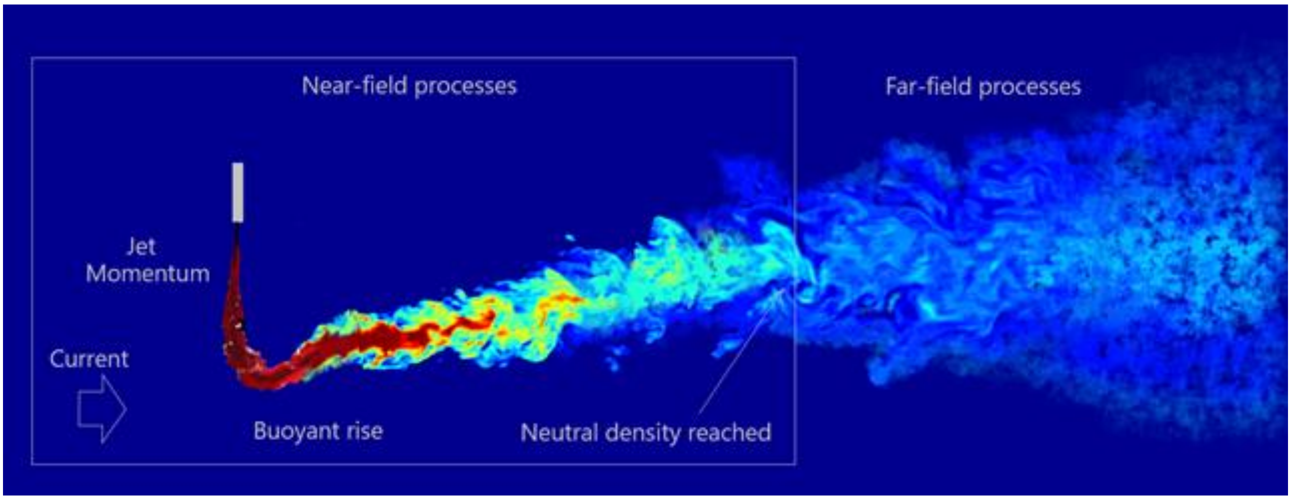


Figure 2.8 Schematic depiction of the near-field and far-field phases of a discharge plume. The depiction is of a downward-facing jet that is positively buoyant, with current flow from left to right.

2.3.3 Setup of Near-Field Model

2.3.3.1 Near-Field Model Assumptions

While near-field seasonal modelling was carried out for each of the well intervals/sections to be drilled and the drilling fluid dump operations, only annualised modelling results for the 17.5” production casing section and associated drilling fluid dump operations are presented in this report. Table 2.6 presents the assumptions for the well interval/section (17.5” production casing) and associated drilling fluid dump operations for discharges at a depth of 20 m below mean sea level (BMSL) through a vertically oriented outlet pipe. The flow was assumed to occur through an outlet of 0.4 m diameter in each case, at a rate of 0.0031 m^3/s, 0.0004 m^3/s and 0.0245 m^3/s for the continuous discharge (drill cuttings and drilling fluids), dilute-and-dump discharge and pit dump discharge, respectively.

Table 2.6 Inputs to near-field modelling for discharge of sediments during drilling for the 17.5” production casing section for combinations of discharge pattern (continuous, dilute-and-dump and pit dump) and discharge depth (20 m).

Parameter	Continuous	Dilute-and-dump	Pit dump
Total solid volume discharged (m^3)	326.2	15.3	50.9
Discharge duration (hrs)	55	12 (single event)	7.2
Mean discharge rate (m^3/s)	0.0031	0.0004	0.0245
Mean discharge velocity (m/s)	0.0186	0.0269	0.1494
Fall velocity (cm/s)	See Table 2.3 & Table 2.4		
Outlet pipe internal diameter (m)	0.4572		
Outlet pipe orientation	Vertical		
Depth of pipe below sea surface (m)	20		
Water column depth (m)	70		

2.3.3.2 Ambient Environmental Conditions

Inputs of ambient environmental conditions to the CORMIX model included a vertical profile of temperature and salinity, along with constant current speeds and general direction. The temperature and salinity profiles are required to accurately account for the relative buoyancy of the diluting plume, while the current speeds control the intensity of initial mixing and the deflection of the sediment plume. These inputs are described in the following sections.

2.3.3.2.1 Ambient Temperature and Salinity

Temperature and salinity data applied to the near-field modelling was sourced from the World Ocean Atlas 2013 (WOA13) database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration, NOAA) and its co-located World Data Center for Oceanography (Levitus *et al.*, 2013).

Table 2.7 and Table 2.8 show the average seasonal water temperature and salinity levels, respectively, at varying depths from 0 m to 70 m. This data can be considered representative of conditions at the discharge location.

The seasonal temperature profiles exhibit a reasonably consistent reduction in temperature with increasing depth. Salinity levels are generally most consistent with depth and indicate a vertically well-mixed water body (34.8-35.1 practical salinity unit, PSU), irrespective of season or depth.

Table 2.7 Average seasonal temperature levels adjacent to the discharge location.

Depth (m)	Temperature (°C)			
	Summer	Winter	Transitional	Annualised
0	27.9	26.8	26.7	27.0
10	27.8	26.8	26.8	27.0
20	27.7	26.7	26.5	26.9
35	27.4	26.7	26.0	26.6
45	26.8	26.5	25.6	26.3
70	24.9	25.5	24.7	25.1

Table 2.8 Average seasonal salinity levels adjacent to the discharge location.

Depth (m)	Salinity (PSU)			
	Summer	Winter	Transitional	Annualised
0	35.0	35.1	34.8	35.0
10	35.0	35.1	34.8	35.0
20	35.0	35.1	34.8	35.0
35	35.0	35.1	34.8	35.0
45	34.9	35.1	34.8	34.9
70	34.9	35.0	34.9	34.9

2.3.3.2.2 Ambient Current

Ocean current data was sourced from a ten-year hindcast data set of combined large-scale ocean (BRAN) and tidal currents (Figure 2.9 to Figure 2.12). The data was statistically analysed to determine the 5th, 50th and 95th percentile current speeds. These statistical current speeds can be considered representative of the range of seasonal conditions at the drilling location.

Table 2.9 to Table 2.11 present the steady-state, unidirectional current speeds at varying depths used as input to the near-field model as forcing for each discharge case and season were calculated as:

- 5th percentile (weak current speed).
- 50th percentile (median current speed).
- 95th percentile (strong current speed).

Table 2.9 Calculations for ambient current conditions adjacent to the proposed drilling location during summer.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.061	0.245	0.534
12.5	0.063	0.246	0.531
22.7	0.066	0.247	0.529
34.2	0.069	0.249	0.530
48.5	0.072	0.254	0.536
75.2	0.058	0.228	0.523

Table 2.10 Calculations for ambient current conditions adjacent to the proposed drilling location during winter.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.070	0.260	0.548
12.5	0.070	0.257	0.540
22.7	0.069	0.255	0.536
34.2	0.067	0.253	0.536
48.5	0.065	0.251	0.537
75.2	0.057	0.232	0.528

Table 2.11 Calculations for ambient current conditions adjacent to the proposed drilling location during transitional periods.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.067	0.254	0.555
12.5	0.070	0.254	0.552
22.7	0.071	0.254	0.551
34.2	0.071	0.256	0.551
48.5	0.074	0.260	0.556
75.2	0.060	0.235	0.553

Table 2.12 Calculations for ambient current conditions adjacent to the proposed drilling location throughout the annualised period.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (median) current speed (m/s)	95th percentile (strong) current speed (m/s)
2.5	0.067	0.254	0.547
12.5	0.068	0.253	0.542
22.7	0.069	0.253	0.539
34.2	0.069	0.253	0.540
48.5	0.070	0.254	0.544
75.2	0.058	0.232	0.535

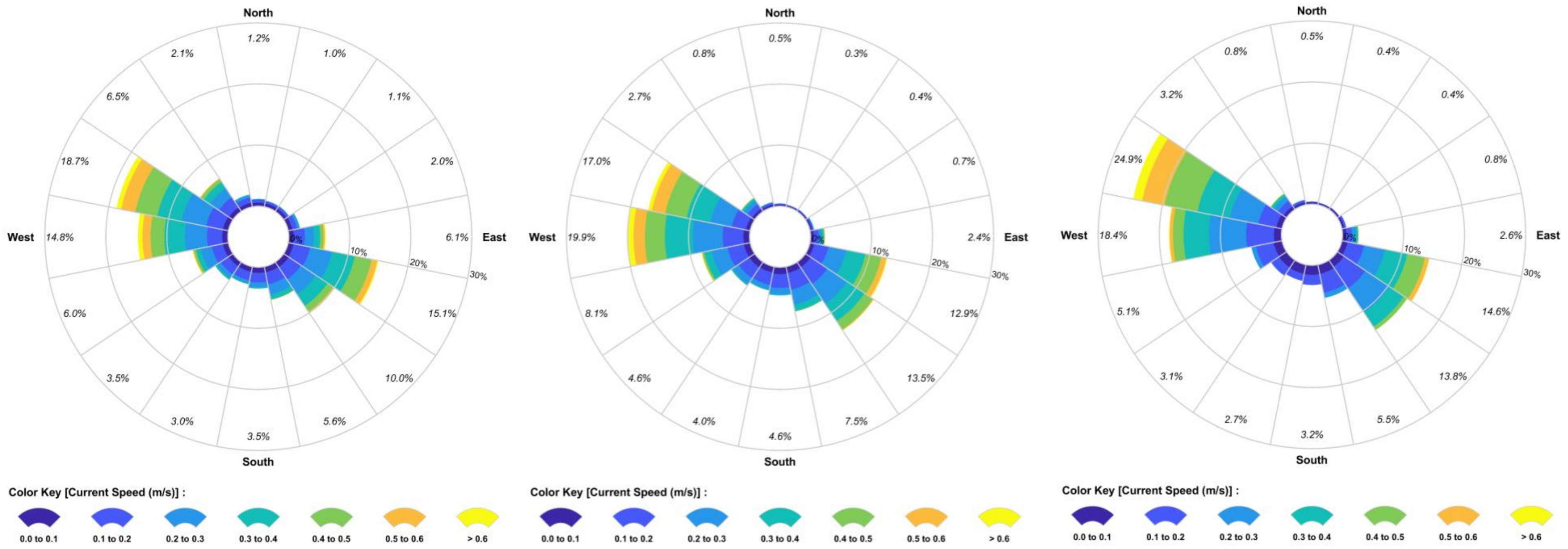


Figure 2.9 **Summer current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.**

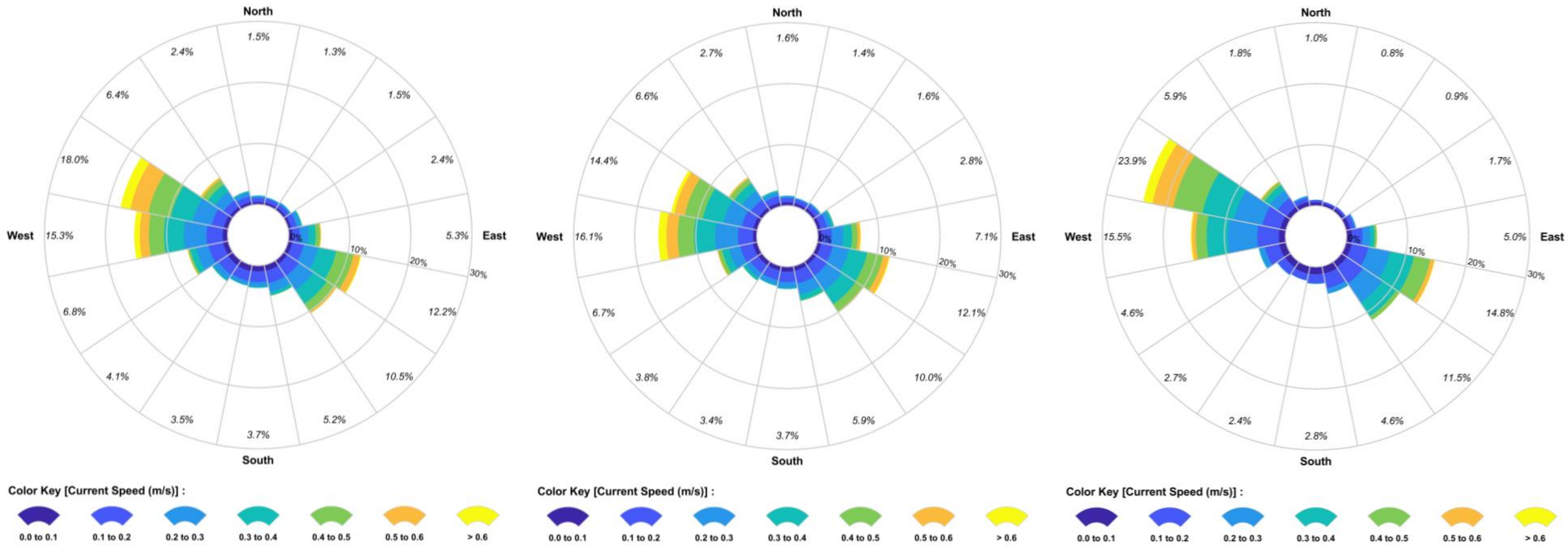


Figure 2.10 Winter current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

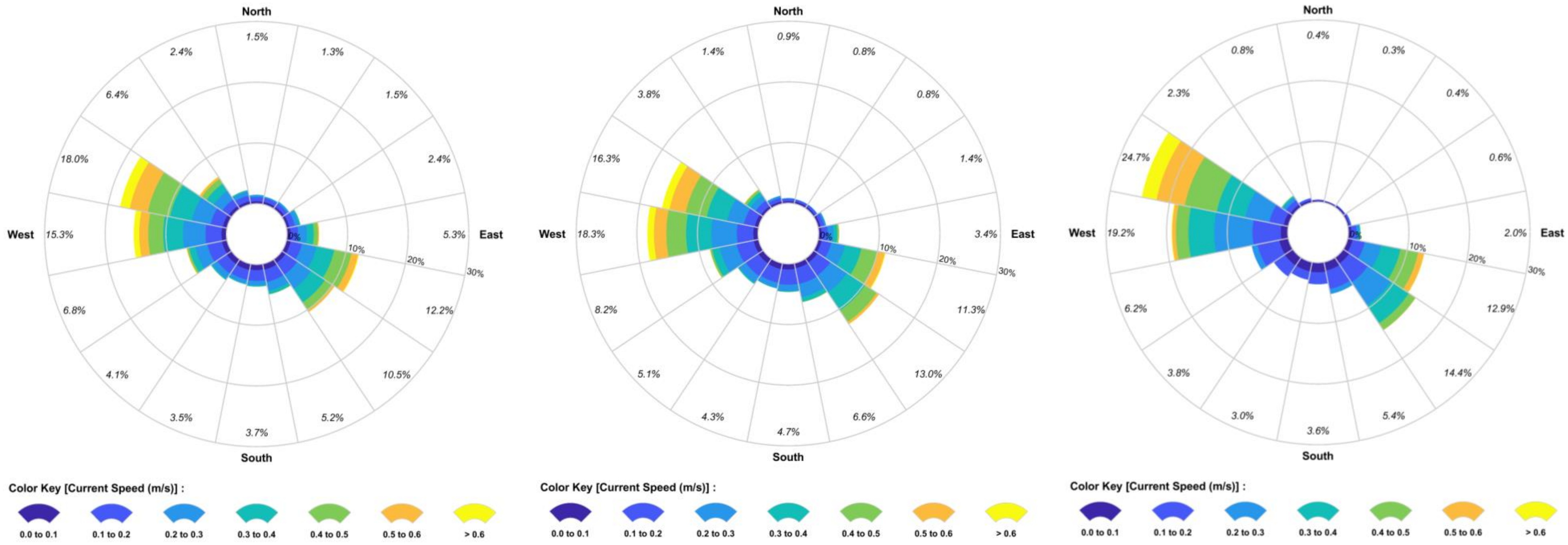


Figure 2.11 Transitional current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

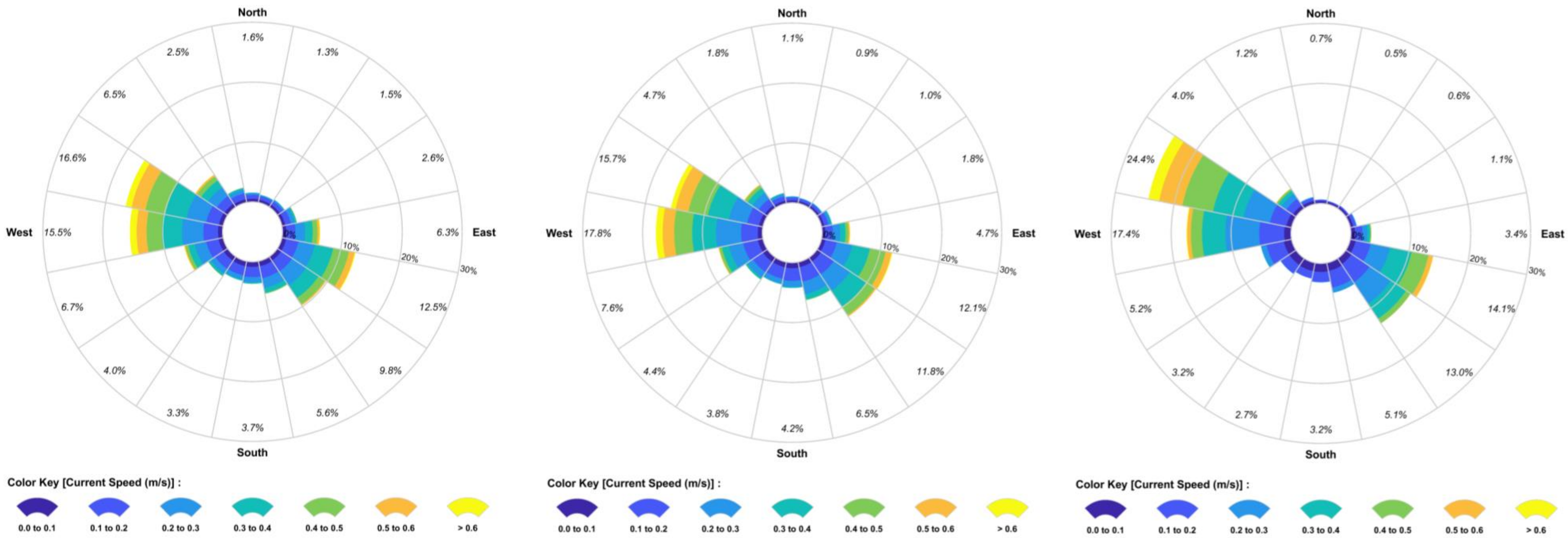


Figure 2.12 Annualised current distribution (2006-2015, inclusive) at depths of 2.5 m (left), 22.7 m (middle) and 75.2 m (right) derived from the combined BRAN and HYDROMAP data near to the proposed discharge location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

2.4 Far-Field Modelling

2.4.1 Overview

The far-field modelling expands on the near-field work by allowing the time-varying nature of currents to be included, with the potential for localised build-up when current speeds are low (e.g., at the turning of the tide) and recirculation of the plume back to the discharge location might occur.

2.4.2 Description of the Far-Field Model: MUDMAP

MUDMAP is a three-dimensional plume model used by industry and regulators to aid in assessing the potential environmental effects from operational discharges such as drill cuttings, drilling fluids and produced formation water.

The far-field calculation (passive dispersion stage) employs a particle-based, random walk procedure. The model predicts the dynamics of the discharge material and resulting seabed concentrations and bottom thicknesses over the far-field (the wider region). Figure 2.13 shows a conceptual diagram of the dispersion and fates of drill cuttings and fluids discharge to the ocean and an idealised representation of the three discharge phases.

Settling under currents is selective for particle size, with the larger particles (rocks, gravel to sand) tending to settle quickly, forming a pile that aligns with the predominant current axis. Smaller particles (especially silts and clays) tend to remain suspended for exponentially longer time periods and will therefore be dispersed more widely by local currents. Dispersion of the finer discharged material will tend to be enhanced with increased current speeds and water depth, and with greater variation in current direction over time and depth.

MUDMAP can simulate up to six classes of material (each with up to six sub-categories, for a total of 36 sub-categories). Each material class can be set up with a unique density and PSD. During the dispersion stage, particles are transported in three dimensions according to the sinking rate applicable to their size, prevailing current, and horizontal and vertical dispersion coefficients at each time step.

MUDMAP has been extensively validated and applied for discharge operations in Australian coastal and ocean waters, and around the world (e.g., Burns *et al.*, 1999; Spaulding, 1994; King & McAllister, 1997, 1998).

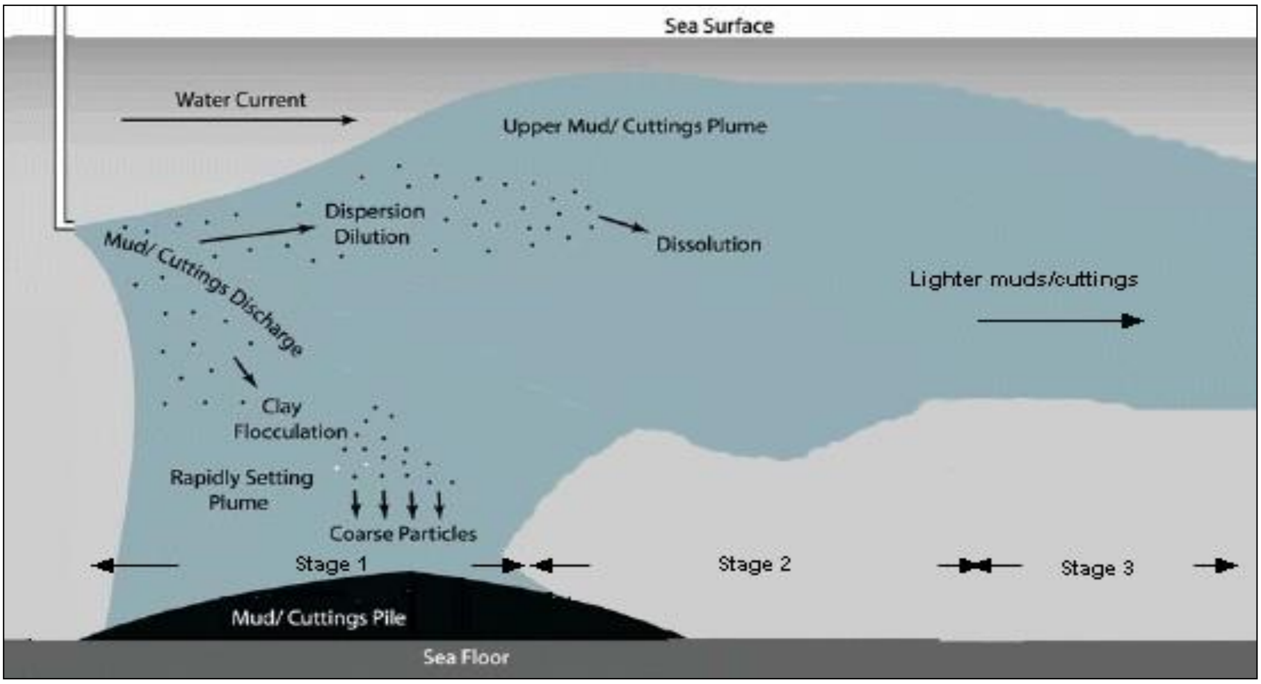


Figure 2.13 Conceptual diagram showing the general behaviour of cuttings and drilling fluids discharged to the ocean and the idealised representation of the three discharge phases (Neff, 2005).

2.4.3 Setup of Far-Field Model

2.4.3.1 Far-Field Model Assumptions

The MUDMAP model was used to discharge into a time-varying current field with the initial discharge depth set by the near-field results described in Section 3.2. Inputs to the far-field modelling are summarised in Table 2.13.

Representation of the full discharge sequence was modelled in a stochastic manner under unique sequences of current conditions to generalise the calculations for a wider range of realistic conditions. Fifty replicate simulations of the full sequence were modelled for each combination and season. Start times for these simulations were randomly selected from times corresponding to each season within a ten-year period that corresponded to a ten-year sample of current data. This approach sampled objectively for different tidal and drift currents with greater weighting for conditions that have occurred more frequently within each season.

Table 2.13 Inputs to far-field modelling for discharge of sediments during drilling of the Wilcox well.

Parameter	Wilcox well
Hindcast modelling period	2006-2015
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August)
Volume of drill cuttings discharged (m^3)	582
Volume of solids in drilling fluids discharged (m^3)	477.2
Particle size distributions	See Table 2.3 and Table 2.4
Discharge Duration (hrs)	249
Outlet pipe internal diameter (m)	0.457
Outlet pipe orientation	Vertical
Depth of pipe below sea surface (m)	20
Water column depth (m)	70
Number of simulations	50 per season

2.4.3.2 Grid Configuration

A three-dimensional cube covering 20 km (longitude, x-direction) by 20 km (latitude, y-direction) around the well location and extending to bed depth was employed to calculate the spatial distribution of drill cuttings and drilling fluids in the water column and on the seafloor. The cube was subdivided into uniformly sized grids cell measuring 20 m (east-west) x 20 m (north-south) x 5 m (depth).

2.4.3.3 Approach to Coupling with Near-Field Model Outputs

Near-field modelling considers dispersion and movement of plumes due to physical processes that occur over smaller time and space scales (metres and minutes, respectively) than were important to this study (tens of kilometres and tens of minutes to hours or days) and only considers steady state conditions (fixed discharge and current).

To assess the far-field behaviour of the discharge plume over the longer term and over a wider area, MUDMAP was applied to simulate the trajectory and fate of the discharge using the initial calculations of the near-field model. The MUDMAP model operates over a coarser grid to calculate the dynamics of the discharge material and resulting seabed concentrations and bottom thicknesses over the wider region, accounting for changing current field. Discharge details may also change over time.

Due to the different time and space scales involved, it is necessary to carefully couple the output from the near-field as input to the far-field model to maintain mass balance.

The coupling method employed by RPS involved translating the modelling results of the near-field (CORMIX) simulations into spatially varying and ambient condition dependent input (sources) for input into the far-field model (MUDMAP). The RPS methodology is designed to be partially dynamic (one-way coupling).

The coupling involved:

1. Running the near-field model (CORMIX) under steady-state discharge configurations (Table 2.6) under a range of ambient current speeds (5th, 25th, 50th, 75th and 95th percentile) for each season (summer, winter and transitional) to define the range of geometries and distributions of the plume that should result after all near-field processes have completed.
2. Using these calculations for mass distributions to define input concentrations and locations within the grid of the far-field model (in the vertical and horizontal), that vary with the prevailing current speed and

direction at the discharge point, ensuring that the initial mass is conserved, without any initial convective descent.

3. Running sensitivity tests to determine the appropriate horizontal and vertical grid scales to apply to the MUDMAP model (to avoid over-dilution of the input concentration) along with the most appropriate mixing parameters (horizontal and vertical dispersion) to avoid over or under-dispersion.

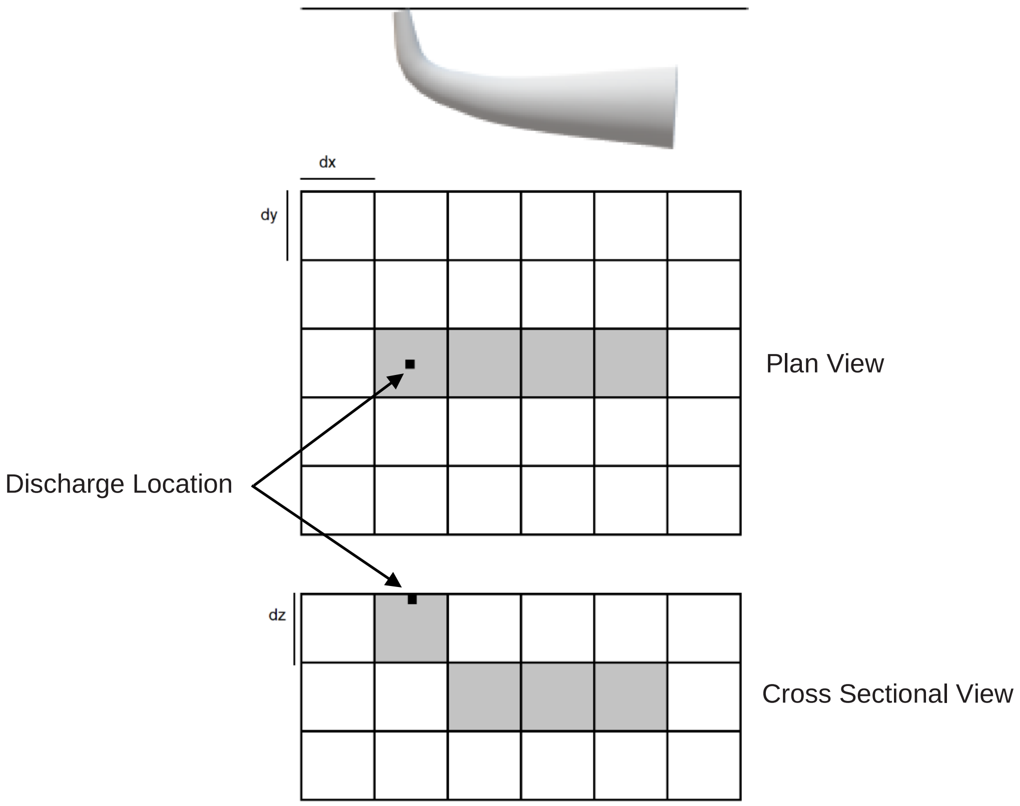


Figure 2.14 Conceptual diagram of the near-field and far-field coupling method.

2.4.3.4 Mixing Parameters

Horizontal and vertical dispersion coefficients are used in dispersion modelling to represent the mixing and diffusion processes caused by turbulence, which are sub-grid processes at the scale of the hydrodynamic data that drives transport of material. The dispersion coefficients are expressed in units of rate of area of change (m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations. Increasing the vertical dispersion coefficient spreads the discharge further across the vertical layers.

The horizontal turbulent diffusion of the plume is dependent on the hydrodynamic conditions (i.e., wind, wave, and current) and the physical scale of the plume compared to the scales of the oceanic processes that disperse the plume. For a plume of approximately 10-100 m width, dispersion occurs primarily through small-scale horizontal swirling motions and vertical mixing, with a horizontal dispersion rate of the order of 0.1 m^2/s. As the plume grows to a scale of 1-10 km, it begins to be subject to mesoscale eddies and the horizontal dispersion rate increases to the order of a few to tens of m^2/s. At even larger scales, the plume would be larger than the mesoscale eddies and eddy mixing becomes the dominant mechanism, with a rate of horizontal dispersion of 100-1,000 m^2/s.

For this project, with an open ocean environment and length scales of 10 m to 1 km, a horizontal diffusion rate of 0.25 m^2/s was applied. A value of 0.10 cm^2/s was set for the vertical dispersion coefficient to account for the influence of turbulence within the water column, as well as wave-induced turbulence. These values are based on previous experience and informed by studies by Copeland (1996).

2.4.3.5 Reporting Thresholds

The three-dimensional plume model (MUDMAP) can track and predict sediment concentrations and thicknesses to very low levels that may not be of practical and ecological significance. Woodside has not defined impact indicators for sedimentation or suspended sediments to apply to this investigation. In lieu, RPS has adopted the criteria defined in the following Sections.

2.4.3.5.1 Sediment Thickness

Based on available literature, a threshold of 6.5 mm was used to define the ecological impact exposure level for this study (Table 2.14). The threshold used is supported by studies from Trannum et al. (2009), which found significant decrease in species count, abundance of individuals, and biomass of marine animals which deposited cuttings 3-24 mm in thickness. Furthermore, a study by Kjeilen-Eilertsen et al. (2004) report that depositional thicknesses greater than 9.6 mm are likely to cause smothering impacts on benthic ecosystems, including corals. A study by Smit et al. (2008) established that a thickness threshold of greater than 6.5 mm would be needed before potential harm to benthic macrofauna occur.

As a conservative measure, a thickness of 0.1 mm was employed as a minimum reporting threshold for the modelling results (Table 2.14).

Table 2.14 Criteria for analysis of exposure in the discharge scenarios.

Component	Parameter	Thresholds
Seabed	Thickness (mm)	Lowest reportable deposition: 0.1 mm Ecological impact: 6.5 mm

2.4.3.5.2 Total Suspended Solids Concentrations

The minimum reporting threshold for TSS concentrations used for this study is 1 mg/L (Table 2.15). Nelson et al. (2016) reports <10 mg/L as a minimal or ‘no effect’ concentration, while concentrations above 10 mg/L have a sublethal effect of pelagic biota. Furthermore, IGOP (2016) cite that very high concentrations (>1,830 mg/L) of TSS have been shown to result in mortality of pelagic biota. Hence, a threshold of 10 mg/L or above was used to define the ecological impact TSS exposure level in this study (Table 2.15).

Table 2.15 Criteria for analysis of exposure in the discharge scenarios.

Component	Parameter	Thresholds
Water column	Total suspended solids (TSS; mg/L)	TSS area of influence: 1-3 mg/L Ecological impact: 10 mg/L

3 MODELLING RESULTS

3.1 Overview

The aims of this study were to:

- Quantify the movement and fate of discharged drill cuttings and unrecoverable drilling fluids that would result from drilling activities in terms of extents of coverage and seabed deposition (thickness and concentration).
- Investigate the risk to submerged sensitive receptors posed by the discharges.

Results are presented for calculations of dispersion and transport for each of the near-field and far-field phases to address these aims.

3.2 Near-Field Modelling (CORMIX)

3.2.1 Discussion of Results

Results of the near-field modelling are presented separately for:

- Releases of continuous discharge of drill cuttings (longer term with attached drilling fluids).
- Pit dump fluid discharged from the MODU at end-of-section (short term episodes for drilling fluid particles only).
- Management of fluids though dilute-and-dump operations (short term episodes for drilling fluid particles only).

While near-field seasonal modelling was carried out for each of the well intervals/sections to be drilled and the drilling fluid dump operations, only annualised modelling results for the 17.5” production casing section and associated drilling fluid dump operations are presented in Section 3.2.

3.2.1.1 Continuous Discharge

Near-field modelling of the 17.5” production casing section drilling operation indicates that the continuous discharge of drill cuttings and drilling fluids would have sufficient momentum to induce a velocity plume intruding into the receiving water and that the geometry and initial dilution of the plume would vary with the prevailing current speed (Figure 3.1 to Figure 3.3; Table 3.1).

Drill cuttings discharged during the 17.5” production casing section drilling operation will consist of relatively large particles (91.02%, ranging from 0.5-4 mm) that will have high fall velocities (7.3-25.4 cm/s). In contrast, particles contributed by drilling fluids will primarily be very fine silts and clay particles (65.7%, >3.9 µm) that will have extremely small fall velocities by comparison (<0.003 cm/s) and will be more subject to turbulent dispersion in the water column if they suspend from attachment to particles.

Near-field simulation of continuous discharge of drill cuttings and drilling fluids indicated that the initial geometry and dilution of the discharge plume would be greatly affected by the prevailing current because the discharge rate (0.019 m/s; Section 2.3.3.1) would be lower than the ambient velocity, which would result in wake-flow conditions that are characterised by unsteady (patchy) plumes with high instantaneous concentrations at the point source. The near-field model calculated that there would be no discharge momentum to induce mixing.

The near-field model calculated that the plume would remain negatively buoyant relative to the receiving water (i.e., denser than the receiving water) and would sink subject to deflection by the prevailing current. The rate of deflection would decrease, and the plume would sink faster under slower current. Stronger current would deflect the sinking plume further from the source. The sinking plume would increase in diameter through entrainment of ambient water until either the plume achieves neutral buoyancy or sinks to the seabed.

Modelling indicated that under all current conditions the plume was arrested when the seafloor layer boundary was reached, and buoyancy reversal occurred in the bottom density current. The maximum horizontal distance before buoyancy reversal occurred was calculated to increase as a function of current speed. The maximum distance is calculated to increasing by an order of magnitude over speeds ranging from the 5th to 95th percentile.

Similar patterns are indicated in the calculations for midline dilution of the plume at the end of the near-field phase. Dilutions under annualised conditions ranged from 7,176 to 86,679 dilutions, increasing with current speed (and hence also distance).

3.2.1.2 Dilute-and-Dump Discharge

Near-field modelling of dilute-and-dump operations indicates that the discharge would have sufficient momentum to induce a velocity plume intruding into the receiving water and that the geometry and initial dilution of the plume would vary with the prevailing current speed (Figure 3.4 to Figure 3.6; Table 3.2).

The plume movement would be dominated by momentum of the discharge jet that will be deflected by the ambient currents. The turbulence generated by the momentum of the jet would begin entraining ambient water, within metres of the source and within seconds to minutes of discharge. Once downward momentum is lost, the fate of the plume will depend upon the relative buoyancy as the dominating factor. The near-field model calculated that the plume would remain negatively buoyant relative to the receiving water (i.e., denser than the receiving water) and would sink subject to deflection by the prevailing current. The rate of deflection would decrease, and the plume would sink faster under slower current. Stronger current would deflect the sinking plume further from the source. The sinking plume would increase in diameter through entrainment of ambient water until either the plume achieves neutral buoyancy or sinks to the seabed.

Modelling indicated that under all current conditions the plume was arrested when the seafloor layer boundary was reached, and buoyancy reversal occurred in the bottom density current. The maximum horizontal distance before buoyancy reversal occurred was calculated to increase as a function of current speed. The maximum distance is calculated to increasing by an order of magnitude over speeds ranging from the 5th to 95th percentile.

Similar patterns are indicated in the calculations for midline dilution of the plume at the end of the near-field phase. Dilutions under annualised conditions ranged from 4,828 to 60,381 dilutions, increasing with current speed (and hence also distance).

3.2.1.3 Pit Dump Discharge

Near-field modelling of pit dump operations indicates that the discharge would have sufficient momentum to induce a velocity plume intruding into the receiving water and that the geometry and initial dilution of the plume would vary with the prevailing current speed (Figure 3.7 and Figure 3.8; Table 3.3).

The plume movement would be dominated by momentum of the discharge jet that will be deflected by the ambient currents. The turbulence generated by the momentum of the jet would begin entraining ambient water, within metres of the source and within seconds to minutes of discharge. Once downward momentum is lost, the fate of the plume will depend upon the relative buoyancy as the dominating factor. The near-field model calculated that the plume would remain negatively buoyant relative to the receiving water (i.e., denser than the receiving water) and would sink subject to deflection by the prevailing current. The rate of deflection would decrease, and the plume would sink faster under slower current. Stronger current would deflect the sinking plume further from the source. The sinking plume would increase in diameter through entrainment of ambient water until either the plume achieves neutral buoyancy or sinks to the seabed.

Modelling indicated that under all current conditions the plume was arrested when the seafloor layer boundary was reached, and buoyance reversal occurred in the bottom density current. The maximum horizontal distance before buoyance reversal occurred was calculated to increase as a function of current speed. The maximum distance is calculated to increasing by an order of magnitude over speeds ranging from the 5th to 95th percentile.

Similar patterns are indicated in the calculations for midline dilution of the plume at the end of the near-field phase. Dilutions under annualised conditions ranged from 1,024 to 11,442 dilutions, increasing with current speed (and hence also distance).

3.2.2 Results – Tables

3.2.2.1 Annualised

Table 3.1 Near-field (CORMIX) results for the drill cuttings and drilling fluids (continuous) scenario from a 20 m discharge under three different current speeds – 0.069, 0.253 and 0.539 m/s (P_5, P_{50} and P_{95}) – under annualised ambient conditions.

Outlet discharge depth (m)		20	
Current percentile (P)	**P_5**	**P_{50}**	**P_{95}**
Current speed (m/s)	**0.069**	**0.253**	**0.539**
Vertical phase (jet module)			
Horizontal distance reached in the jet phase (m)	28.45	233.74	718.8
Maximum plume diameter (m)	13.24	21.24	20.82
Plunge depth (m) from the surface	63.38	59.38	59.59
Time to reach the end of the jet phase (s)	164.7	844.5	1,312.9
Dilution rate at end of the jet phase (X)	7,176	42,876	86,679
Possible centreline TSS concentration at end of jet phase (mg/L)	79.2	13.3	6.6
Spreading phase (spreading module)			
Horizontal distance reached in the spreading phase (m)	41.69	254.98	739.59
The plume half-width (y-axis spread) (m)	16.43	20.97	20.43
Time to reach the end of the spreading phase (s)	356.5	928.4	1,351
Dilution rate at end of the spreading phase (X)	12,199	72,889	147,311
Possible centreline TSS concentration at end of spreading phase (mg/L)	46.6	7.8	3.9

Table 3.2 Near-field (CORMIX) results for the drilling fluids (dilute-and-dump) scenario from a 20 m discharge under three different current speeds – 0.069, 0.253 and 0.539 m/s (P_5, P_{50} and P_{95}) – under annualised ambient conditions.

Outlet discharge depth (m)		**20**	
Current percentile (P)	**P_5**	**P_{50}**	**P_{95}**
Current speed (m/s)	**0.069**	**0.253**	**0.539**
Vertical phase (jet module)			
Horizontal distance reached in the jet phase (m)	24.96	205.75	634.97
Maximum plume diameter (m)	12.50	21.22	20.90
Plunge depth (m) from the surface	63.75	59.39	59.55
Time to reach the end of the jet phase (s)	139.7	728.6	1,160.5
Dilution rate at end of the jet phase (X)	4,828	29,689	60,381
Possible centreline TSS concentration at end of jet phase (mg/L)	118.0	19.2	9.4
Spreading phase (spreading module)			
Horizontal distance reached in the spreading phase (m)	37.46	226.97	655.86
The plume half-width (y-axis spread) (m)	16.21	20.99	20.51
Time to reach the end of the spreading phase (s)	320.9	812.4	1.199.2
Dilution rate at end of the spreading phase (X)	8,208	50,472	102,639
Possible centreline TSS concentration at end of spreading phase (mg/L)	69.3	11.3	5.5

Table 3.3 Near-field (CORMIX) results for the drilling fluids (pit dump) scenario from a 20 m discharge under three different current speeds – 0.069, 0.253 and 0.539 m/s (P_5, P_{50} and P_{95}) – under annualised ambient conditions.

Outlet discharge depth (m)		20	
Current percentile (P)	P_5	P_{50}	P_{95}
Current speed (m/s)	0.069	0.253	0.539
Vertical phase (jet module)			
Horizontal distance reached in the jet phase (m)	11.21	83.60	273.65
Maximum plume diameter (m)	9.96	19.54	21.34
Plunge depth (m) from the surface	65.02	60.23	59.33
Time to reach the end of the jet phase (s)	62.0	223.2	474.3
Dilution rate at end of the jet phase (X)	1,024	4,861	11,442
Possible centreline TSS concentration at end of jet phase (mg/L)	555.0	117.0	49.7
Spreading phase (spreading module)			
Horizontal distance reached in the spreading phase (m)	N/A	103.13	295.00
The plume half-width (y-axis spread) (m)	N/A	20.02	21.04
Time to reach the end of the spreading phase (s)	N/A	300.4	513.9
Dilution rate at end of the spreading phase (X)	N/A	8,264	19,452
Possible centreline TSS concentration at end of spreading phase (mg/L)	N/A	68.8	29.2

3.2.3 Results – Figures

3.2.3.1 Annualised

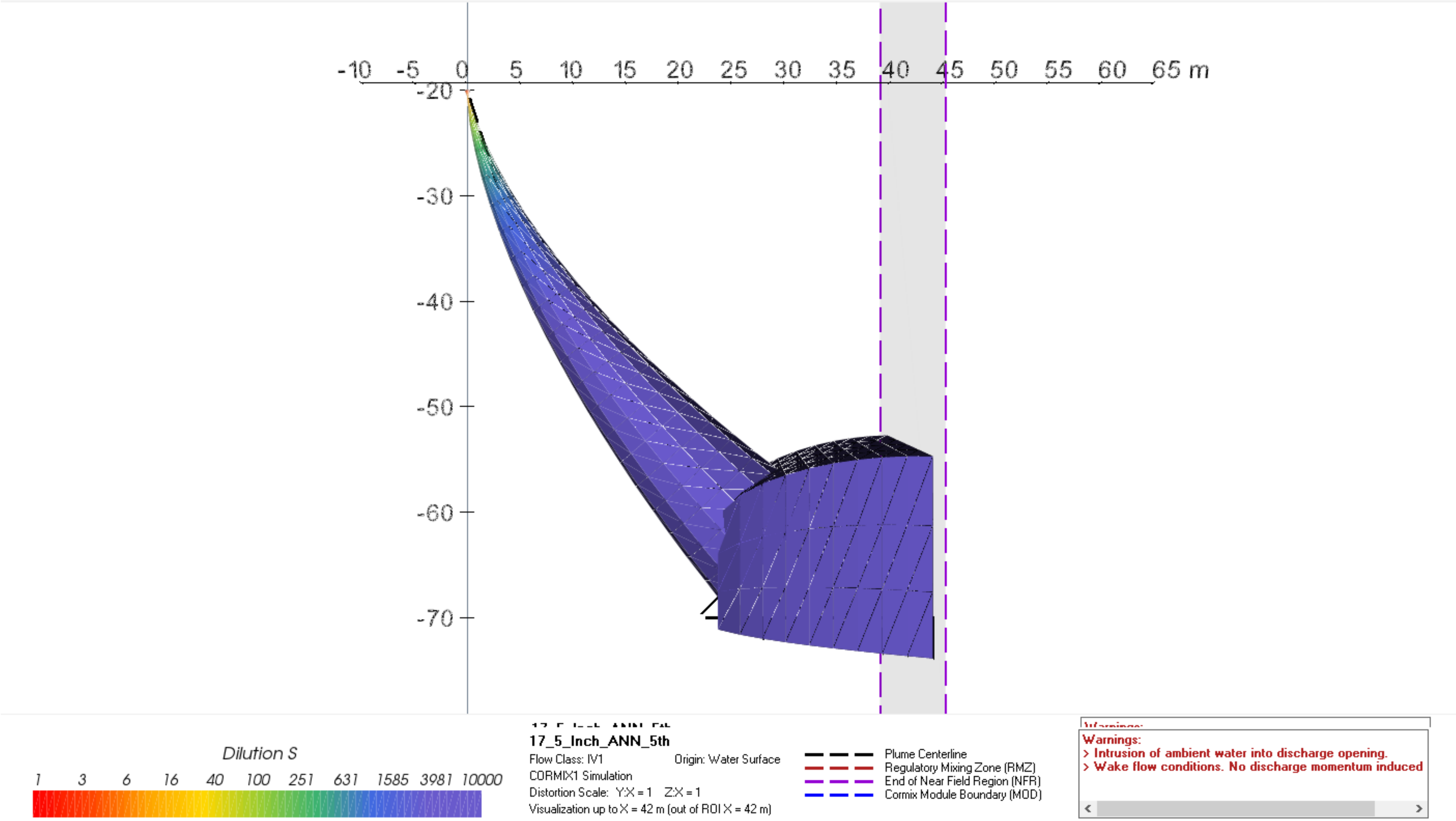


Figure 3.1 **Near-field dilutions calculated for a drill cuttings and drilling fluids (continuous) scenario, released at 20 m BMSL under annualised P_5 current speeds.**

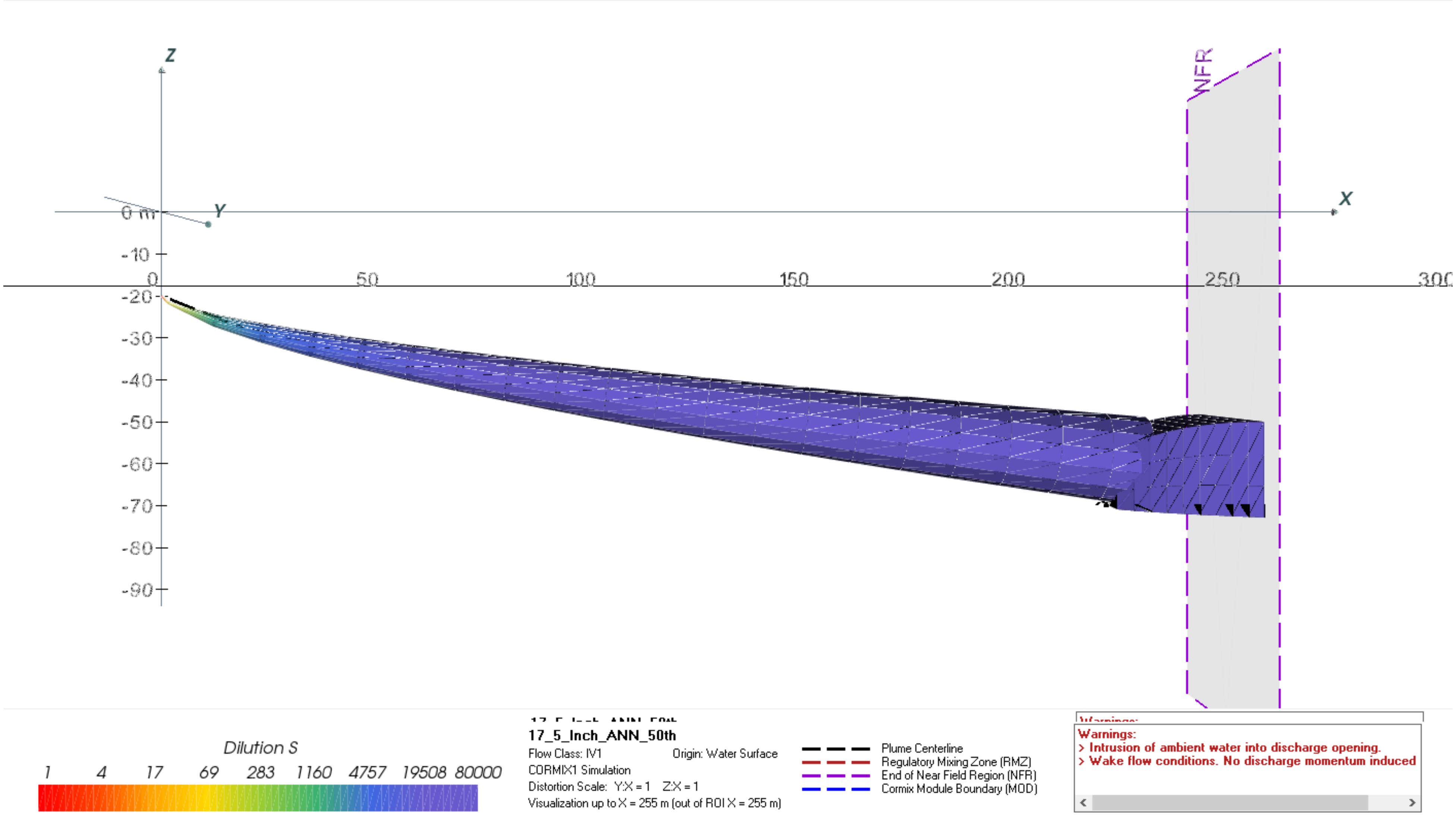


Figure 3.2 **Near-field dilutions calculated for a drill cuttings and drilling fluids (continuous) scenario, released at 20 m BMSL under annualised P_{50} current speeds.**

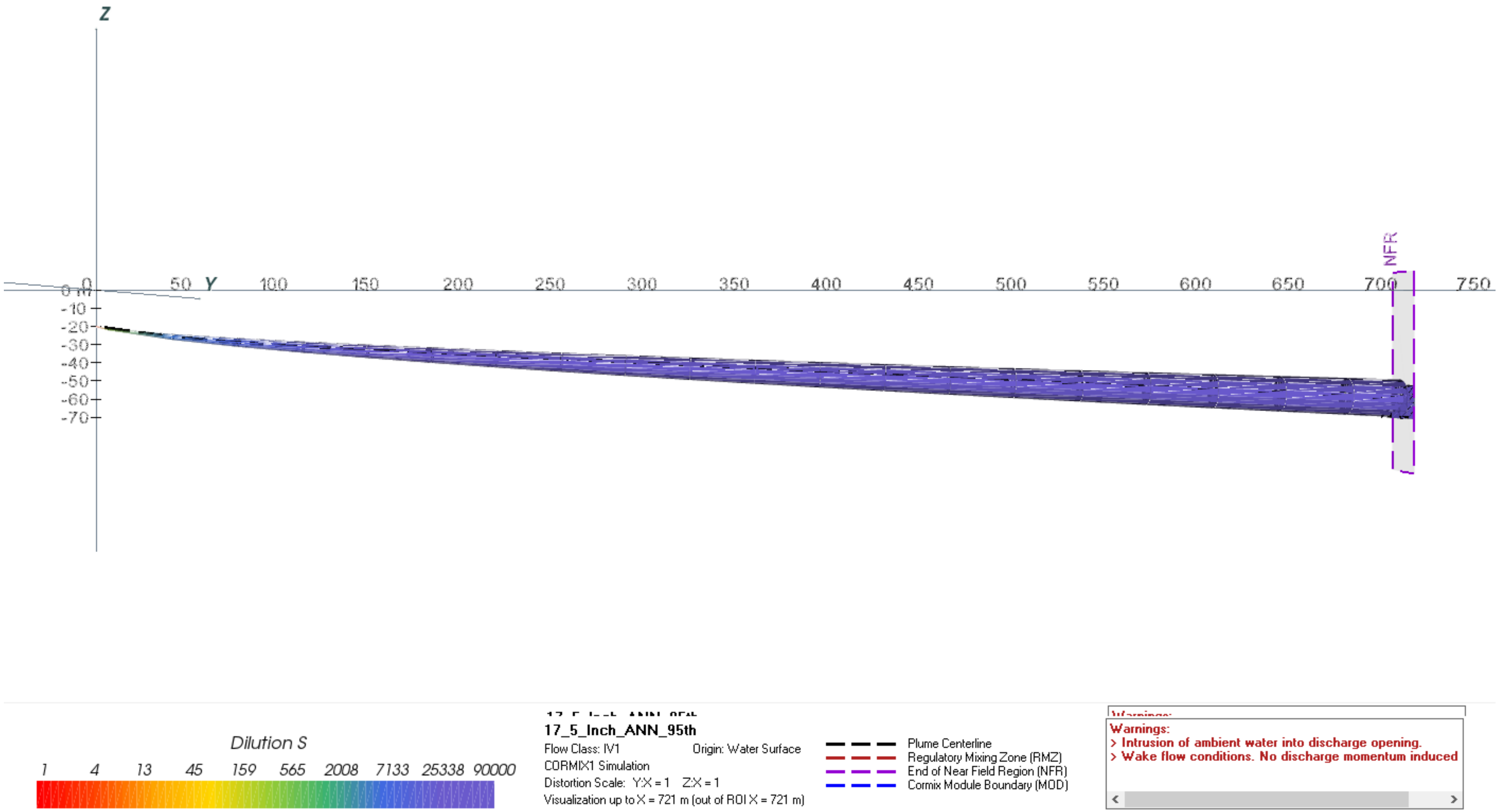


Figure 3.3 **Near-field dilutions calculated for a drill cuttings and drilling fluids (continuous) scenario, released at 20 m BMSL under annualised P_{95} current speeds.**

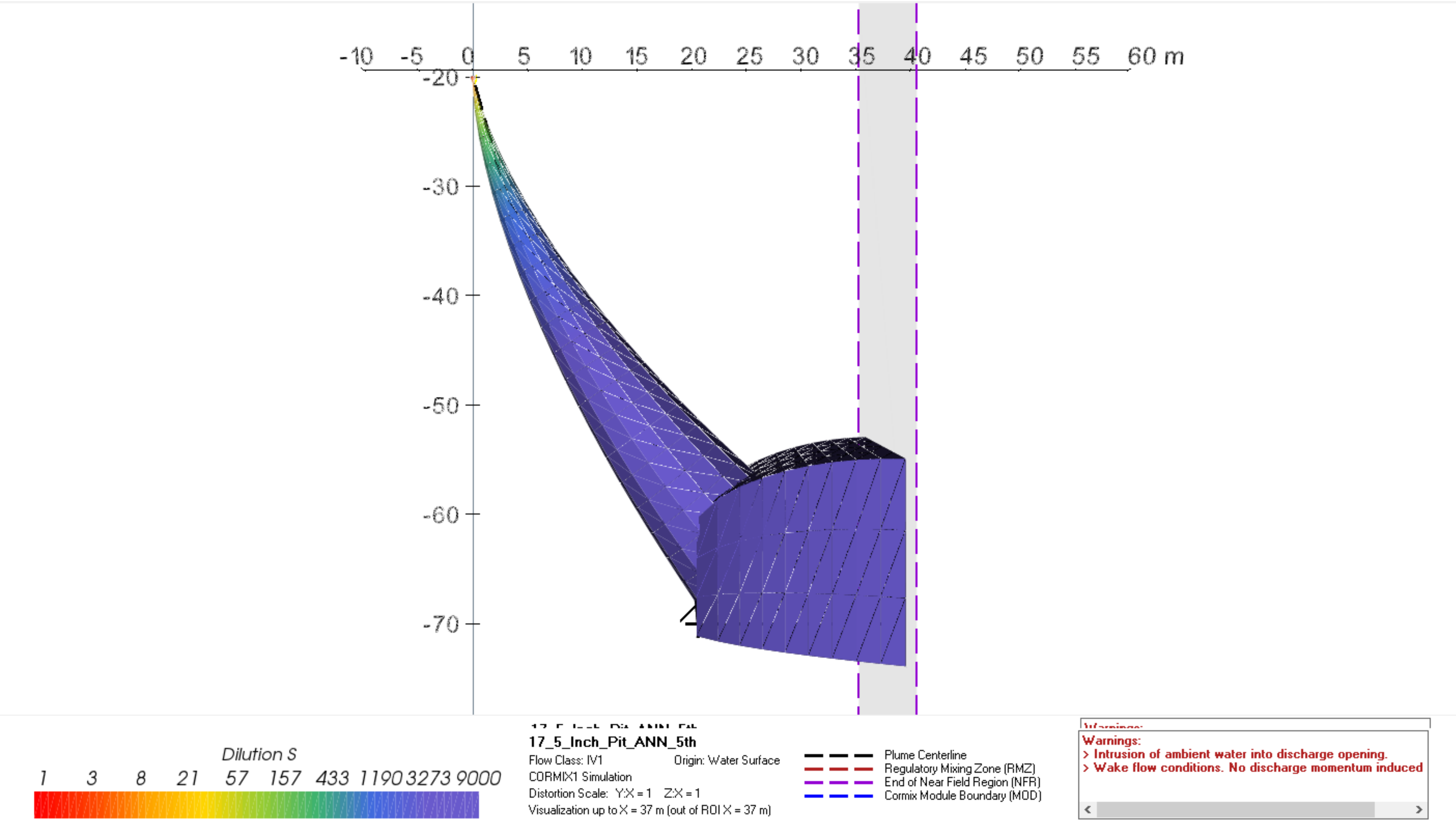


Figure 3.4 **Near-field dilutions calculated for a drilling fluids (dilute-and-dump) scenario, released at 20 m BMSL under annualised P_5 current speeds.**

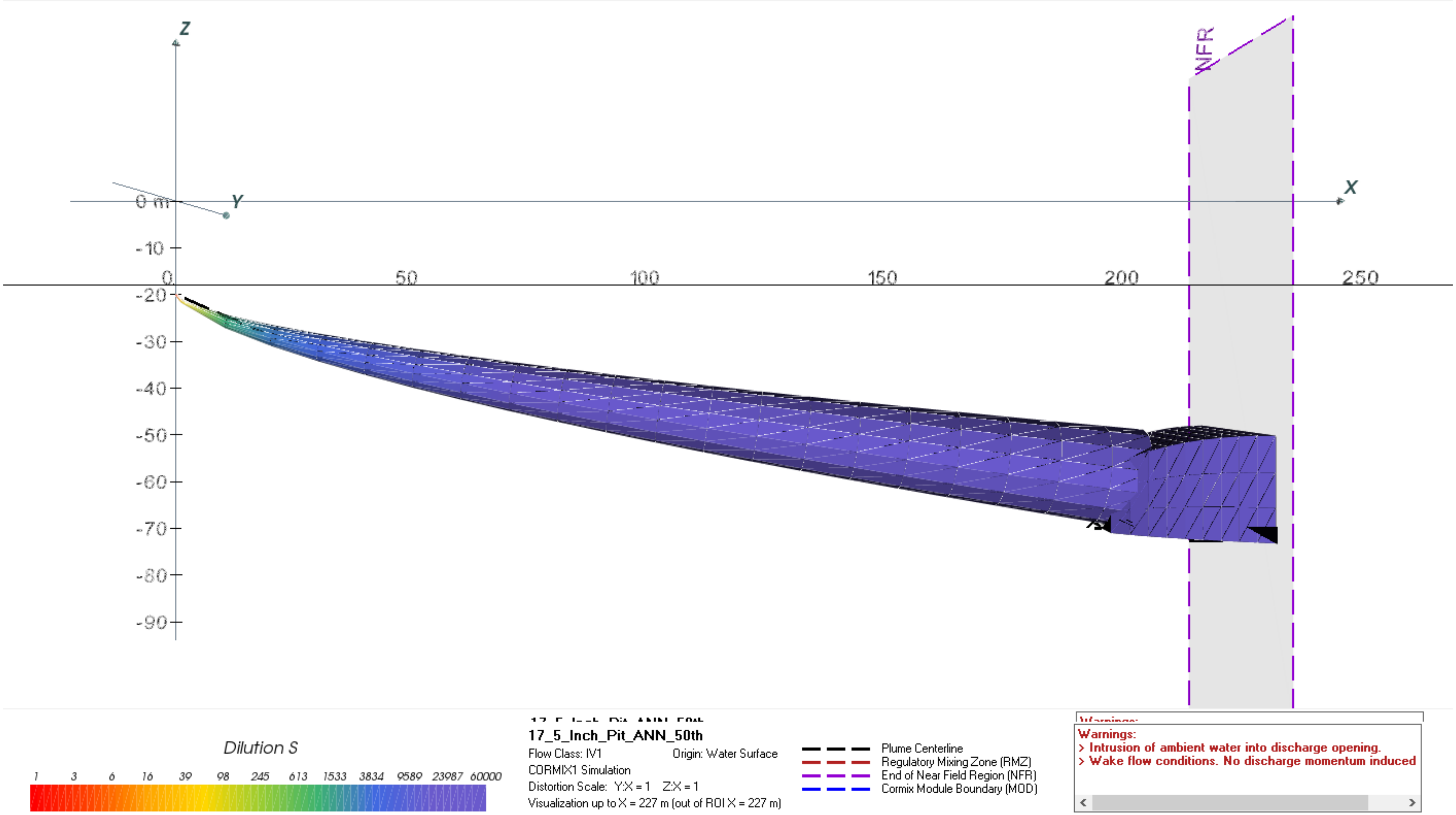


Figure 3.5 **Near-field dilutions calculated for a drilling fluids (dilute-and-dump) scenario, released at 20 m BMSL under annualised P_{50} current speeds.**

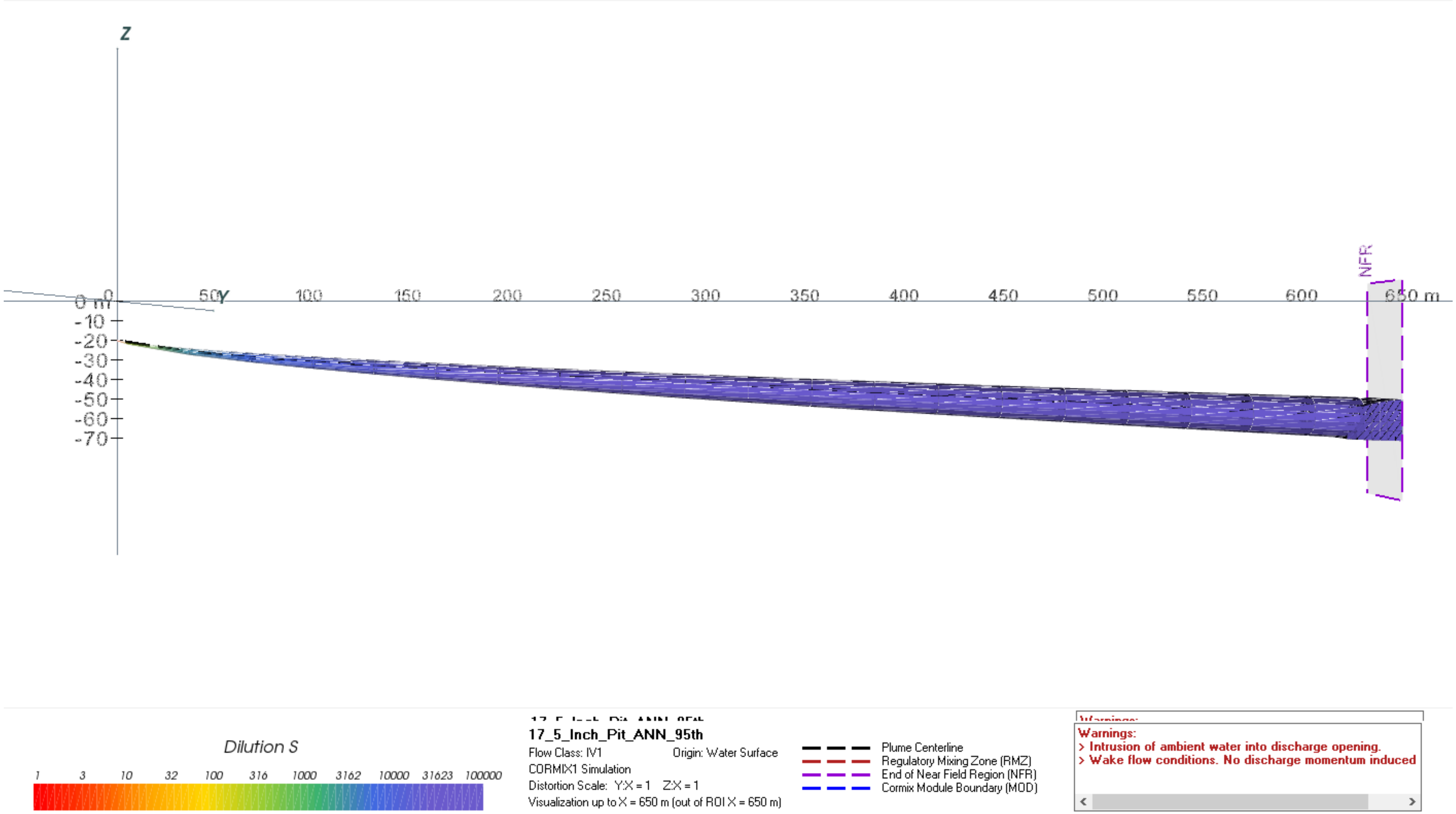


Figure 3.6 **Near-field dilutions calculated for a drilling fluids (dilute-and-dump) scenario, released at 20 m BMSL under annualised P_{95} current speeds.**

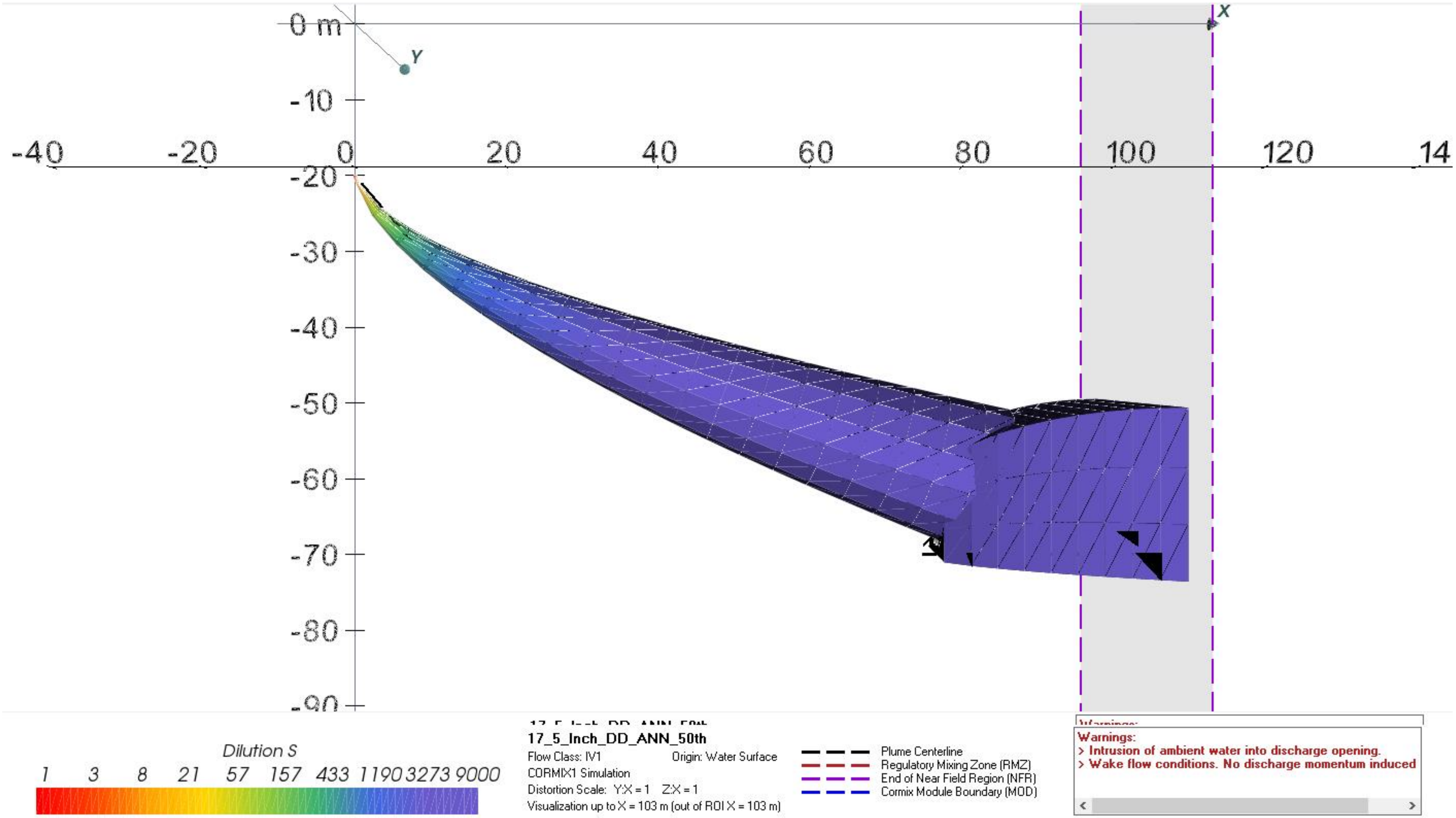


Figure 3.7 **Near-field dilutions calculated for a drilling fluids (pit dump) scenario, released at 20 m BMSL under annualised P_{50} current speeds.**

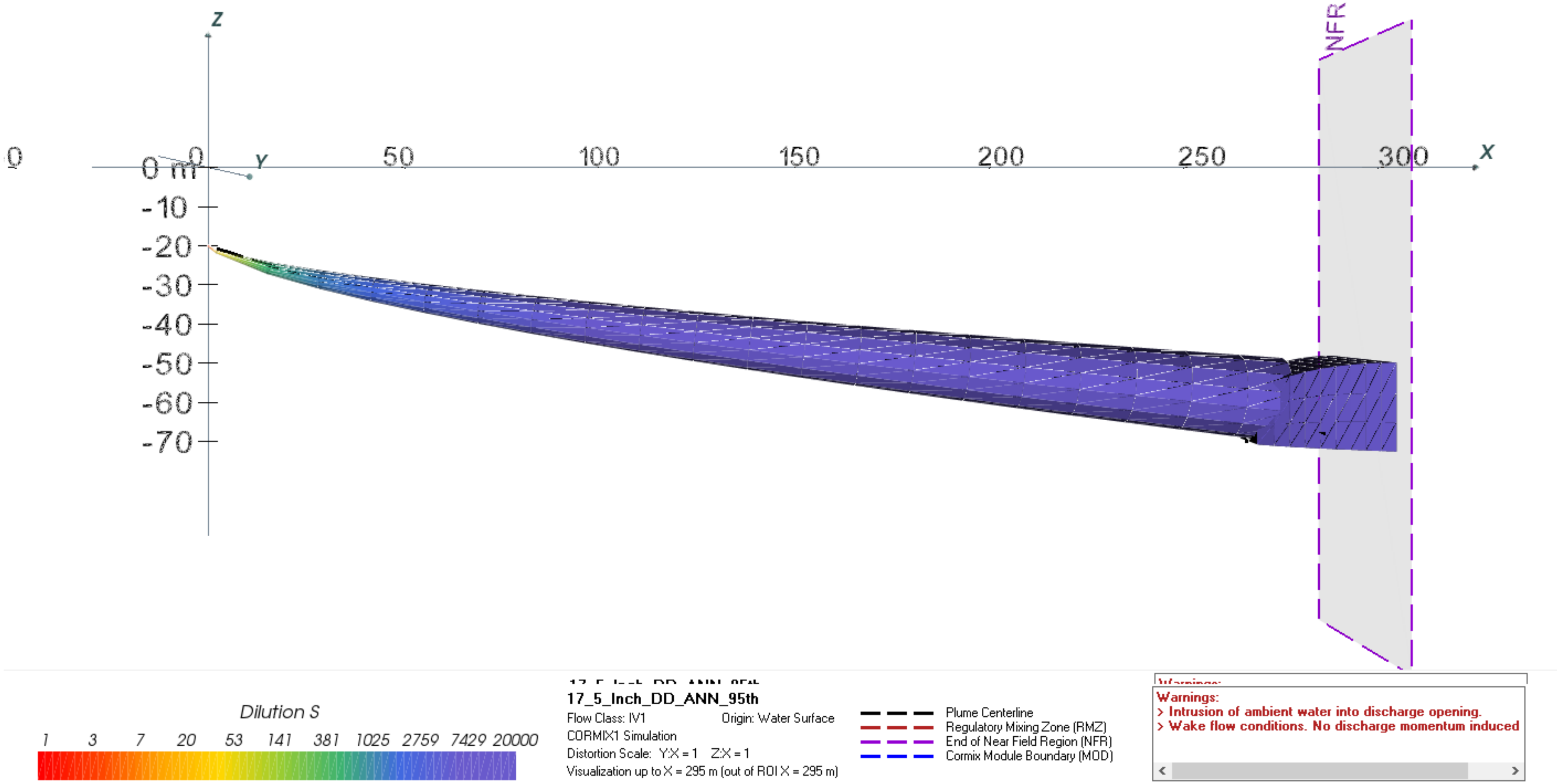


Figure 3.8 **Near-field dilutions calculated for a drilling fluids (pit dump) scenario, released at 20 m BMSL under annualised P_{95} current speeds.**

3.3 Far-Field Modelling (MUDMAP)

3.3.1 Overview

Outcomes of the far-field modelling and analysis are summarised in tables (Section 3.3.3) and distribution maps (Section 3.3.4) with results shown for the combined discharges of drill cuttings and drilling fluids. Within each section, summaries are further broken down into separate outcomes for sedimentation and suspended sediment concentrations.

All results are summarised for the more extreme values that were calculated over time. Results are presented as:

- Highest 95th and 99th percentile values over time in any simulation for the stochastic simulations.

The 95th percentile values would not be exceeded more than 5% of the time while the 99th percentile values would not be exceeded more than 1% of the time. By simulating for more varied conditions, the highest 95th and 99th percentile values from stochastic modelling will tend to identify more extreme (higher) values than the deterministic simulations. Annualised results then provide a summary of the worst-case (highest values for the 95th and 99th percentiles) from among the stochastic modelling for seasonal effects.

3.3.2 Stochastic Analysis

Calculations for sedimentation due to the combined outcomes of the continuous discharges, dilute-and-dump and pit dump operations for all well intervals reflect the combined findings. Local sedimentation will occur as a mound around the well site, with the major contribution by larger sediments (fine sand and larger) released by continuous discharges, while finer, slower sinking particles that represent a proportion of the sediment release by continuous discharge would disperse more widely with the prevailing current. The finer particles that make up the larger proportion of the dilute-and-dump and pit dump operations would also disperse widely with the prevailing current. Prevailing currents will be due to a combination of tidal and ocean drift currents. While the tidal currents are highly predictable and will follow an ellipse, with the main axis orientated west-north-west to east-south-east with reversal of the tide at approximately 6-hour intervals, the drift currents will be more variable and can persist over longer time scales.

The thickness of the deposits generated by settling of these particles is calculated to decrease exponentially with distance from the drilling centre, with the maximum thickness calculated around the drilling centre. Relatively thin deposits were calculated for the deposition footprint. Stochastic modelling under randomly selected sequences of current for each season indicated that most of the sediment released by continuous discharges will settle out over an elliptical area with a long axis aligned with the tidal currents (Figure 3.9 to Figure 3.16). The stochastic modelling indicated similar dimensions for the main mound, irrespective of the season. These outcomes indicate a high reliability for the calculation of the main deposition area, without specific controls on the season, tidal phase, tidal direction, or tidal speed. The potential for thin (0.1 mm) deposits of sediment to settle out at distances > 1,000 m is very low in all seasons at either the 95th or 99th percentile (Table 3.4).

Calculations for the distribution of suspended sediments released during drilling operations indicate that concentrations exceeding 10 mg/L might extend ~100-150 m from the source up to 5% of the time and ~2,000 m from the source up to 1% of the time. Concentrations exceeding 1 mg/L were calculated to extend ~10,000-12,000 m from the source up to 1% of the time (Table 3.5).

Maps summarising the more extreme concentrations of suspended sediments calculated at any depth for the stochastic simulations (Figure 3.17 to Figure 3.24) indicate a distribution that generally conforms to the main deposition mound and is also aligned with the tidal axis at higher water column concentrations.

3.3.3 Results – Tables

3.3.3.1 Calculations for Sedimentation

Table 3.4 Calculations for the maximum thickness, area of coverage above thickness thresholds, and maximum distance to these thresholds resulting from the combined cuttings and drilling fluids discharge. Results are calculated from stochastic modelling and show the more extreme values calculated at any time in any one simulation. Annualised results summarise the most extreme values in any season.

Season	Depth BMSL (m)	Maximum bottom thickness (mm)	Total area of coverage (km^2) above threshold		Maximum distance (m) from well to threshold	
			0.1 mm	6.5 mm	0.1 mm	6.5 mm
Stochastic Results						
Highest 95th percentile value						
Summer	20	67.3	0.26	0.05	923.2	192.7
Winter		69.7	0.29	0.04	599.3	221.5
Transitional		66.8	0.27	0.04	627.6	181.3
Annualised		69.7	0.33	0.05	923.2	221.5
Highest 99th percentile value						
Summer	20	71.2	0.27	0.05	923.2	192.7
Winter		72.6	0.29	0.04	599.3	221.5
Transitional		68.7	0.27	0.04	627.6	181.3
Annualised		72.6	0.33	0.05	923.2	221.5

‘- ‘Indicates threshold not exceeded.

3.3.3.2 Calculations for Total Suspended Sediment Concentration

Table 3.5 Calculations for the maximum water column concentration, area of coverage above the defined thresholds, and maximum distance to these thresholds resulting from continuous discharge. Results are calculated from stochastic modelling and show the more extreme values calculated at any time in any one simulation. Annualised results summarise the most extreme values in any season.

Season	Depth BMSL (m)	Maximum water column concentration (mg/L)	Total area of coverage (km^2) above threshold			Maximum distance (m) from well to threshold		
			1 mg/L	3 mg/L	10 mg/L	1 mg/L	3 mg/L	10 mg/L
Stochastic Results								
Highest 95th percentile value								
Summer	20	69.5	12.00	2.40	0.02	5,209.7	2,926.7	103.2
Winter	20	69.1	13.06	1.62	0.01	8,150.0	1,938.2	103.2
Transitional	20	84.4	17.93	2.20	0.02	8,186.2	2,569.2	142.6
Annualised	20	84.4	20.81	3.31	0.02	8,186.2	2,926.7	142.6
Highest 99h percentile value								
Summer	20	196.8	49.72	11.02	0.11	12,056.9	8,937.1	393.9
Winter	20	178.1	49.25	10.60	0.08	11,957.2	7,301.6	1,310.5
Transitional	20	197.0	46.65	11.53	0.22	10,305.0	8,133.2	1,920.4
Annualised	20	197.0	66.00	17.69	0.26	12,056.9	8,937.1	1,920.4

‘- ‘indicates threshold not exceeded.

3.3.4 Results – Figures

3.3.4.1 Calculations for Sedimentation

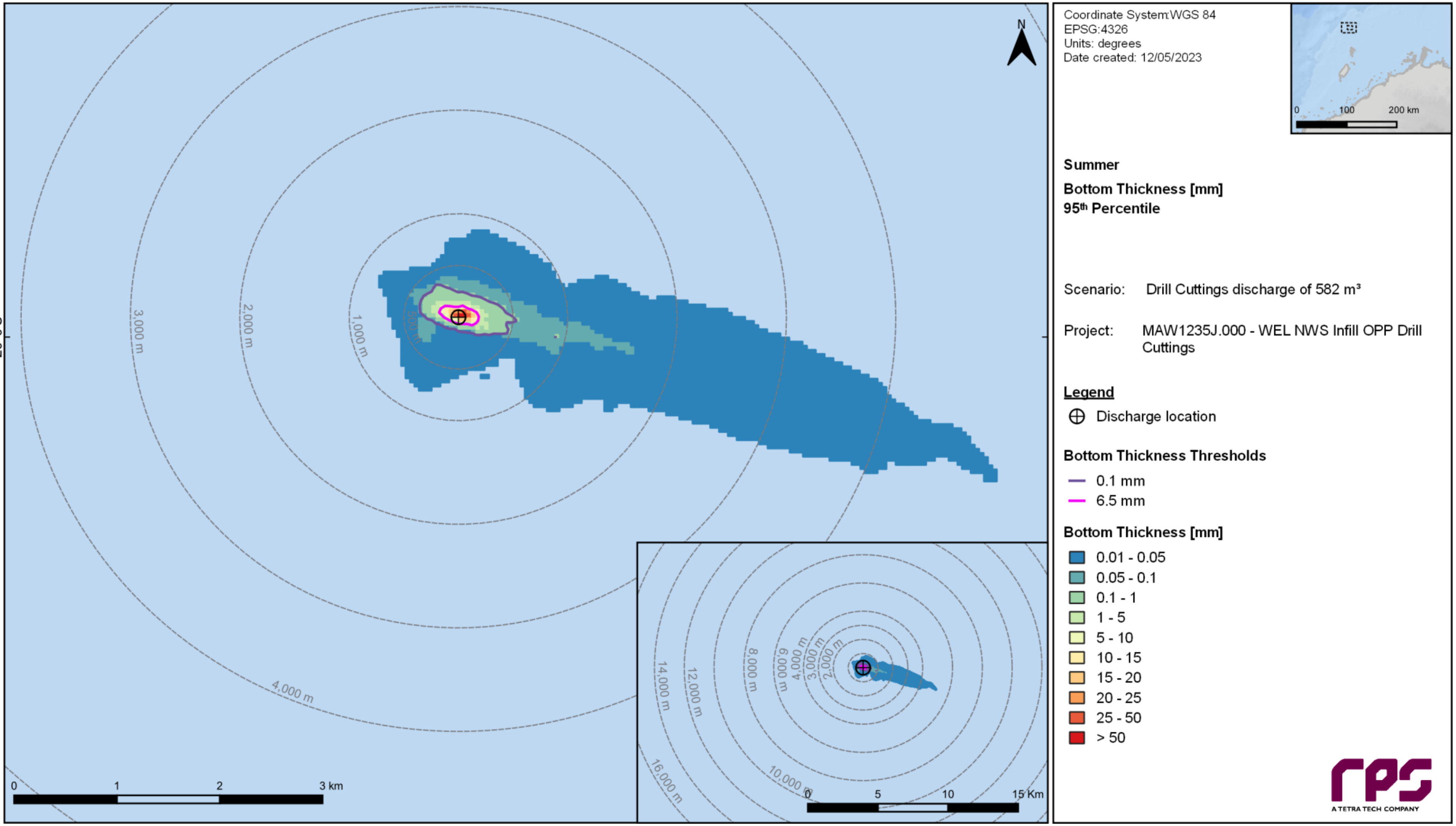


Figure 3.9 **Calculations of extreme sediment thickness for locations due to continuous discharges under summer conditions. Results show the 95th percentile values for each model grid cell.**

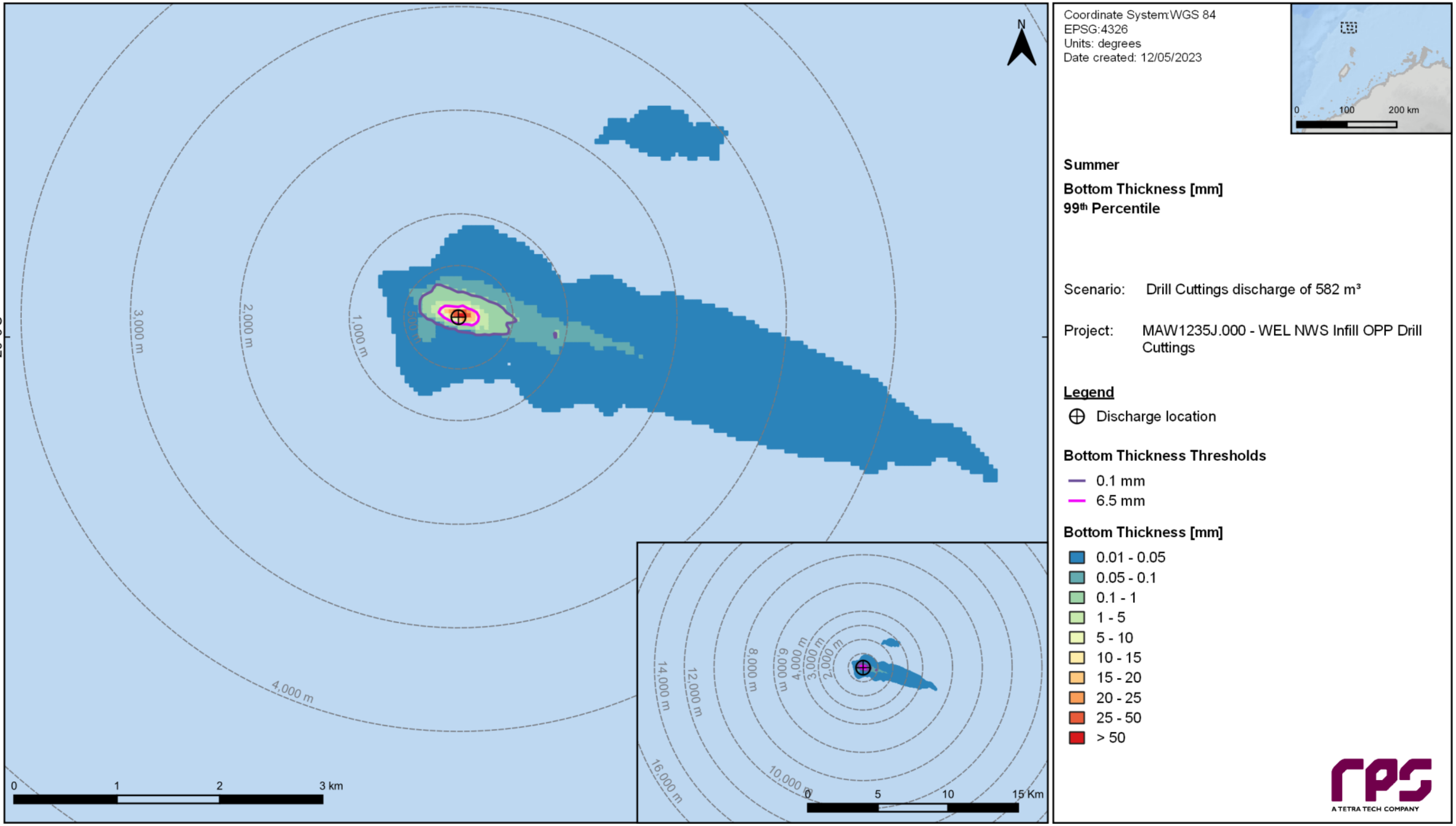


Figure 3.10 Calculations of extreme sediment thickness for locations due to continuous discharges under summer conditions. Results show the 99th percentile values for each model grid cell.

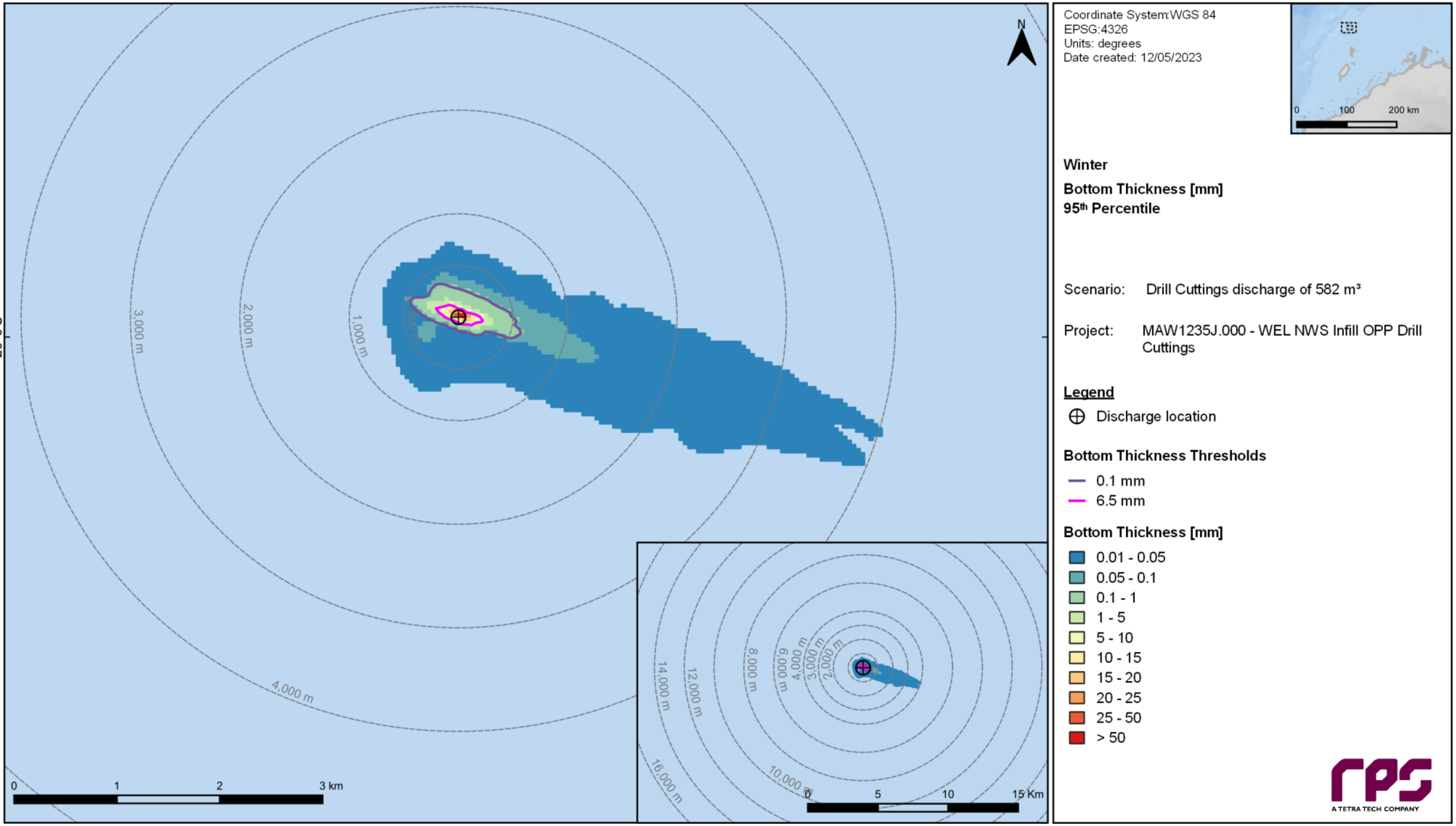


Figure 3.11 Calculations of extreme sediment thickness for locations due to continuous discharges under winter conditions. Results show the 95th percentile values for each model grid cell.

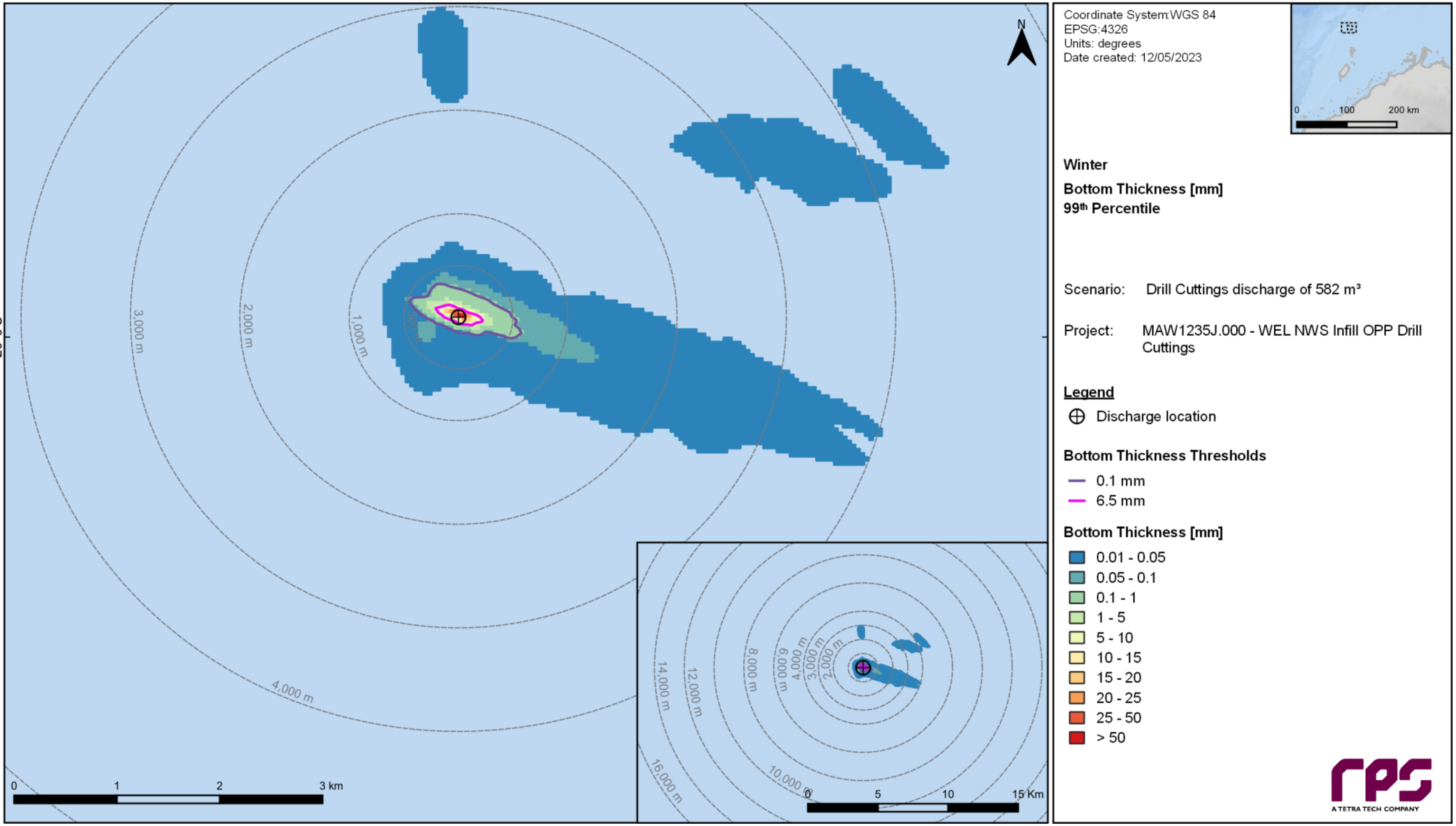


Figure 3.12 **Calculations of extreme sediment thickness for locations due to continuous discharges under winter conditions. Results show the 99th percentile values for each model grid cell.**

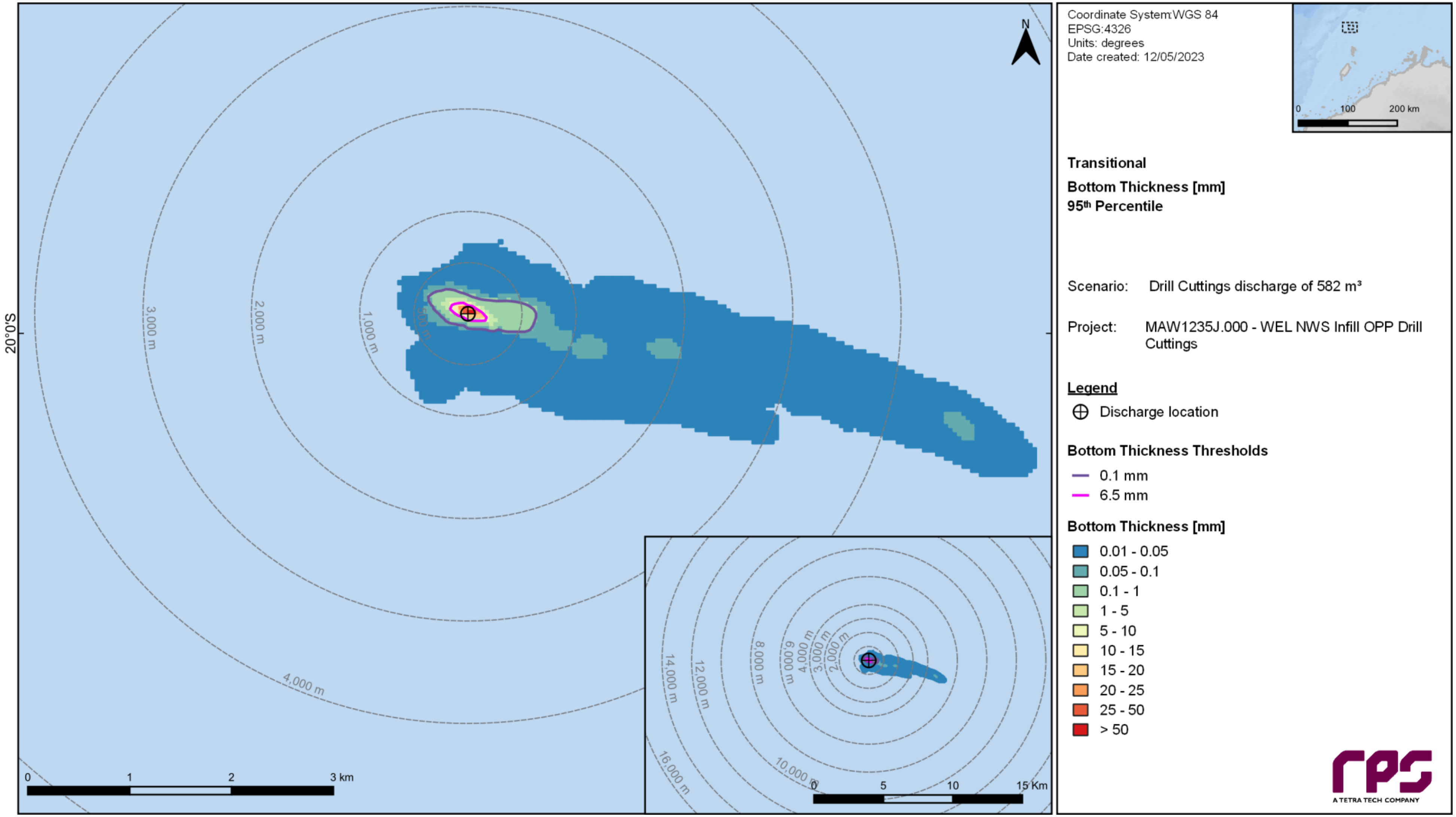


Figure 3.13 Calculations of extreme sediment thickness for locations due to continuous discharges under transitional conditions. Results show the 95th percentile values for each model grid cell.

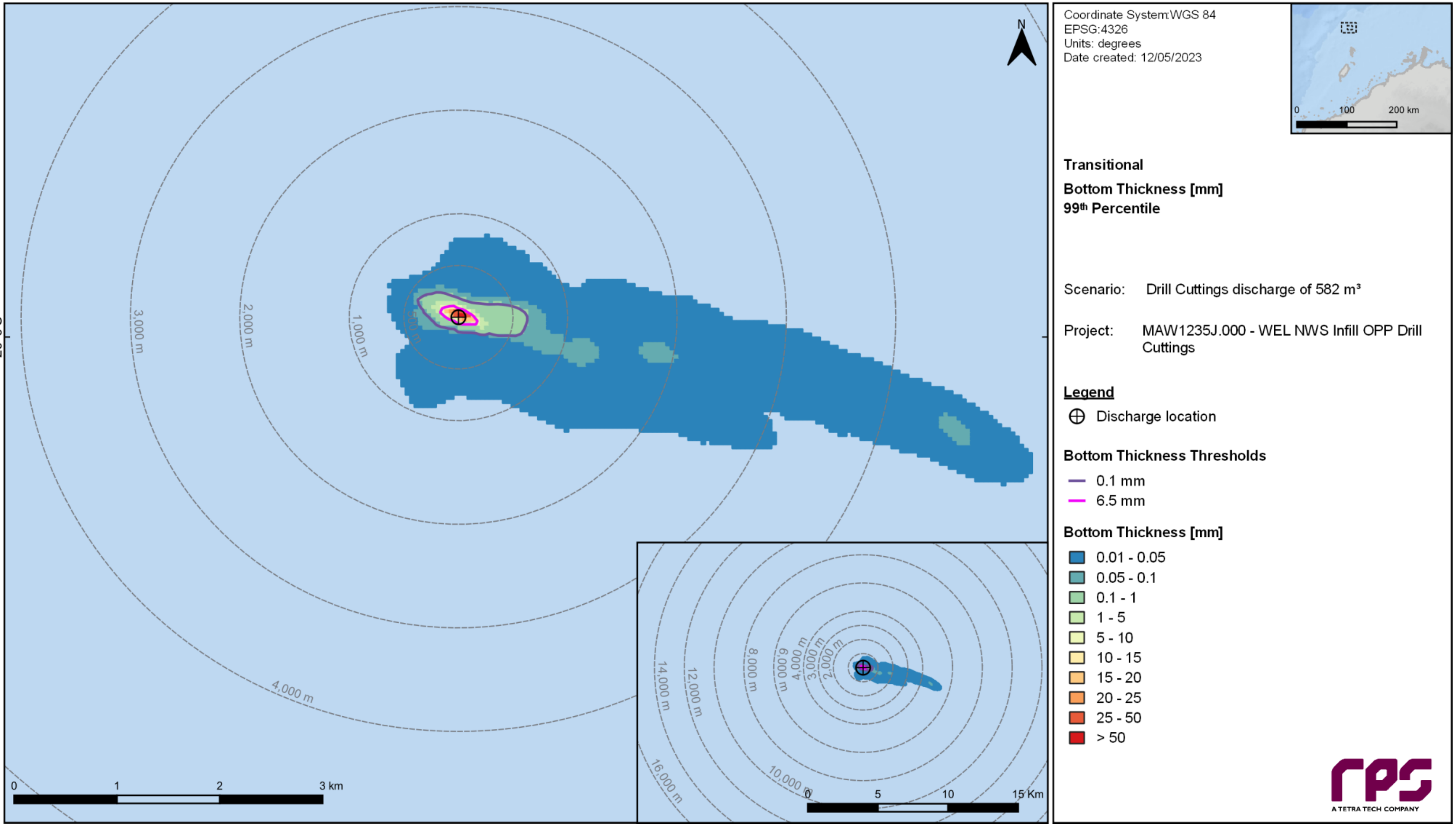


Figure 3.14 Calculations of extreme sediment thickness for locations due to continuous discharges under transitional conditions. Results show the 99th percentile values for each model grid cell.

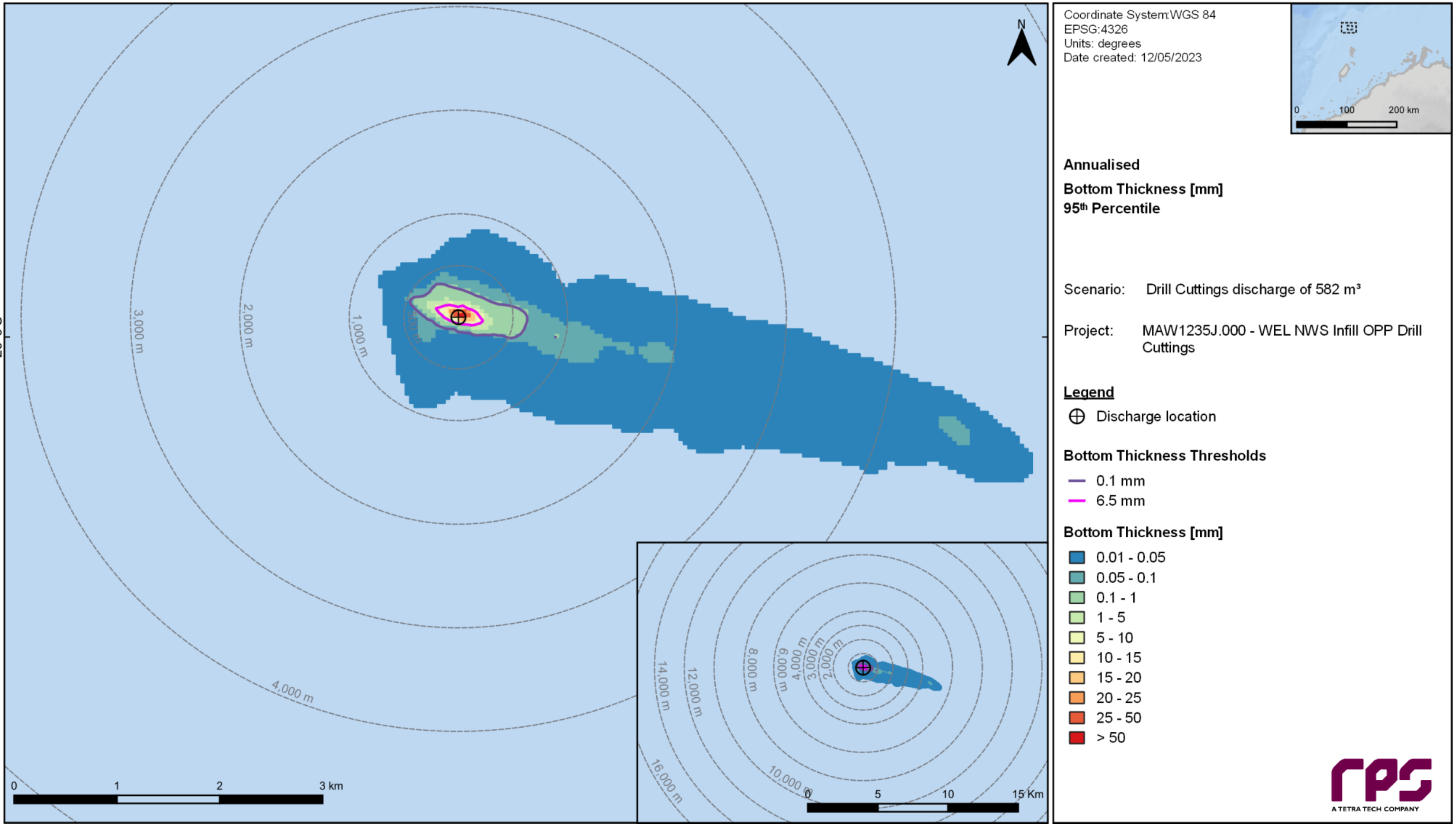


Figure 3.15 Calculations of extreme sediment thickness for locations due to continuous discharges under annualised conditions. Results show the 95th percentile values for each model grid cell.

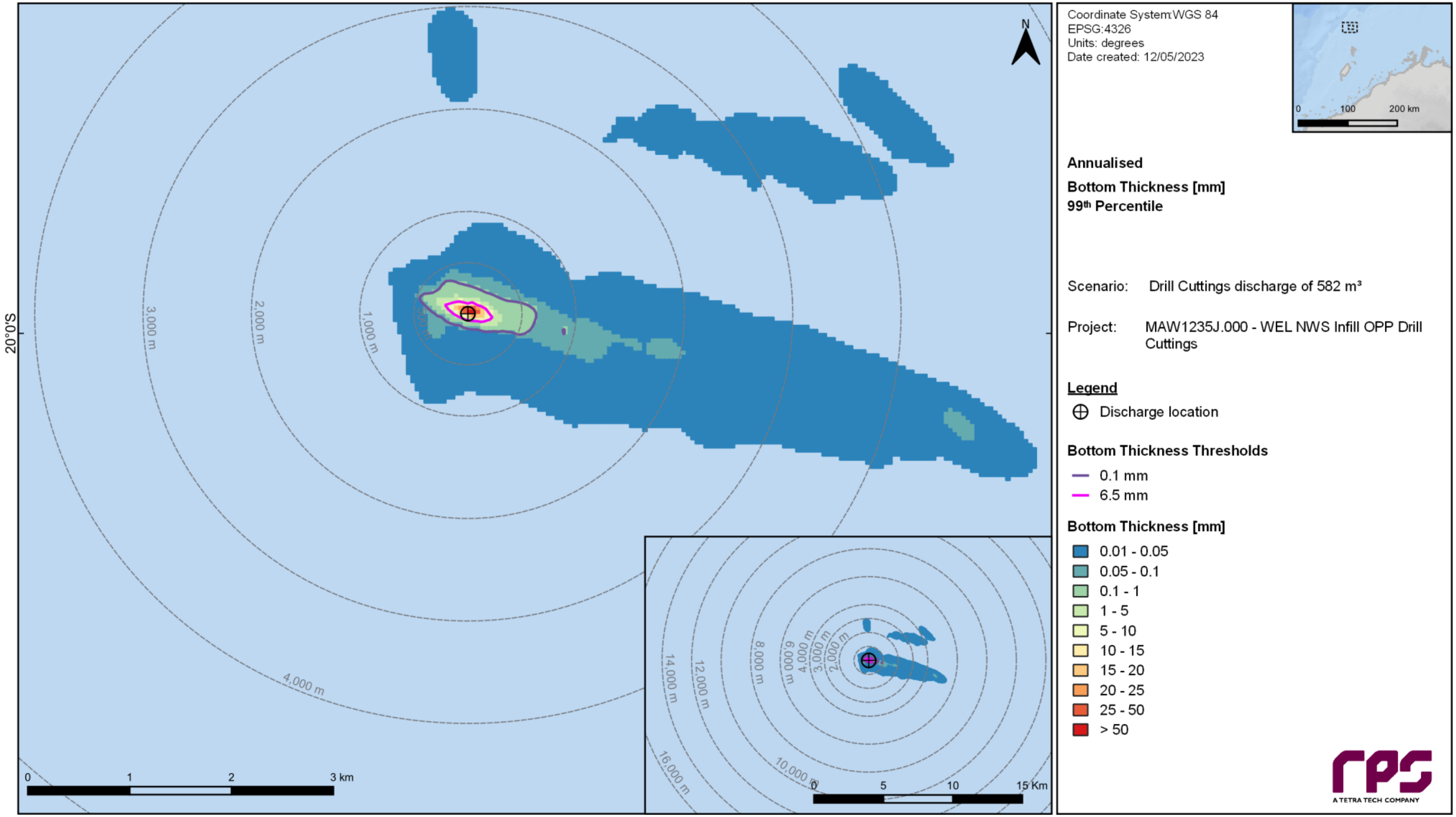


Figure 3.16 **Calculations of extreme sediment thickness for locations due to continuous discharges under annualised conditions. Results show the 99th percentile values for each model grid cell.**

3.3.4.2 Calculations for Total Suspended Sediment Concentration

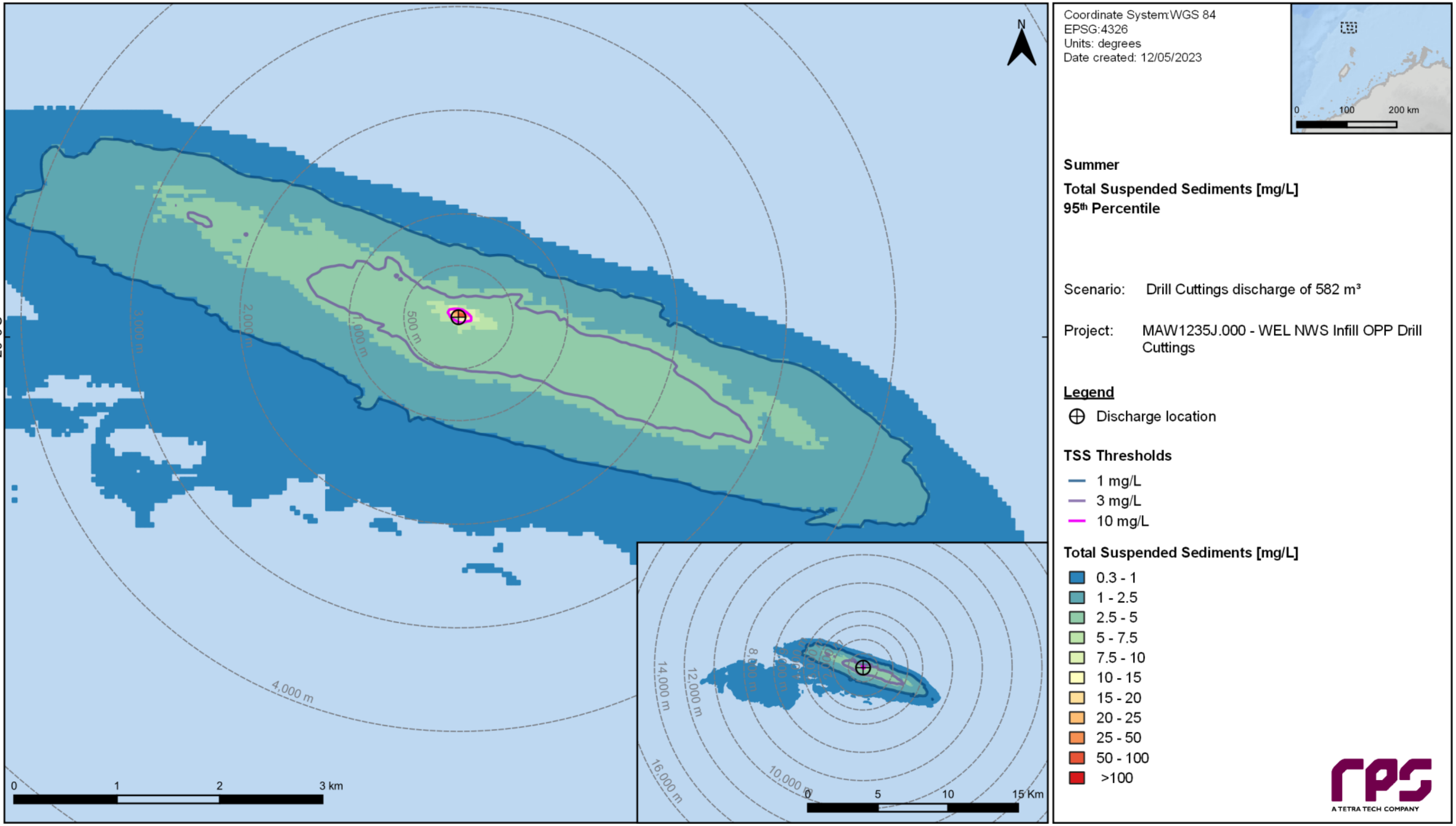


Figure 3.17 **Calculations of extreme water column concentration for locations due to continuous discharges under summer conditions. Results show the 95th percentile values for each model grid cell.**

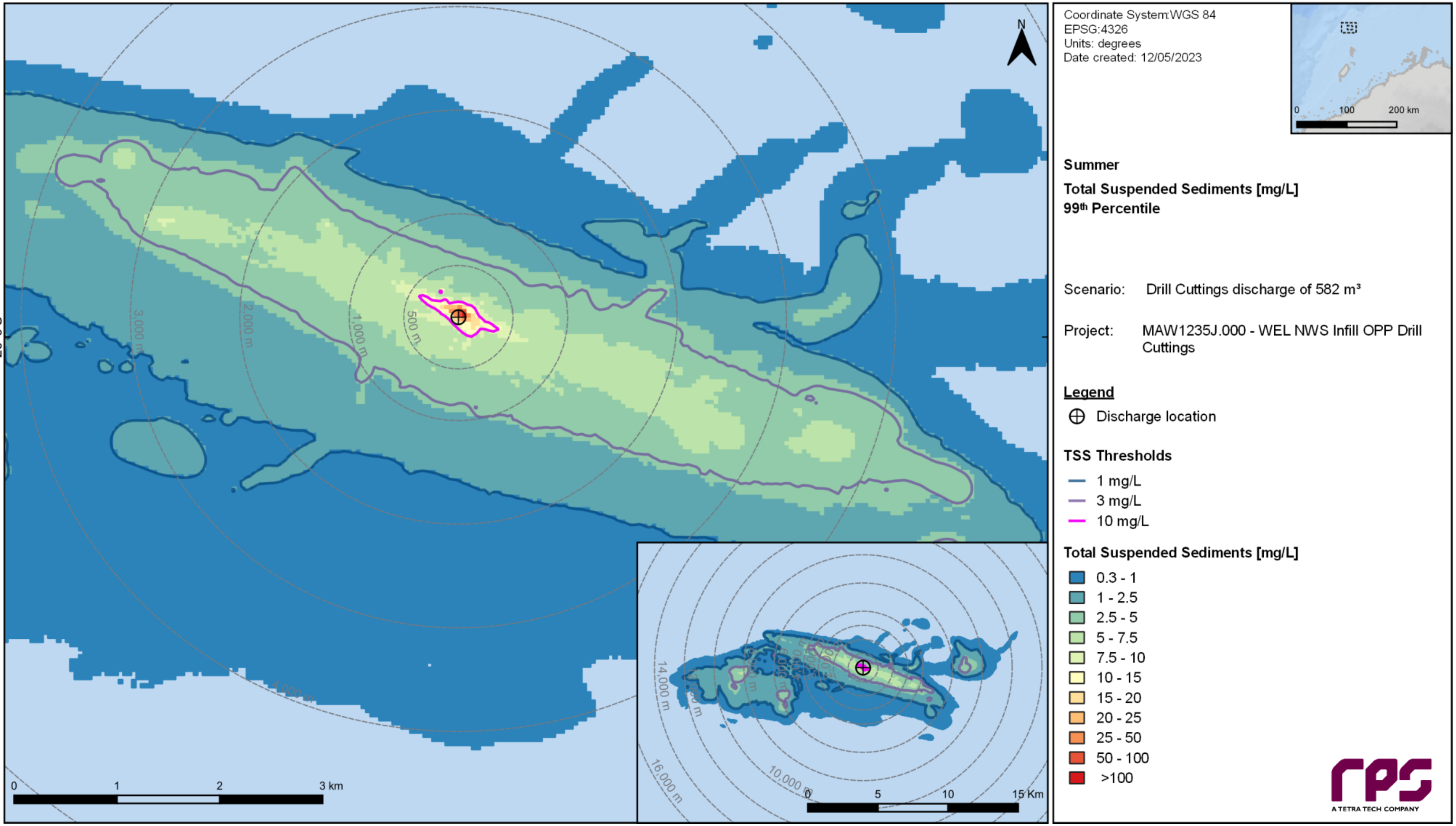


Figure 3.18 **Calculations of extreme water column concentration for locations due to continuous discharges under summer conditions. Results show the 99th percentile values for each model grid cell.**

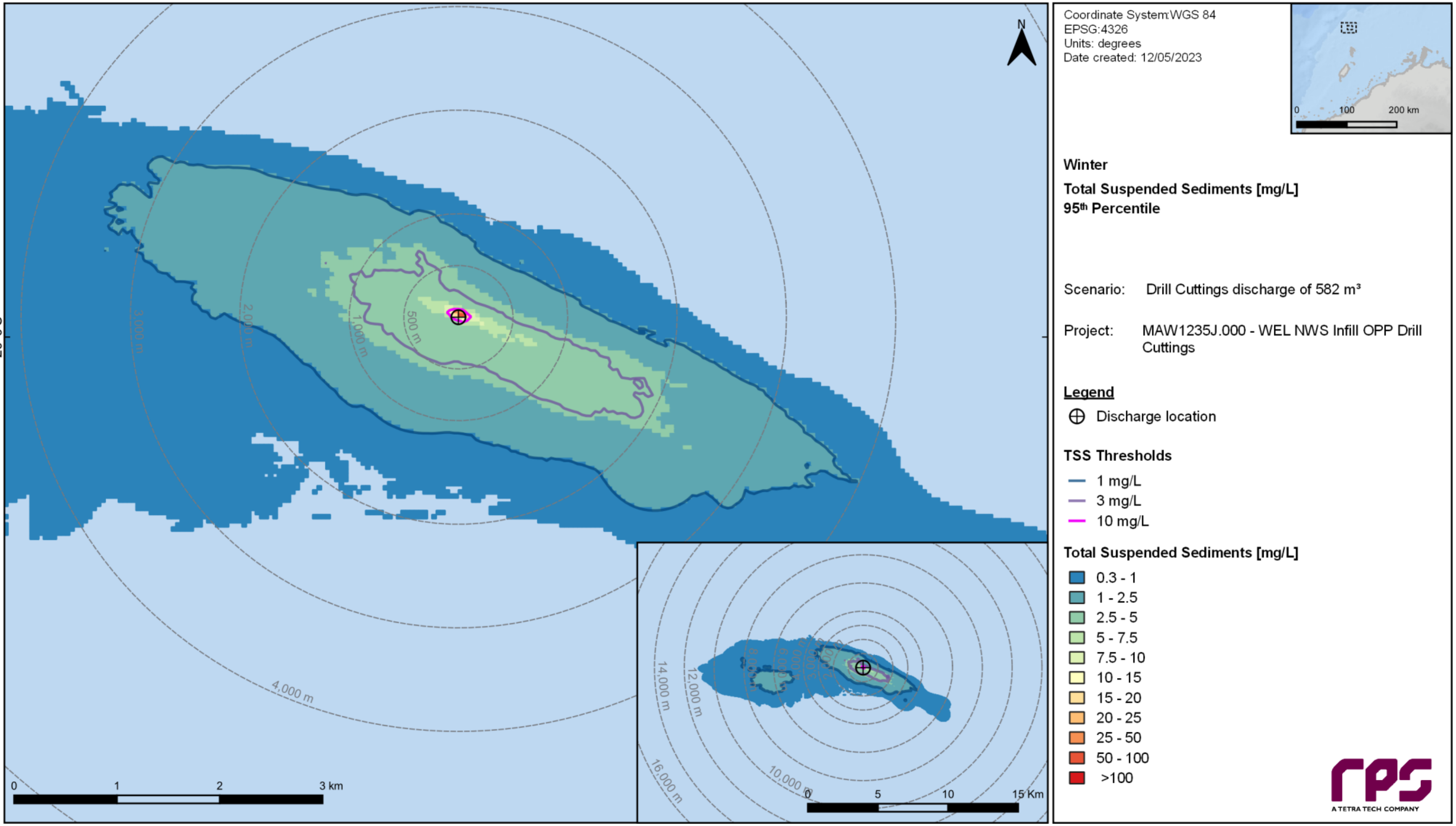


Figure 3.19 Calculations of extreme water column concentration for locations due to continuous discharges under winter conditions. Results show the 95th percentile values for each model grid cell.

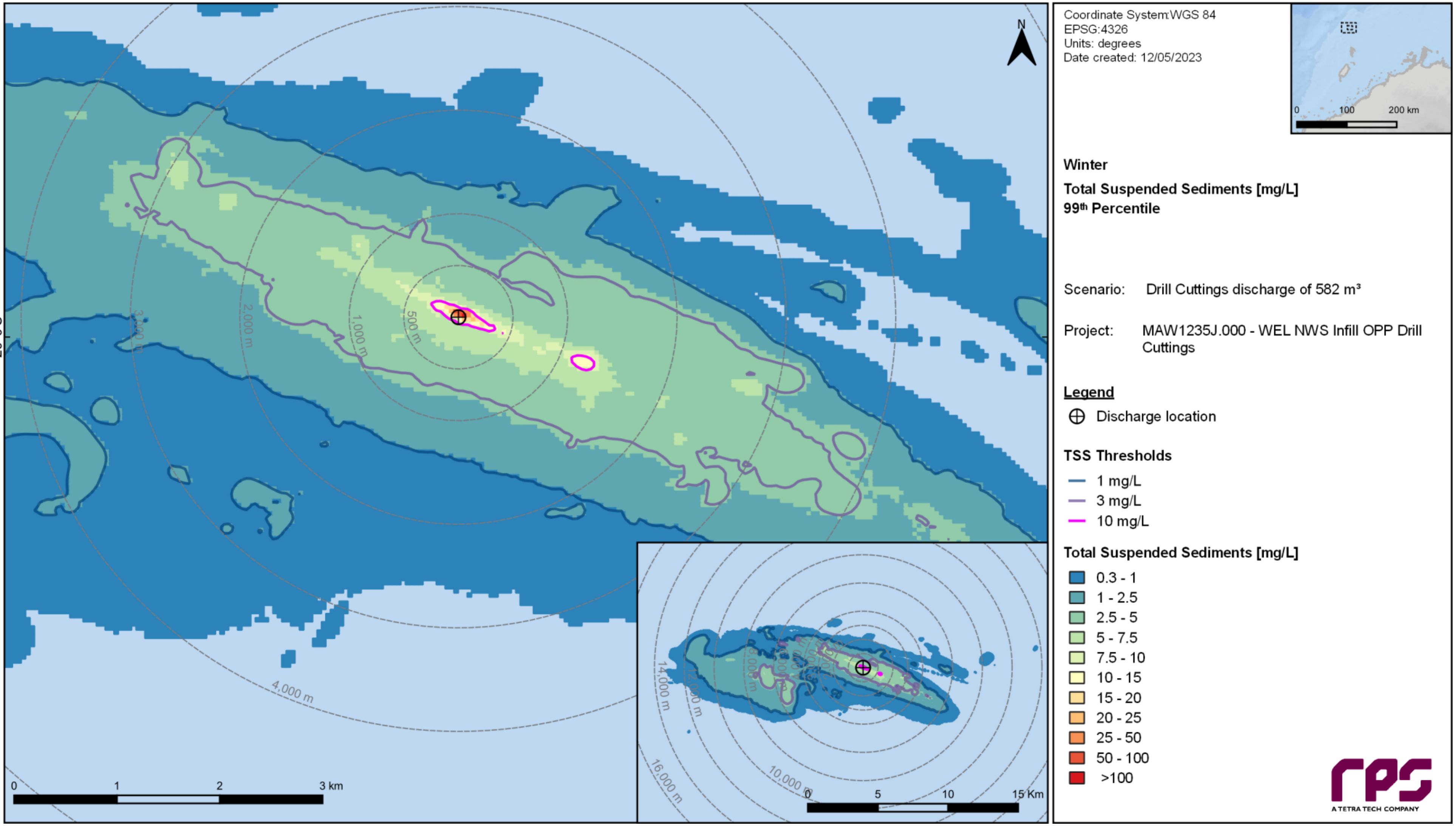


Figure 3.20 Calculations of extreme water column concentration for locations due to continuous discharges under winter conditions. Results show the 99th percentile values for each model grid cell.

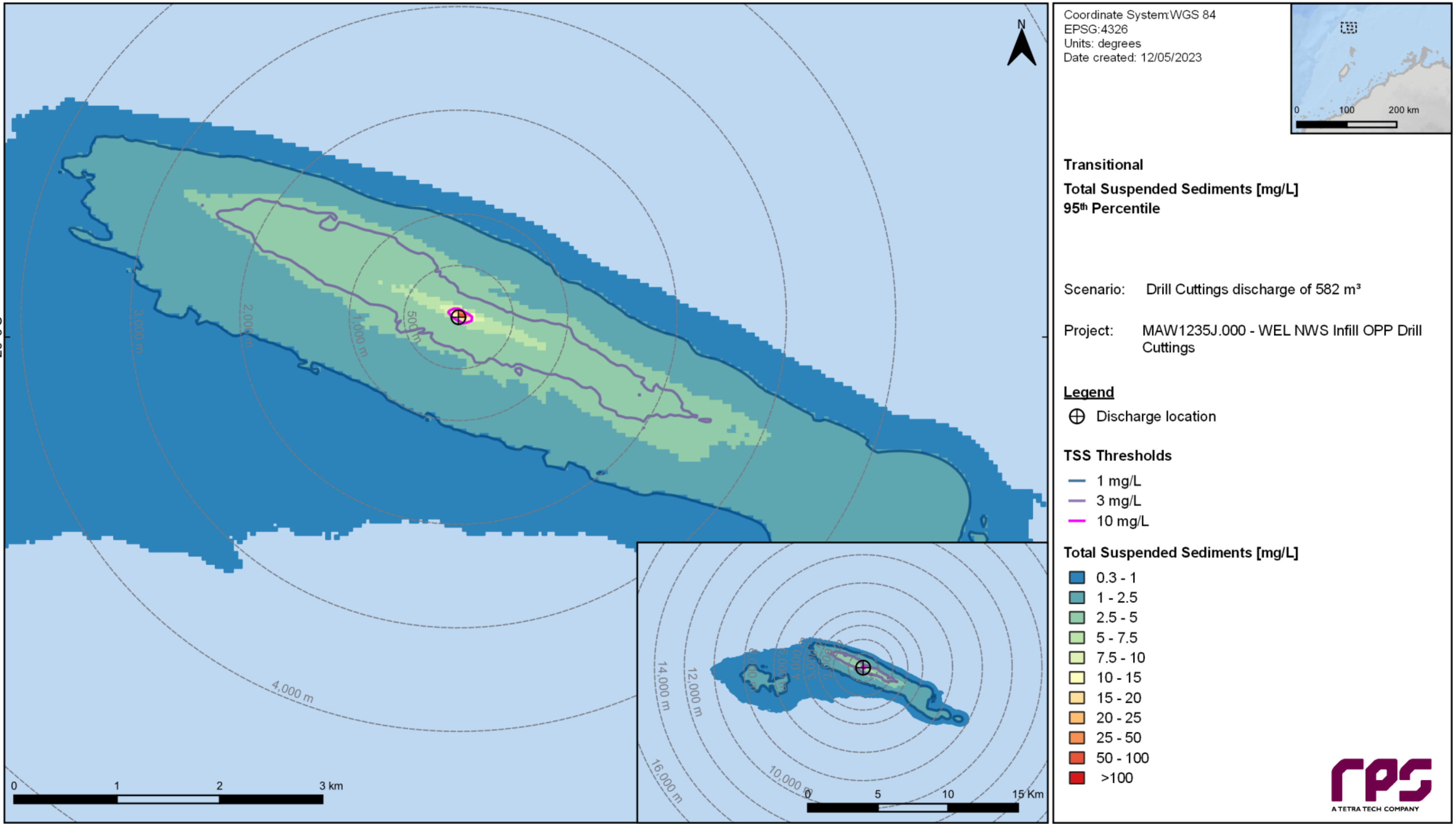


Figure 3.21 **Calculations of extreme water column concentration for locations due to continuous discharges under transitional conditions. Results show the 95th percentile values for each model grid cell.**

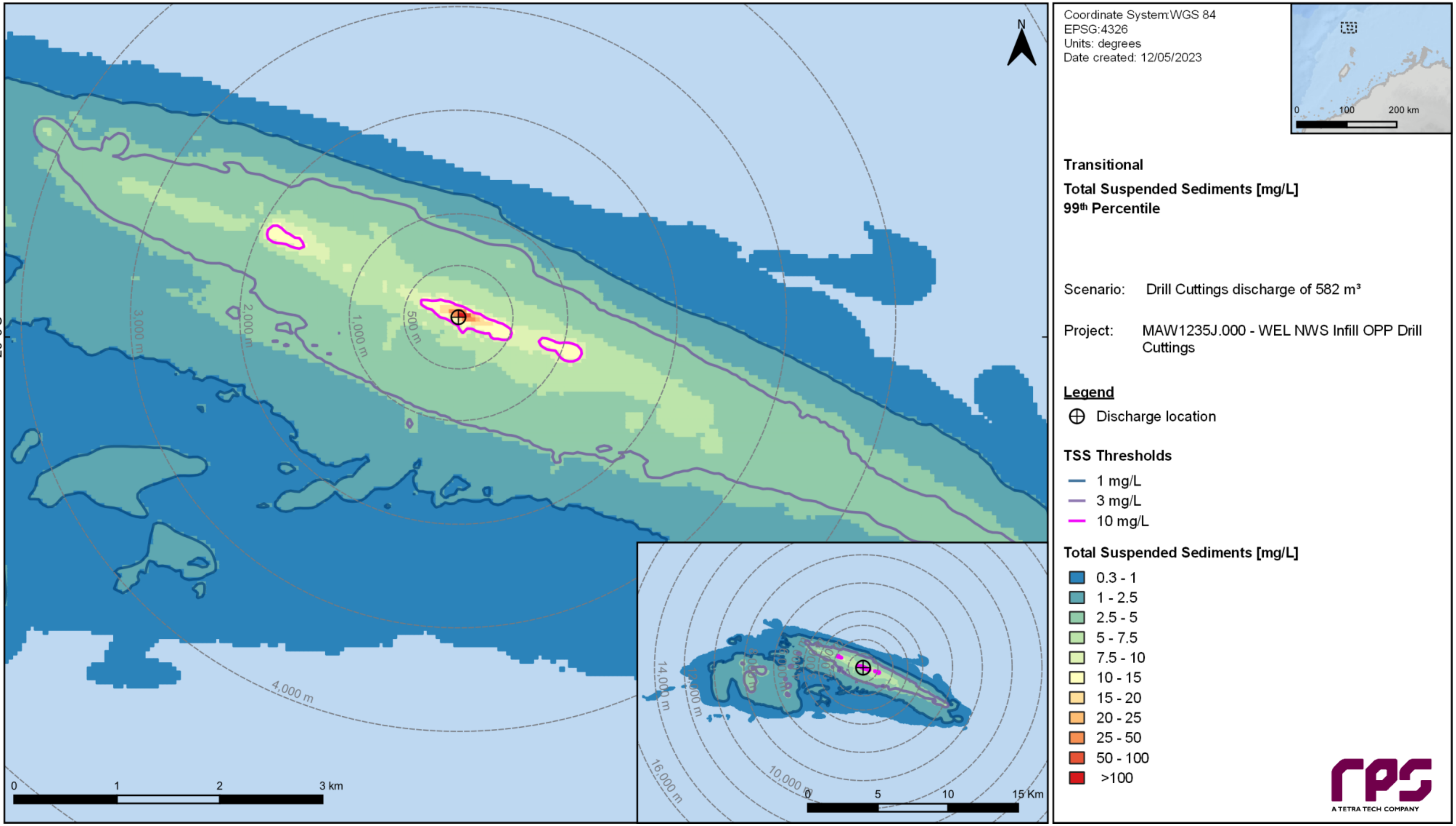


Figure 3.22 Calculations of extreme water column concentration for locations due to continuous discharges under transitional conditions. Results show the 99th percentile values for each model grid cell.

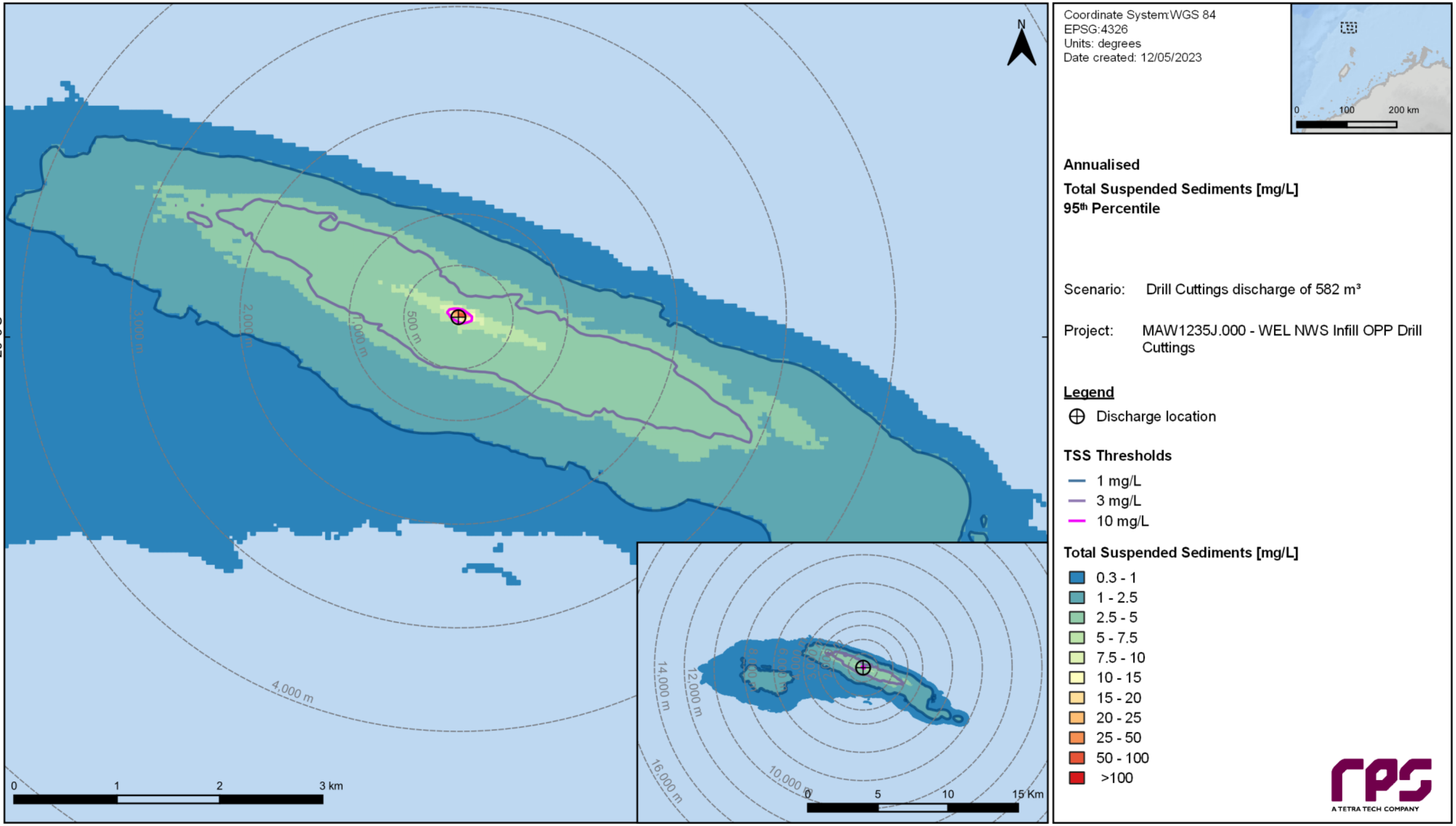


Figure 3.23 Calculations of extreme water column concentration for locations due to continuous discharges under annualised conditions. Results show the 95th percentile values for each model grid cell.

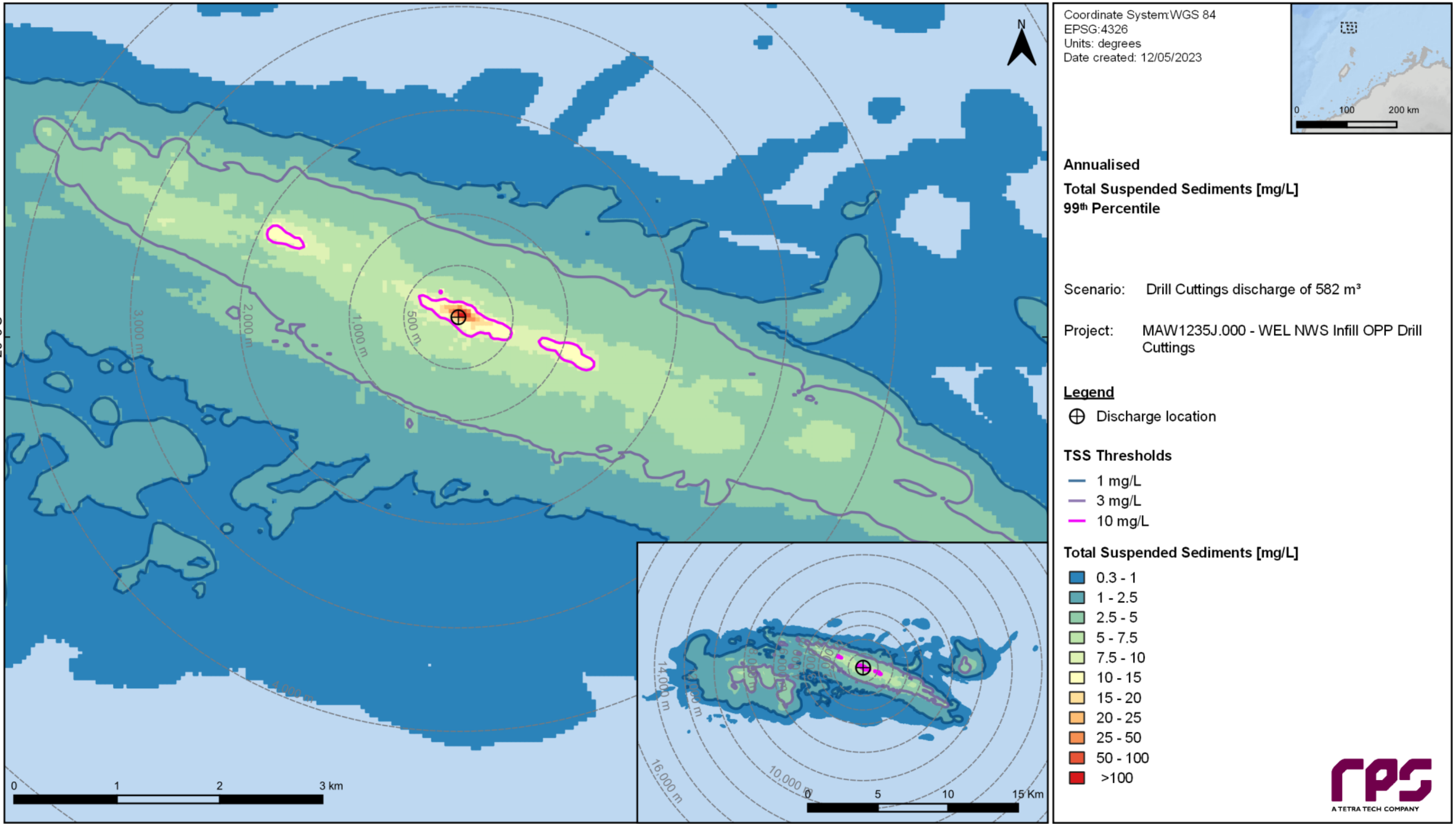


Figure 3.24 Calculations of extreme water column concentration for locations due to continuous discharges under annualised conditions. Results show the 99th percentile values for each model grid cell.

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APPENDIX I PRODUCED WATER MONITORING AND MANAGEMENT FRAMEWORK

MONITORING AND MANAGEMENT FRAMEWORK FOR PRODUCED WATER DISCHARGE FROM THE GWA PLATFORM

The description below has been extracted from the NOPSEMA-accepted GWA Facility Operations EP, and outlines the monitoring and management framework Woodside has developed to support the monitoring of produced water (PW) discharges from offshore assets.

In the absence of any Commonwealth guidelines, the State Waters Technical Guidance: Protecting the Quality of Western Australia's Marine Environment (EPA 2016) has been considered and is consistent with the principles of the National Water Quality Management Strategy.

Environmental values are defined as particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits (ANZG 2018). The relevant environmental values considered are:

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

The relationship between key elements of ecosystem integrity, indicators and relevant monitoring activities undertaken on a routine and non-routine basis are shown in Figure A. As per EPA guideline (2016) key elements to maintain ecosystem integrity have been identified as water quality, sediment quality and biological indicators (biota). By limiting the changes to these key elements to acceptable levels there is high confidence ecosystem integrity is maintained. For each of these elements an indicator has been identified and monitoring designed to identify change. Monitoring change in water quality as well as investigating potential toxicity via whole effluent toxicity (WET) testing and implementing management to maintain acceptable levels of changes is standard industry practice in Commonwealth and State waters.

The relevant indicator to understand changes in key elements and therefore potential for impact to ecosystem integrity are physio-chemical stressors, toxicants in water and biological indicators. A number of trigger values for each indicator have been defined and are monitored to detect change. Trigger values serve as an early warning that potential changes beyond the acceptable limits may occur. The acceptable limits of change are no impacts from PW beyond the approved mixing zone. To determine if acceptable limits have been exceeded, routine monitoring of trigger values is undertaken. An approved mixing zone protects 99% of species, as calculated using the Warne et al. (2018) statistical distribution methodology on the results of direct toxicity assessment using sub-lethal chronic endpoints. The protection of 99% of species maintains a high level of ecological protection and represents no detectable change from natural variation (as per ANZG (2018)).

The approved mixing zone boundary for GWA is 1,200 m.

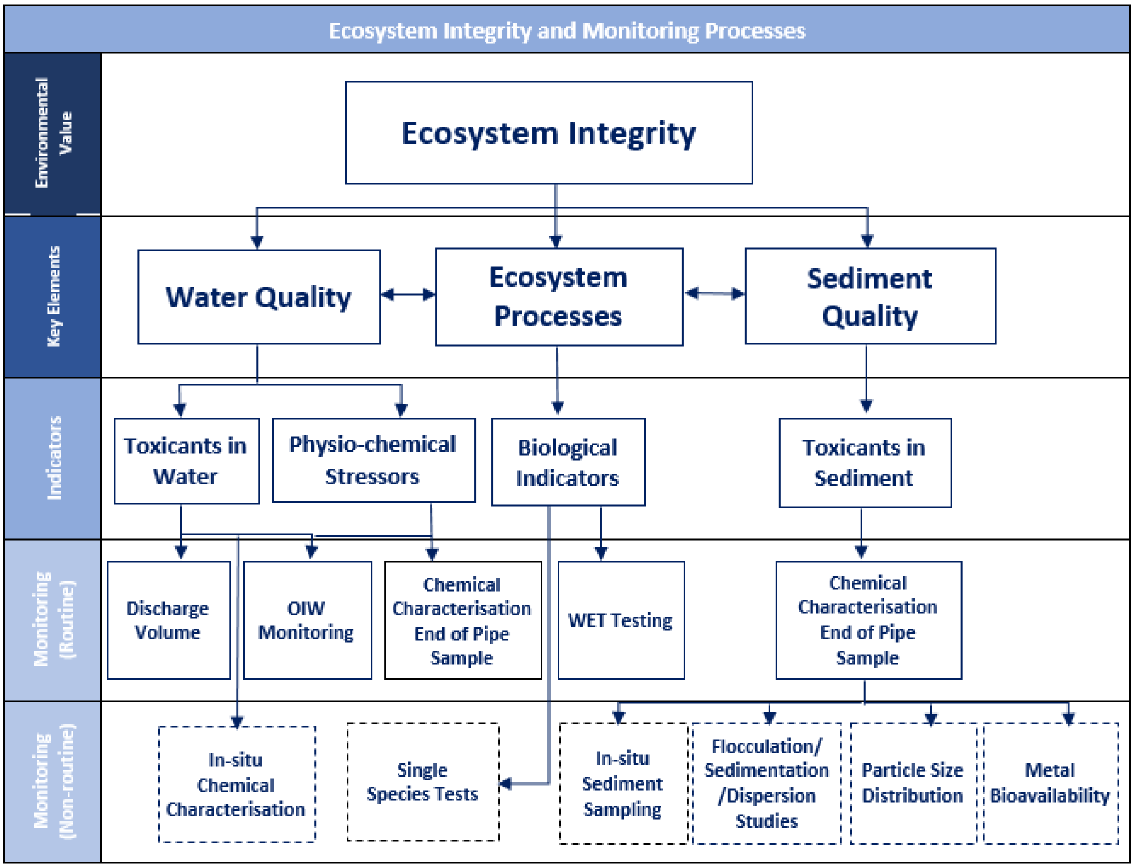

Figure A: Ecosystem Integrity and Monitoring Process

Operational Monitoring

Oil-in-water (OIW) monitoring is undertaken via an online analyser, or manual sampling when the analyser is not available. Online analyser information is sent via transmitter instantaneously and reported to the distributed control system (DCS) and is also captured within the process historian database (PHD). The DCS facilitates visibility in the control room, for manual or automated process control changes to be made, and/or annunciate alarms (e.g. high OIW specification). PHD information is available onshore for analysis and trending. The results of manual sampling while the analyser is not available, are stored in a spreadsheet contained on the GWA server.

Routine Monitoring

The monitoring and management framework is implemented in accordance with the Offshore Marine Discharges Adaptive Management Plan (OMDAMP). The OMDAMP details trigger values, routine monitoring assessment against trigger values, analytical methods, and actions when a trigger value is exceeded.

The trigger values are applied through a risk-based approach that is intended to capture any uncertainty around the level of impact, by staging monitoring and management responses according to the degree of risk to ecosystem integrity. The approach provides a level of confidence that management responses are not triggered too early (i.e. when there is no actual impact) or too late after significant or irreversible damage to the surrounding ecosystem (EPA 2016). Routine monitoring applicable to the facility, is undertaken to compare against trigger values (described in Table A). Changes in water quality and raw PW toxicity can be detected early and can indicate the potential for an impact prior to an impact occurring. WET testing confirms if there is a potential for impact on biota. It is not appropriate to monitor for changes in species composition, diversity, etc., as there are limited receptors in the approved mixing zone (a surface buoyant plume), and such changes may be detected after an impact occurs rather than providing early detection.

PW samples should represent normal operations and be undertaken during periods of normal production for the facility. Where practicable, samples are taken at a time when all (or as many as reasonably possible) PW-producing wells are online. WET tests are undertaken on a broad range of taxa of ecological relevance for which accepted standard test protocols are well established. WET tests mainly focus on the early life stages of test organisms, when organisms are typically most sensitive to contaminants; the tests are designed to represent local trophic level receptors. For WET testing, a range of tropical and temperate Australian marine species were selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols, and known reproducibility and sensitivity as test species. The dilutions required to protect 99% of species are calculated using the Warne et al. (2018) methodology. The protection of 99% of species maintains a high level of ecological protection at the boundary of the approved mixing zone.

If a trigger value is exceeded it raises uncertainty around whether the environmental value is being protected, and further investigation is required (Figure B).

Table A: Trigger values used during routine monitoring

Routine Monitoring	Trigger Value	Frequency
Chemical characterisation: end of pipe sample – physiochemical and toxicants	Results that are predicted to be higher than the 99% species protection guideline value at approved mixing zone boundary and are above the results from the earlier toxicity year1 or above the toxicity year when no guideline was available.	Annual - timed to be representative aiming to detect change, considering when high water cut wells are producing and/or new reservoirs cut water.
WET testing	The 99% species protection safe dilutions derived from the WET testing species sensitivity distributions are not predicted to be achieved at the boundary of approved mixing zone and are higher than previous years.	Three yearly. Conducted in parallel with annual chemical characterisation where feasible.
Review of continuous operational OIW monitoring results	Increases in the average monthly OIW concentration by 5 mg/L for more than six consecutive months or by 10 mg/L for two consecutive months.	Monthly review

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

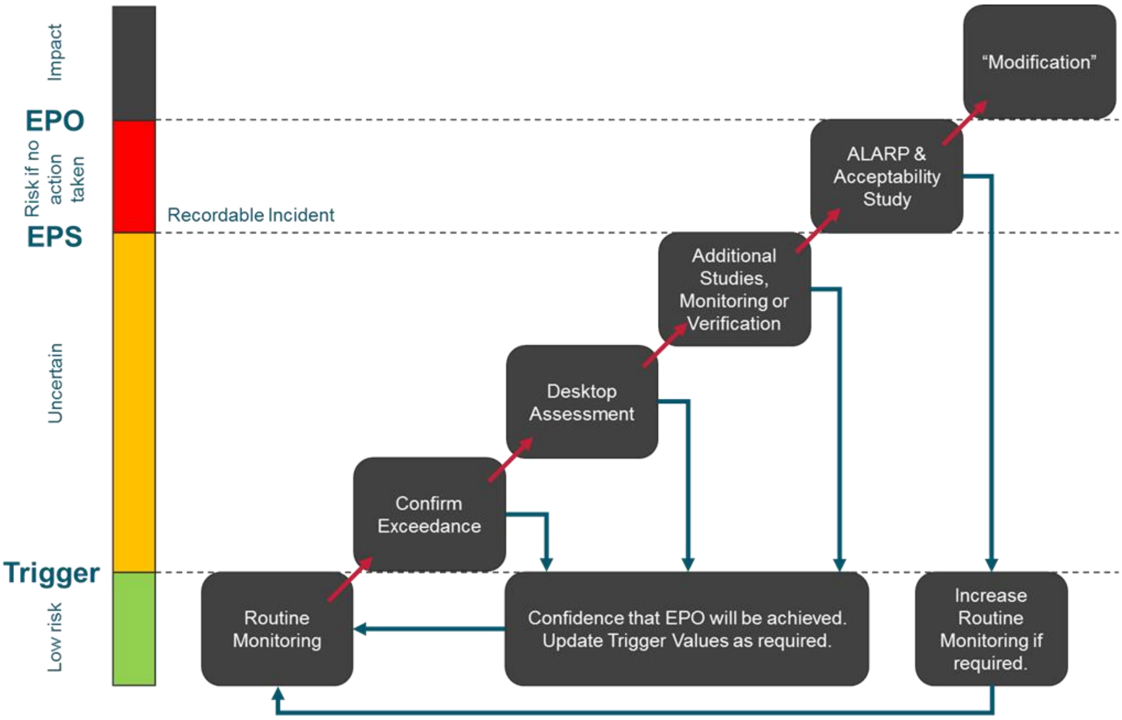

Figure B: Routine monitoring and adaptive management framework for PW

Further Investigations

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

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

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

Routine monitoring activities may be required ahead of schedule; additional monitoring not listed may be undertaken as appropriate. In-situ monitoring is undertaken in accordance with a plan that details timing, locations and objectives of monitoring.

3. **Conduct additional studies to confirm the EPS is not at risk**—Monitoring results provide additional lines of evidence to determine whether there is a risk to ecosystem integrity due to changes in water quality, sediment, or biological indicators. Given the significant health, safety and technical risks, monitoring of the receiving environment is only considered when all other sources of evidence are insufficient to demonstrate that ecological integrity is not at risk. The OMDAMP provides detailed guidance on the steps and actions required to be undertaken if a trigger value is exceeded and this may include additional non-routine monitoring to verify that ecological integrity is maintained.

If environmental impact is deemed to be within acceptable limits of change, the desktop assessment may consider a review of trigger values to ensure they are appropriate. If the environmental impact is deemed to be outside of the acceptable limits of change, an ALARP/Acceptability study is required to determine what additional controls can be implemented to ensure the impacts are acceptable.

In line with the adaptive management framework described above, sampling results for non-routine in-situ water or sediment quality monitoring will be compared against national guidelines to ascertain if triggers (Figure B) have been exceeded. Should a trigger value be exceeded, further investigations as described above and managed via the OMDAMP are implemented. Results of non-routine sampling will also be utilised to drive improvement and efficiencies to the monitoring and adaptive management framework (i.e. OMDAMP) described above.

Table B: Trigger values used during non-routine in-situ water and sediment monitoring

Routine Monitoring	Trigger Value
In-situ water sampling	Results that are higher than the 99% species protection guideline value at the boundary of the approved mixing zone.
In-situ sediment sampling	Results that are higher than the ANZECC/ARMCANZ interim sediment quality guideline (ISQG) low trigger values1 at the boundary of the approved mixing zone.

Note: Where no guideline is specified for a contaminant of concern, derive a value on the basis of natural background (reference) concentration multiplied by an appropriate factor (2-3) as described by the ANZECC guidelines.

References

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APPENDIX J HYDROCARBON SPILL MODELLING FOR SUBSEA RELEASE AT WILCOX

GOODWYN AREA INFILL DEVELOPMENT QUANTITATIVE SPILL RISK ASSESSMENT

Report

MAW1236J.000
Rev 2
12 September 2023

Contents

Tables

Figures

EXECUTIVE SUMMARY

Woodside Energy Ltd (Woodside) has commissioned RPS to undertake a quantitative spill risk assessment in support of several development opportunities in GWA Infill, Dixon hub & Wilcox Prospect.

The assessment focused on the risk of exposure to hydrocarbons for surrounding resources and sensitive receptors if the defined spill scenario was to occur.

The main objectives of the study are: (i) to quantify the movement and fate of spilled hydrocarbons that would result from accidental, uncontrolled releases, and (ii) to investigate the risk to sensitive receptors (emergent features, submerged features, and shorelines) posed by the release.

Woodside has identified two spill scenarios for investigation. The scenarios were modelled in a stochastic manner and assessed over an annual period.

Details of the scenarios are as follows:

- **Scenario 1A:** A surface/subsurface release of 645,721 m^3 of PYA-01 Condensate over 77 days from a loss of well integrity in the Wilcox Prospect.
- **Scenario 1B:** A surface/subsurface release of 745,012 m^3 of PYA-01 Condensate over 77 days from a loss of well integrity in the Wilcox Prospect.

Oil spill modelling was undertaken using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Model Application Package), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces.

The main findings of this study are as follows:

Metocean Influences

- Large-scale drift currents will have a significant influence on the trajectory of any oil spilled at the modelled release sites, irrespective of the seasonal conditions. The prevailing drift currents will determine the trajectory of oil that is entrained beneath the water surface.
- Interactions with the prevailing wind will provide additional variation in the trajectory of spilled oil that is afloat at the surface.
- Marked variation in the prevailing drift current and wind conditions will be expected over the duration of a multi-week simulation. This will be expected to increase the spread of hydrocarbon during any single event as well as the range of trajectories that could occur.

Oil Characteristics and Weathering Behaviour

- PYA-01 condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi-volatile components. In favourable evaporation conditions, about 48% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); up to a further 19% could evaporate within the first 24 hours (180 °C < BP < 265 °C); and a further 30% should evaporate over several days (265 °C < BP < 380 °C).
- Physical entrainment will slow down the evaporation of the condensate.
- The aromatic content of the oil is approximately 3%. Dissolution of these water-soluble components will occur from below the surface slicks, and from the entrained droplets generated by wave mixing and released subsea.

Summary of Stochastic Assessment Results

Scenario 1A: 77-day uncontrolled surface/subsurface release of 645,721 m^3 of PYA-01 Condensate

- As the hypothetical spill site is located within Montebello Marine Park, the probabilities of contact for all thresholds tested for floating oil, entrained oil and dissolved hydrocarbons is 100%.
- The combination of low viscosity and high volatility of the condensate is expected to limit the distance that visible films will occur from the source. Floating oil concentrations equal to or greater than the 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds could potentially be found, in the form of slicks, up to 395 km, 270 km and 51 km from the spill site, respectively.
- Floating oil concentrations for thresholds $\geq$ 50 g/m^2 are not predicted to contact any receptors aside from Montebello Marine Park.
- Shoreline oil concentrations for threshold $\geq$ 250 g/m^2 are predicted to contact Peak Island and Southern Pilbara Islands at a 4% probability.
- The worst-case accumulated concentration is predicted as 1,302 g/m^2 at Muiron Island. Up to 44 m^3 of oil was calculated to arrive on any shoreline section over the duration of an event.
- A large proportion of released condensate should entrain. Entrained oil concentrations $\geq$ 10 ppb and 100 ppb thresholds are predicted to be found up to 1,666 km and 1,202 km from the spill site, respectively.
- The greatest probabilities of contact by entrained oil concentrations at $\geq$ 10 ppb threshold are predicted at 100% for Tryal Rocks, Montebello Islands, Barrow Islands and Gascoyne Marine Park.
- At the higher threshold of 100 ppb, Montebello Marine Park is calculated to have 100% probability of contact while Barrow Island is calculated to have 99% probability.
- The maximum entrained oil concentration forecast for any receptor is predicted to be 84,164 ppb at Montebello Marine Park.
- Dissolved aromatic hydrocarbon concentrations $\geq$ 10 ppb and 50 ppb thresholds are predicted to be found up to around 1,286 km and 955 km from the spill site, respectively.
- The greatest probabilities of contact by dissolved aromatic hydrocarbon concentrations $\geq$ 10 ppb are predicted at 100% for Montebello Marine Park and Tryal Rocks. Receptors Gascoyne Marine Park, Ningaloo Marine Park, Barrow Island, Southern Pilbara Island and Penguin Bank all have probabilities of contact more than 90%.
- The worst maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 28,974 ppb at Montebello Marine Park.

Scenario 1B: 77-day uncontrolled surface/subsurface release of 745,012 m^3 of PYA-01 Condensate

- The combination of low viscosity and high volatility of the condensate is expected to limit the distance that visible films will occur from the source. Floating oil concentrations equal to or greater than the 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds could potentially be found, in the form of slicks, up to 385 km, 271 km and 54 km from the spill site, respectively.
- Floating oil concentrations for thresholds $\geq$ 50 g/m^2 are not predicted to contact any receptors aside from Montebello Marine Park.
- Shoreline oil concentrations for threshold $\geq$ 250 g/m^2 are predicted to contact Peak Island and Southern Pilbara Islands at a 4% probability.
- The worst-case accumulated concentration is predicted as 3,133 g/m^2 at Muiron Island. Up to 44 m^3 of oil was calculated to arrive on any shoreline section over the duration of an event.
- A large proportion of released condensate should entrain. Entrained oil concentrations $\geq$ 10 ppb and 100 ppb thresholds are predicted to be found up to 1,667 km and 1,206 km from the spill site, respectively.

- The greatest probabilities of contact by entrained oil concentrations ≥ 10 ppb threshold are predicted at 100% for Tryal Rocks, Montebello Islands, Barrow Islands and Gascoyne Marine Park.
- At higher threshold of 100 ppb, Montebello Marine Park and Tryal Rocks is calculated to have 100% probability of contact.
- The maximum entrained oil concentration forecast for any receptor is predicted to be 85,992 ppb at Montebello Marine Park.
- Dissolved aromatic hydrocarbon concentrations ≥ 10 ppb and 50 ppb thresholds are predicted to be found up to around 1,250 km and 975 km from the spill site, respectively.
- The greatest probabilities of contact by dissolved aromatic hydrocarbon concentrations ≥ 10 ppb are predicted at 100% for Montebello Marine Park and Tryal Rocks. Receptors Gascoyne Marine Park, Ningaloo Marine Park, Barrow Island, Southern Pilbara Island and Penguin Bank all have probabilities of contact more than 90%.
- The worst replicate of maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 24,018 ppb at Montebello Marine Park.
- As the hypothetical spill site is located within Montebello Marine Park, the probabilities of contact for all thresholds tested for floating oil, entrained oil and dissolved hydrocarbons is 100%.

1 INTRODUCTION

1.1 Background

RPS was commissioned by Woodside Energy Ltd (Woodside) to undertake a quantitative spill risk assessment of a hydrocarbon spill scenario in support of several development opportunities in the GWA Infill, Dixon hub & Wilcox Prospect. These opportunities span several title areas including WA-A5-L, WA-23-L, WA-24-L, WA-56-L, and WA-7-R R4. The current iteration involves up to 14 production wells which are intended to be tied back to GWA Platform in a phased approach. Water depths range from 80 to 180 m across the various titles and prospective opportunities.

The Wilcox prosect includes a multi-well-tie-back via a 25 km long pipeline to the Lady-Nora Pemberton Pipe-line End Termination facility (PLET). The Wilcox prospect is located within the boundary of the Montebello Marine Park Multiple Use Zone, however, will be drilled outside the marine park.

To support the assessment of hydrocarbon release risk, two credible hydrocarbon spill scenarios have been determined for the NWS Infill Development.

The assessment is focused on the risk of exposure to hydrocarbons for surrounding resources and sensitive receptors if the defined spill scenarios were to occur.

The main objectives of the study are: (i) to quantify the movement and fate of spilled hydrocarbons that would result from accidental, uncontrolled releases; and (ii) to investigate the risk to sensitive receptors (emergent features, submerged features, and shorelines) posed by the release.

The regional context of the spill location for the assessed scenario is shown Figure 1.1.

The details of the scenarios assessed in this study are summarised in Table 1.1 and listed here:

- **Scenario 1A:** A surface/subsurface release of 645,721 m^3 of PYA-01 Condensate over 77 days from a loss of well integrity in the Wilcox Prospect.
- **Scenario 1B:** A surface/subsurface release of 745,012 m^3 of PYA-01 Condensate over 77 days from a loss of well integrity in the Wilcox Prospect.

Table 1.1 Summary of the hydrocarbon spill scenario assessed in a stochastic manner in this study.

Scenario	Description	Oil Type	Spilled Volume	Release Coordinates	Release Depth (BMSL)	Spill Duration	Simulation Duration
1A	5 days Surface release followed by 72 days Subsurface release	PYA-01 Condensate	645,721 m^3	19˚59'53.8"S 115˚29'38.44"E	80	77 days	105 days
1B	5 days Surface release followed by 72 days Subsurface release	PYA-01 Condensate	745,012 m^3	19˚59'53.8"S 115˚29'38.44"E	80	77 days	105 days

Characteristics of the oil type used in the modelling of the scenario are summarised in Section 2.3.7. The potential weathering behaviour of the oil when exposed to idealised and representative environmental conditions is detailed in Section 2.3.8.

Oil spill modelling was undertaken using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces.

Probability contour figures and tabulated results showing risk estimates for the nearest receptors nominated by Woodside have been produced for defined floating oil, shoreline oil, entrained oil and dissolved aromatic hydrocarbon threshold concentrations. These results are presented in Section 4.

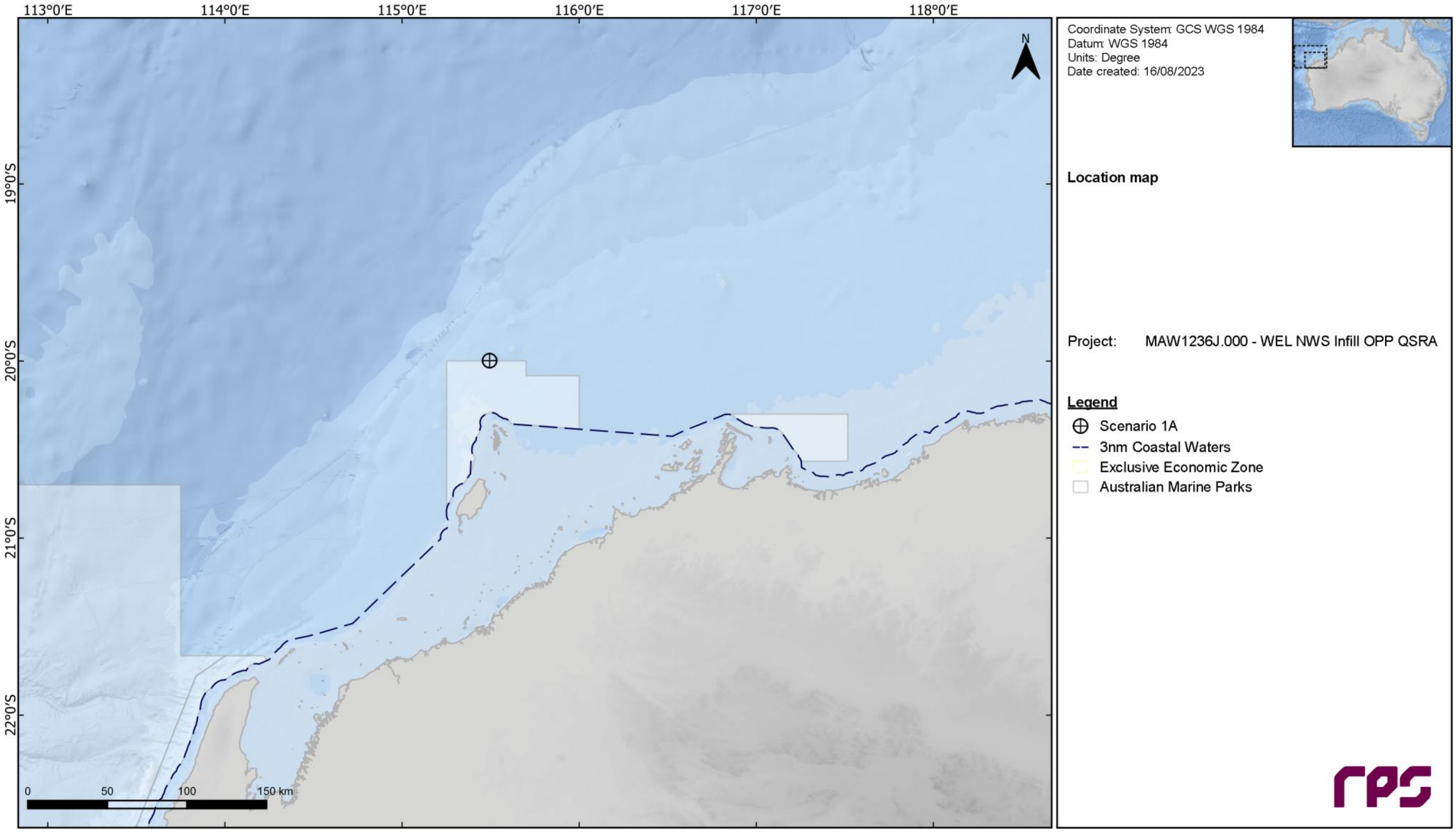


Figure 1.1 Location of the modelled hydrocarbon spill scenario release site (Scenario 1A and Scenario 1B).

1.2 Stochastic Modelling of Spill Scenario

Oil spill modelling was undertaken using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces.

The SIMAP model simulates both surface and subsurface releases and uses the unique physical and chemical properties of an oil type to calculate rates of evaporation and viscosity change, including the tendency to form oil-in-water emulsions. Moreover, the unique transport and dispersion of surface slicks and in-water components (entrained and dissolved) are modelled separately. Thus, the model can be used to understand the wider potential consequences of a spill, including direct contact to slick oil for surface features and exposure to entrained and dissolved oil for organisms in the water column.

To define trends and variations in the potential outcomes of a given scenario, a stochastic modelling scheme was followed in this study, whereby SIMAP was applied to repeatedly simulate the defined spill scenario using different samples of current and wind data selected randomly from an historic time series of wind and current data representative of the study area. Results of the replicate simulations were then statistically analysed and mapped to define contours of risk around the release point.

For this purpose, a long-term archive of spatially variable wind and current data covering the North West Shelf and spanning 10 years (2006-2015, inclusive) was assembled. Current patterns accounted for temporal and spatial variations in large-scale drift currents over the outer shelf waters (typically > 200 m depth) together with tidal and wind-driven currents. Modelling was carried out using current and wind data sampled from the data archive for periods corresponding to the nominated quarters to quantify annualised risks of contact at surrounding locations.

Each simulation was run for 28 days to allow a sufficient period after the cessation of discharge for oil concentrations to decrease below the threshold concentrations applied in the analysis. It is expected that remnant floating oil, which may be present at low thresholds at the end of each simulation, would represent highly weathered and degraded products.

It is important to note that the modelling results presented in this document relate to the predicted outcomes once defined spill events have occurred. The probability of the spill scenario occurring is not considered. The results should therefore be viewed as a guide to the likely outcomes should the spill scenario occur. Furthermore, the results are presented in terms of statistical probability maps, based on many simulations under different conditions. Different locations within the potential zone of influence would be affected under each different time series of environmental forces. Consequently, these contours for the potential zone of influence will cover a larger area than the area that is likely to be affected during any one single spill event. The contours should therefore be judged as contours of probability and not representations of the area swept by individual spill slicks.

Risk estimates were calculated from the multiple replicate simulations for the scenario, including the probability of contact, the minimum time to contact, and the potential concentrations that might be involved.

The results of the stochastic modelling are presented in Section 4.

1.3 Calculation of Inputs for Financial Assurance Assessment

For drilling activities and wells, where the credible worst-case incident is likely to be a loss of well control, the costs considered are:

- The cost of well control.
- The cost of operational response.

The operational response to a pollution incident includes activities such as containment and recovery, dispersant application, shoreline clean-up, waste management, monitoring and evaluation, pre- and post-wildlife response and other associated field activities.

In this study, inputs to the financial assurance assessment to be undertaken by Woodside are presented in Section 5.

Please note that the worst-case shoreline volume presented in the tables of Section 5 represents the maximum instantaneous volume calculated across all receptors during any replicate simulation within the corresponding set. In contrast, the tabulated worst-case shoreline volumes presented in Section 4 represent maximum instantaneous volumes calculated individually for each receptor and will inevitably indicate outcomes at different times within the replicate simulation. Summing the maximum volumes from each individual receptor would therefore yield a total accumulated shoreline volume that would not be representative of the actual spill outcomes at any given point in time. For this reason, shoreline volumes presented in Sections 4 and Section 5 cannot be directly compared.

1.4 Report Structure

The far-field computational models, risk assessment methodology, environmental data used as input to the model, environmental threshold trigger levels defined for the assessment, and characteristics of the oil type used in the modelling of the defined scenario, are described in detail in Section 2.

Contour figures and tabulated results showing risk estimates for the receptors nominated by Woodside, produced for defined floating oil, shoreline oil, entrained oil and dissolved aromatic hydrocarbon threshold concentrations, are presented in Section 4 to summarise the stochastic modelling outcomes.

The financial assurance assessment inputs calculated for each of the defined scenario are presented in Section 5.

The overall findings of the study are summarised in Section 6.

2 MODELLING METHODOLOGY

2.1 Description of the Models

2.1.1 SIMAP

The spill modelling was carried out using a purpose-developed oil spill trajectory and fates model, SIMAP (Spill Impact Mapping and Assessment Program). This model is designed to simulate the transport and weathering processes that affect the outcomes of hydrocarbon spills to the sea, accounting for the specific oil type, spill scenario, and prevailing wind and current patterns.

SIMAP is the evolution of the United States Environmental Protection Agency (US EPA) Natural Resource Damage Assessment model (French and Rines, 1997; French, 1998; French *et al.*, 1999) and is designed to simulate the fate and effects of spilled oils and fuels for both the surface slick and the three-dimensional plume that is generated in the water column. SIMAP includes algorithms to account for both physical transport and weathering processes. The latter are important for accounting for the partitioning of the spilled mass over time between the water surface (surface slick), water column (entrained oil and dissolved compounds), atmosphere (evaporated compounds) and land (stranded oil). The model also accounts for the interaction between weathering and transport processes.

The physical transport algorithms calculate transport and spreading by physical forces, including surface tension, gravity and wind and current forces for both surface slicks and oil within the water column. The fates algorithms calculate all weathering processes known to be important for oil spilled to marine waters. These include droplet and slick formation, entrainment by wave action, emulsification, dissolution of soluble components, sedimentation, evaporation, bacterial and photo-chemical decay, and shoreline interactions. These algorithms account for the specific oil type being considered.

Entrainment is the physical process where globules of oil are transported from the sea surface into the water column by wind and wave-induced turbulence or be generated subsea by a pressurised discharge at depth. It has been observed that entrained oil is broken into droplets of varying sizes. Small droplets spread and diffuse into the water column, while larger ones rise rapidly back to the surface (Delvigne and Sweeney, 1988; Delvigne, 1991).

Dissolution is the process by which soluble hydrocarbons enter the water from a surface slick or from entrained droplets. The lower molecular weight hydrocarbons tend to be both more volatile and more soluble than those of higher molecular weight.

The formation of water-in-oil emulsions, or mousse, which is termed ‘emulsification’, depends on oil composition and sea state. Emulsified oil can contain as much as 80% water in the form of micrometre-sized droplets dispersed within a continuous phase of oil (Wheeler, 1978; Bobra, 1991; Daling and Brandvik, 1991; Daling *et al.*, 1997; Fingas, 1996, 1995).

Evaporation can result in the transfer of large proportions of spilled oil from the sea surface to the atmosphere, depending on the type of oil (Gundlach and Boehm, 1981).

Evaporation rates vary over space and time dependent on the prevailing sea temperatures, wind and current speeds, the surface area of the slick and entrained droplets that are exposed to the atmosphere as well as the state of weathering of the oil. Evaporation rates will decrease over time, depending on the calculated rate of loss of the more volatile compounds. By this process, the model can differentiate between the fates of different oil types.

Sedimentation of hydrocarbons occurs when the specific gravity increases over that of the surrounding seawater. Several processes may act on entrained oil and surface slicks to increase density: weathering (evaporation, dissolution, and emulsification), adhesion or sorption onto suspended particles or detrital matter, and incorporation of sediment into oil during interaction with suspended particulates, bottom sediments, and shorelines.

Decay (degradation) of hydrocarbons may occur as the result of photolysis, which is a chemical process energised by ultraviolet light from the sun, and by biological breakdown, termed biodegradation. Many types of marine organisms ingest, metabolise, and utilise oil as a carbon source, producing carbon dioxide and water as by-products. The biodegradable portions of various crude oils range from 11% to 90% (NRC, 1989, 1985).

Entrainment, dissolution, and emulsification rates are correlated to wave energy, which is accounted for by estimating wave heights from the sustained wind speed, direction, and fetch (i.e., distance downwind from land barriers) at different locations in the domain. Dissolution rates are dependent upon the proportion of soluble, short-chained hydrocarbon compounds, and the surface area at the oil/water interface of slicks. Dissolution rates are also strongly affected by the level of turbulence. For example, dissolution rates will be relatively high at the site of the release for a deep-sea discharge at high pressure.

In contrast, the release of hydrocarbons onto the water surface will not generate high concentrations of soluble compounds. However, subsequent exposure of the surface slick to breaking waves will enhance entrainment of oil into the upper water column as oil droplets, which will enhance dissolution of the soluble components. Because the compounds that have high solubility also have high volatility, the processes of evaporation and dissolution will be in dynamic competition with the balance dictated by the nature of the release and the weather conditions that affect the oil after release. The SIMAP weathering algorithms include terms to represent these dynamic processes. Technical descriptions of the algorithms used in SIMAP and validations against real spill events are provided in French (1998), French *et al.* (1999) and French-McCay (2004).

Input specifications for oil types include the density, viscosity, pour-point, distillation curve (volume of oil distilled off versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges. The model calculates a distribution of the oil by mass into the following components:

- Surface-bound or floating oil.
- Entrained oil (non-dissolved oil droplets that are physically entrained by wave action).
- Dissolved hydrocarbons (principally the aromatic and short-chained aliphatic compounds).
- Evaporated hydrocarbons.
- Sedimented hydrocarbons.
- Decayed hydrocarbons.

2.1.2 OILMAP Deep

During the subsea phase of the release, the discharge will occur as a pressurised flow, from a restriction, of condensate and gas. High-pressure releases that involve oil alone will tend to generate relatively small droplet sizes that have slow rise rates, due to viscous resistance imparted by the surrounding seawater, and may become trapped by density layers in the water column (Chen & Yapa, 2002). When the discharge is a mixture of gas and oil, the buoyancy of the gas cloud will lift entrained oil droplets and a rising column of water entrained from the water column near seabed at a substantially faster rate than would occur from the relative buoyancy of the oil alone. However, the rising oil/water plume will become increasingly dense relative to the warmer water approaching surface and may become trapped before reaching surface while the gas may continue to rise. The rate at which oil droplets rise from the trapping height will be determined by multiple factors, including the relative buoyancy of the oil versus local water density, the size of the droplets (increased viscous resistance for smaller sizes), the presence of density barriers in the water column and the action of shear currents that might be present in the water column.

The most likely subsea behaviour of the well fluids that would be discharged during the subsea release phase was calculated using the OILMAP Deep model. OILMAP Deep is an oil spill trajectory and fates model extended for the prediction of oil from subsea oil/gas blowouts, including those in deep water (> 600 m) where gas hydrate formation can affect the fate of discharged oil (Spaulding *et al.*, 2000). The blowout model predicts the droplet sizes that are generated by the turbulence of the discharge as well as the centreline velocity, buoyancy, width, and trapping depth (if any) of the rising oil or oil and gas plumes. Inputs to the model include the depth (hence water pressure); discharge rate; hole size; oil density and viscosity, and the vertical temperature/salinity profile of the receiving water. The model input also includes vertical profiles of temperature and salinity (hence density) representative of the location.

OILMAP Deep is an oil spill trajectory and fates model extended for the prediction of oil from subsurface oil/gas blowouts, including those in deep water (>600 m) where gas hydrate formation can affect the fate of discharged oil (Spaulding *et al.*, 2000). The blowout model predicts the centreline velocity, buoyancy, width, and trapping depth (if any) of the rising gas plume. Inputs to the model include the depth (hence water pressure); discharge rate; hole size; oil density and viscosity, and the vertical temperature/salinity profile of the receiving water. This model was applied to supply the plume dimensions to the SIMAP model, for the long-term discharge simulations. The droplet size distribution was calculated using a modified form of the OILMAP Deep droplet size algorithm (Li *et al.*, 2017). For releases in shallow water (< 300 m) or with high gas to oil ratios, the modified algorithm improves the accuracy of the droplet prediction with a scaled pressure term that represents a balance between ambient hydrostatic pressure and the reservoir pressure. The typical effect of the inclusion of reservoir pressure in the droplet size algorithm is to increase predicted droplet sizes relative to those that would have been predicted if ambient hydrostatic pressure alone were used.

2.2 Calculation of Exposure Risks

2.2.1 Overview

The stochastic model within SIMAP performs many simulations for a given spill site, randomly varying the spill time for each simulation. The model uses the spill time to select sequences of current and wind data from a long time series of wind and current data for the area. Hence, the transport and weathering of each slick will be subject to a different sequence of wind and current conditions.

This stochastic sampling approach provides an objective measure of the possible outcomes of a spill because environmental conditions will be selected at a rate that is proportional to the frequency that these conditions occur over the study region. More simulations will tend to use the most commonly occurring conditions, while conditions that are more unusual will be represented less frequently.

During each simulation, the SIMAP model records the location (by latitude, longitude, and depth) of each of the particles (representing a given mass of oil) on or in the water column, at regular time steps. For any particles that contact a shoreline, the model records the accumulation of oil mass that arrives on each section of shoreline over time, less any mass that is lost to evaporation and/or subsequent removal by current and wind forces.

The collective records from all simulations are then analysed by dividing the study region into a three-dimensional grid. For oil particles that are classified as being at the water surface (floating oil), the sum of the mass in all oil particles (including accounting for spreading and dispersion effects) located within a grid cell, divided by the area of the cell provides estimates of the concentration of oil in that grid cell, at each time step. For entrained and dissolved oil particles, concentrations are calculated at each time step by summing the mass of particles within a grid cell and dividing by the volume of the grid cell.

The concentrations of oil calculated for each grid cell, at each time step, are then analysed to determine whether concentration estimates exceed defined threshold concentrations over time.

Risks are then summarised as follows:

- The probability of exposure to a grid cell is calculated by dividing the number of spill simulations where any instantaneous contact occurred above a specified threshold at that location by the total number of replicate spill simulations. For example, if contact occurred at a location (above a specified threshold) during 21 out of 100 simulations, a probability of exposure of 21% is indicated.
- The minimum potential time to a shoreline grid cell is calculated by the shortest time over which oil at a concentration above a particular threshold was calculated to travel from the source to the location in any of the replicate simulations.
- The maximum potential concentration of oil predicted for each shoreline section (composed of a collection of grid cells) is the greatest mass per square metre (m^2) of shoreline calculated to strand at any location within that section during any of the replicate simulations.
- The average of the maximum concentrations of oil predicted to potentially accumulate on each shoreline section is calculated by determining the greatest mass per square metre (m^2) of shoreline during each replicate simulation and calculating an average of these estimates across the simulations.
- Similar treatments are undertaken for entrained oil and dissolved aromatic hydrocarbons.

Thus, the minimum time to shoreline and the maximum potential concentration estimates indicate the worst potential outcome of the modelled spill scenario for each section of shoreline. However, the average over the replicates presents an average of the potential outcomes, in terms of oil that could strand.

Note also that results quoted for sections of shoreline or shoal are derived for any individual grid cell within that section or shoal, as a conservative estimate. Grid cells will represent shoreline lengths of the order of ~1.0 km, while sections or regions will represent shorelines spanning tens to hundreds of kilometres, and it is not implied that the maximum potential concentrations quoted will occur over the full extent of each section. We therefore warn against multiplying the maximum concentration estimates by the full area of the section because this will greatly overestimate the total volume expected on that section.

Noting the grid resolution of 1.0 km, it is not possible to resolve individual sensitive receptors with shorelines of lesser length (e.g., ~100 m). All receptors are assumed to have a minimum length equal to the grid resolution. This is a conservative approach to estimating risks to shorelines and may over-predict length of shoreline oiled.

The maximum entrained hydrocarbon and maximum dissolved aromatic hydrocarbon concentration are calculated for areas surrounding each defined shoreline (see Section 2.2.2). These areas extend outwards from the coast to provide a buffer zone enclosing shallow (< 10 m) habitats close to shore. If oil passes through this zone, calculations for shoreline exposure will be made. This is a conservative approach to estimating risks to shorelines allowing for spatial errors in model forecasts. The greatest calculated value at any time step during any replicate simulation is listed. These values therefore represent worst-case localised estimates (within a grid cell). The averages over all replicate simulations represent a central tendency of these simulated worst-case estimates.

It is important to note that the stochastic modelling results presented in this document relate to the predicted outcomes once defined spill events have occurred. The probability of the spill scenario occurring is not considered. The results should therefore be viewed as a guide to the likely outcomes should the spill scenario occur. Different locations within the potential zone of influence would be affected under different time series of environmental forces. Consequently, the potential zone of influence will cover a larger area than the area that is likely to be affected during any one single spill event. The contours should therefore be judged as contours of probability and not representations of the area swept by individual spill slicks.

2.2.2 Sensitive Receptor Areas

Individual grid cells were grouped by geographic bounds to define sensitive receptor areas for special consideration. Sensitive receptor areas included sections of shorelines, islands, banks, reefs, Australian and State marine, and national parks (Figure 2.1 to Figure 2.6). The bounds of the sensitive receptor areas were defined with buffer zones that consider the bathymetry bordering each receptor, natural boundaries, or sensible legislative boundaries. Risks of exposure were separately calculated for each sensitive receptor area and have been tabulated.

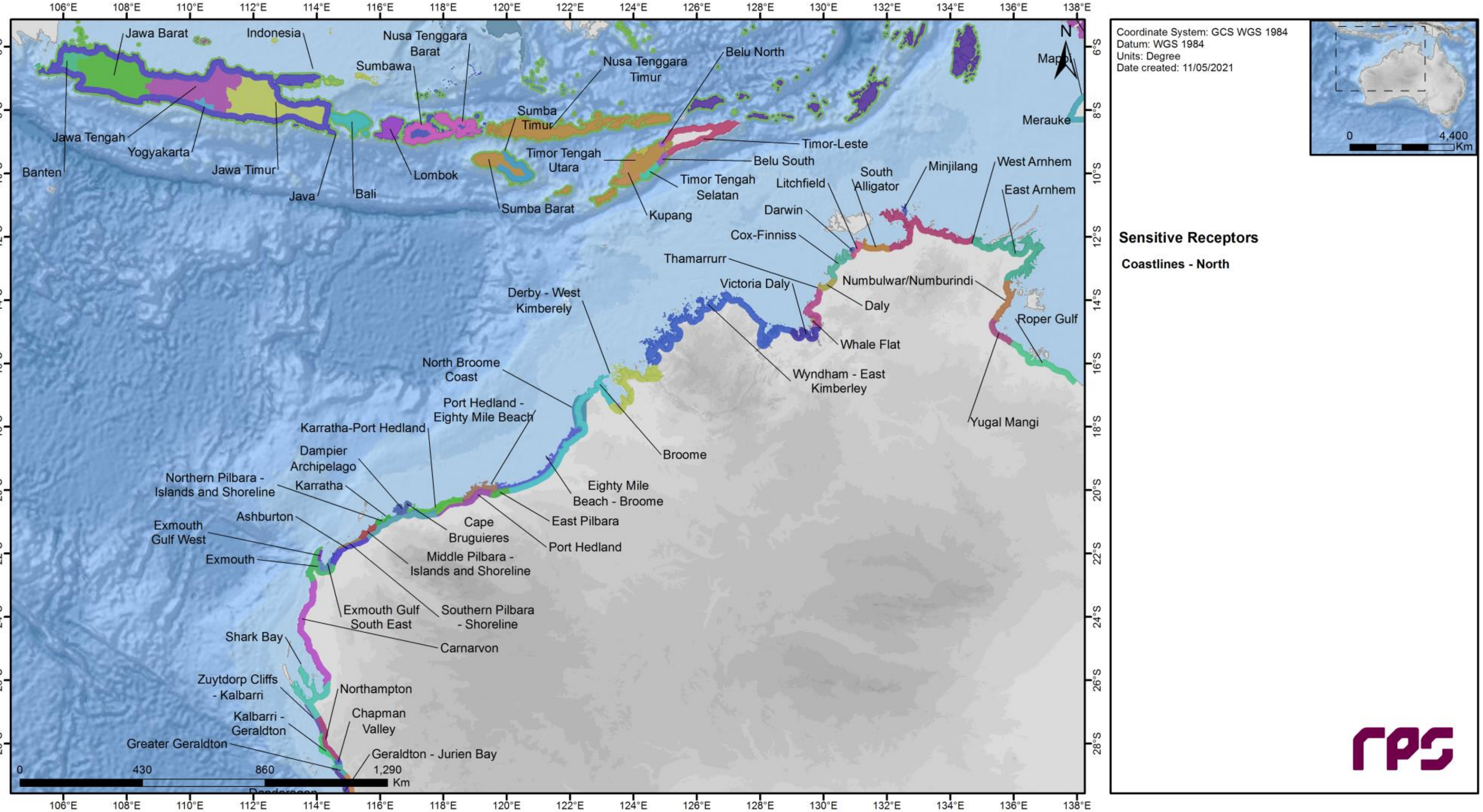


Figure 2.1 Locations of 'Coastline' sensitive receptors within the study region.

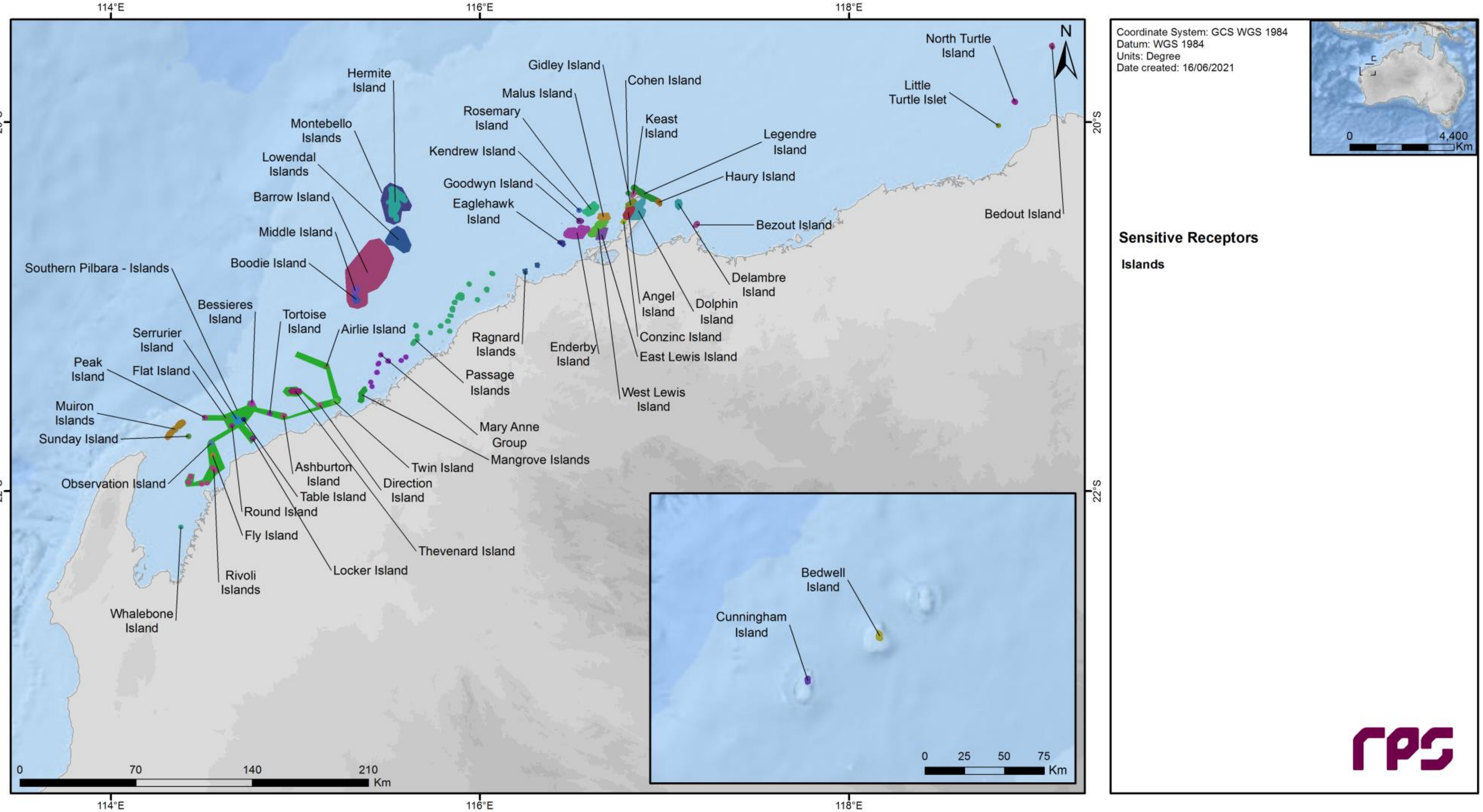


Figure 2.2 Locations of ‘Island’ sensitive receptors within the study region.

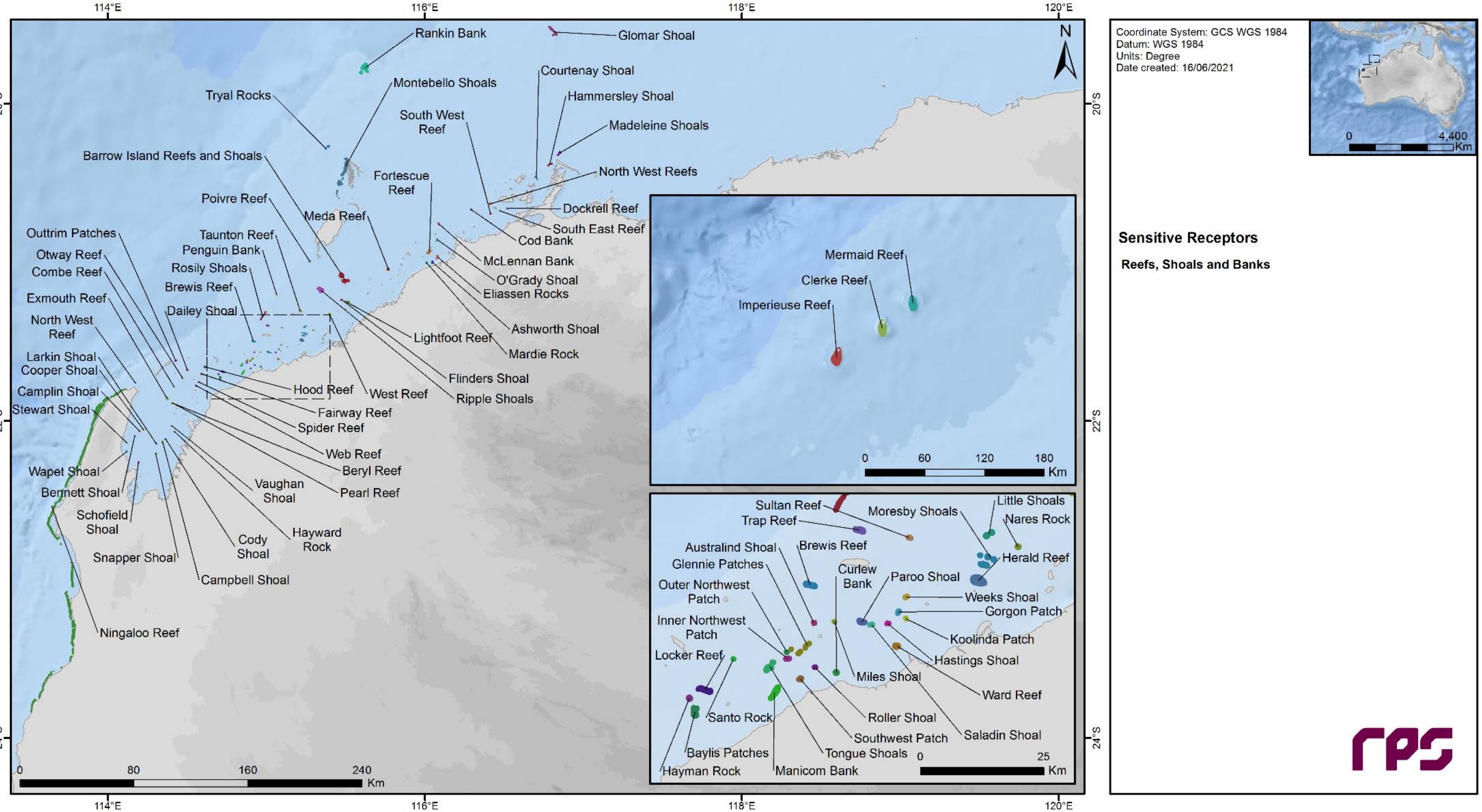


Figure 2.3 Locations of 'Reef, Shoal and Bank' sensitive receptors within the study region.

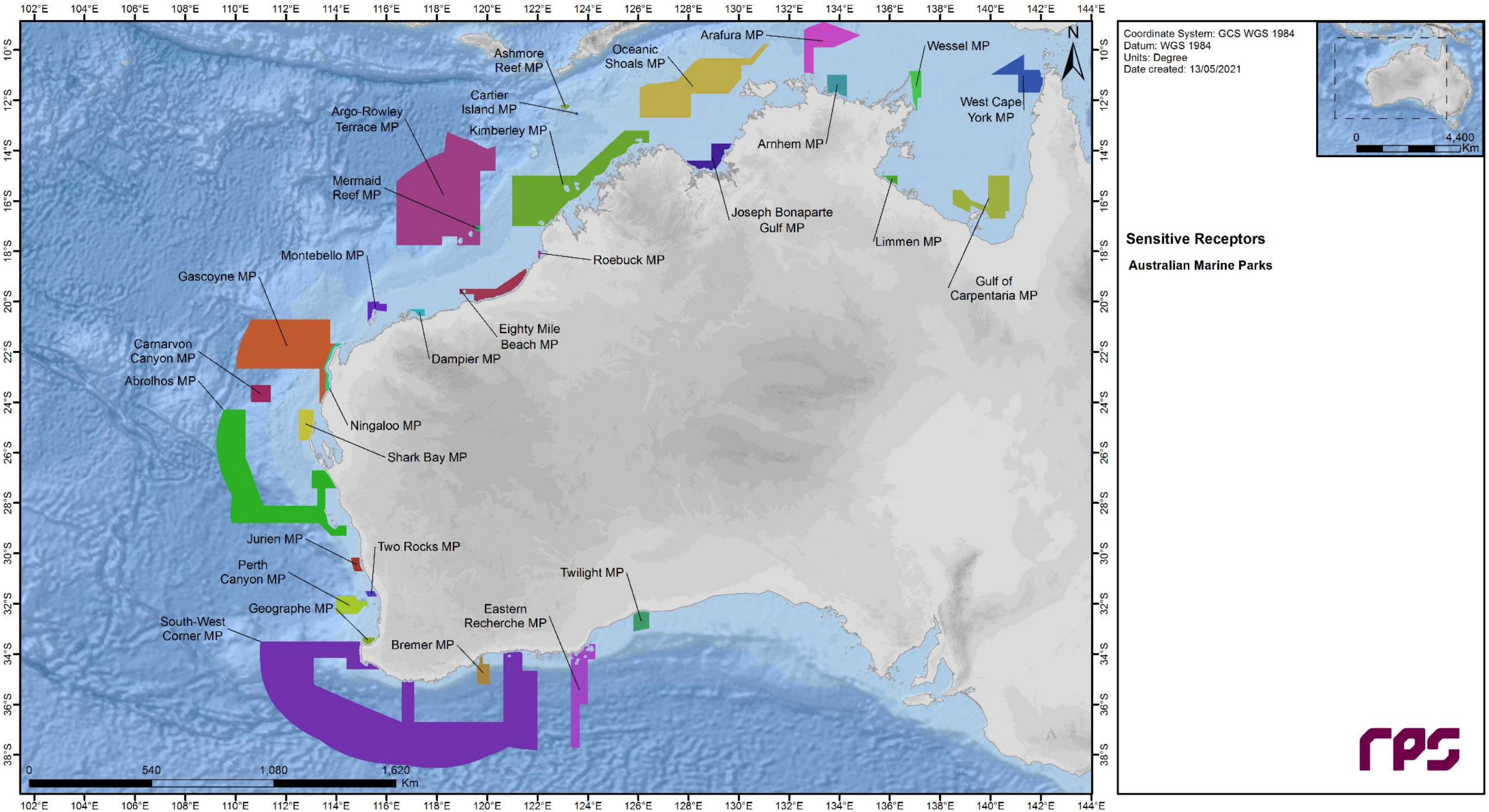


Figure 2.4 **Locations of 'Australian Marine Park' sensitive receptors within the study region.**

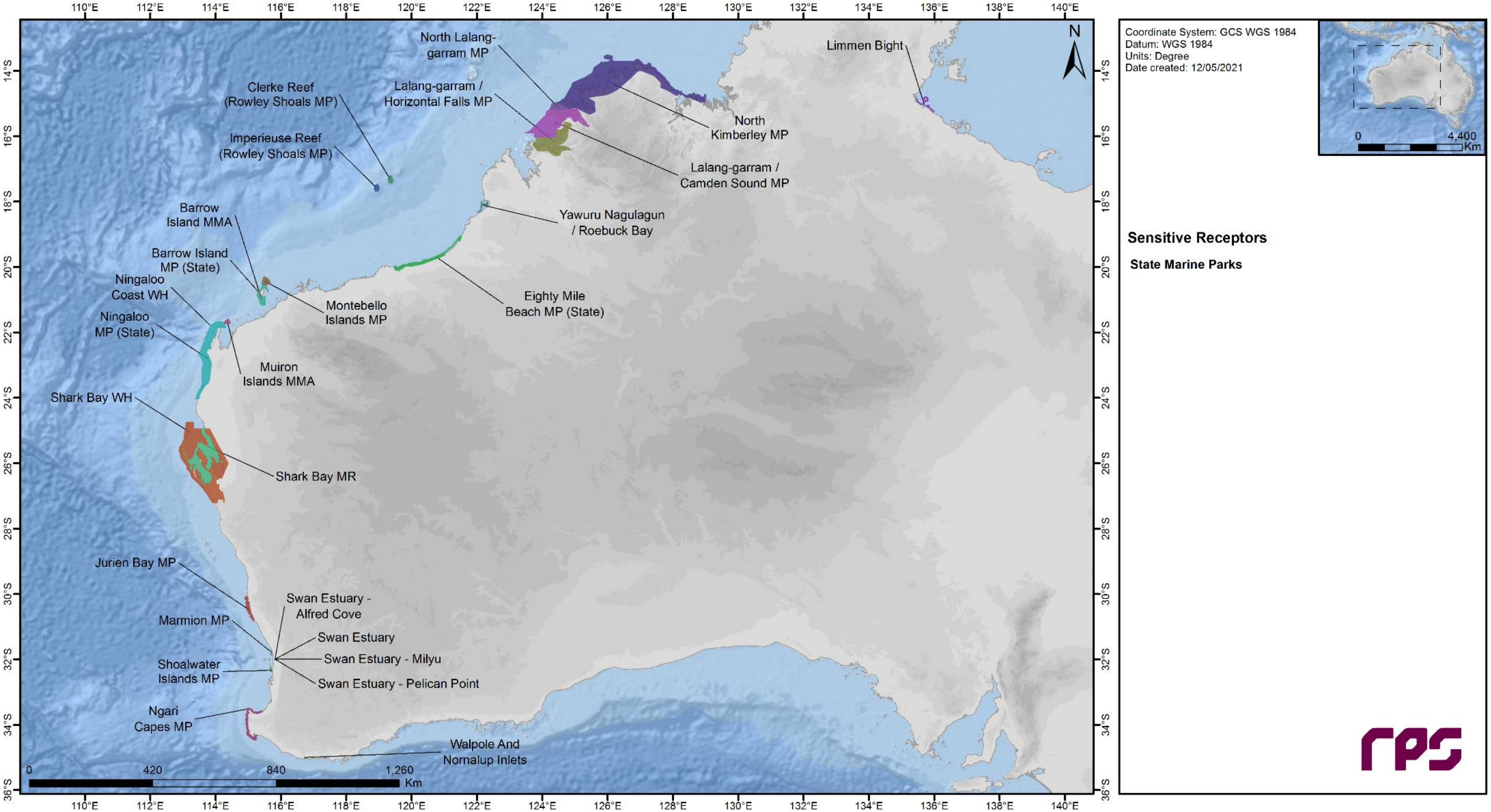


Figure 2.5 Locations of 'State Marine Park' sensitive receptors within the study region.

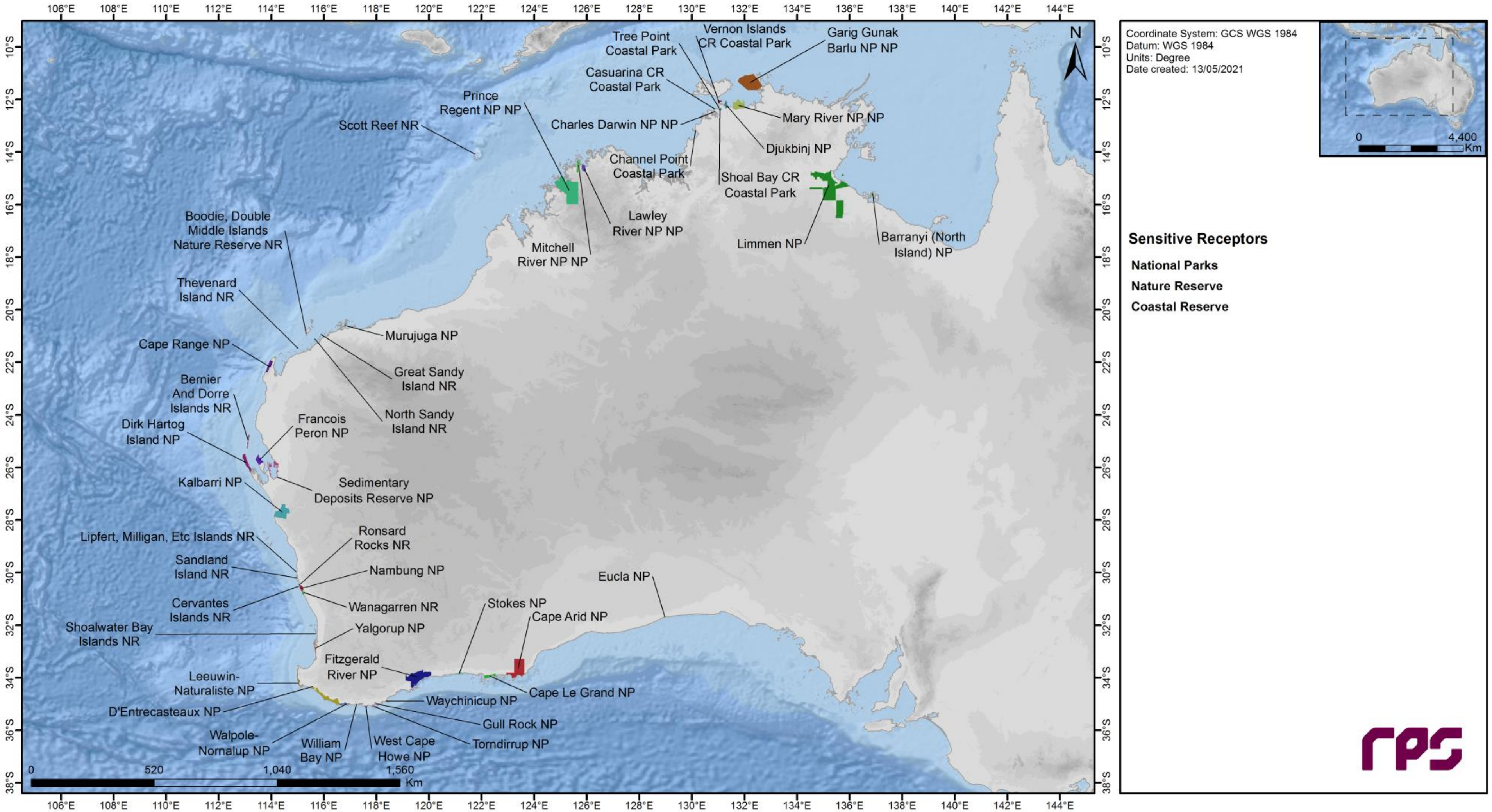


Figure 2.6 Locations of 'National Park', 'Nature Reserve' and 'Coastal Reserve' sensitive receptors within the study region.

2.3 Inputs to the Risk Assessment

2.3.1 Ocean Current Data

2.3.1.1 Background

The area of interest for this study is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf. While the mass flow is generally towards the south-west, year-round, the internal gyres generate local currents in all directions. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. Further south of the project area, the Leeuwin Current becomes the dominant large-scale current system, flowing poleward down the pressure gradient along the Western Australian coastline and past Cape Leeuwin.

Offshore regions with water depths exceeding 100-200 m experience significant large-scale drift currents. These drift currents can be relatively strong (1-2 knots) and complex, manifesting as a series of eddies, meandering currents, and connecting flows. These offshore drift currents also tend to persist longer (days to weeks) than tidal current flows (hours between reversals) and thus will have greater influence upon the net trajectory of plumes over time scales exceeding a few hours.

Wind shear on the water surface also generates local-scale currents that can persist for extended periods (hours to days) and result in long trajectories. Persistent winds along the mainland coast can induce Ekman transport, where surface waters move offshore and facilitate upwelling events in which cold nutrient-rich waters from the deep Indian Ocean are brought to the surface. However, due to the opposing transport of warm tropical waters by the Leeuwin Current, large-scale persistent upwelling along the Western Australian coast is suppressed. Therefore, upwelling events are sporadic, short-term and localised to areas of the coastline where the continental shelf narrows, including the area around the Capes and the Ningaloo coast (IMOS, 2014). This process is seasonal/transient and affected by the strength of the Leeuwin Current, with minimal upwelling in times with strong Leeuwin Current flow.

The current-induced transport of plumes can be variably affected by combinations of tidal, wind-induced, and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to rigorously understand patterns of potential transport from a given discharge location.

To appropriately allow for temporal and spatial variation in the current field, dispersion modelling requires the current speed and direction over a spatial grid covering the potential migration trajectories of plumes. As long-term measured current data is not available for simultaneous periods over a network of locations covering the offshore areas relevant to this study, the analysis relied upon hindcasts of the circulation generated through numerical modelling by internationally recognised organisations.

A composite modelled ocean current data product was derived by combining predictions of mesoscale circulation currents, available at daily resolution from global ocean models, with predictions of the hourly tidal currents generated by the RPS HYDROMAP model. By combining a drift current model with a tidal model, the influences of inter-annual and seasonal drift patterns, and the more regular variations in tide, were depicted, ensuring nearshore and offshore hydrodynamic processes were represented.

2.3.1.2 Mesoscale Circulation Model

2.3.1.2.1 Description of Mesoscale Model: BRAN

Representation of the drift currents that affect the area were available from the output of the BRAN (Oke *et al.*, 2013, 2009, 2008; Schiller *et al.*, 2008) ocean model, which is sponsored by the Australian Government through the Commonwealth Bureau of Meteorology (BoM), Royal Australian Navy and CSIRO. BRAN is a data-assimilative, three-dimensional ocean model that has been run as a hindcast for many periods and is now used for ocean forecasting (Schiller *et al.*, 2008).

BRAN routinely assimilates sea level anomaly data, tide gauge data, sea surface temperature and in situ temperature and salinity measurements (Oke *et al.*, 2009). Comparisons of BRAN hindcast outputs to satellite and independent in situ observations found that BRAN was reliably representing the broad-scale ocean circulation, the mesoscale surface eddy field, and shelf circulation around Australia (Oke *et al.*, 2008; Schiller *et al.*, 2008). Additionally, reanalysis of past periods using the BRAN model has been shown to realistically represent upwelling events, in particular along the Bonney Coast of South Australia, a region of frequent wind-driven upwellings (Oke *et al.*, 2009).

The BRAN predictions for drift currents are produced at a horizontal spatial resolution of approximately 0.1° over the region, at a frequency of once per day, averaged over the 24-hour period. Hence, the BRAN model data provides estimates of mesoscale circulation with horizontal resolution suitable to resolve eddies of a few tens of kilometres' diameter, as well as connecting stream currents of similar spatial scale. Drift currents that are represented over the inner shelf waters in the BRAN data are principally attributable to wind induced drift.

There are several versions of the BRAN database available. The latest BRAN simulation spans the period of January 1994 to August 2016. From this database, three-dimensional data representing horizontal water movement at discrete depths was extracted for all points in the model domain for the years 2006-2015 (inclusive). The data was assumed to be a suitably representative sample of the current conditions over the study area for future years.

Although this data should represent effects of upwelling and downwelling processes on horizontal transport at a given depth, the data does not explicitly represent vertical currents between horizontal layers. This was considered reasonable because vertical currents associated with episodic upwelling and downwelling events are relatively small in magnitude (3-30 cm/s; Kämpf *et al.*, 2004) compared to horizontal currents represented in the tidal and non-tidal current data (0.5-2 m/s), and considering allowances for dispersion rates in the horizontal (0.1-50 m/s) and vertical (1-10 cm/s) planes.

2.3.1.2.2 Mesoscale Currents at the Spill Locations

The data for the scenario indicates that higher average current speeds are characteristic of the April to June period, with the highest average speeds (0.20 m/s) occurring near the release site in June (Figure 2.7). Lower average current speeds are more common during the January to March months, with the lowest average speeds (0.11 m/s) occurring near release site in October. Current directions near the spill site are predominately westerly across the year.

The extracted current data near the spill location provides an insight into the expected initial behaviour of any released oil due to the drift currents alone. Oil moving beyond the release sites, particularly towards the coast, would be subject to considerable variation in the drift current regime.

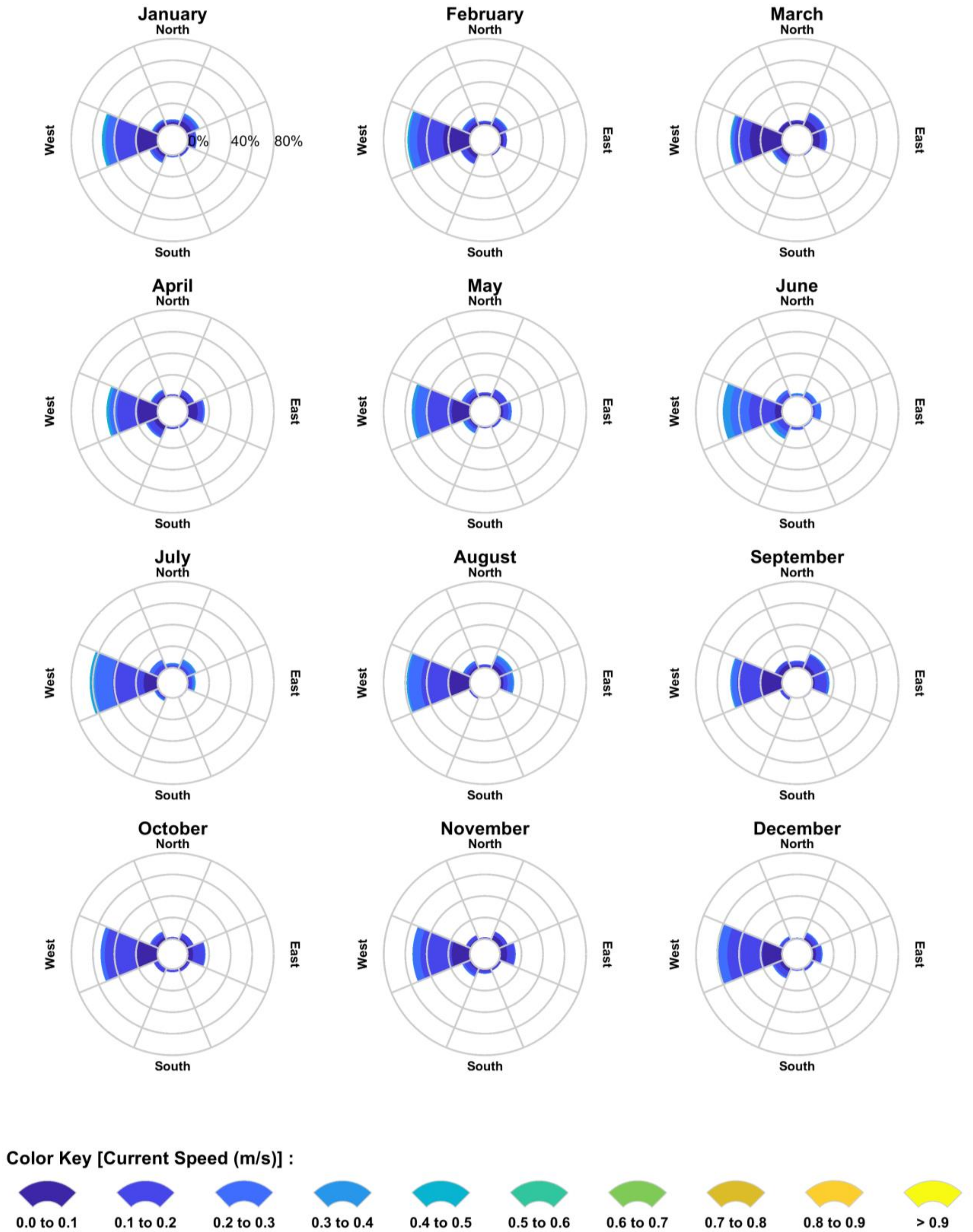


Figure 2.7 Monthly current distribution (2006-2015, inclusive) derived from the BRAN database near to the release location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

2.3.1.3 Tidal Circulation

2.3.1.3.1 Description of Tidal Model: HYDROMAP

As the BRAN model does not include tidal forcing, and because the data is only available at a daily frequency, a tidal model was developed for the study region using RPS' three-dimensional hydrodynamic model, HYDROMAP.

The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 30 years (Isaji and Spaulding, 1986, 1984; Isaji *et al.*, 2001; Zigic *et al.*, 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the National Marine Oil Spill Contingency Plan for the Australian Maritime Safety Authority (AMSA, 2002).

HYDROMAP simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction. The model employs a sophisticated dynamically nested-gridding strategy, supporting up to six levels of spatial resolution within a single domain. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

The numerical solution methodology of HYDROMAP follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji & Spaulding (1984).

2.3.1.3.2 Tidal Domain Setup

A HYDROMAP model was established over a domain that extended approximately 3,300 km east-west by 3,100 km north-south over the eastern Indian Ocean. The grid extends beyond Eucla in the south and beyond Bathurst Island in the north (Figure 2.8).

Approximately 98,600 cells were used to define the region, with four layers of sub-gridding applied to provide variable resolution throughout the domain. The resolution at the primary level was 15 km. The finer levels were defined by subdividing these cells into 4, 16 and 64 cells, resulting in resolutions of 7.5 km, 3.75 km, and 1.88 km.

The finer grids were allocated in a step-wise fashion to areas where higher resolution of circulation patterns was required to resolve flows through channels, around shorelines or over more complex bathymetry. Figure 2.9 shows a zoomed subset of the hydrodynamic model grid in the North West Shelf region, showing the finer resolution grids surrounding the numerous shoals, islands, and complex areas of the mainland coastline.

Bathymetric data used to define the three-dimensional shape of the study domain was extracted from the Geoscience Australia 250 m resolution bathymetry database (Whiteway, 2009) and the CMAP electronic chart database, supplemented where necessary with manual digitisation of chart data supplied by the Australian Hydrographic Office. Depths in the domain ranged from shallow intertidal areas through to approximately 7,200 m.

2.3.1.3.3 Tidal Boundary Conditions

Ocean boundary data for the HYDROMAP model was obtained from the TOPEX/Poseidon global tidal database (TPXO7.2) of satellite-measured altimetry data, which provided estimates of tidal amplitudes and phases for the eight dominant tidal constituents (designated as K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1) at a horizontal scale of approximately 0.25°. Using the tidal data, sea surface heights are firstly calculated along the open boundaries at each time step in the model.

The TOPEX/Poseidon satellite data is produced, and quality controlled by the US National Atmospheric and Space Agency (NASA). The satellites, equipped with two highly accurate altimeters capable of taking sea level measurements accurate to less than ±5 cm, measured oceanic surface elevations (and the resultant tides) for over 13 years (1992-2005). In total, these satellites carried out more than 62,000 orbits of the planet. The TOPEX/Poseidon tidal data has been widely used amongst the oceanographic community, being the subject of more than 2,100 research publications (e.g. Andersen, 1995; Ludicone *et al.*, 1998; Matsumoto *et al.*, 2000; Yaremchuk and Qu, 2004; Qiu and Chen, 2010). As such, the TOPEX/Poseidon tidal data is considered suitably accurate for this study.

2.3.1.3.4 Tidal Elevation Validation

For the purpose of verification of the tidal predictions, the model output was compared against independent predictions of tides using the XTide database (Flater, 1998). The XTide database contains harmonic tidal constituents derived from measured water level data at locations around the world. Overall, there are more than 120 tidal stations within the HYDROMAP model domain; however, some of these are in areas that are not sufficiently resolved by this large-scale ocean model. More than 80 stations along the coastline were suitable for comparisons of the model performance with the observed data. These stations covered the mid-to-northwest regions of the Western Australian coastline, encompassing the locales of the marine discharges considered in this study.

For the purposes of brevity and clarity, a selected representative subset of the available tidal station validation data is presented here.

Water level time series for the selected subset of ten stations are shown in Figure 2.10 and Figure 2.11 for a one-month period (January 2018). All comparisons show that the model produces a very good match to the known tidal behaviour for a wide range of tidal amplitudes and clearly represents the varying diurnal and semi-diurnal nature of the tidal signal.

The model skill was further evaluated through a comparison of the predicted and observed tidal constituents, derived from an analysis of model-predicted time series at each of the tidal station locations. Scatter plots of the observed and modelled amplitude (top) and phase (bottom) of the five dominant tidal constituents (S_2, M_2, N_2, K_1 and O_1) for all relevant stations within the model domain (>80) are presented in Figure 2.12. The red line on each plot shows the 1:1 line, which would indicate a perfect match between the modelled and observed data. Note that the data is generally closely aligned to the 1:1 line demonstrating the high quality of the model performance.

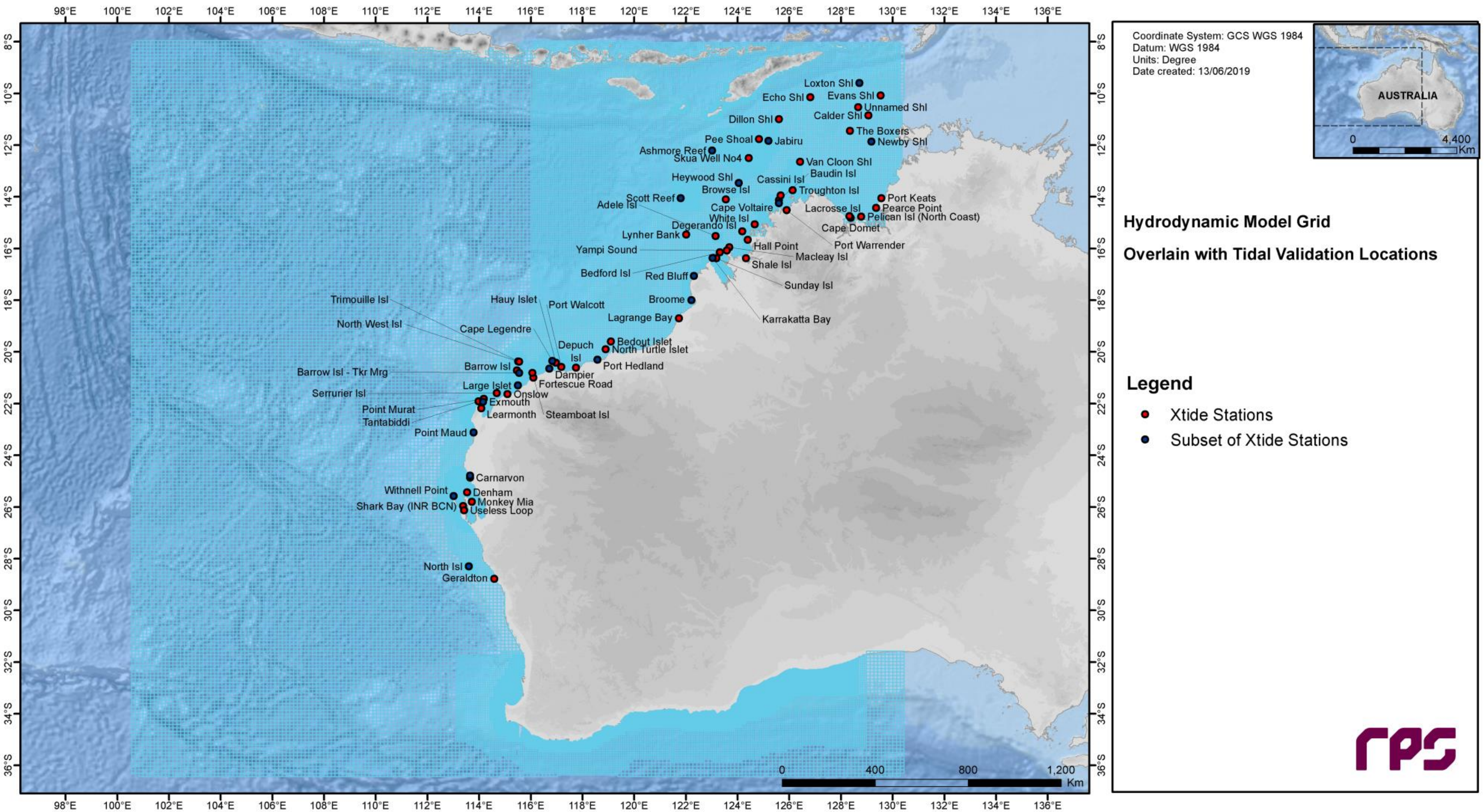


Figure 2.8 **Hydrodynamic model grid (blue wire mesh) used to generate the tidal currents, showing the full domain in context with the continental land mass and the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.**

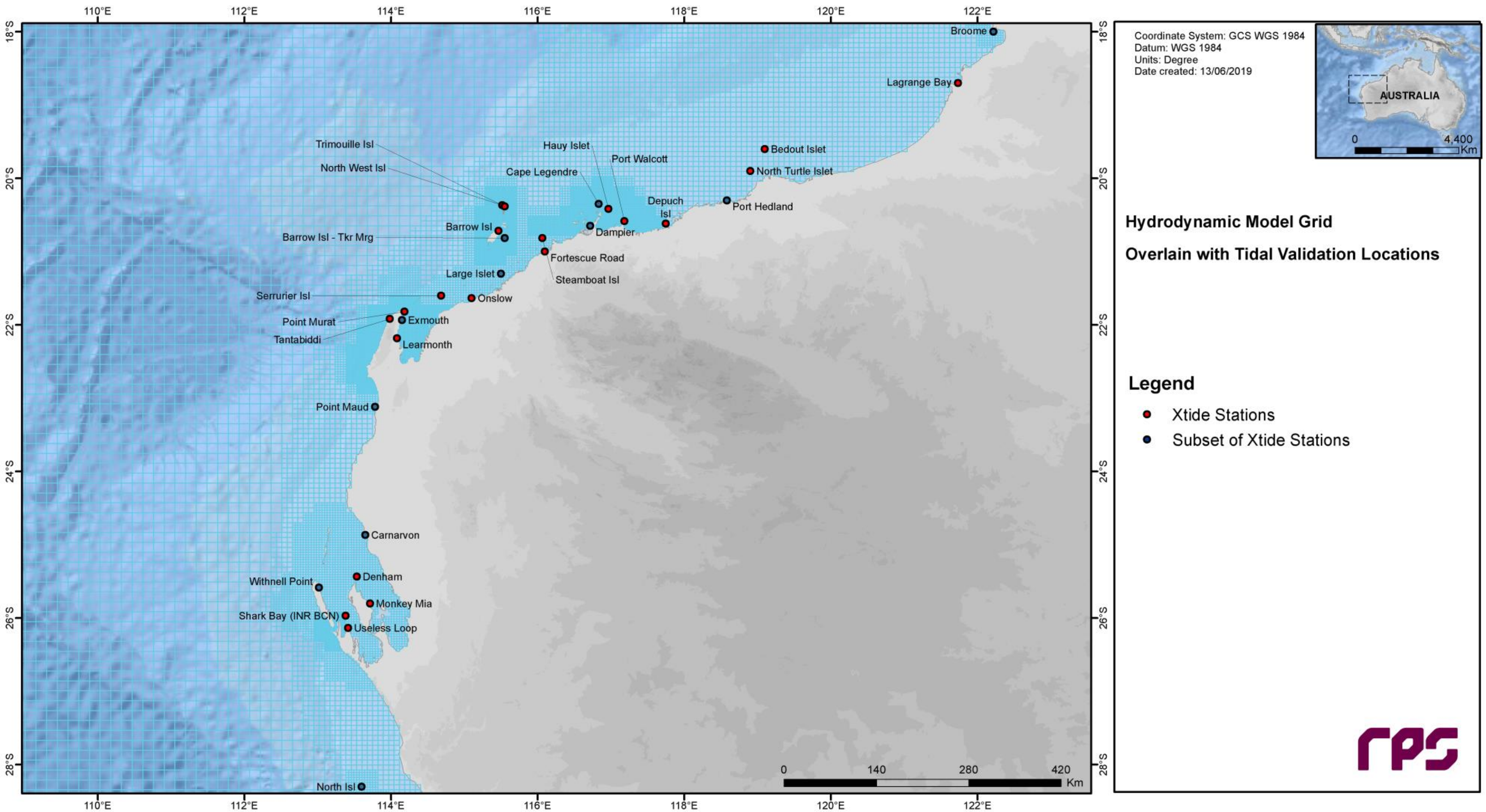


Figure 2.9 **Zoomed subset of the hydrodynamic model grid (blue wire mesh) for the North West Shelf area, showing the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.**

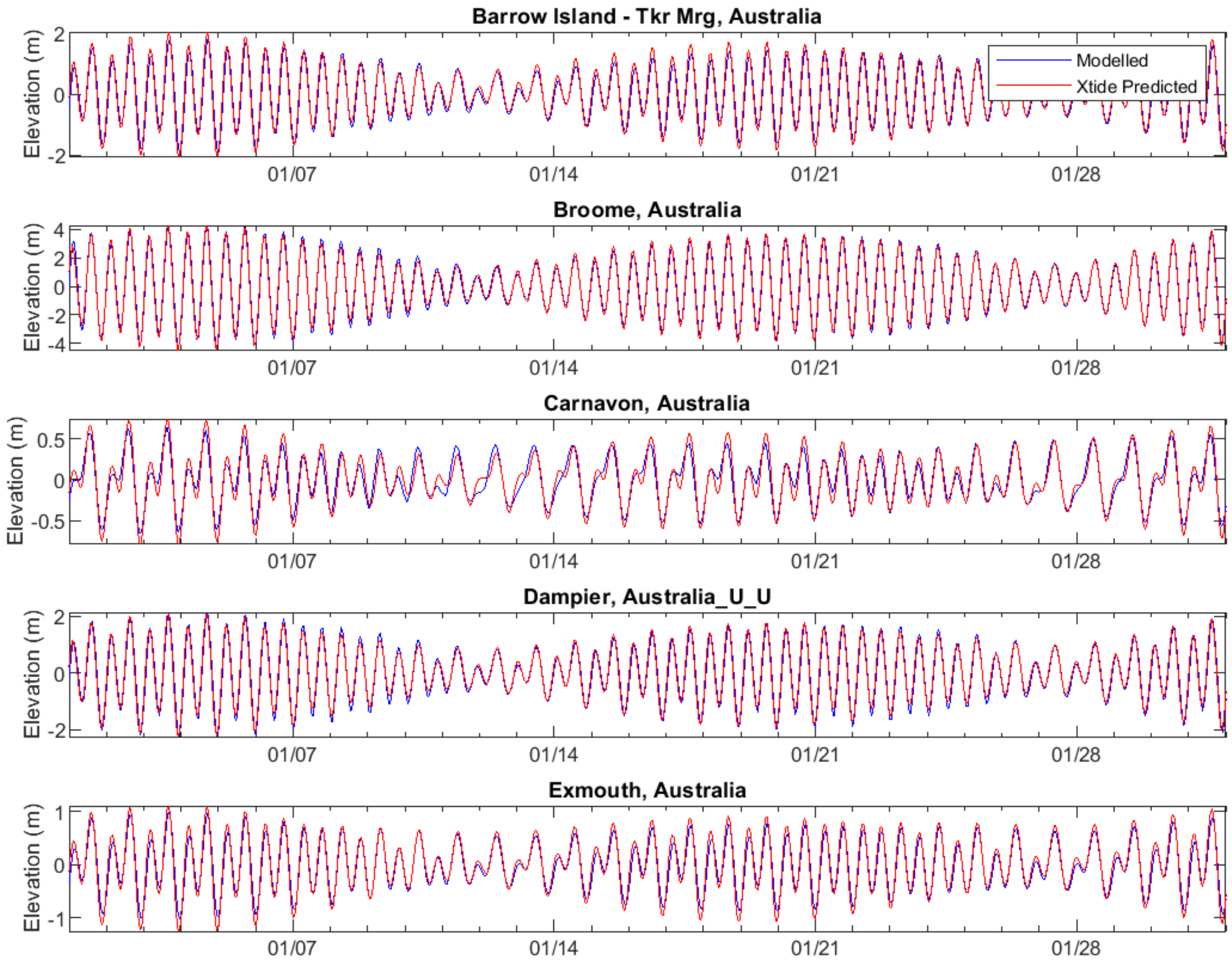


Figure 2.10 Comparisons between the predicted (blue line) and Xtide predicted (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.

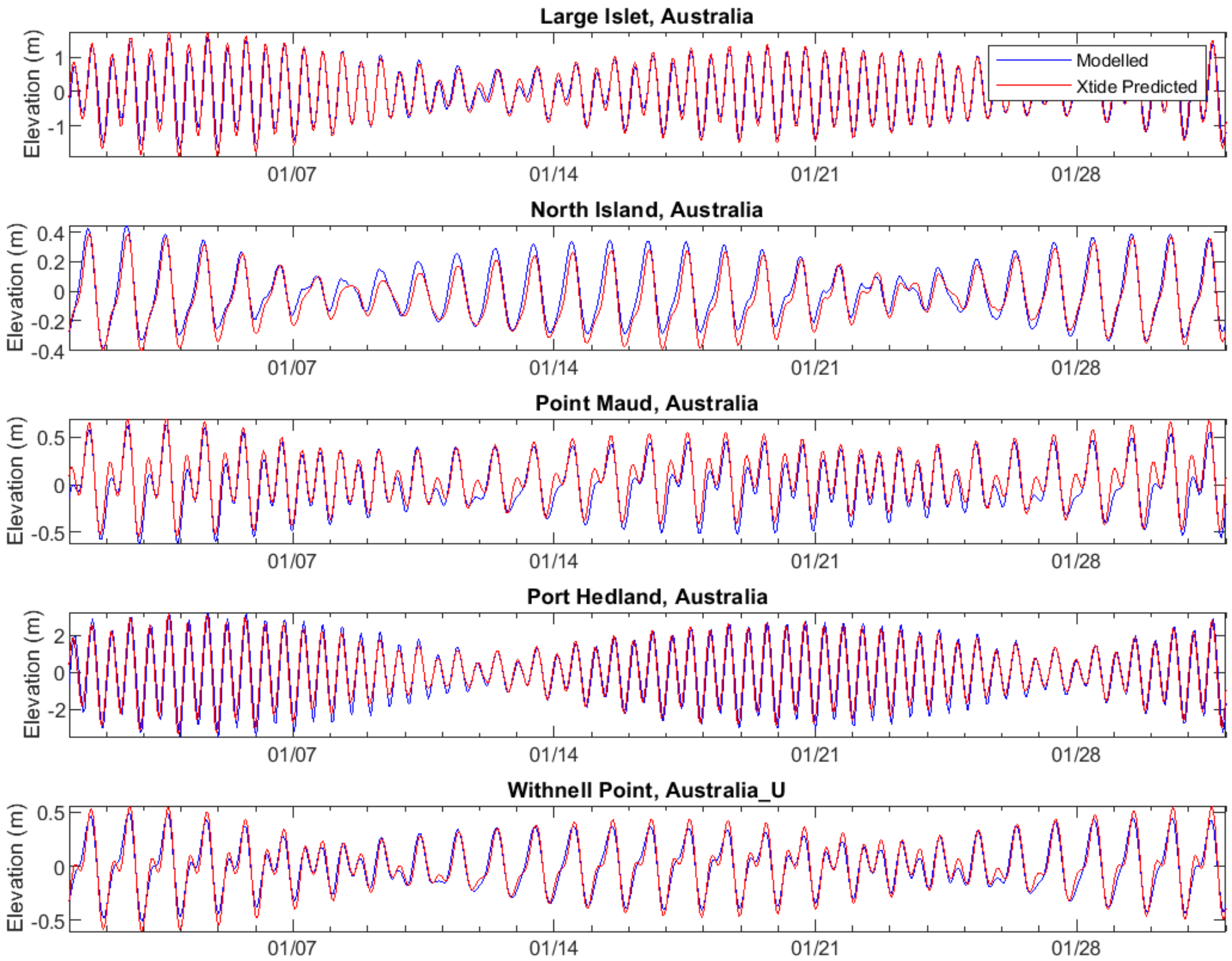
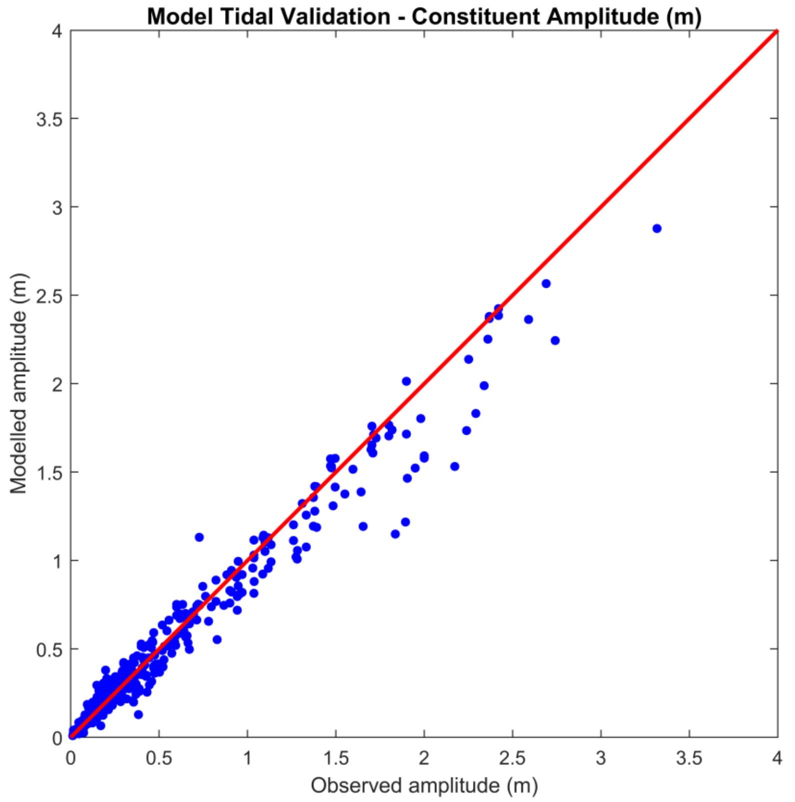


Figure 2.11 Comparisons between the predicted (blue line) and Xtide predicted (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.



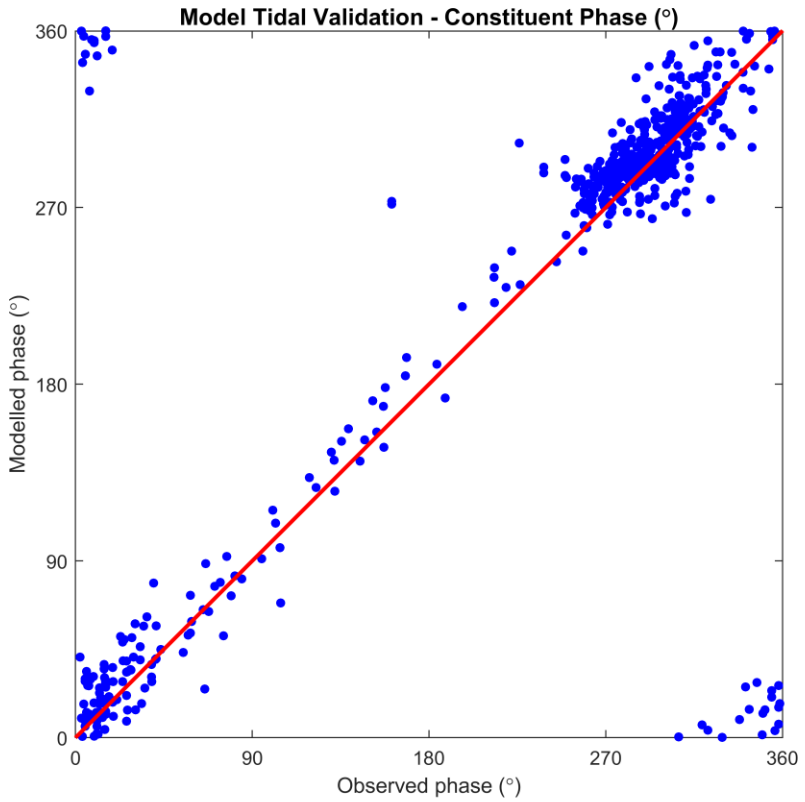


Figure 2.12 Comparisons between modelled and observed tidal constituent amplitudes (top) and phases (bottom) at all relevant stations (> 80) in the HYDROMAP model domain. The red line indicates a 1:1 correlation between the modelled and observed data.

2.3.1.3.5 Tidal Currents at the Spill Location

The monthly distributions of current speeds and directions for the HYDROMAP data point closest to the spill locations are displayed in Figure 2.13. Note that the convention for defining current direction is the direction *towards* which the current flows.

The data indicates cyclical tidal flow directions along a southeast-northwest axis at the modelled spill site for the scenarios. The extracted current data near the spill location provides an insight into the expected initial behaviour of any released oil due to the tidal currents alone. Oil moving beyond the release sites, particularly towards the coast, would be subject to considerable variation in the tidal current regime.

Figure 2.13 Monthly current distribution (2006-2015, inclusive) derived from the HYDROMAP database near to the release location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

2.3.2 Wind Data

To account for the influence of the wind on surface-bound oil slicks, representation of the wind conditions was provided by spatial wind fields sourced from the National Center for Environmental Prediction (NCEP), from the National Oceanic and Atmospheric Administration (NOAA) and Cooperative Institute for Research in Environmental Sciences (CIRES) Climate Diagnostics Center (CDC). The NCEP Climate Forecast System Reanalysis (CFSR; Saha *et al.*, 2010) is a fully-coupled, data-assimilative hindcast model representing the interaction between the Earth’s oceans, land and atmosphere. The gridded data output, including surface winds, is available at 0.25° resolution and 1-hourly time intervals.

Time series of wind speed and direction were extracted from the CFSR database for all nodes in the model domain for the same temporal coverage as the current data (2006-2015, inclusive). The data was assumed to be a suitably representative sample of the wind conditions over the study area for future years.

Figure 2.14 shows the monthly distributions of wind speeds and directions for the CFSR data points closest to the release locations for both scenarios. Note that the convention for defining wind direction is the direction *from* which the wind blows.

Based on the release location, the wind roses indicate predominantly easterly between May and June and south-westerly winds dominating in the October to February period. Average wind speeds across the year near the release site vary in the range 5.1-7.1 m/s, with year-round maximum speeds of 25.5 m/s.

The extracted wind data near the spill location suggests possible initial trajectories due to the wind acting on surface slicks in the absence of any current effects. Note that the actual trajectories of surface slicks will be the net result of a combination of the prevailing wind and current vectors acting at a given time and location.

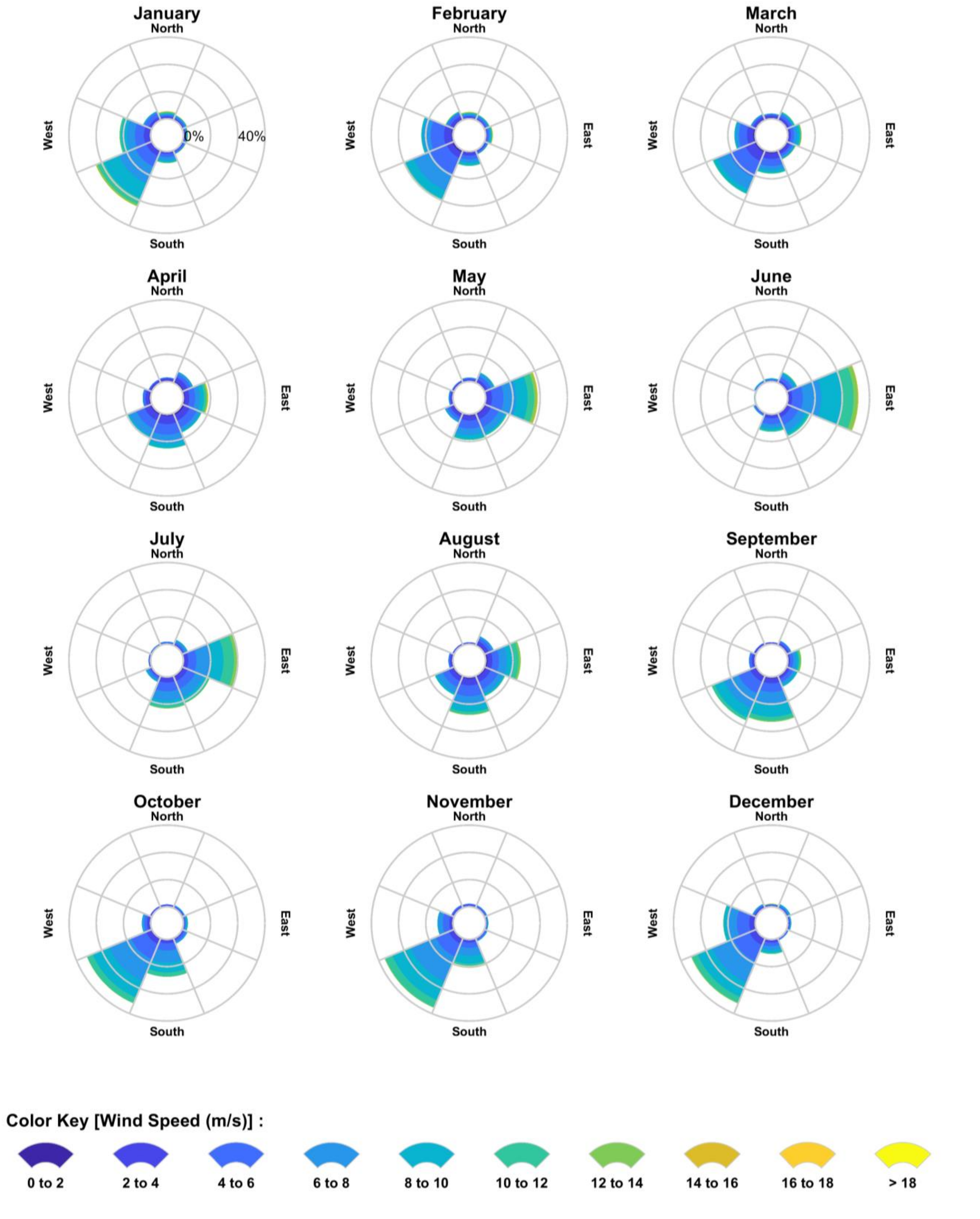


Figure 2.14 Monthly wind distribution (2006-2015, inclusive) derived from the CFSR database near to the release location. The colour key shows the wind magnitude, the compass direction provides the direction from which the wind is blowing, and the size of the wedge gives the percentage of the record.

2.3.3 Water Temperature and Salinity Data

Vertical profiles of sea temperature and salinity at the spill locations were retrieved from a data point in the The World Ocean Atlas 2013 (WOA13) database near the study area, with monthly averages used as input to SIMAP. WOA13 is provided by NOAA and is a hindcast model of the climatological fields of in situ temperature, salinity, and a number of additional variables (NOAA, 2013). WOA13 has a 0.25° resolution and has standard depth levels ranging from the water surface to 5,500 m (Levitus *et al.*, 2013; Locarnini *et al.*, 2013; Zweng *et al.*, 2013).

Figure 2.15 shows the variation in water temperature and salinity both seasonally and over depth for the selected data point nearest to the release location. The mixed layer is most pronounced in July and becomes shallower in March.

The average temperature over the upper 100 m of the water column varies from approximately 23-27°C across the year, while the average salinity over this depth varies from approximately around 34.9 PSU year-round.

2.3.4 Dispersion

A horizontal dispersion coefficient of 10 m^2/s was used to account for dispersive processes acting at the surface that are below the scale of resolution of the input current field, based on typical values for open waters (Okubo, 1971). Dispersion rates within the water column (applicable for entrained and dissolved plumes of hydrocarbons) were specified at 1 m^2/s, based on empirical data for the dispersion of hydrocarbon plumes over offshore waters (King and McAllister, 1998).

2.3.5 Replication

Multiple replicate simulations were completed for the scenario to account for trends and variations in the trajectory and weathering of spilled oil, with an even number of replicates completed using samples of metocean data that commenced within each calendar quarter.

For each scenario, a total of 100 replicate simulations were run over an annual period. Tabulated probabilities were assessed to a minimum level of 1%.

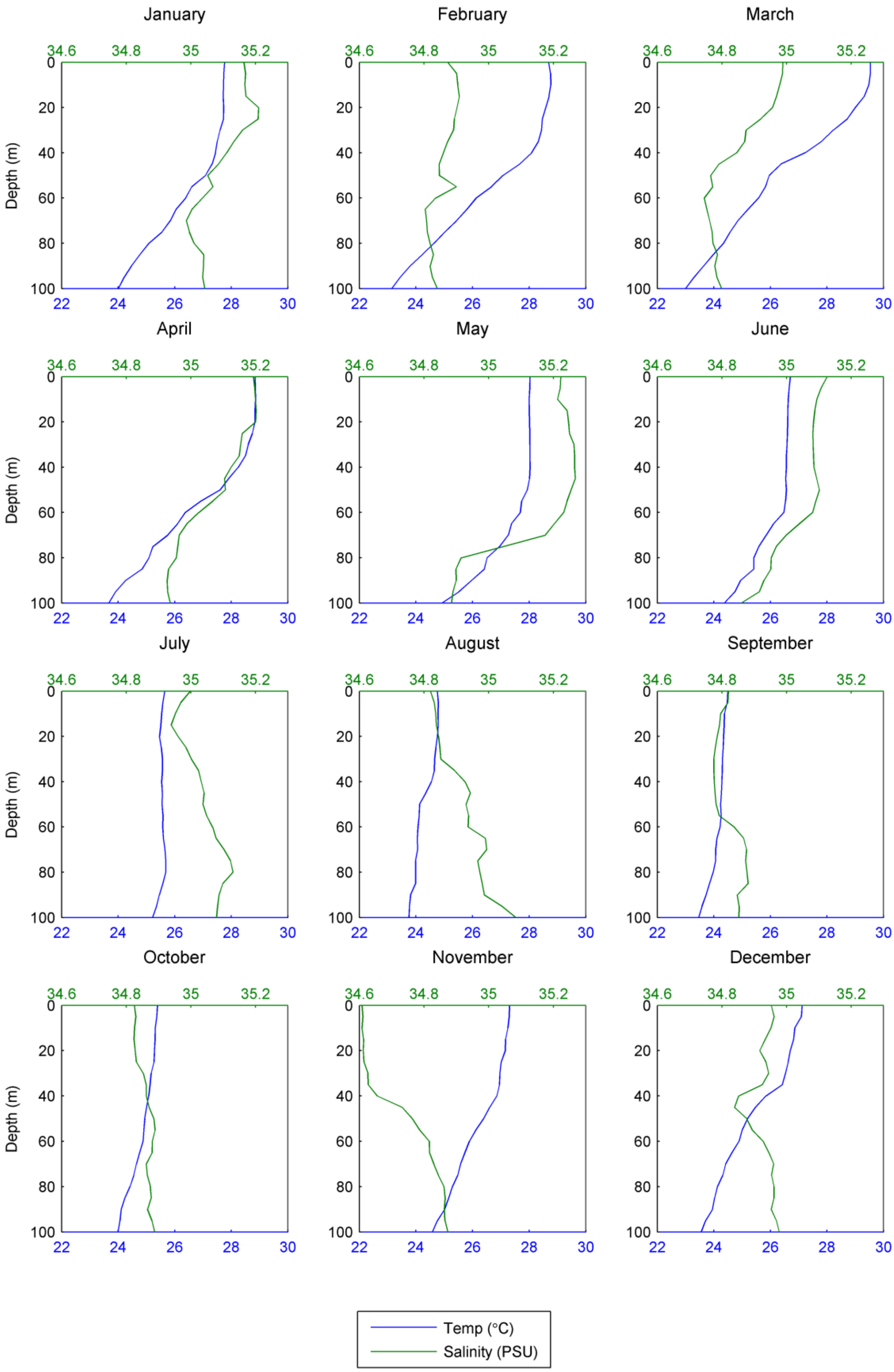


Figure 2.15 Temperature (blue line) and salinity (green line) profiles derived from the WOA13 database near the release location.

2.3.6 Contact Thresholds

2.3.6.1 Overview

The SIMAP model will track oil concentrations to very low levels. Hence, it is useful to define meaningful threshold concentrations for the recording of contact by oil components and determining the probability of exposure at a location (calculated from the number of replicate simulations in which this contact occurred).

The judgement of meaningful levels is complicated and will depend upon the mode of action, sensitivity of the biota contacted, the duration of the contact and the toxicity of the compounds that are represented in the oil. The latter factor is further complicated by the change in the composition of an oil type over time due to weathering processes. Without specific testing of the oil types, at different states of weathering against a wide range of the potential local receptors, such considerations are beyond the scope of this investigation.

For this case, thresholds for floating, shoreline, entrained and dissolved aromatic hydrocarbons were specified by Woodside for use in defining the potential zone of influence of the spill event. These thresholds are summarised in Table 2-1 and discussed afterwards.

Table 2-1 Summary of the thresholds applied in this study.

Floating Oil Concentration (g/m^2)	Shoreline Oil Concentration (g/m^2)	Entrained Oil Concentration (ppb)	Dissolved Aromatic Hydrocarbon Concentration (ppb)
1 10 50	10 100 250	10 100	10 50

2.3.6.2 Floating Oil

Floating oil concentrations are relevant to describing the risks of oil coating emergent reefs, vegetation in the littoral zone and shoreline habitats, as well as the risk to wildlife found on the water surface, such as marine mammals, reptiles, and birds. Floating oil is also visible at relatively low concentrations (> ~0.05 g/m^2). Hence, the area affected by visible oil, which might trigger social or economic impacts, will be larger than the area where biological impacts might be expected.

Estimates for the minimal thickness of floating oil that might result in harm to seabirds through ingestion from preening of contaminated feathers, or the loss of the thermal protection of their feathers, has been estimated by different researchers at approximately 10 g/m^2 (French-McCay, 2009) to 25 g/m^2 (Koops *et al.*, 2004). Hence, the 10 g/m^2 threshold is likely to be moderately conservative in terms of environmental harm for effects on seabirds, for example. The lower threshold of 1 g/m^2 is likely to be an indicator of where there is a visual presence of an oil slick that may trigger social and economic impacts but where there is little potential for environmental impact.

The 50 g/m^2 threshold is above the minimum threshold observed to cause ecological impact and would therefore be considered high exposure.

It is important to note that real spill events generate surface slicks that break up into multiple patches separated by areas of open water. Concentrations calculated and presented in this study represent necessary areal averaging over discrete model cells, and therefore indicate the potential for both higher and lower relative concentrations in the surrounding space.

2.3.6.3 Shoreline Oil

Shoreline oil concentrations are relevant to describing the risks of oil stranding on shorelines and beaches. French *et al.* (1996) and French-McCay (2009) have defined an oil exposure threshold of 100 g/m^2 for shorebirds and wildlife (furbearing aquatic mammals and marine reptiles) on or along the shore, which is based on studies for sub-lethal and lethal impacts. The 100 g/m^2 threshold has been used in previous environmental risk assessment studies (French McCay *et al.*, 2004; French-McCay, 2003; 2012, 2011; NOOA, 2013). This threshold is also recommended in AMSA's foreshore assessment guide as the acceptable minimum thickness that does not inhibit the potential for recovery and is best remediated by natural coastal processes alone (AMSA, 2015). The 250 g/m^2 threshold is above the levels observed to cause ecological impact and would therefore be considered a high exposure threshold. Contact within these exposure zones may result in impacts to the marine environment.

A threshold of 10 g/m^2 has been defined as the zone of potential 'low' exposure. This exposure zone represents the area visibly contacted by the spill and defines the outer boundary of the area of influence from a hydrocarbon spill.

2.3.6.4 Entrained Oil

Oil can be entrained into the water column from surface slicks due to wind and wave-induced turbulence or be generated subsea by a pressurised discharge at depth. Entrained oil presents several possible mechanisms for exerting exposure. The entrained oil droplets may contain soluble compounds and hence have the potential to generate elevated concentrations of dissolved hydrocarbons (e.g., if mixed by breaking waves against a shoreline). Physical and chemical effects of the entrained oil droplets have also been demonstrated through direct contact with organisms; for example, through physical coating of gills and body surfaces, or accidental ingestion (NRC, 2005).

The 10 ppb threshold represents the lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) (ANZECC & ARMCANZ, 2000) water quality guidelines. Due to the requirement for relatively long exposure times (>24 hours) for these concentrations to be significant, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained plumes, or when entrained hydrocarbons adhere to organisms or is trapped against a shoreline for periods of several days or more. The 10 ppb threshold exposure zone is not considered to be of significant biological impact. This exposure zone represents the area contacted by the spill and conservatively defines the outer boundary of the area of influence from a hydrocarbon spill.

The 100 ppb threshold is considered conservative in terms of potential for toxic effects leading to mortality for sensitive mature individuals and early life stages of species. This threshold has been defined to indicate a potential zone of acute exposure, which is more meaningful over shorter exposure durations. The 100 ppb threshold has been selected to define the moderate exposure zone. Contact within this exposure zone may result in impacts to the marine environment.

2.3.6.5 Dissolved Aromatic Hydrocarbons

The mode of action of soluble hydrocarbons is a narcotic effect resulting from uptake into the tissues of organisms. This effect is additive, increasing with exposure concentration or with time of exposure (French-McCay, 2002; NRC, 2005). For many oil mixtures, the concentration of aromatic hydrocarbons, and specifically the polyaromatic hydrocarbons (PAHs), in the water-soluble fraction is the best predictor of the toxicity of the oil.

Actual toxicity depends on both concentration and the duration of exposure, being a balance between acute and chronic effects. To put these thresholds into context, global data from French *et al.* (1999) and French-McCay (2003, 2002), which showed that species sensitivity (fish and invertebrates) to dissolved aromatics exposure in the water column > 4 days (96-hour LC_{50}) under different environmental conditions varied from 6 ppb-400 ppb, with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae).

Based on scientific literature, the lower threshold of 10 ppb is not considered to be of significant biological impact and represents the low exposure area contacted by the spill. The higher thresholds of 50 ppb and 400 ppb is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay, 2002).

2.3.7 Oil Characteristics

2.3.7.1 Overview

The characteristics of PYA-01 Condensate, as specified by Woodside (2023) is summarised in Table 2.2. Viscosity values were assumed be similar as JULA-P Condensate as it was not provided.

Table 2.2 Characteristics of the oil types used in the modelling.

Oil Type	Density (g/cm^3)	Viscosity (cP)	Component	Volatile (%)	Semi-volatile (%)	Low volatility (%)	Residual	Aromatics
			Boiling point (°C)	<180 C4 to C10	180-265 C11 to C20	265-380 C16 to C20	>380 >C20	Of whole oil <380 BP
PYA-01 Condensate	0.801 at 15 °C	1.390 at 20 °C	**% of total**	48	19	30	3	21.1
			% aromatics	10.1	4.0	6.3	0.7	-

The boiling points are dictated by the length of the carbon chains, with the longer and more complex compounds having a higher boiling point, and therefore lower volatility and evaporation rate.

The aromatic components within the volatile to low-volatility range are also soluble (with decreasing solubility following decreasing volatility) and will dissolve across the oil-water interface. The rate of dissolution will increase with increased surface area. Hence, dissolution rates will be higher under discharge conditions that generate smaller oil droplets.

Atmospheric weathering will commence when oil droplets float to the water surface. Typical evaporation times once the hydrocarbons reach the surface and are exposed to the atmosphere are:

- Up to 12 hours for the C4 to C10 compounds (or less than 180 °C BP).
- Up to 24 hours for the C11 to C15 compounds (180-265 °C BP).
- Several days for the C16 to C20 compounds (265-380 °C BP).
- Not applicable for the residual compounds (BP > 380 °C), which will resist evaporation, persist in the marine environment for longer periods, and be subject to relatively slow degradation.

The actual fate of released oil in the marine environment will depend greatly on the amount of oil that reaches the surface, either through the initial release or by rising after discharge in the water column.

2.3.7.2 PYA-01 Condensate

PYA-01 condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi-volatile components. In favourable evaporation conditions, about 48% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); up to a further 19% could evaporate within the first 24 hours (180 °C < BP < 265 °C); and a further 30% should evaporate over several days (265 °C < BP < 380 °C). Approximately 3% of the oil is shown to be persistent.

The whole condensate has a low asphaltene content (< 0.5%), indicating a low propensity for the mixture to take up water to form water-in-oil emulsion over the weathering cycle.

Soluble, aromatic hydrocarbons contribute approximately 21.1% by mass of the whole oil. Around 10.1% by mass is highly soluble and highly volatile. A further 4% by mass has semi-to-low volatility. These compounds dissolve more slowly but tend to persist in soluble form for longer. Discharge onto the water surface will favour the process of evaporation over dissolution under calm sea conditions, but increased entrainment of oil and dissolution of soluble compounds can be expected under breaking wave conditions.

2.3.8 Surface Weathering Characteristics

2.3.8.1 Overview

A series of model weather tests were conducted to illustrate the potential behaviour of PYA-01 Condensate when exposed to idealised and representative environmental conditions:

- Instantaneous release onto the water surface at a discharge rate of 50 m^3/hr under calm wind conditions (constant 5 knots), assuming low seasonal water temperature (27 °C) and average air temperature (25 °C). Slick also subject to ambient tidal and drift currents.
- Instantaneous release onto the water surface at a discharge rate of 50 m^3/hr under variable wind conditions (4-19 knots, drawn from representative data files), assuming low seasonal water temperature (27 °C) and average air temperature (25 °C). Slick also subject to ambient tidal and drift currents.

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

2.3.8.2 PYA-01 Condensate

The mass balance forecast for the constant-wind case (Figure 2.16) for PYA-01 condensate shows that approximately 66% of the oil is predicted to evaporate within 12 hours. Under these calm conditions most of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (Figure 2.17), where the winds are of greater strength, entrainment of the condensate into the water column is indicated to be significant. Approximately 12 hours after the spill, around 33.7% of the oil mass is forecast to have entrained and a further 58.2% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (< 1%). The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately > 6 m/s).

The increased level of entrainment in the variable-wind case will result in a higher percentage of biological and photochemical degradation, where the decay of the floating slicks and oil droplets in the water column occurs at an approximate rate of 1.5% per day with an accumulated total of ~10.6% after 7 days, in comparison to a rate of ~0.22% per day and an accumulated total of 1.52% after 7 days in the constant-wind case. Given the considerable proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay and/or evaporate over time scales of several weeks to a few months. This long weathering duration will extend the area of potential effect, requiring the break-up and dispersion of the slicks and droplets to reduce concentrations below the thresholds considered in this study.

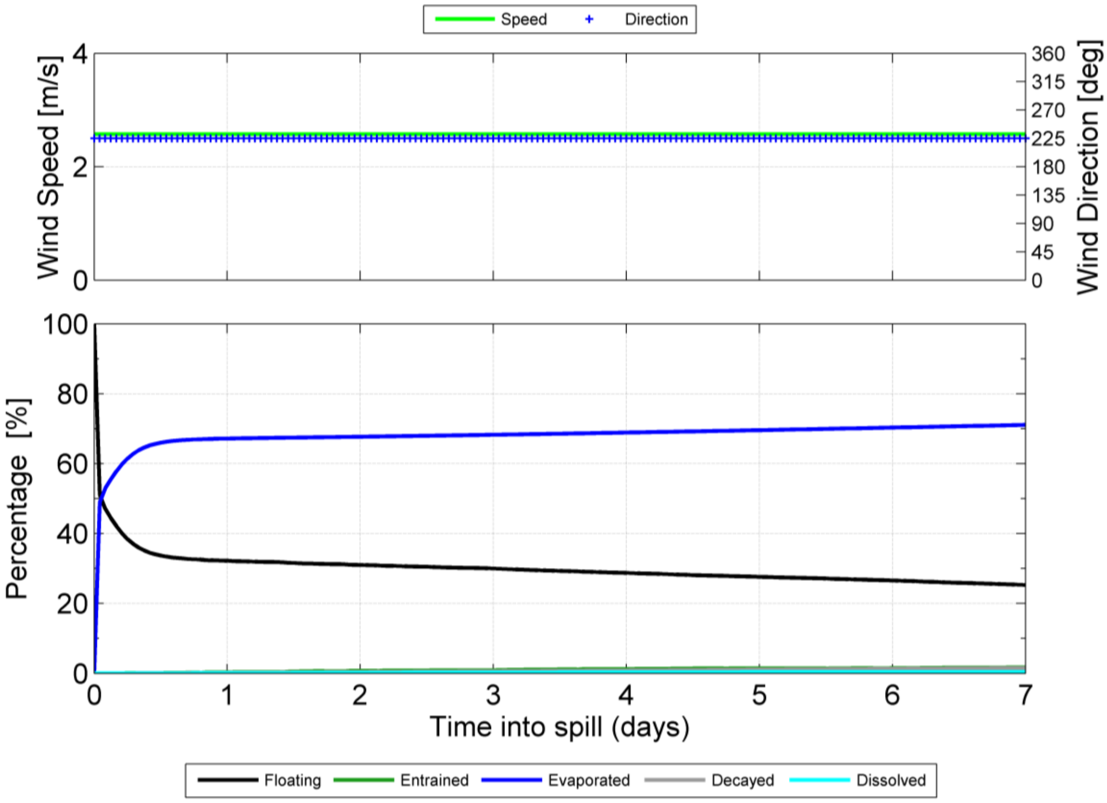


Figure 2.16 Proportional mass balance plot representing the weathering of PYA-01 condensate spilled onto the water surface as a one-off release (50 m³) and subject to a constant 5 kn (2.6 m/s) wind at 27 °C water temperature and 25 °C air temperature.

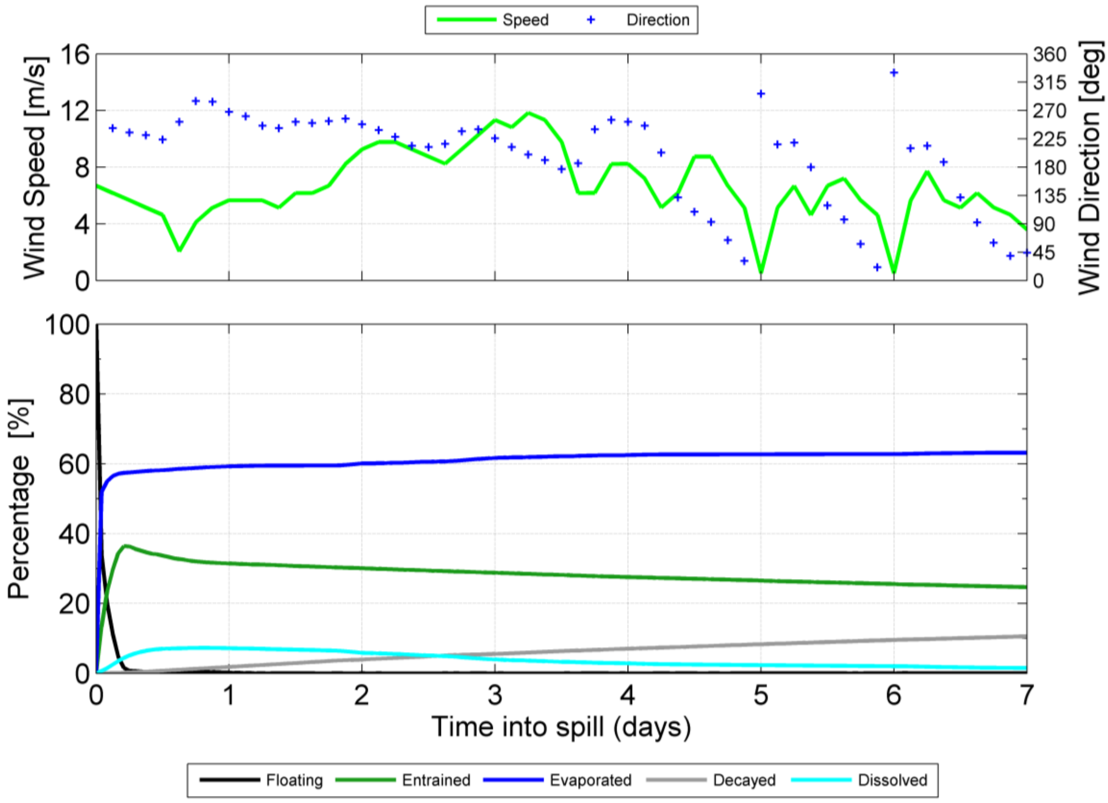


Figure 2.17 Proportional mass balance plot representing the weathering of PYA-01 condensate spilled onto the water surface as a one-off release (50 m³) and subject to variable wind at 27 °C water temperature and 25 °C air temperature.

3 SUBSURFACE DISCHARGE CHARACTERISTICS

3.1 Scenario 1A: 77-day uncontrolled surface/subsurface release of 645,721 m^3 of PYA-01 Condensate

The OILMAP input parameters and the resulting output parameters that were used as input to SIMAP are presented in Table 3.1. The model input also included temperature and salinity profiles representative of the release location.

The results of the OILMAP simulation predict that the discharge will initially generate a cone of rising gas that will entrain the oil droplets and ambient sea water to the sea surface. In the first week (Week 1), the mixed plume was initially forecast to jet towards the water surface with a vertical velocity of around 22.5 m/s, gradually slowing and increasing the plume diameter as more ambient water is entrained. The terminal velocity of rising water and oil at the point of surfacing was predicted to be approximately 18.17 m/s with a cone diameter of approximately 10.32 m. In the last week (Week 11), the mixed plume was initially forecast to jet towards the water surface with a vertical velocity of around 17.15 m/s, slowing and increasing the plume diameter as more ambient water is entrained. The terminal velocity of rising water and oil at the point of surfacing was predicted to be 13.96 m/s with a cone diameter of approximately 10.32 m.

Given the discharge velocity and turbulence generated by the expanding gas plume, the release is predicted to generate droplet sizes ranging from approximately 66 µm to 612 µm. These droplets will be subject to mixing due to turbulence generated by the lateral displacement of the rising plume. The plume mixture is expected to reach the surface in less than 1 minute.

The ongoing nature of the release combined with the potential for the plume to breach the water surface may present other hazards, including conditions that may lead to high local concentrations of atmospheric volatiles. These issues should be considered when evaluating the practicality of response operations at or near the blowout site. The results suggest that beyond the immediate vicinity of the release most of the released hydrocarbons will be present in the upper layers of the ocean, with the potential for oil to form floating slicks under sufficiently calm local wind conditions.

Table 3.1 Near-field subsurface discharge model parameters for Scenario 1A.

OILMAP	Parameter	Value										
Inputs	Release depth (m BMSL)	80										
	Oil density (g/cm^3) (at 15 °C)	0.801										
	Oil viscosity (cP) (at 40 °C)	1.39										
	Oil temperature (°C)	90										
	Hole diameter (m) [in]	0.25 [9.875]										
	Period	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**	**Week 9**	**Week 10**	**Week 11 (2 days)**
	Oil flow rate (m^3/hr) [bbl/hr]	506 [3,185]	444 [2,791]	397 [2,495]	360 [2,265]	330 [2,078]	306 [1,923]	285 [1,792]	267 [1,679]	251 [1,581]	238 [1,495]	230 [1,444]
	Gas:oil ratio (m^3/m^3) [scf/bbl]	2,301 [12,919]	2,308 [12,961]	2,314 [12,993]	2,318 [13,015]	2,321 [13,033]	2,324 [13,047]	2,326 [13,059]	2,327 [13,068]	2,329 [13,077]	2330 [13,084]	2,331 [13,088]
	Reservoir pressure (psi)	5,942										
Outputs	Plume diameter (m)	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32
	Plume height (m ASB)	80	80	80	80	80	80	80	80	80	80	80
	Plume initial rise velocity (m/s)	22.25	21.32	20.55	19.35	19.35	18.86	18.86	18.88	18.87	18.88	17.15
	Plume terminal rise velocity (m/s)	18.17	17.40	16.77	15.78	15.78	15.38	15.38	15.38	15.39	15.39	13.96
Predicted Oil Droplet Size Distribution	20% droplets of size (µm)	66.2	86.7	97.1	107.2	117.1	126.7	136.2	145.6	154.88	164.1	170.0
	20% droplets of size (µm)	96.6	126.6	141.8	156.6	170.9	185.0	198.9	212.6	226.2	239.6	248.3
	20% droplets of size (µm)	125.6	164.5	184.3	203.5	222.2	240.5	258.5	276.3	293.9	311.5	322.7
	20% droplets of size (µm)	163.3	213.8	239.6	264.5	288.8	312.6	336.0	359.2	382.1	404.8	419.5
	20% droplets of size (µm)	238.4	312.3	349.8	386.2	421.7	456.5	490.7	524.5	557.9	591.1	612.5

3.2 Scenario 1B: 77-day uncontrolled surface/subsurface release of 745,012 m^3 of PYA-01 Condensate

The OILMAP input parameters and the resulting output parameters that were used as input to SIMAP are presented in Table 3.1. The model input also included temperature and salinity profiles representative of the release location.

The results of the OILMAP simulation predict that the discharge will initially generate a cone of rising gas that will entrain the oil droplets and ambient sea water to the sea surface. In the first week (Week 1), the mixed plume was initially forecast to jet towards the water surface with a vertical velocity of around 22.8 m/s, gradually slowing and increasing the plume diameter as more ambient water is entrained. The terminal velocity of rising water and oil at the point of surfacing was predicted to be approximately 18.6 m/s with a cone diameter of approximately 10.3 m. In the last week (Week 11), the mixed plume was initially forecast to jet towards the water surface with a vertical velocity of around 18.6 m/s, slowing and increasing the plume diameter as more ambient water is entrained. The terminal velocity of rising water and oil at the point of surfacing was predicted to be 15.14 m/s with a cone diameter of approximately 10.3 m.

Given the discharge velocity and turbulence generated by the expanding gas plume, the release is predicted to generate droplet sizes ranging from approximately 116 µm to 783 µm. These droplets will be subject to mixing due to turbulence generated by the lateral displacement of the rising plume. The plume mixture is expected to reach the surface in less than 1 minute.

The ongoing nature of the release combined with the potential for the plume to breach the water surface may present other hazards, including conditions that may lead to high local concentrations of atmospheric volatiles. These issues should be considered when evaluating the practicality of response operations at or near the blowout site. The results suggest that beyond the immediate vicinity of the release most of the released hydrocarbons will be present in the upper layers of the ocean, with the potential for oil to form floating slicks under sufficiently calm local wind conditions.

Table 3.2 Near-field subsurface discharge model parameters for Scenario 1B.

OILMAP	Parameter	Value										
Inputs	Release depth (m BMSL)	80										
	Oil density (g/cm^3) (at 15 °C)	0.801										
	Oil viscosity (cP) (at 40 °C)	1.39										
	Oil temperature (°C)	90										
	Hole diameter (m) [in]	0.25 [9.875]										
	Period	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**	**Week 9**	**Week 10**	**Week 11 (2 days)**
	Oil flow rate (m^3/hr) [bbl/hr]	538 [3,384]	490 [3,084]	452 [2,840]	419 [2,639]	392 [2,465]	368 [2,318]	348 [2,189]	330 [2,076]	314 [1,975]	300 [1,885]	291 [1,831]
	Gas:oil ratio (m^3/m^3) [scf/bbl]	2,316 [13,002]	2,320 [13,023]	2,322 [13,040]	2,325 [13,053]	2,327 [13,065]	2,329 [13,074]	2,330 [13,082]	2,331 [13,089]	2,332 [13,095]	2,333 [13,099]	2,334 [13,103]
	Reservoir pressure (psi)	5,968										
Outputs	Plume diameter (m)	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32
	Plume height (m ASB)	80	80	80	80	80	80	80	80	80	80	80
	Plume initial rise velocity (m/s)	22.76	22.08	21.48	20.96	20.50	20.09	19.71	19.37	19.05	18.58	18.58
	Plume terminal rise velocity (m/s)	18.59	18.03	17.54	17.11	16.73	16.39	16.01	15.80	15.53	15.14	15.14
Predicted Oil Droplet Size Distribution	20% droplets of size (µm)	116	127	139	149	160	171	181	191	201	211	217
	20% droplets of size (µm)	169	186	202	218	234	249	264	279	294	308	317
	20% droplets of size (µm)	220	242	263	284	304	324	343	363	382	400	412
	20% droplets of size (µm)	286	314	342	369	395	421	446	471	496	520	536
	20% droplets of size (µm)	417	459	499	538	577	615	652	688	724	760	783

4 STOCHASTIC ASSESSMENT RESULTS

4.1 Overview

Predictions for the probability of contact and time to contact by oil concentrations equalling or exceeding defined thresholds for floating oil, shoreline oil, entrained oil and dissolved aromatic hydrocarbons are provided in the following sections to summarise the results of the annualised stochastic modelling.

Contour maps present estimates for the annualised probabilities of contact by instantaneous concentrations of at least the defined minimum threshold concentrations (≥1 g/m^2, ≥10 g/m^2 and 50 g/m^2 for floating oil; ≥10 g/m^2, ≥100 g/m^2 and 250 g/m^2 for shoreline oil; ≥10 ppb and ≥100 ppb for entrained oil and ≥10 ppb, ≥50 ppb and ≥400 ppb for dissolved aromatic hydrocarbons) for at least one time step. These contours summarise the outcomes for all replicate simulations commencing across the annual period – a total of 100 replicates (25 per quarter).

Readers should note that the contour maps presented in this report do not represent the predicted coverage of any one hydrocarbon spill or a depiction of a slick or plume at any particular instant in time. Rather, the contours are a composite of a large number of theoretical slick paths, integrated over the full duration of the simulations relevant to each scenario. The contour maps should be treated as indications of the probability of exposure at defined concentrations, for individual locations, at some point in time after the defined spill commences, given the trends and variations in metocean conditions that occur around the study area.

Locations with higher probability ratings were exposed during a greater number of spill simulations, indicating that the combination of the prevailing wind and current conditions are more likely to result in contact to these locations if the spill scenario were to occur in the future. The areas outside of the lowest-percentage contour indicate that contact will be less likely under the range of prevailing conditions for this region than areas falling within higher probability contours. It is important to note that the probabilities are derived from the samples of data used in the modelling. Therefore, locations that are not calculated to receive exposure at threshold concentrations or greater in any of the replicate simulations might possibly be contacted if very unusual conditions were to occur. Hence, we do not attribute a probability of nil to areas beyond the lowest probability contour.

Tables are presented to summarise estimates of contact risk for locations within potentially sensitive receptors that were defined by Woodside. All sensitive receptors considered for Woodside spill risk assessments were included in the analysis, with those outlined here being the receptors shown to be at risk of contact for the scenarios in this study.

The probability estimates for contact by floating oil that are presented in the tables summarise the probability that oil will arrive at any part of the sensitive receptor as floating films at the specified threshold concentration or greater for at least one-time step (1-hour). For shoreline oil, the probabilities are estimated as the probability that oil will accumulate on a least one segment of the receptor shoreline at the specified threshold concentration or greater for at least one-time step. The tables show the annualised probabilities determined from the results across the calendar quarters.

The minimum time estimates shown in the tables present the shortest time for any oil to drift from the source to any part of the sensitive receptor for floating oil and to the coastline for shoreline oil, relative to the commencement of the spill. These times then indicate the minimum weathering time for oil that might make contact with the receptor. The annualised minimum time is calculated as the lowest minimum time in any calendar quarter, for those quarters where contact was indicated in at least one replicate.

The mean and maximum shoreline concentrations indicate the concentrations forecast to potentially accumulate over time on any discrete part of a shoreline (calculated for individual portions of ~1 km length). Accumulated concentrations are calculated by summing the mass of oil that arrives at any concentration (including that below threshold) over time at a model cell and subtracting any mass lost through evaporation and washing off, where relevant.

The maximum local accumulated concentration in the worst replicate spill is the greatest accumulation predicted for any point on the shoreline during any replicate simulation, and thus represents an extreme estimate. The maximum local accumulated concentration averaged over all replicate spills is the greatest concentration calculated for any point on the shoreline after averaging over all replicate simulations. The annual average is calculated by averaging the maxima calculated for each calendar quarter, for those quarters where contact was indicated in at least one replicate.

Note that it is possible that oil films arriving at concentrations that are less than the threshold may accumulate over the course of a spill event to result in concentrations that apparently exceed the threshold. Hence, the mean and maximum concentrations of accumulated oil can exceed the threshold applied to the probability calculations for the arrival of floating oil even where no instantaneous exceedances above threshold are predicted. It is important to understand that the two parameters (floating concentration and shoreline concentration) are quite distinct, calculated in different ways and representative of alternative outcomes. The floating probability estimates and the shoreline accumulative estimates should therefore be treated as independent estimators of different exposure outcomes, and not directly compared.

For the entrained and dissolved components, the tabulated results summarise interrogations of cells representing the water surrounding the sensitive receptor shorelines (or submerged features), with individual buffer zones as illustrated in Figure 2.1 to Figure 2.6. Buffer zones were defined with consideration of the local bathymetry, natural boundaries, or sensible legislative boundaries.

The modelling for each scenario assumed no mitigation efforts were undertaken to collect or otherwise affect the natural transport and weathering of the oil.

The predicted outcomes based on the modelling results are discussed in the following sections in terms of floating, shoreline, entrained and dissolved aromatic hydrocarbons. Discussion is based around the outcomes of stochastic risk contours. Plots of the Environments that May Be Affected (EMBAs) and minimum time to exceedance of concentration thresholds are presented for the assessed thresholds.

4.2 Scenario 1A: 77-day uncontrolled surface/subsurface release of 645,721 m^3 of PYA-01 Condensate

4.2.1 Overview

The scenario investigated the probability of oil exposure to surrounding regions due to a 77-day surface/subsurface release of 645,721m^3 of PYA-01 Condensate due to a loss of well integrity, 80m below the surface. Results have been separately calculated for four components:

- Floating oil.
- Floating oil that strands on shorelines.
- Oil entrained in the water column as droplets.
- Soluble, aromatic, hydrocarbons dissolved ion the water column.

4.2.1.1 Floating and Shoreline Oil

The stochastic modelling indicated a relatively restricted migration distance before floating slicks reduced below the applied thresholds. This can be attributed to rapid evaporation of a high proportion of the condensate components and the propensity of the condensate to entrain, commencing at wind speeds that occur frequently over the area. The probability contour figures for floating oil indicate a decrease in the potential drift distance for increasing concentrations. Floating oil at the 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds could potentially be found up to 395 km, 270 km, and 51 km from the spill site, respectively. (Table 4-1, Figure 4.1, Figure 4.2, Figure 4.3).

Floating oil concentrations at the 1 g/m^2 threshold are predicted to contact both Rankin Bank and Tryal Rocks at a 40% probability. The probabilities of contact above a threshold of 10 g/m^2 on Rankin Bank and Tryal Rocks are 6% and 8%, respectively (Table 4.4). Floating oil concentrations for thresholds greater than 50 g/m^2 are not predicted to contact any receptors aside from Montebello Marine Park, which has a 100% probability of contact for all assessed thresholds. This is due to the spill site being within the boundaries of the Montebello Marine Park.

Table 4-1 Maximum distances from the release location to zones of floating oil exposure.

Distance and direction travelled	Zones of potential sea surface exposure		
	1 g/m^2	10 g/m^2	50 g/m^2
Maximum distance travelled (km) by a spill trajectory	395	270	51
Direction of maximum travel	Southwest	Southwest	South

The worst-case for maximum local accumulation of oil on any surrounding shoreline was calculated as 1,302 g/m^2 at Muiron Island (Table 4.4).

The minimum times to contact with surrounding locations at the assessed thresholds for floating oil are depicted in Figure 4.4 to Figure 4.6. The environments that may be affected (EMBA) for floating oil thresholds are depicted in Figure 4.7 to Figure 4.9, with smoothed EMBA contours depicted in Figure 4.10 to Figure 4.12.

The predicted probabilities of shoreline oil concentration above the 10 g/m^2, 100 g/m^2 and 250 g/m^2 thresholds are presented in Figure 4.13, Figure 4.14 and Figure 4.15. Shoreline oil concentrations at 10 g/m^2 are predicted to contact Muiron Islands with 50% probability. The highest probability of shoreline contact above 250 g/m^2 is 4% at Peak Island.

4.2.1.2 Entrained Oil

As noted in the weathering assessments, the properties of the condensate and the release conditions are expected to favour the entrainment of condensate released under the spill scenario. Subsurface release of a larger part (89.7%) of the spill volume would result in condensate releasing and rising as entrained oil then dispersing in the surface layer as entrained droplets. Consequently, condensate that does form slicks on the surface during the initial surface release or though floating to the surface from the subsea release phase will more frequently entrain into the surface layer. The entrained plumes will then be subject to transport by prevailing currents, with reduced influence of the prevailing wind compared to floating slicks. Reduced weathering rates are also calculated for entrained oil. Hence, the entrained oil may travel larger distances than floating oil before dispersion reduces the concentration of droplets below the thresholds applied in this study, with the potential for transport into shallow or shoreline zones.

Entrained oil concentrations greater than 10 ppb are predicted to drift up to 1,666 km from the spill site, and at the 100 ppb threshold the maximum distance is predicted to be 1,202 km (Table 4-2, Figure 4.16, Figure 4.17).

Table 4-2 Maximum distances from the release location to zones of entrained oil exposure.

Distance and direction travelled	Zones of potential entrained oil exposure	
	10 ppb	100 ppb
Maximum distance travelled (km) by a spill trajectory	1,666	1,202
Direction of maximum travel	South	South

The contour plots showing the probability of entrained oil reaching locations at concentrations exceeding thresholds (Figure 4.16 and Figure 4.17) indicate that entrained condensate could drift over a band that extends along a northeast to southwest axis around the hypothetical spill site, with longest trajectories of concentration towards the south, following the prevailing ocean currents.

The greatest probability of contact for entrained oil above 10 ppb is calculated at 100% for Tryal Rocks, Montebello Islands, Barrow Islands and Gascoyne Marine Park. The probability of contact for entrained oil at a concentration above 100 ppb is 100% at Montebello Marine Park and 99% at Barrow Island. The worst-case entrained oil concentration for any receptor is ~84,164 ppb at Montebello Marine Park (Table 4.5).

The forecast minimum times to contact, EMBA and smoothed EMBA for the assessed entrained oil thresholds are depicted in Figure 4.18 to Figure 4.23.

Cross-sectional transects of maximum entrained oil concentrations at surrounding locations, compiled from the multiple replicate simulations indicates that concentrations above 100 ppb could extend to approximately 55 m depth (Figure 4.24 and Figure 4.25).

4.2.1.3 Dissolved Aromatic Hydrocarbons

Dissolved aromatic hydrocarbon concentrations above the 10 ppb and 50 ppb thresholds were calculated to potentially occur up to 1,286 km and 955 km from the spill site, respectively (Table 4-3, Figure 4.26, Figure 4.27).

Table 4-3 Maximum distances from the release location to zones of dissolved aromatic hydrocarbon exposure.

Distance and direction travelled	Zones of potential dissolved aromatic hydrocarbon exposure	
	10 ppb	50 ppb
Maximum distance travelled (km) by a spill trajectory	1,286	955
Direction of maximum travel	Southwest	South

The probability of contact by dissolved aromatic hydrocarbon above a concentration of 10 ppb is predicted to be 100% at Montebello Marine Park and Tryal Rocks, and the probability of contact is more than 90% for Gascoyne Marine Park, Ningaloo Marine Park, Barrow Island, Southern Pilbara Island and Penguin Bank (Table 4.6).

The maximum dissolved aromatic hydrocarbon concentration forecast in the worst replicate is calculated as 28,974 ppb at Montebello Marine Park.

The annualised minimum times to contact, EMBA, and smoothed EMBA for dissolved aromatic hydrocarbons at or above the 10 ppb and 50 ppb threshold concentrations are depicted Figure 4.28 to Figure 4.33.

Cross-sectional transects of maximum dissolved aromatic hydrocarbon concentrations in the vicinity of the release site indicate that concentrations above 50 ppb could affect depth above approximately 150 m BMSL from the release site due to dissolved components entering the water column as the condensate rises from the subsea release phase (Figure 4.34 and Figure 4.35).

4.2.2 Results – Tables and Figures

4.2.2.1 Floating Oil and Shoreline Oil

Table 4.4 Expected annualised floating and shoreline oil outcomes at sensitive receptors resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Australian Marine Parks	Abrolhos MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Argo-Rowley Terrace MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Carnarvon Canyon MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dampier MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Eighty Mile Beach MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Gascoyne MP*	6	<1	<1	330	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Geographe MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jurien MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Kimberley MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Mermaid Reef MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Montebello MP*	100	100	100	1	1	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Ningaloo MP*	9	1	<1	286	1,284	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Perth Canyon MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Shark Bay MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	South-West Corner MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Two Rocks MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coastlines	Ashburton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Augusta - Margaret River	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Augusta - Walpole	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Bali	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Busselton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Cape Bruguieres	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Carnamah	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Carnarvon	<1	<1	<1	NC	NC	NC	1	<1	<1	1,469	NC	NC	0.3	16	<1	<1
	Chapman Valley	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Coorow	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Dampier Archipelago	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Dandaragan	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2	<1	<1
	Dawesville - Bunbury	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Exmouth	2	<1	<1	595	NC	NC	22	7	2	576	712	714	16	489	3	21
	Exmouth Gulf South East	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Exmouth Gulf West	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2	<1	<1
	Geographe Bay	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Geographe Bay - Augusta	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Geraldton - Jurien Bay	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
	Gingin	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	1.5	<1	<1
	Greater Geraldton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Harvey	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Indonesia	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Irwin	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Joondalup	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Jurien Bay - Yanchep	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2	<1	<1
	Kalbarri - Geraldton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	1.4	<1	<1
	Karratha	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Karratha-Port Hedland	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Mandurah	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Mandurah - Dawesville	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Manjimup	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Middle Pilbara - Islands and Shoreline	<1	<1	<1	NC	NC	NC	2	<1	<1	1,157	NC	NC	0.9	44	<1	2
	Nannup	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Northampton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	1.4	<1	<1
	Northern Pilbara - Islands and Shoreline	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2.1	<1	<1
	Perth Northern Coast	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Perth Southern Coast	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Rockingham	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Shark Bay	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.1	6	<1	<1
	Southern Pilbara - Shoreline	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Wanneroo	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Waroona	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Zuytdorp Cliffs - Kalbarri	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2.1	<1	<1
Fish Habitat Protection Area	Abrolhos Islands*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Miaboolya Beach*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Point Quobba*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Islands	Abrolhos Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	3.1	<1	<1
	Airlie Island	<1	<1	<1	NC	NC	NC	10	<1	<1	386	NC	NC	3.1	45	<1	<1
	Angel Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Ashburton Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2.1	<1	<1
	Barrow Island	7	<1	<1	189	NC	NC	23	1	<1	559	914	NC	7.4	172	2	9
	Bedout Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Bedwell Island	<1	<1	<1	NC	NC	NC	2	<1	<1	1,729	NC	NC	0.5	32	<1	<1
	Bernier Island	<1	<1	<1	NC	NC	NC	1	<1	<1	2,396	NC	NC	0.2	14	<1	<1
	Bessieres Island	<1	<1	<1	NC	NC	NC	7	<1	<1	518	NC	NC	2.1	26	<1	<1
	Bezout Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Boodie Island	<1	<1	<1	NC	NC	NC	23	<1	<1	696	NC	NC	7.4	69	<1	2

Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Cohen Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Conzinc Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Cunningham Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Delambre Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Direction Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Dolphin Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Dorre Island	<1	<1	<1	NC	NC	NC	1	<1	<1	2,224	NC	NC	0.2	14	<1	<1
Eaglehawk Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
East Lewis Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Easter Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	1.5	<1	<1
Enderby Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Flat Island	<1	<1	<1	NC	NC	NC	2	<1	<1	614	NC	NC	0.8	12	<1	<1
Fly Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Garden Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Gidley Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Goodwyn Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Haury Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Hermite Island	3	1	<1	357	364	NC	40	5	3	361	364	365	47	1,210	3	16
Keast Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Kendrew Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Legendre Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Locker Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Lowendal Islands	<1	<1	<1	NC	NC	NC	10	<1	<1	575	NC	NC	3.8	74	<1	4
Malus Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Mangrove Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Mary Anne Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.2	8.7	<1	<1
Middle Island	<1	<1	<1	NC	NC	NC	23	<1	<1	696	NC	NC	7.4	69	<1	2
Montebello Islands	5	3	<1	352	359	NC	40	5	3	361	364	365	47	1,210	3	16
Muiron Islands	6	<1	<1	302	NC	NC	50	13	2	323	650	720	53	1,302	4	44
North Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	3.1	<1	<1
Observation Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Passage Islands	<1	<1	<1	NC	NC	NC	2	<1	<1	1,157	NC	NC	0.9	44	<1	<1
Peak Island	2	<1	<1	320	NC	NC	38	11	4	396	803	1,029	43	625	2	12
Pelsaert Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2.7	<1	<1
Ragnard Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Rivoli Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Rosemary Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Rottnest Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Round Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Serrurier Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.3	9.7	<1	<1
Southern Pilbara - Islands	2	<1	<1	210	NC	NC	38	11	4	386	438	1,029	43	625	2	12

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
	Sunday Island	<1	<1	<1	NC	NC	NC	16	4	<1	668	1,060	NC	9	183	<1	3
	Table Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	3.3	<1	<1
	Thevenard Island	<1	<1	<1	NC	NC	NC	16	4	<1	388	438	NC	6.8	155	<1	4
	Tortoise Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Twin Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Wallabi Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2	<1	<1
	West Lewis Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Marine Parks	Barrow Island MMA*	9	1	<1	131	1,261	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Barrow Island MP (State)*	5	<1	<1	188	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Clerke Reef (Rowley Shoals MP)	<1	<1	<1	NC	NC	NC	2	<1	<1	1,729	NC	NC	0.5	32	<1	<1
	Imperieuse Reef (Rowley Shoals MP)	<1	<1	<1	NC	NC	NC	2	<1	<1	1,655	NC	NC	0.4	13	<1	<1
	Jurien Bay MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2	<1	<1
	Marmion MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Montebello Islands MP	10	3	<1	132	349	NC	40	5	3	361	364	365	47	1,210	3	16
	Muiron Islands MMA	9	<1	<1	274	NC	NC	50	13	2	323	650	720	53	1,302	4	44
	Ngari Capes MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Ningaloo Coast WH	9	1	<1	275	1,284	NC	22	7	2	576	712	714	16	489	3	21
	Ningaloo MP (State)	9	<1	<1	275	NC	NC	22	7	2	576	712	714	16	489	3	21
	Shark Bay MR	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.1	6	<1	<1
	Shark Bay WH	<1	<1	<1	NC	NC	NC	2	<1	<1	2,087	NC	NC	0.4	24	<1	5
	Shoalwater Islands MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
National Park	Cape Range	<1	<1	<1	NC	NC	NC	22	7	<1	675	896	NC	16	241	2	16
	D'Entrecasteaux*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dirk Hartog Island	<1	<1	<1	NC	NC	NC	2	<1	<1	2,087	NC	NC	0.4	24	<1	4
	Kalbarri	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Nature Reserve	Bernier And Dorre Islands NR	<1	<1	<1	NC	NC	NC	1	<1	<1	2,224	NC	NC	0.2	14	<1	<1
	Boodie, Double Middle Islands Nature Reserve NR	<1	<1	<1	NC	NC	NC	23	<1	<1	696	NC	NC	7.4	69	<1	2
	Great Sandy Island NR	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.2	8.7	<1	<1
	North Sandy Island NR	<1	<1	<1	NC	NC	NC	2	<1	<1	1,157	NC	NC	0.9	44	<1	<1
	Scott Reef NR	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Thevenard Island NR	<1	<1	<1	NC	NC	NC	16	4	<1	388	438	NC	6.8	155	<1	4
	Y Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Boullanger, Whitlock, Favourite,Tern & Osprey Islands Nature Reserve*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Buller,Whittell & Green Islands Nature Reserve*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Reefs, Shoals and Banks	Ashworth Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Assail Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Australind Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Barrow Island Reefs and Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Baylis Patches*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Beagle Knoll*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Bennett Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Beryl Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Brewis Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Camplin Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Clerke Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Clio Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Cod Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Combe Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Cooper Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Courtenay Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Curlew Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dailey Shoal*	1	<1	<1	677	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dart Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Direction Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dockrell Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Eliassen Rocks*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Exmouth Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Fairway Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Fantome Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Flinders Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Fortescue Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Gee Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Geelvink Channel Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Glennie Patches*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Glomar Shoal*	3	<1	<1	316	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Gorgon Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hammersley Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hastings Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hayman Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Herald Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hood Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Imperieuse Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Inner Northwest Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Koolinda Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Lightfoot Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Little Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Locker Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Madeleine Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manicom Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mardie Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
McLennan Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Meda Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mermaid Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mid Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Montebello Shoals*	4	3	<1	354	359	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Moresby Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nares Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ningaloo Reef*	8	<1	<1	595	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North Tail Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North West Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North West Reefs*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
O'Grady Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Otway Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Outtrim Patches*	1	<1	<1	558	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Paroo Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pearl Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pelsaert Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Penguin Bank*	2	<1	<1	316	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Poivre Reef*	1	<1	<1	702	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rankin Bank*	40	6	<1	56	371	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ripple Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Roller Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rosily Shoals*	1	<1	<1	332	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Saladin Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sand Knoll Ledge*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Santo Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Scott Reef South	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Snapper Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South East Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South West Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Southwest Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Spider Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stewart Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sultan Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Taunton Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Tongue Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trap Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tryal Rocks*	40	8	<1	49	52	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Turtle Dove Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wapet Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ward Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Web Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Weeks Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
West Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NC No contact to receptor predicted for specified threshold.

* Floating oil will not accumulate on submerged features and at open ocean locations. NA Not applicable

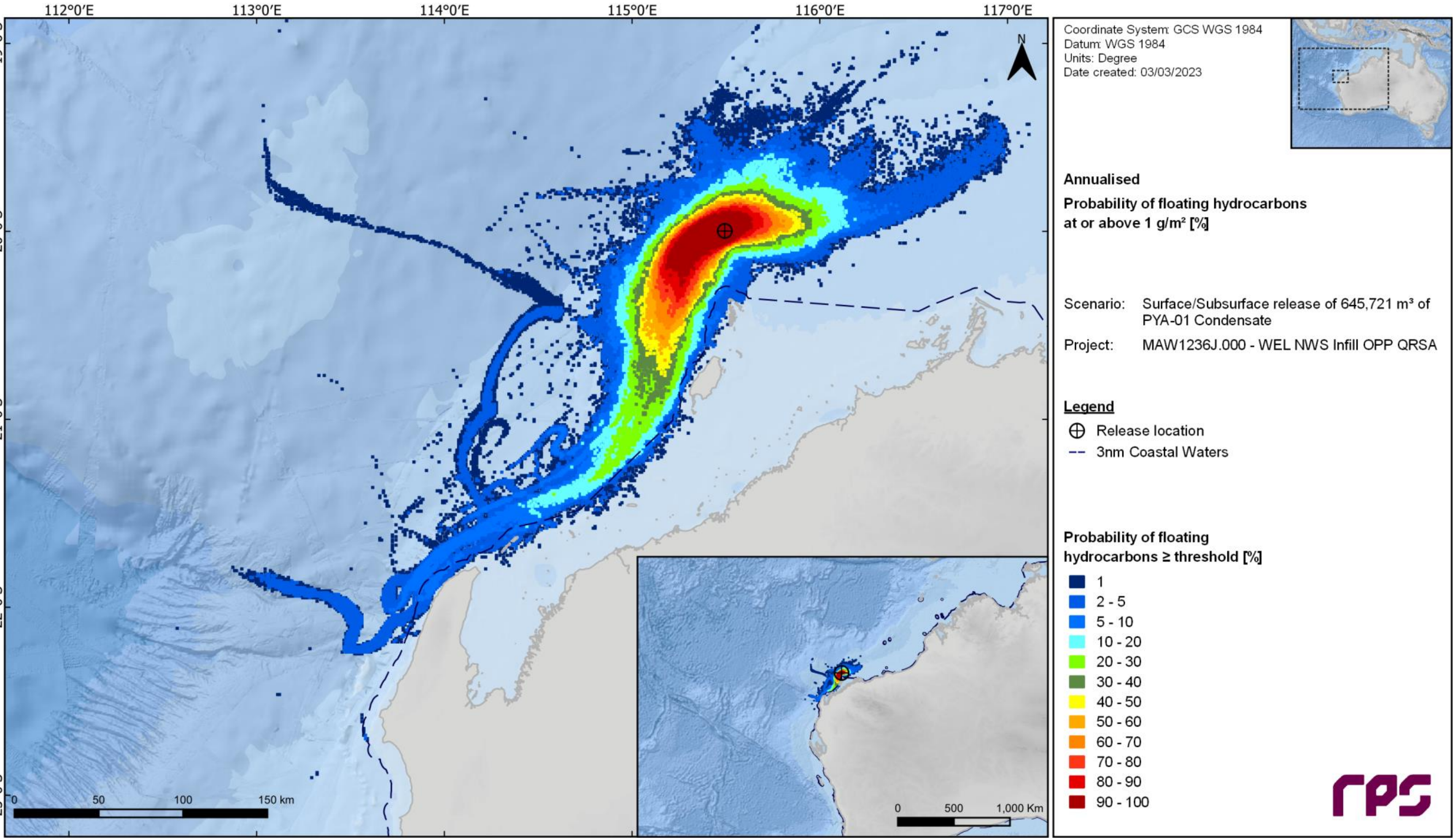


Figure 4.1 **Predicted annualised probability of floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

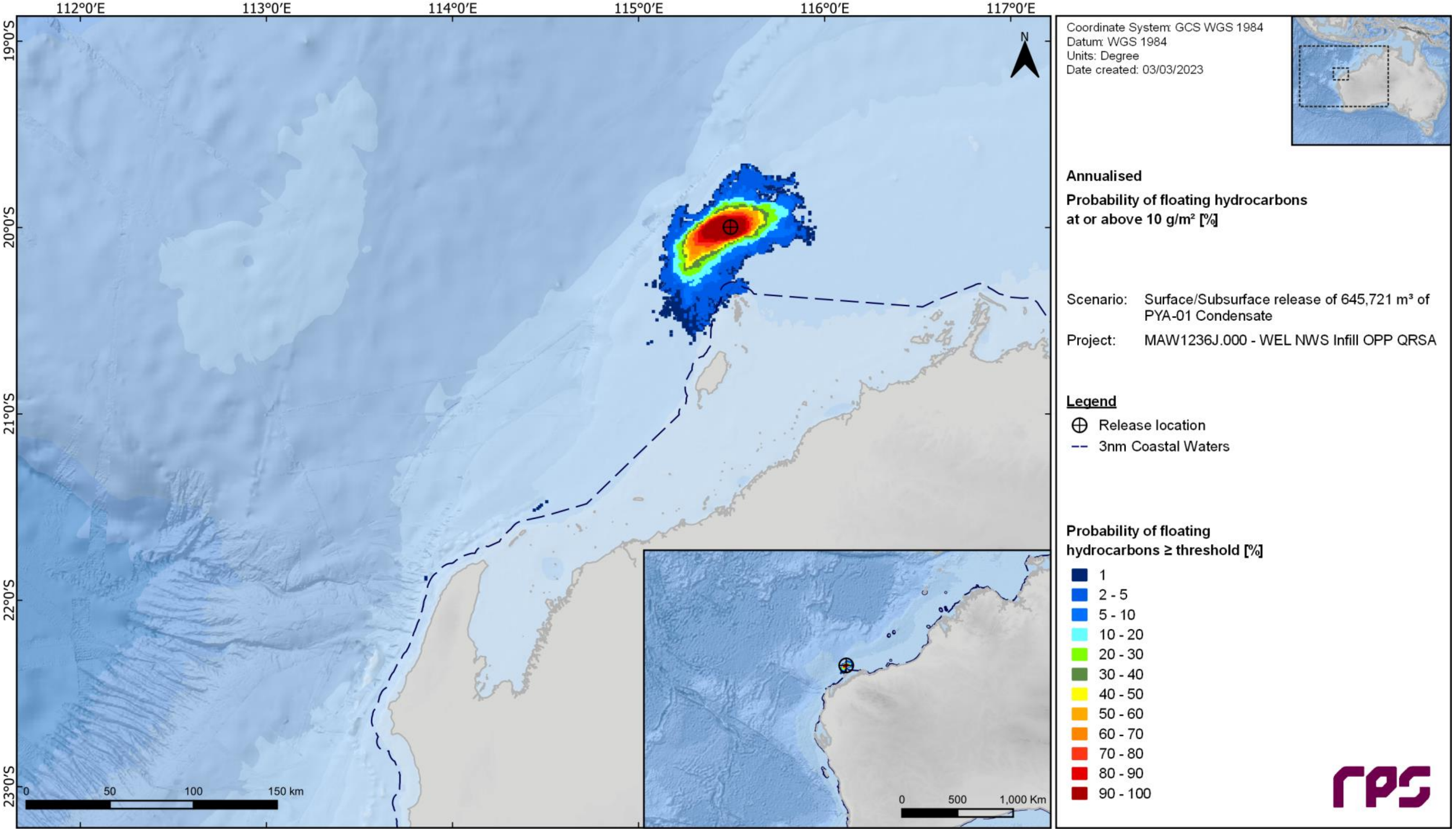


Figure 4.2 **Predicted annualised probability of floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

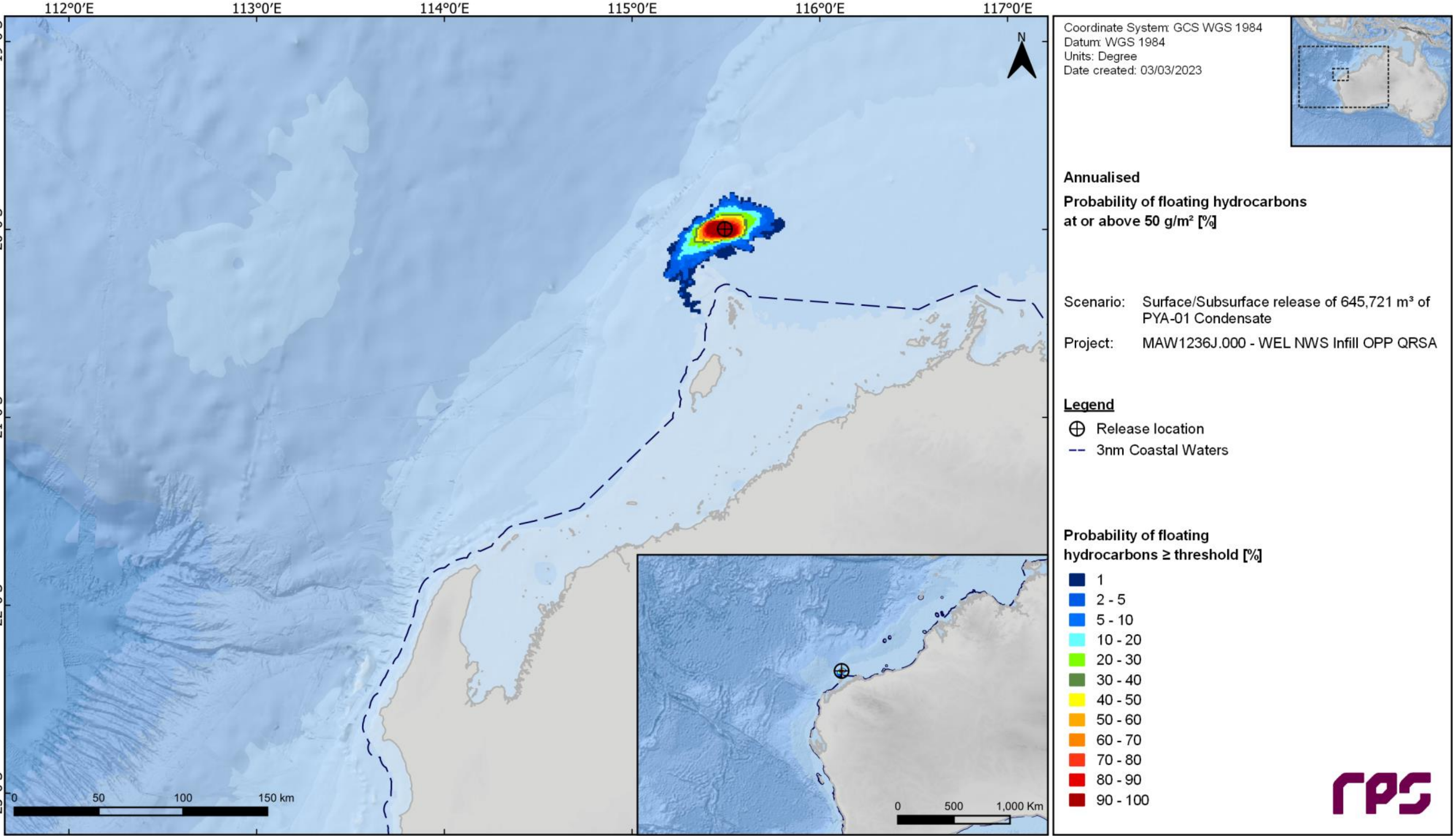


Figure 4.3 Predicted annualised probability of floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

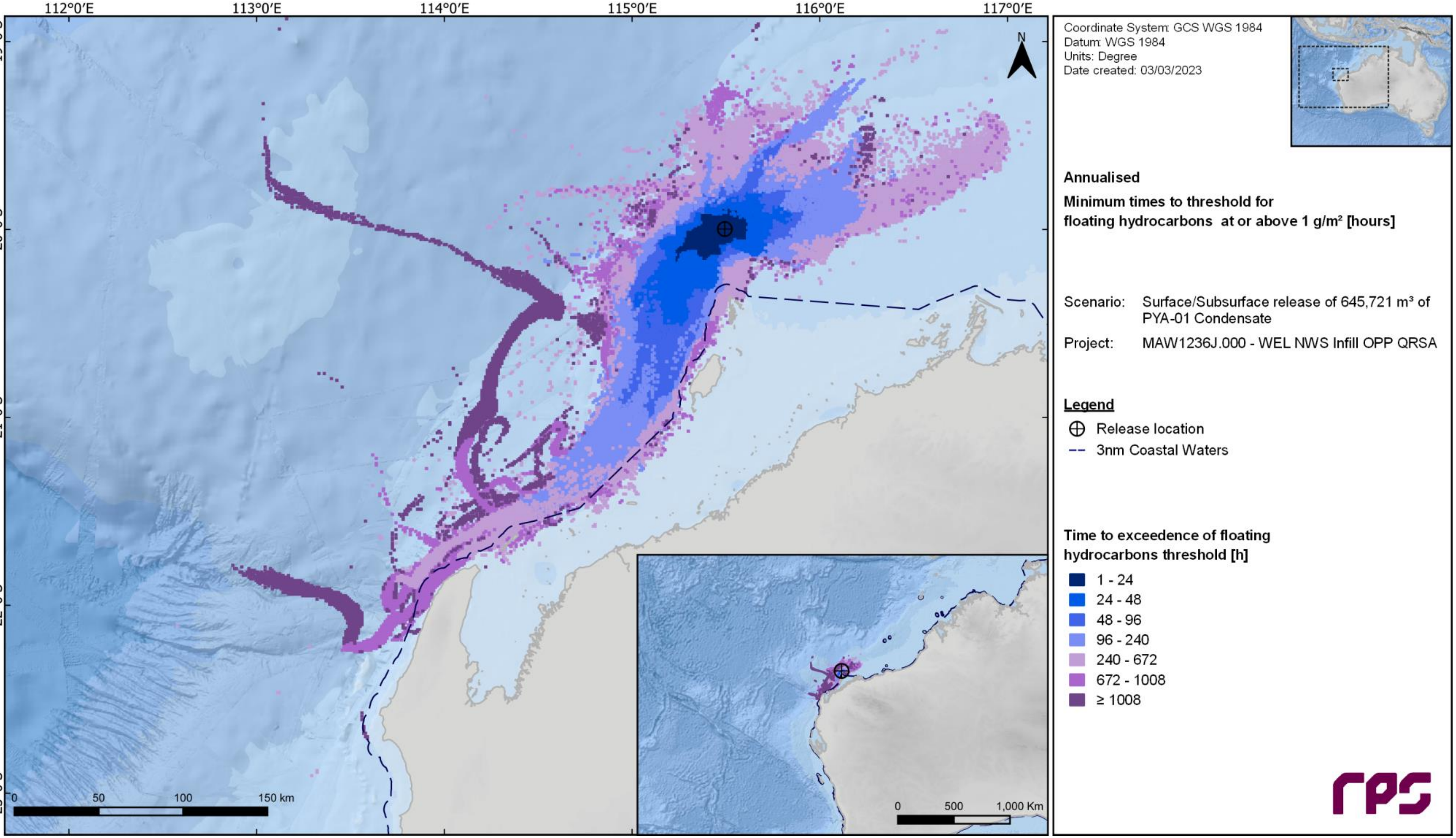


Figure 4.4 **Predicted annualised minimum times to contact by floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

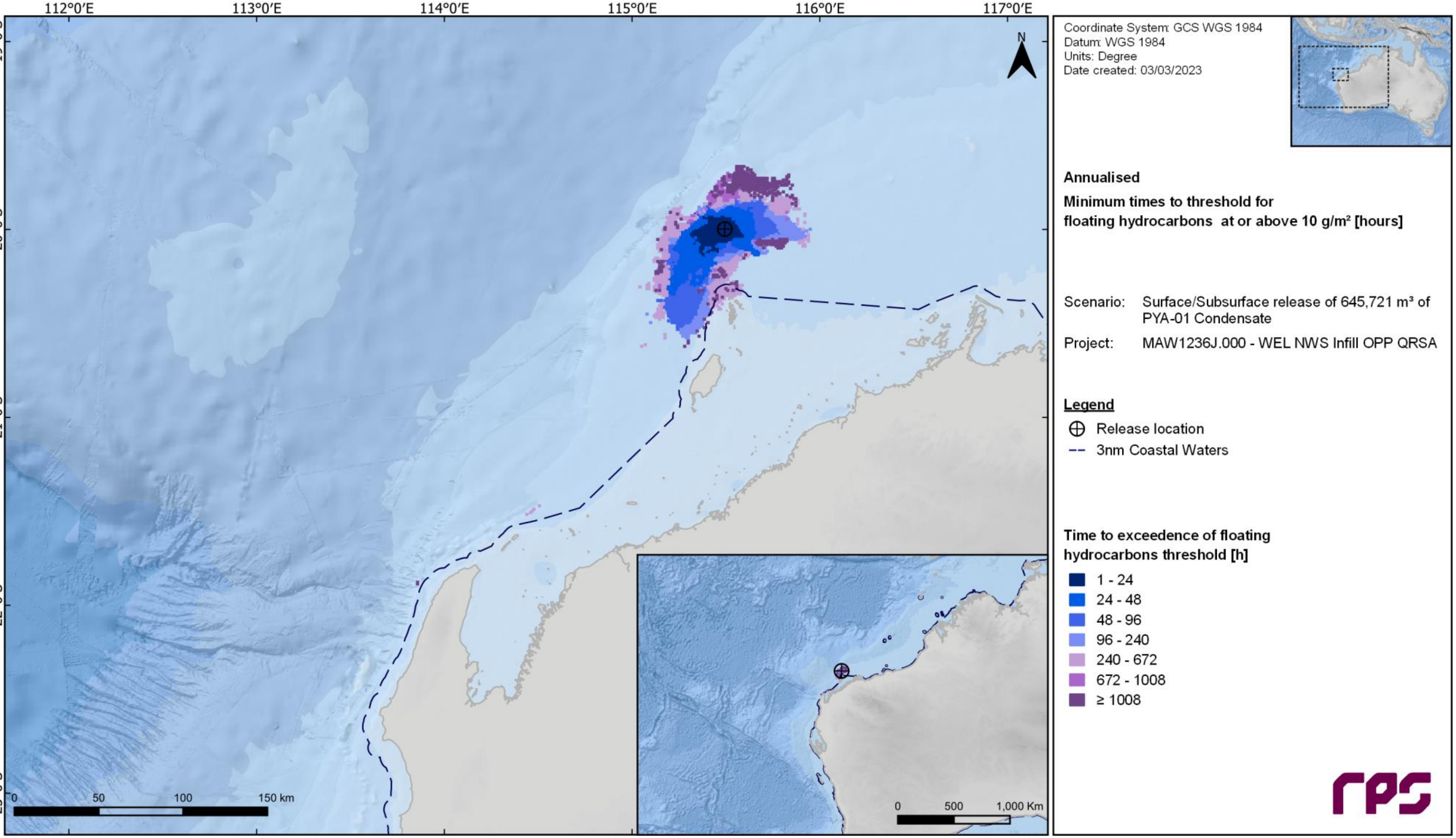


Figure 4.5 **Predicted annualised minimum times to contact by floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

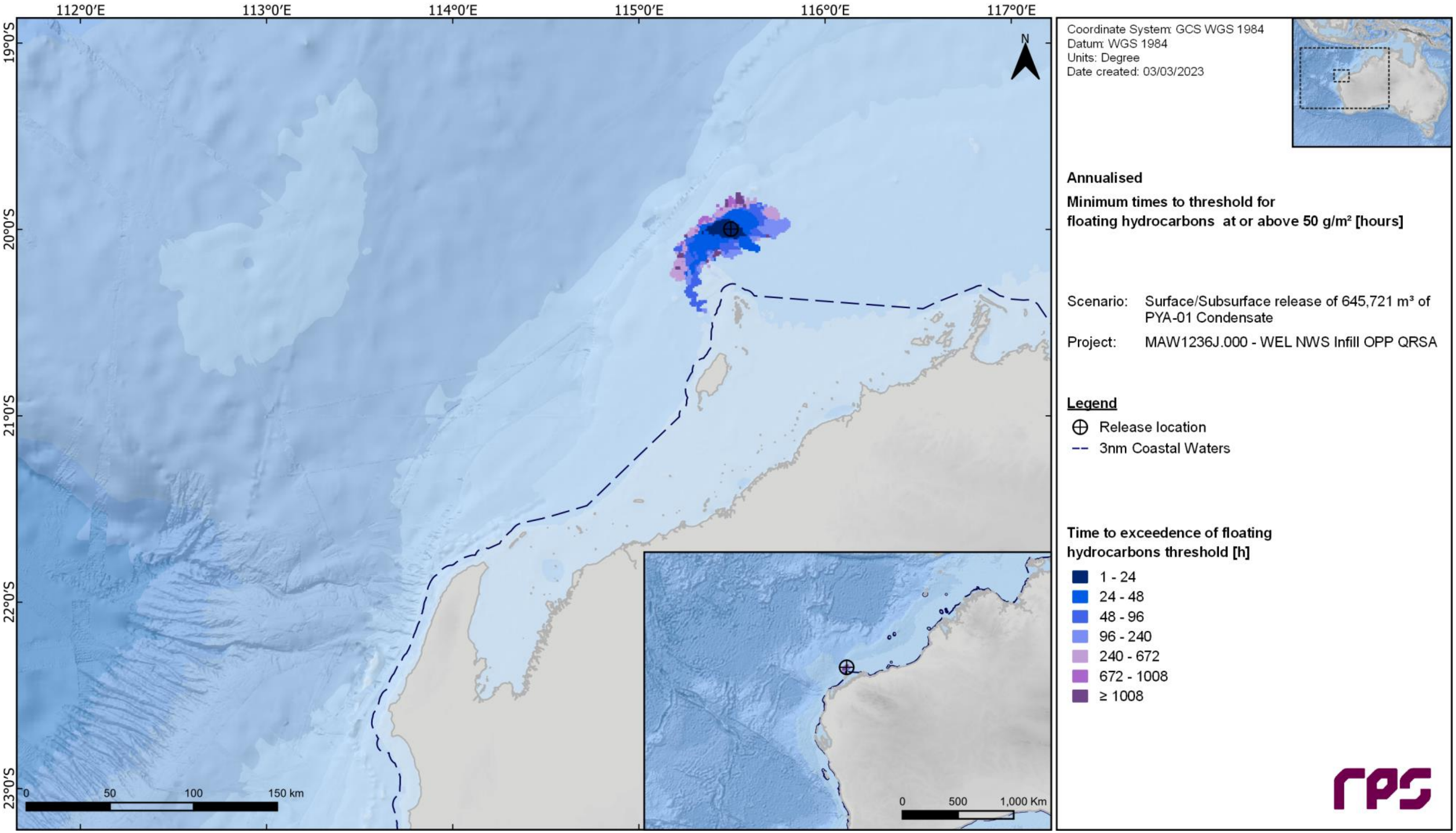


Figure 4.6 Predicted annualised minimum times to contact by floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

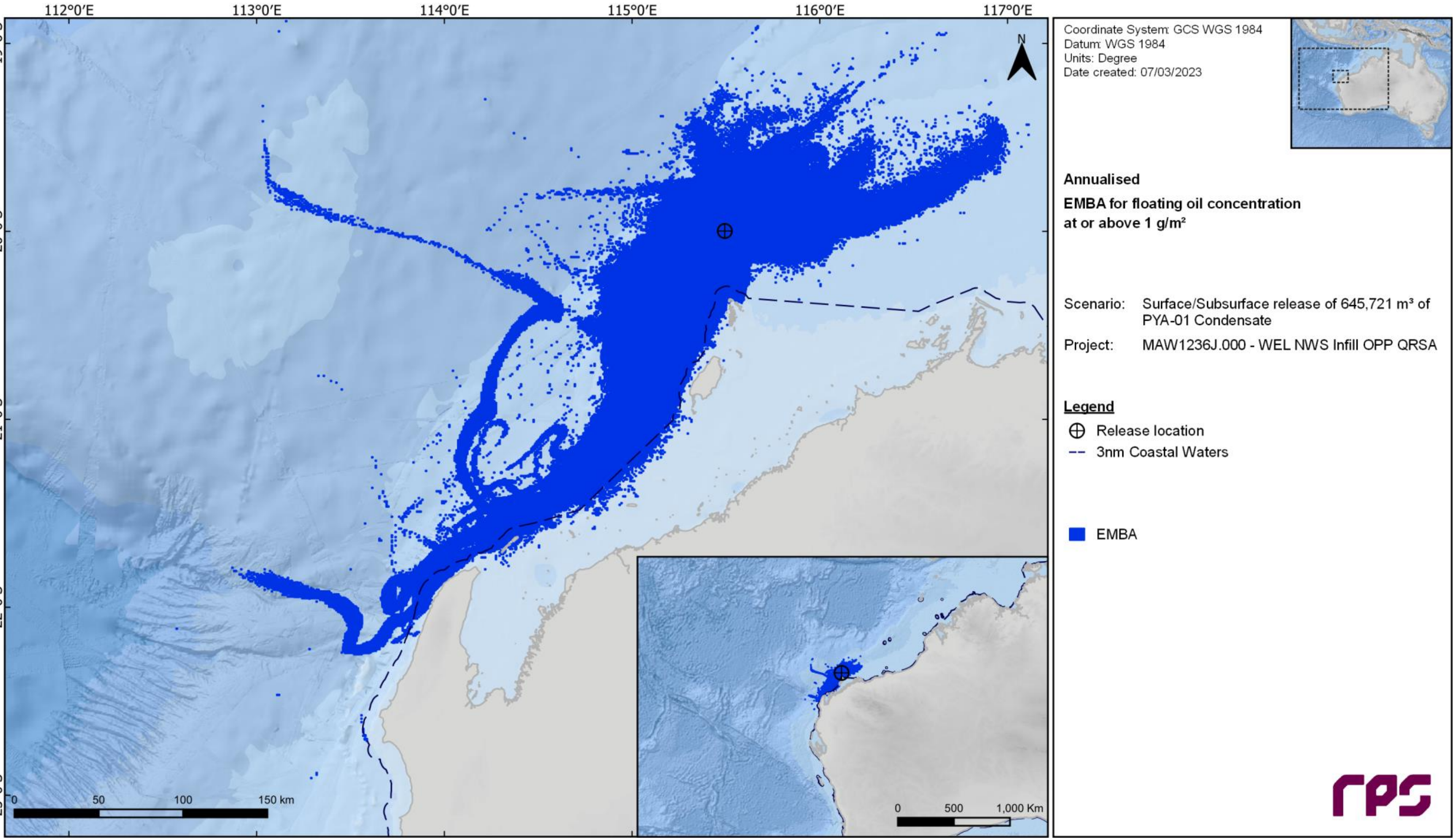


Figure 4.7 **Predicted annualised EMBA of floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

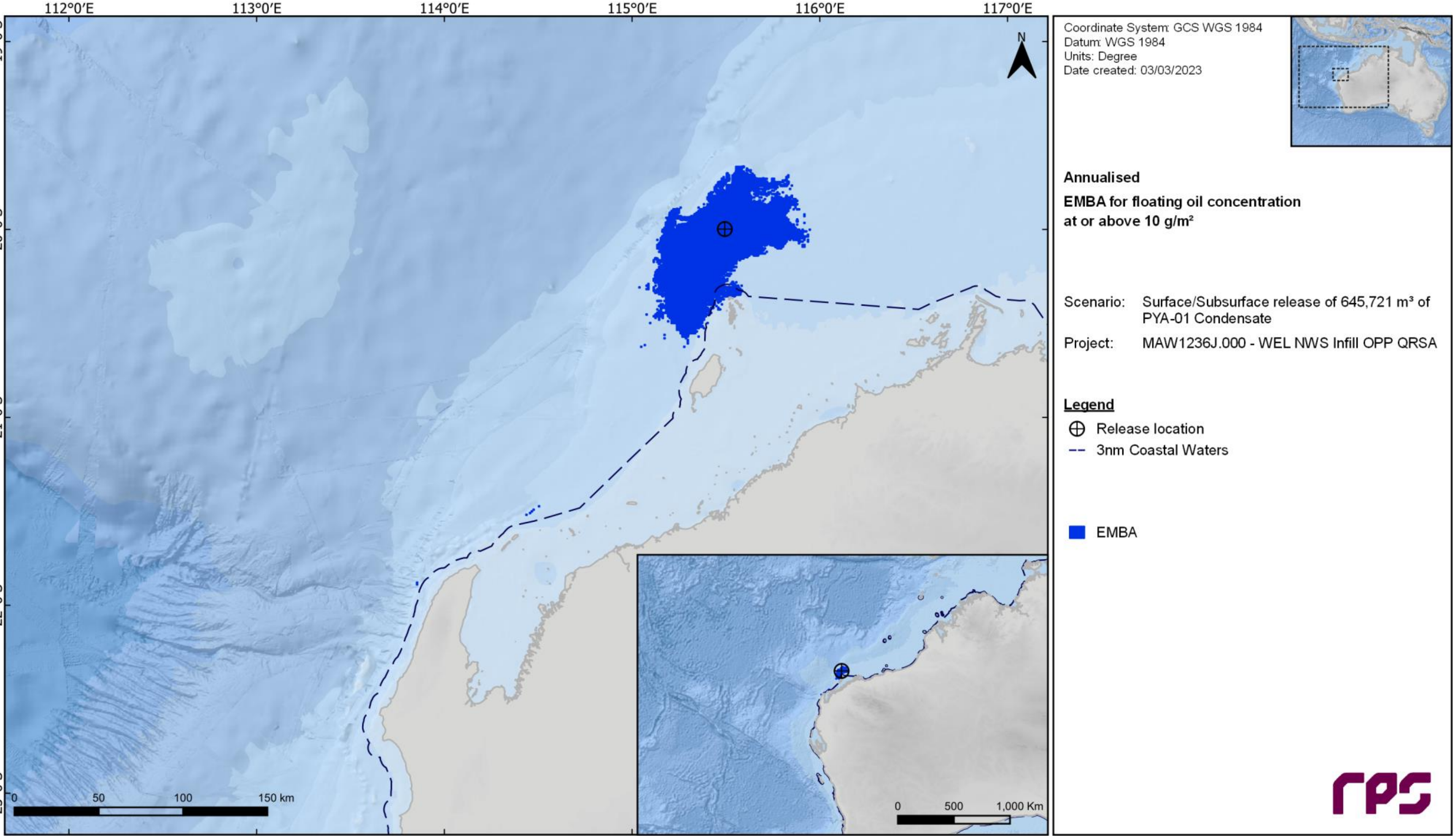


Figure 4.8 Predicted annualised EMBA of floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

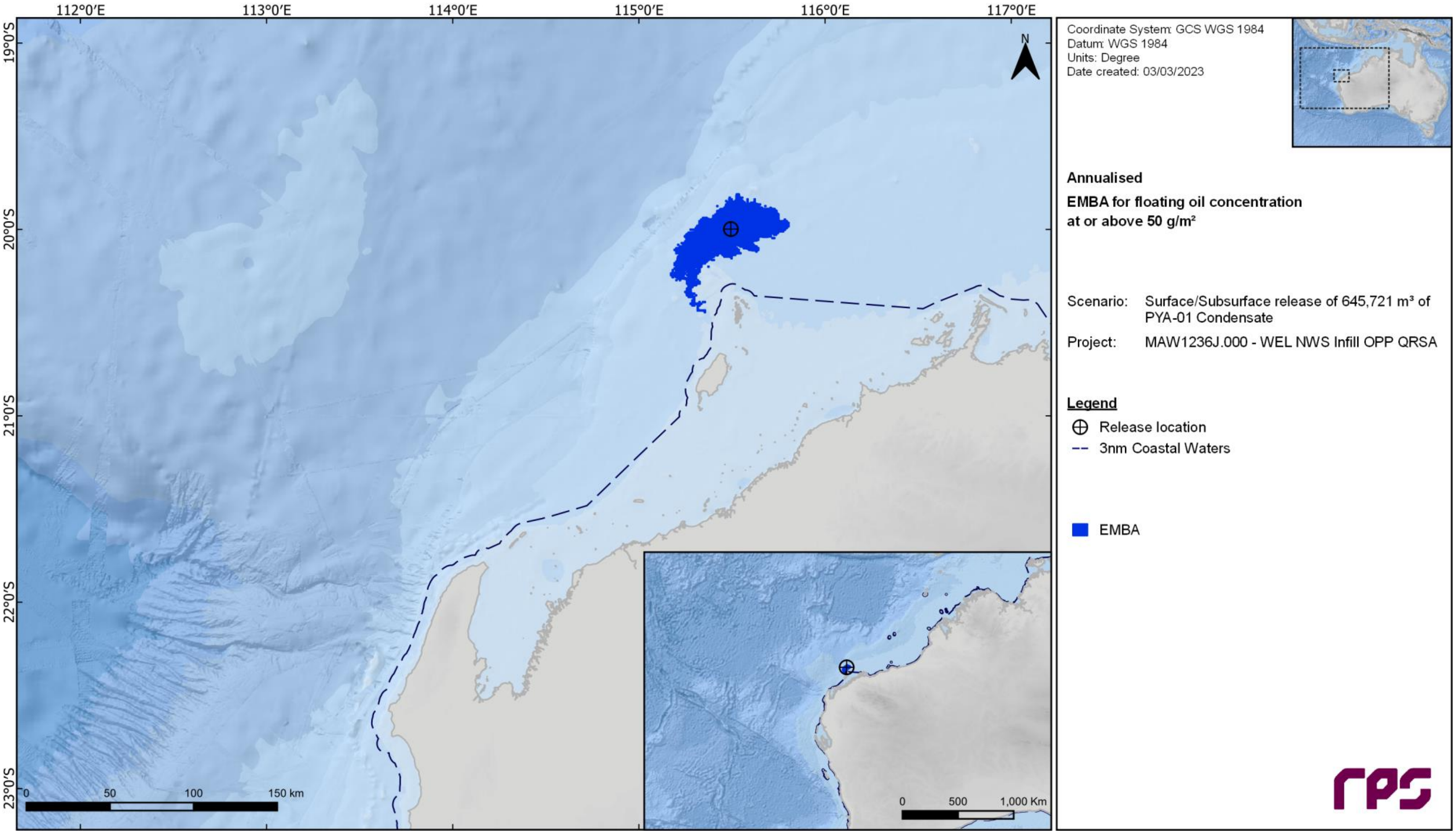


Figure 4.9 **Predicted annualised EMBA of floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

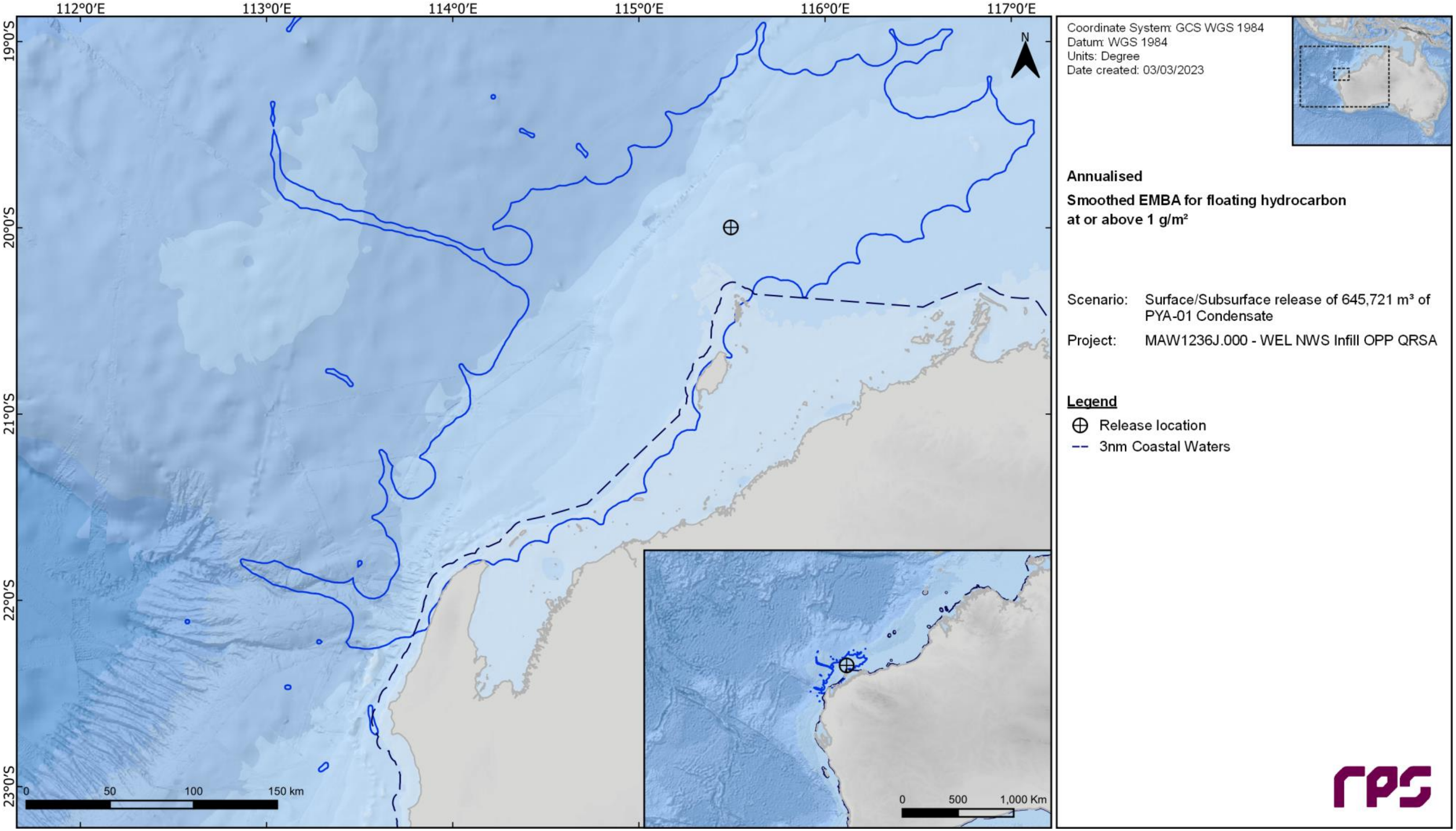


Figure 4.10 Predicted annualised smoothed EMBA of floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

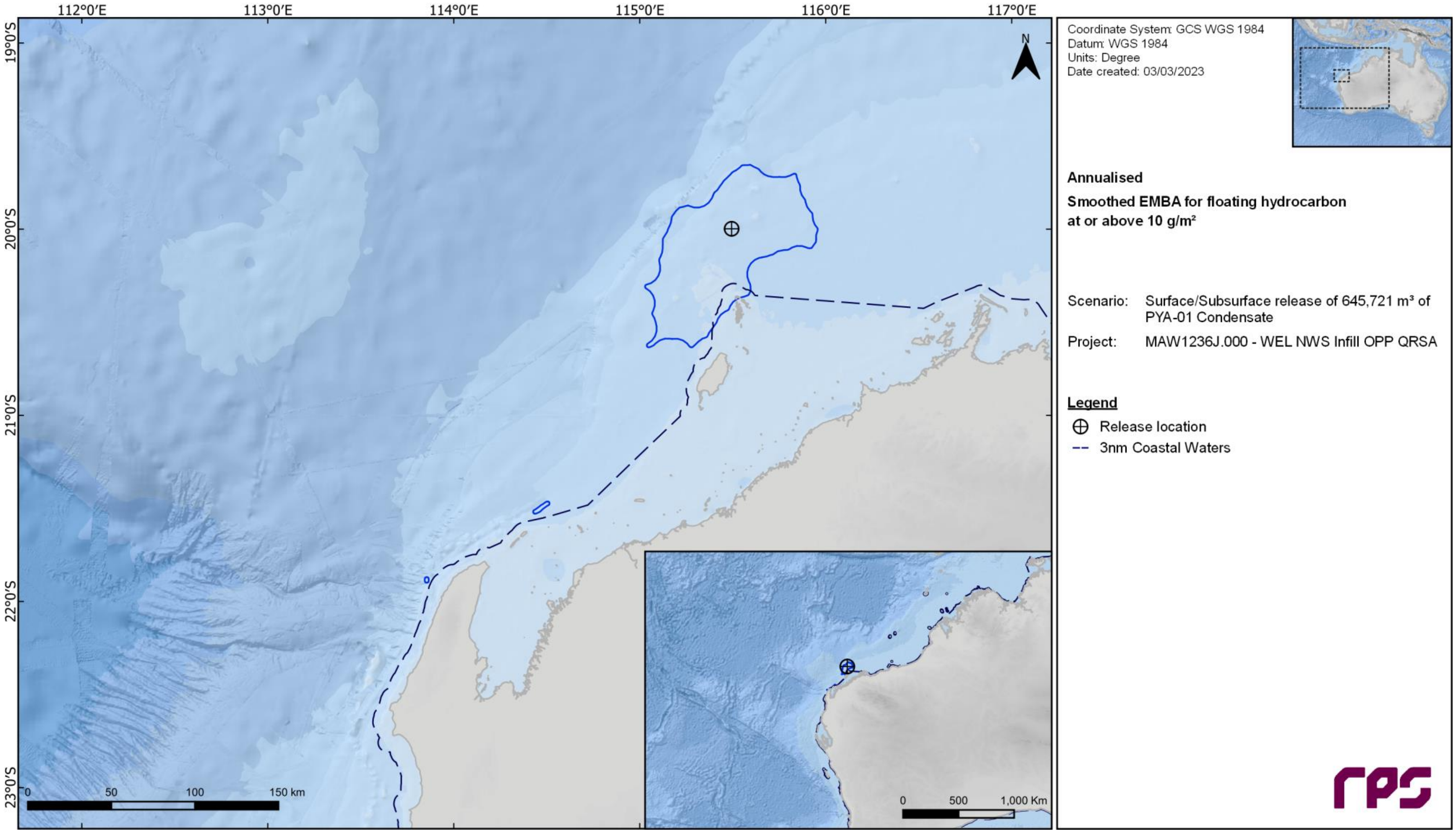


Figure 4.11 Predicted annualised smoothed EMBA of floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

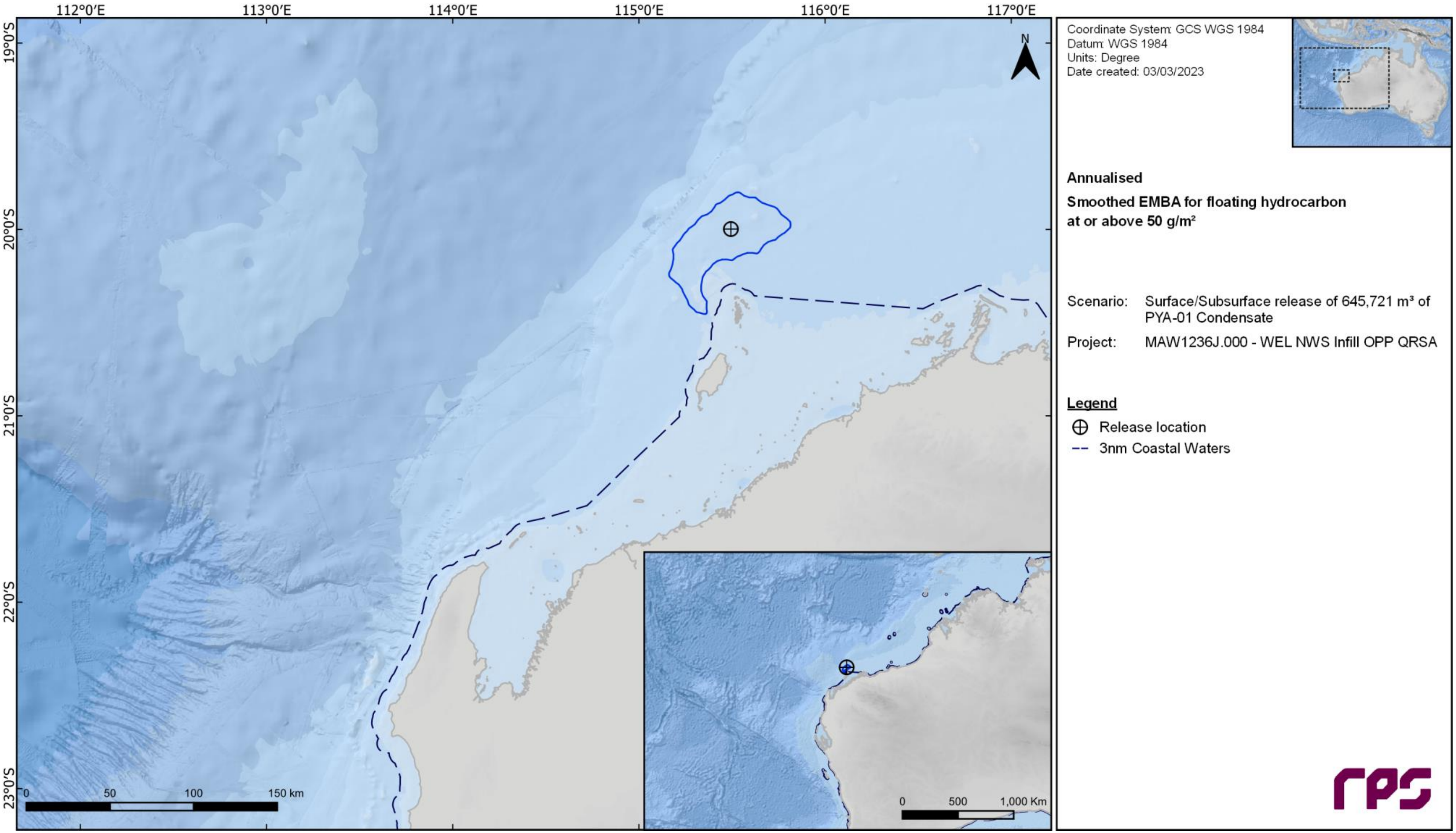


Figure 4.12 Predicted annualised smoothed EMBA of floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

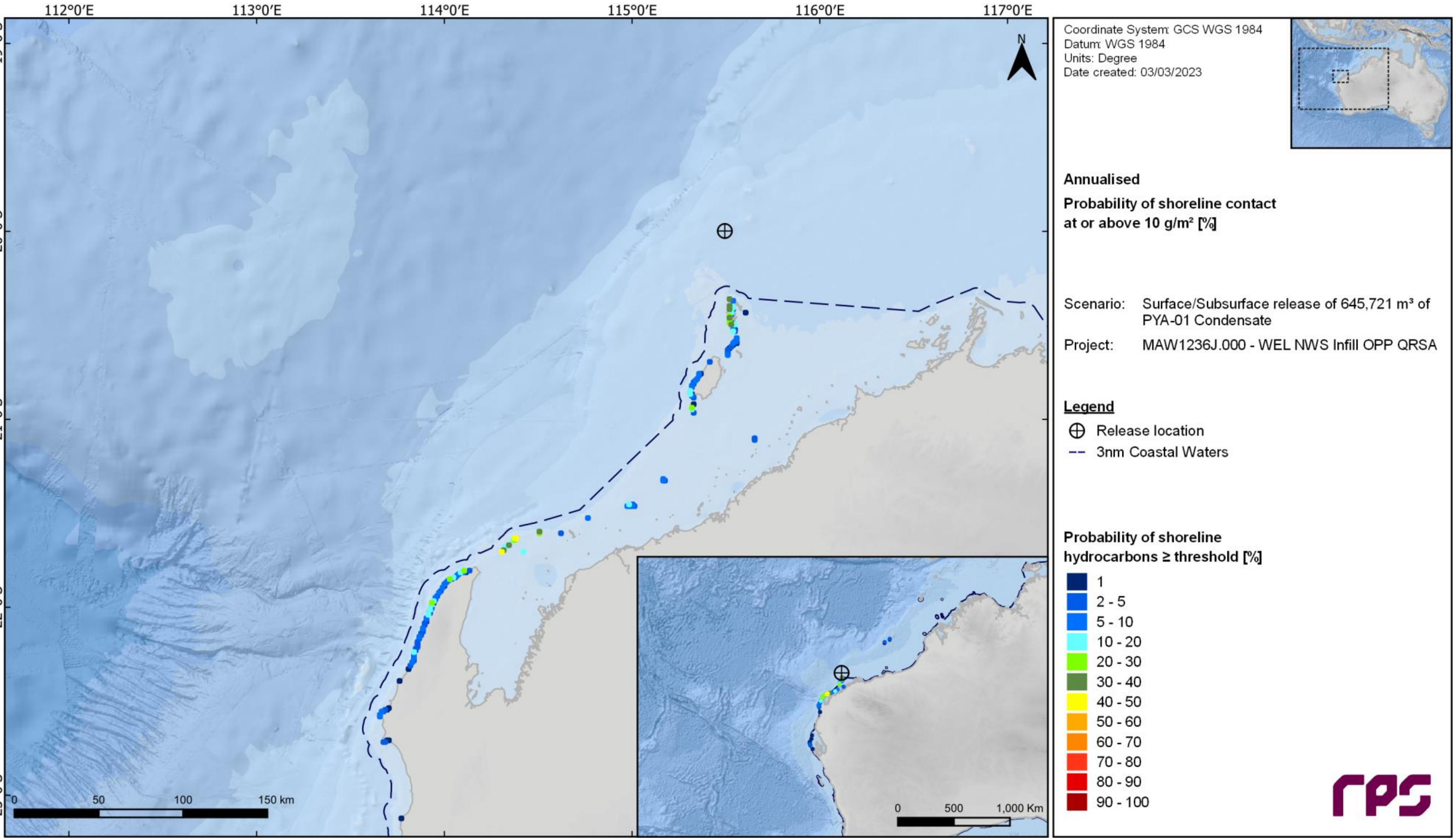


Figure 4.13 Predicted annualised probability of shoreline oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

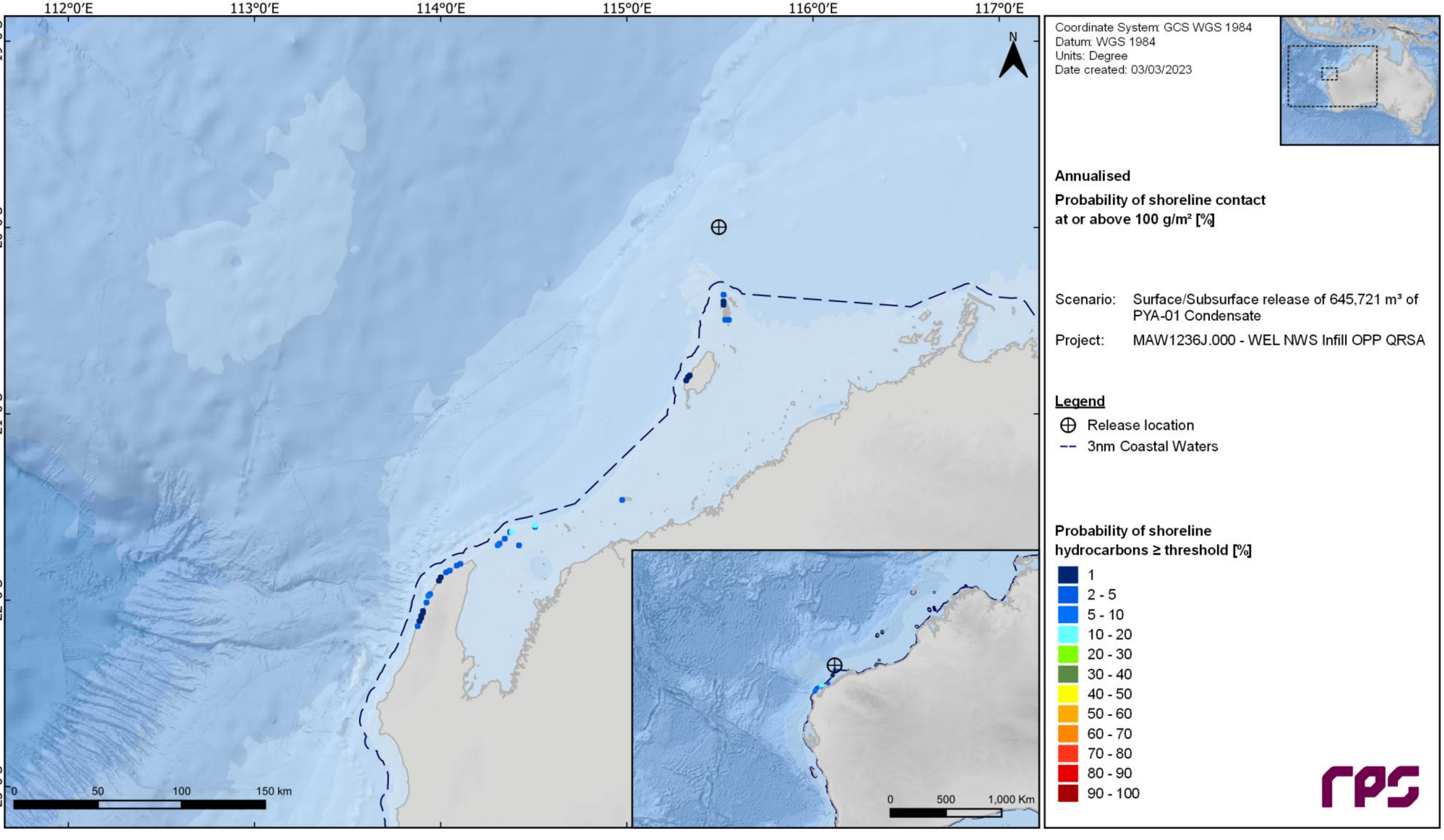


Figure 4.14 Predicted annualised probability of shoreline oil concentrations at or above 100 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

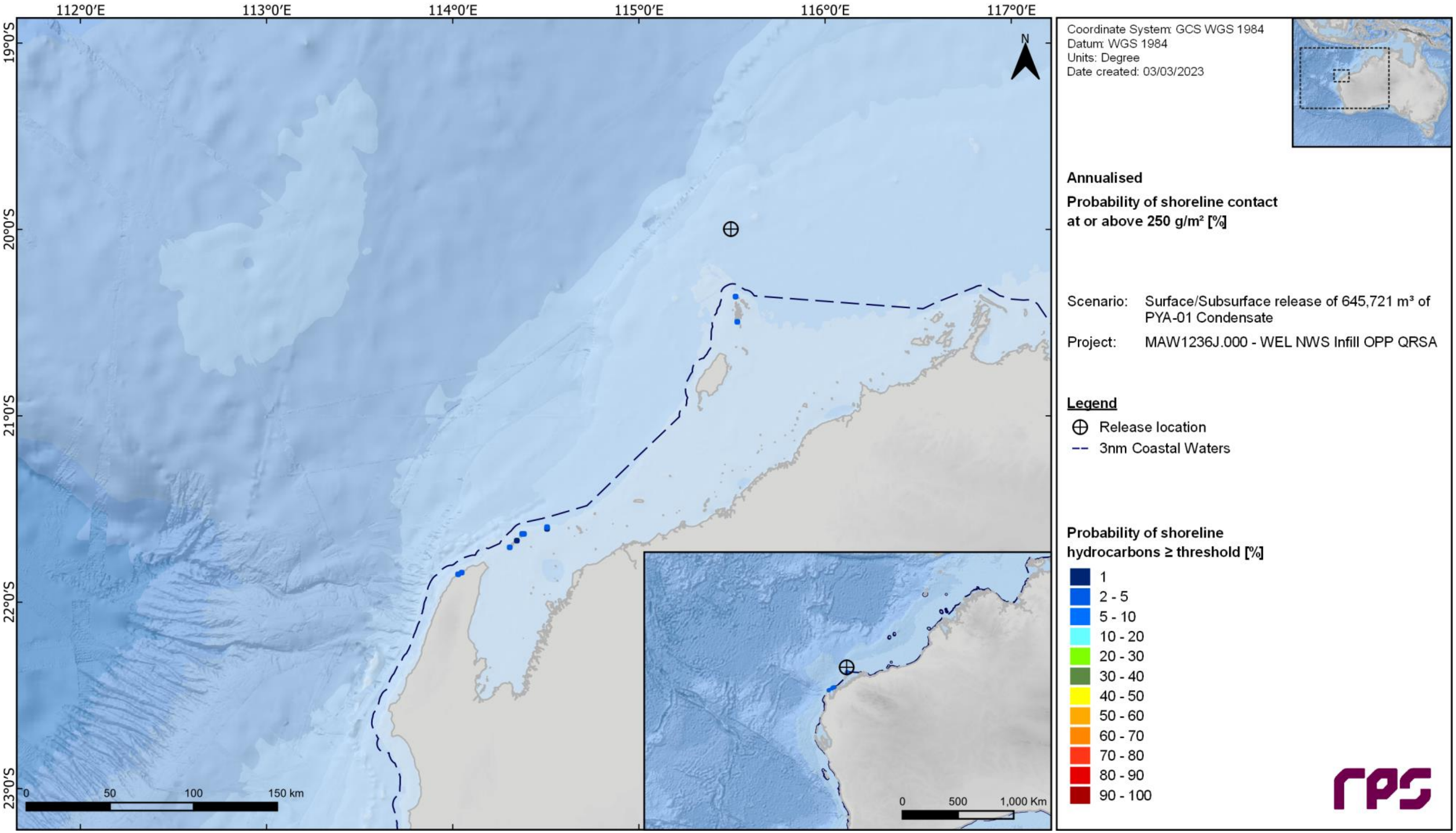


Figure 4.15 Predicted annualised probability of shoreline oil concentrations at or above 250 g/m² resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

4.2.2.2 Entrained Oil

Table 4.5 Expected annualised of entrained oil outcomes at sensitive receptors resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Australian Marine Parks	Abrolhos MP	20	1	729	994	7	172
	Argo-Rowley Terrace MP	15	6	728	774	18	656
	Carnarvon Canyon MP	25	3	833	1,223	10	144
	Dampier MP	4	<1	1,109	NC	2	35
	Eighty Mile Beach MP	9	<1	1,631	NC	3	62
	Gascoyne MP	100	87	258	270	2,242	12,519
	Geographe MP	<1	<1	NC	NC	<1	2
	Jurien MP	<1	<1	NC	NC	<1	7
	Kimberley MP	1	<1	2,217	NC	<1	19
	Mermaid Reef MP	2	<1	1,883	NC	<1	45
	Montebello MP	100	100	1	1	39,851	84,164
	Ningaloo MP	98	80	263	266	2,554	13,909
	Perth Canyon MP	1	<1	1,525	NC	<1	48
	Shark Bay MP	54	15	702	759	36	331
	South-West Corner MP	<1	<1	NC	NC	<1	8
	Two Rocks MP	<1	<1	NC	NC	<1	4
Coastlines	Ashburton	3	<1	1,513	NC	2	39
	Augusta - Margaret River	<1	<1	NC	NC	<1	4
	Augusta - Walpole	<1	<1	NC	NC	<1	3
	Bali	<1	<1	NC	NC	<1	2
	Busselton	<1	<1	NC	NC	<1	2
	Cape Bruguieres	<1	<1	NC	NC	<1	5
	Carnamah	<1	<1	NC	NC	<1	2
	Carnarvon	30	7	1,101	1,413	22	269
	Chapman Valley	<1	<1	NC	NC	<1	2
	Coorow	<1	<1	NC	NC	<1	2
	Dampier Archipelago	2	<1	1,859	NC	2	17
	Dandaragan	<1	<1	NC	NC	<1	4
	Dawesville - Bunbury	<1	<1	NC	NC	<1	2
	Exmouth	87	63	300	338	878	7,145
	Exmouth Gulf South East	<1	<1	NC	NC	<1	3
	Exmouth Gulf West	47	17	388	473	39	254
	Geographe Bay	<1	<1	NC	NC	<1	2

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
	Geographe Bay - Augusta	<1	<1	NC	NC	<1	4
	Geraldton - Jurien Bay	<1	<1	NC	NC	<1	5
	Gingin	<1	<1	NC	NC	<1	3
	Greater Geraldton	<1	<1	NC	NC	<1	4
	Harvey	<1	<1	NC	NC	<1	2
	Indonesia	<1	<1	NC	NC	<1	2
	Irwin	<1	<1	NC	NC	<1	3
	Joondalup	<1	<1	NC	NC	<1	2
	Jurien Bay - Yanchep	<1	<1	NC	NC	<1	4
	Kalbarri - Geraldton	<1	<1	NC	NC	<1	5
	Karratha	4	<1	1,373	NC	3	65
	Karratha-Port Hedland	<1	<1	NC	NC	<1	5
	Mandurah	<1	<1	NC	NC	<1	2
	Mandurah - Dawesville	<1	<1	NC	NC	<1	3
	Manjimup	<1	<1	NC	NC	<1	2
	Middle Pilbara - Islands and Shoreline	30	5	796	1,228	20	335
	Nannup	<1	<1	NC	NC	<1	2
	Northampton	<1	<1	NC	NC	<1	4
	Northern Pilbara - Islands and Shoreline	20	1	883	1,817	7	118
	Perth Northern Coast	<1	<1	NC	NC	<1	3
	Perth Southern Coast	<1	<1	NC	NC	<1	3
	Rockingham	<1	<1	NC	NC	<1	2
	Shark Bay	15	<1	1,429	NC	5	84
	Southern Pilbara - Shoreline	2	<1	1,422	NC	<1	21
	Wanneroo	<1	<1	NC	NC	<1	2
	Waroona	<1	<1	NC	NC	<1	2
	Zuytdorp Cliffs - Kalbarri	<1	<1	NC	NC	<1	9
Fish Habitat Protection Area	Abrolhos Islands	4	<1	1,320	NC	2	34
	Miaboolya Beach	<1	<1	NC	NC	<1	2
	Point Quobba	<1	<1	NC	NC	<1	6
Islan ds	Abrolhos Islands	4	<1	1,324	NC	2	33
	Airlie Island	78	30	358	359	156	1,668

Receptors	Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Angel Island	<1	<1	NC	NC	<1	2
Ashburton Island	28	<1	383	NC	10	84
Barrow Island	99	99	120	122	1,353	5,012
Bedout Island	<1	<1	NC	NC	<1	8
Bedwell Island	3	2	1,677	1,704	4	161
Bernier Island	9	<1	1,333	NC	4	55
Bessieres Island	82	45	283	334	192	1,963
Bezout Island	<1	<1	NC	NC	<1	3
Boodie Island	88	56	211	352	338	2,828
Cohen Island	<1	<1	NC	NC	<1	6
Conzinc Island	<1	<1	NC	NC	<1	2
Cunningham Island	6	2	1,392	1,594	4	119
Delambre Island	<1	<1	NC	NC	<1	5
Direction Island	11	<1	1,140	NC	4	41
Dolphin Island	<1	<1	NC	NC	<1	3
Dorre Island	9	<1	1,360	NC	4	69
Eaglehawk Island	<1	<1	NC	NC	<1	8
East Lewis Island	<1	<1	NC	NC	<1	2
Easter Group	<1	<1	NC	NC	<1	6
Enderby Island	1	<1	2,482	NC	<1	12
Flat Island	71	42	238	264	132	770
Fly Island	<1	<1	NC	NC	2	10
Garden Island	<1	<1	NC	NC	<1	2
Gidley Island	<1	<1	NC	NC	<1	3
Goodwyn Island	<1	<1	NC	NC	<1	7
Haury Island	<1	<1	NC	NC	<1	4
Hermite Island	88	76	222	226	594	2,718
Keast Island	<1	<1	NC	NC	<1	5
Kendrew Island	<1	<1	NC	NC	<1	9
Legendre Island	<1	<1	NC	NC	<1	8
Locker Island	4	<1	967	NC	3	23
Lowendal Islands	76	39	286	574	203	1,808
Malus Island	<1	<1	NC	NC	<1	4
Mangrove Islands	2	<1	1,349	NC	<1	28
Mary Anne Group	23	3	801	1,261	11	162
Middle Island	87	58	212	366	350	2,918
Montebello Islands	94	83	135	221	747	3,310
Muiron Islands	91	73	234	236	1,613	7,380
North Island	4	<1	1,326	NC	2	21
Observation Island	29	6	640	812	15	128
Passage Islands	31	6	796	1,299	21	335

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
	Peak Island	89	57	219	222	611	6,023
	Pelsaert Group	<1	<1	NC	NC	<1	9
	Ragnard Islands	<1	<1	NC	NC	<1	4
	Rivoli Islands	<1	<1	NC	NC	<1	4
	Rosemary Island	<1	<1	NC	NC	<1	9
	Rottnest Island	<1	<1	NC	NC	<1	4
	Round Island	44	1	447	695	15	112
	Serrurier Island	66	24	250	373	76	890
	Southern Pilbara - Islands	98	90	151	187	1,433	8,837
	Sunday Island	72	55	248	250	404	2,183
	Table Island	45	3	372	457	22	377
	Thevenard Island	82	46	305	347	288	3,741
	Tortoise Island	49	4	359	457	21	244
	Twin Island	2	<1	1,365	NC	2	46
	Wallabi Group	4	<1	1,349	NC	2	24
	West Lewis Island	<1	<1	NC	NC	<1	3
Marine Parks	Barrow Island MMA	100	99	113	121	1,550	5,352
	Barrow Island MP (State)	99	98	124	124	1,196	3,849
	Clerke Reef (Rowley Shoals MP)	3	2	1,653	1,668	4	168
	Imperieuse Reef (Rowley Shoals MP)	7	2	1,349	1,568	5	150
	Jurien Bay MP	<1	<1	NC	NC	<1	6
	Marmion MP	<1	<1	NC	NC	<1	3
	Montebello Islands MP	100	96	101	125	1,520	8,922
	Muiron Islands MMA	92	77	227	230	2,092	9,623
	Ngari Capes MP	<1	<1	NC	NC	<1	4
	Ningaloo Coast WH	98	80	263	266	2,554	13,909
	Ningaloo MP (State)	94	76	267	271	1,764	12,954
	Shark Bay MR	15	<1	1,458	NC	5	81
	Shark Bay WH	17	2	1,287	1,916	6	169
	Shoalwater Islands MP	<1	<1	NC	NC	<1	2
National Park	Cape Range	86	54	396	412	637	4,760
	D'Entrecasteaux	<1	<1	NC	NC	<1	2
	Dirk Hartog Island	15	2	1,399	2,113	6	169
	Kalbarri	<1	<1	NC	NC	<1	2
Nature Reserve	Bernier And Dorre Islands NR	9	<1	1,333	NC	4	80
	Boodie, Double Middle Islands Nature Reserve NR	90	61	200	329	407	4,195
	Great Sandy Island NR	51	12	450	790	43	672

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
	North Sandy Island NR	31	6	796	1,299	21	335
	Scott Reef NR	<1	<1	NC	NC	<1	2
	Thevenard Island NR	80	46	306	347	269	3,593
	Y Island	<1	<1	NC	NC	<1	2
	Boullanger, Whitlock, Favourite,Tern & Osprey Islands Nature Reserve	<1	<1	NC	NC	<1	2
	Buller,Whittell & Green Islands Nature Reserve	<1	<1	NC	NC	<1	2
Reefs, Shoals and Banks	Ashworth Shoal	<1	<1	NC	NC	<1	4
	Assail Bank	4	<1	1,347	NC	<1	18
	Australind Shoal	34	2	374	892	14	165
	Barrow Island Reefs and Shoals	50	12	450	790	43	672
	Baylis Patches	5	<1	796	NC	3	20
	Beagle Knoll	<1	<1	NC	NC	<1	8
	Bennett Shoal	<1	<1	NC	NC	<1	9
	Beryl Reef	8	<1	1,134	NC	3	27
	Brewis Reef	73	37	305	347	160	2,080
	Camplin Shoal	<1	<1	NC	NC	<1	8
	Clerke Reef	3	2	1,662	1,679	4	161
	Clio Bank	<1	<1	NC	NC	<1	4
	Cod Bank	1	<1	2,374	NC	2	18
	Combe Reef	54	24	386	387	77	513
	Cooper Shoal	<1	<1	NC	NC	<1	10
	Courtenay Shoal	<1	<1	NC	NC	<1	3
	Curlew Bank	2	<1	2,443	NC	<1	16
	Dailey Shoal	62	36	269	394	137	711
	Dart Shoal	<1	<1	NC	NC	<1	2
	Direction Bank	<1	<1	NC	NC	<1	6
	Dockrell Reef	<1	<1	NC	NC	<1	2
	Eliassen Rocks	<1	<1	NC	NC	<1	4
	Exmouth Reef	48	6	357	463	24	174
	Fairway Reef	21	<1	773	NC	6	37
	Fantome Shoal §	<1	<1	NC	NC	<1	4
	Flinders Shoal	27	3	804	1,228	13	216
	Fortescue Reef	2	<1	1,850	NC	<1	22
	Gee Bank	<1	<1	NC	NC	<1	3
	Geelvink Channel Shoals	<1	<1	NC	NC	<1	5
	Glennie Patches	8	<1	778	NC	3	22
	Glomar Shoal §	22	<1	299	302	357	69

Receptors	Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Gorgon Patch	12	<1	748	NC	5	47
Hammersley Shoal	<1	<1	NC	NC	<1	6
Hastings Shoal	3	<1	1,564	NC	3	34
Hayman Rock	10	<1	743	NC	5	36
Herald Reef	2	<1	1,360	NC	3	63
Hood Reef	29	1	576	1,119	12	102
Imperieuse Reef	6	2	1,364	1,574	4	144
Inner Northwest Patch	4	<1	756	NC	3	14
Koolinda Patch	3	<1	1,553	NC	2	34
Lightfoot Reef	21	3	844	1,254	10	165
Little Shoals	22	3	701	1,101	13	128
Locker Reef	14	<1	565	NC	6	46
Madeleine Shoals	4	<1	1,134	NC	2	15
Manicom Bank	<1	<1	NC	NC	<1	7
Mardie Rock	<1	<1	NC	NC	<1	8
McLennan Bank	13	<1	1,152	NC	4	25
Meda Reef	20	2	852	1,791	9	178
Mermaid Reef	2	<1	2,089	NC	<1	43
Mid Reef	<1	<1	NC	NC	<1	3
Montebello Shoals	93	80	135	222	729	3,567
Moresby Shoals	11	<1	1,113	NC	6	88
Nares Rock	6	<1	1,338	NC	4	74
Ningaloo Reef	90	65	312	335	1,152	7,895
North Tail Reef	<1	<1	NC	NC	<1	3
North West Reef	80	56	288	306	320	1,746
North West Reefs	1	<1	2,482	NC	<1	11
O'Grady Shoal	<1	<1	NC	NC	<1	9
Otway Reef	53	15	431	641	55	468
Outtrim Patches	85	65	228	233	1,148	8,706
Paroo Shoal	24	<1	384	NC	10	93
Pearl Reef	<1	<1	NC	NC	<1	6
Pelsaert Bank	<1	<1	NC	NC	<1	7
Penguin Bank	99	90	149	184	1,428	7,511
Poivre Reef	90	80	150	187	562	3,800
Rankin Bank §	87	72	40	42	4,282	1,757
Ripple Shoals	61	24	379	427	117	2,542
Roller Shoal	2	<1	2,450	NC	<1	12
Rosily Shoals	98	77	174	200	700	5,564
Saladin Shoal	14	<1	482	NC	5	46
Sand Knoll Ledge	<1	<1	NC	NC	<1	3
Santo Rock	36	1	420	671	12	138

Receptors	Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Scott Reef South	<1	<1	NC	NC	<1	2
Snapper Bank	<1	<1	NC	NC	<1	4
South East Reef	<1	<1	NC	NC	<1	2
South West Reef	<1	<1	NC	NC	<1	5
Southwest Patch	<1	<1	NC	NC	<1	7
Spider Reef	4	<1	1,045	NC	3	12
Stewart Shoal	<1	<1	NC	NC	<1	3
Sultan Reef	62	24	358	359	105	1,546
Taunton Reef	61	22	373	383	81	1,084
Tongue Shoals	9	<1	657	NC	4	34
Trap Reef	87	51	238	346	378	2,921
Tryal Rocks	100	100	49	61	3,185	9,556
Turtle Dove Shoal	<1	<1	NC	NC	<1	7
Wapet Shoal	<1	<1	NC	NC	<1	2
Ward Reef	2	<1	2,225	NC	<1	22
Web Reef	1	<1	1,084	NC	2	13
Weeks Shoal	26	<1	385	NC	11	84
West Reef	11	<1	1,150	NC	7	75

NC No contact to receptor predicted for specified threshold.

§ Probabilities and maximum concentrations calculated at depth of submerged feature

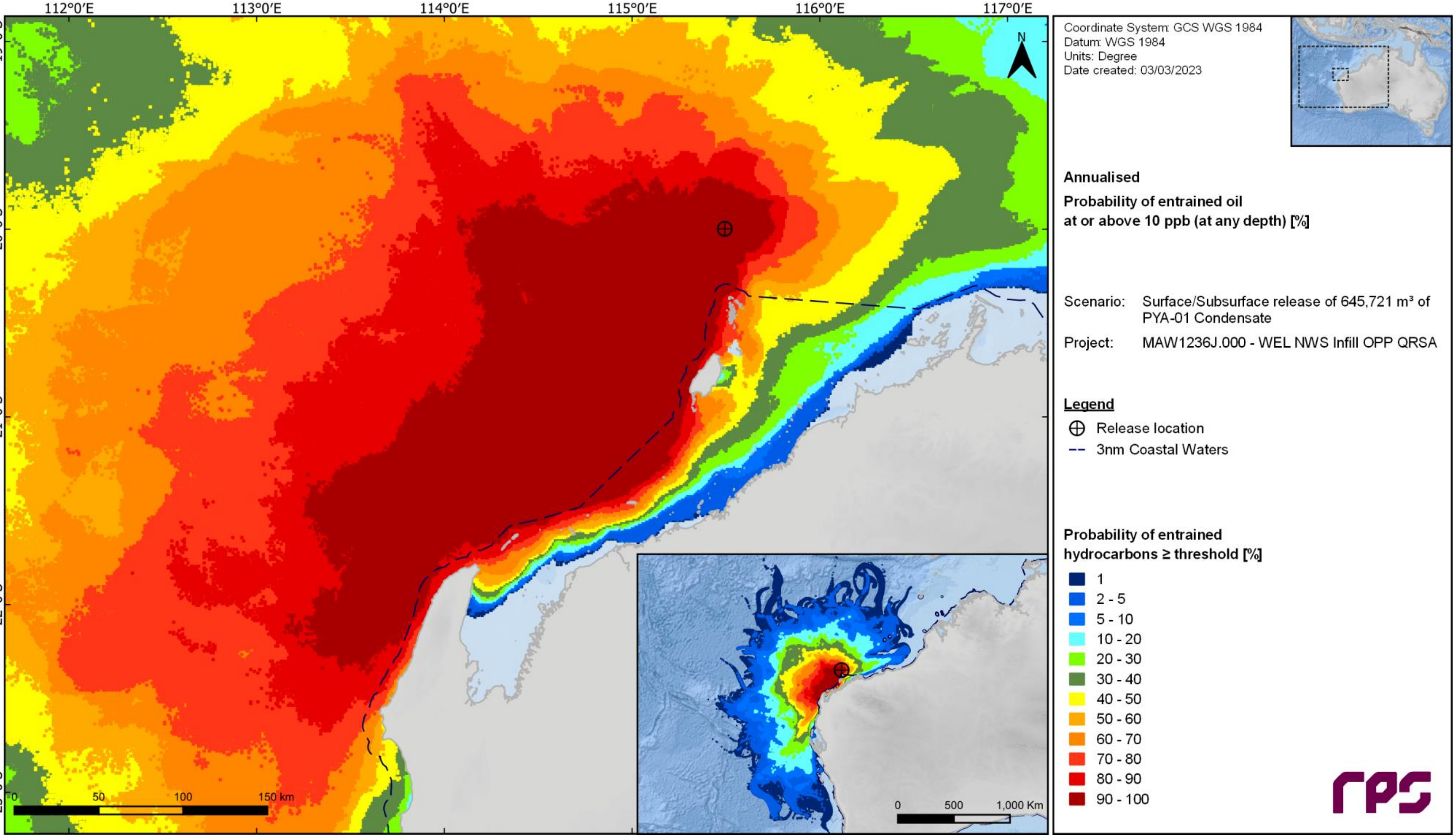


Figure 4.16 Predicted annualised probability of entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

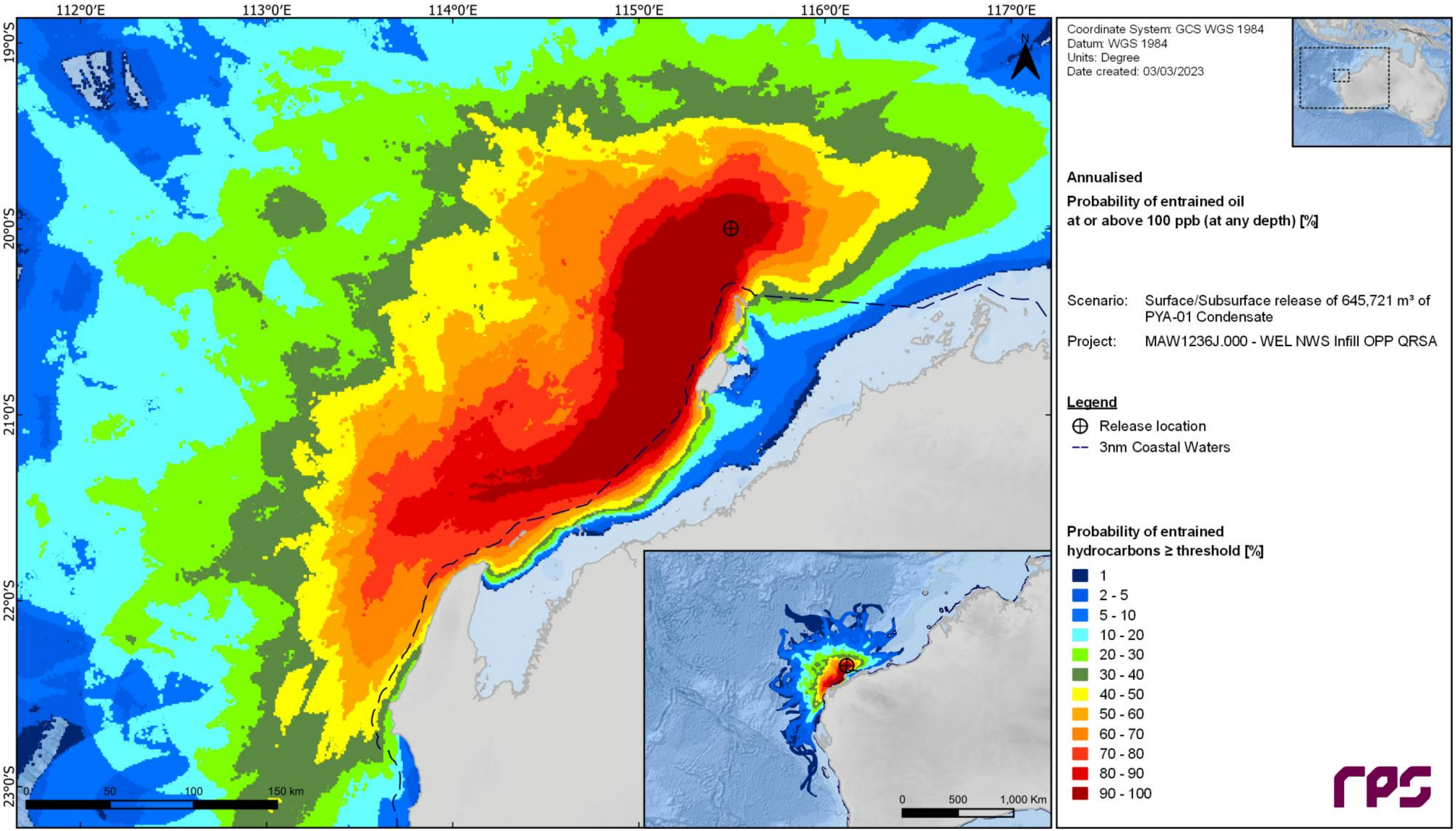


Figure 4.17 Predicted annualised probability of entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

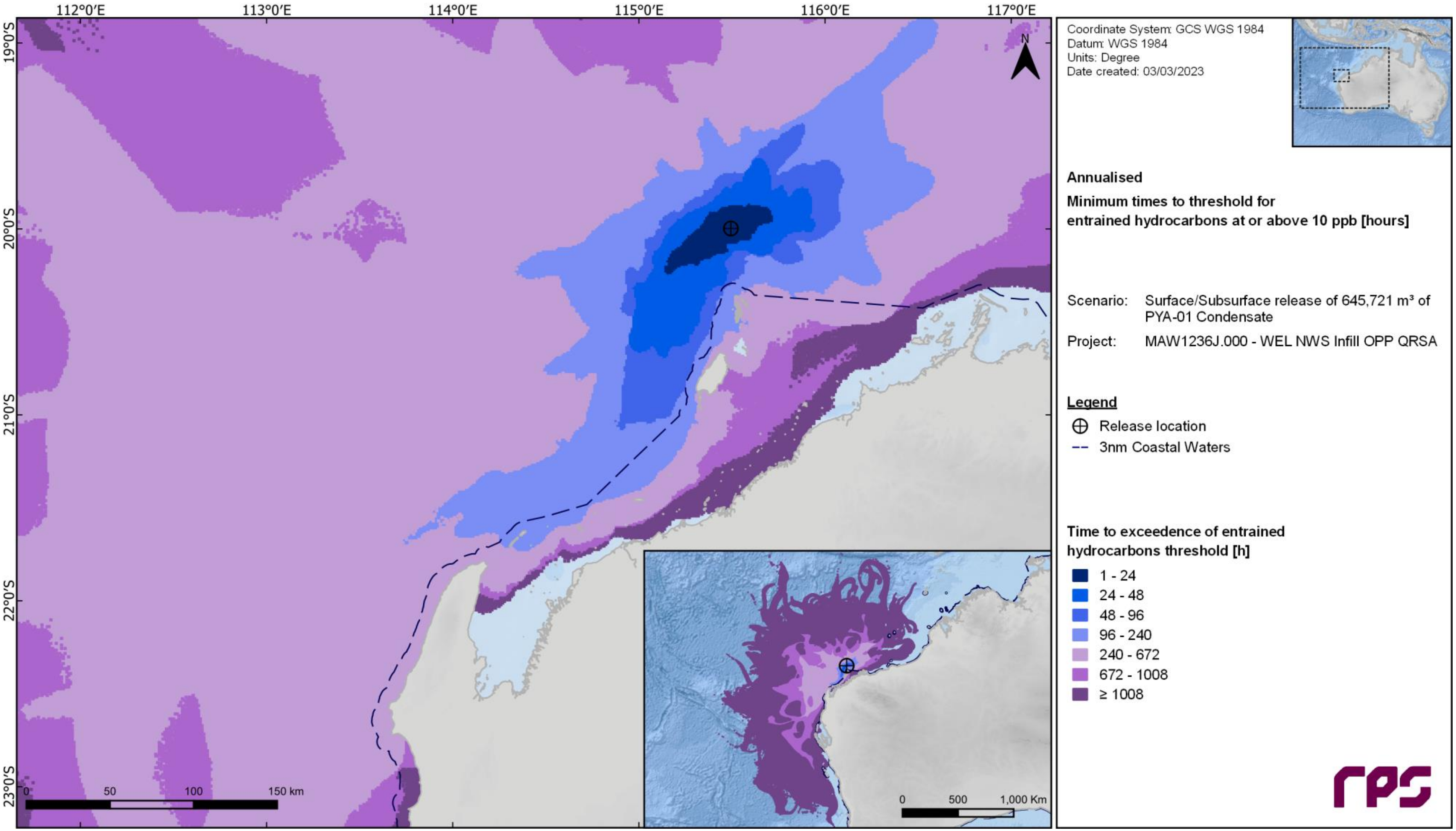


Figure 4.18 Predicted annualised minimum times to contact by entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

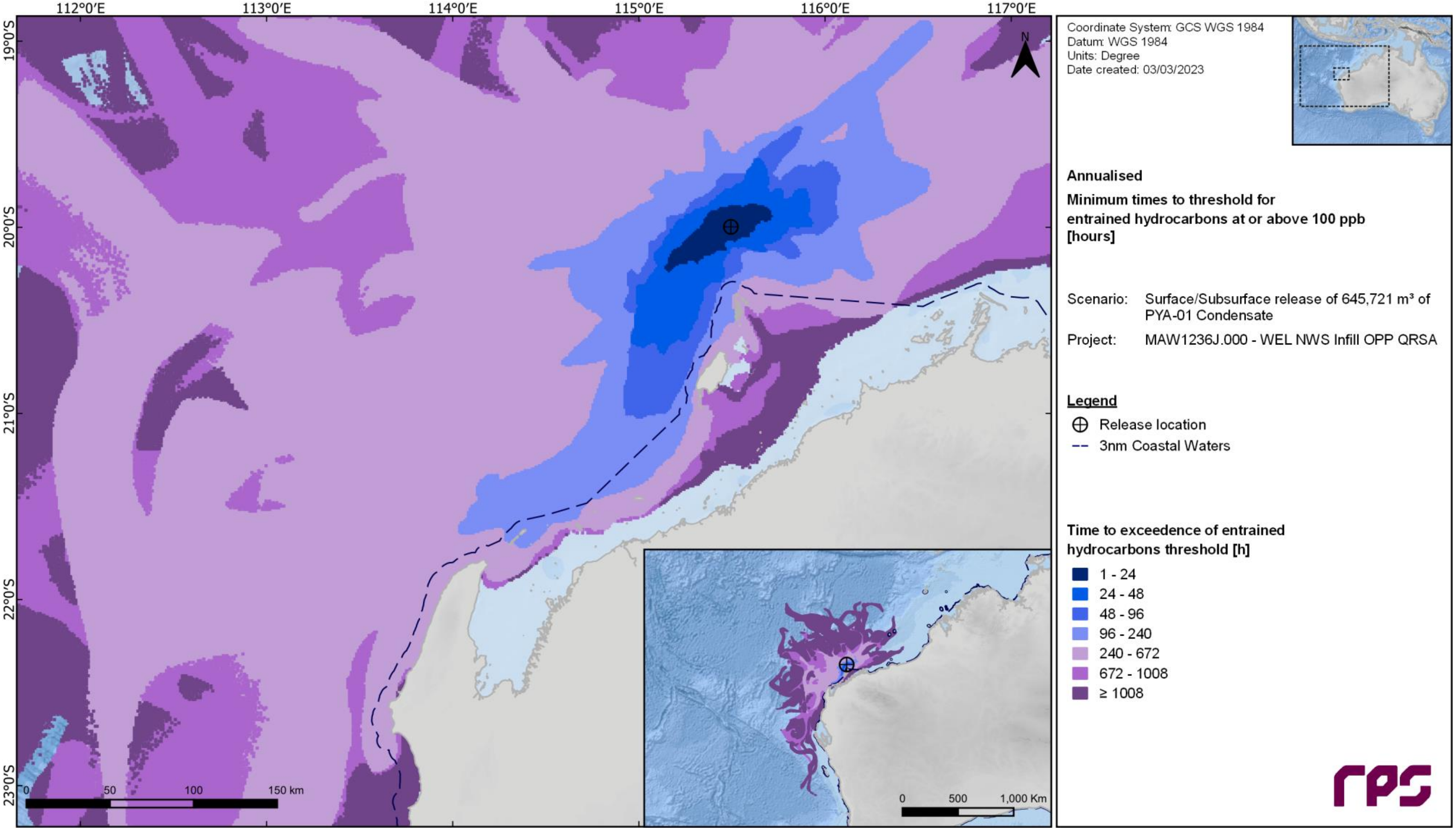


Figure 4.19 **Predicted annualised minimum times to contact by entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

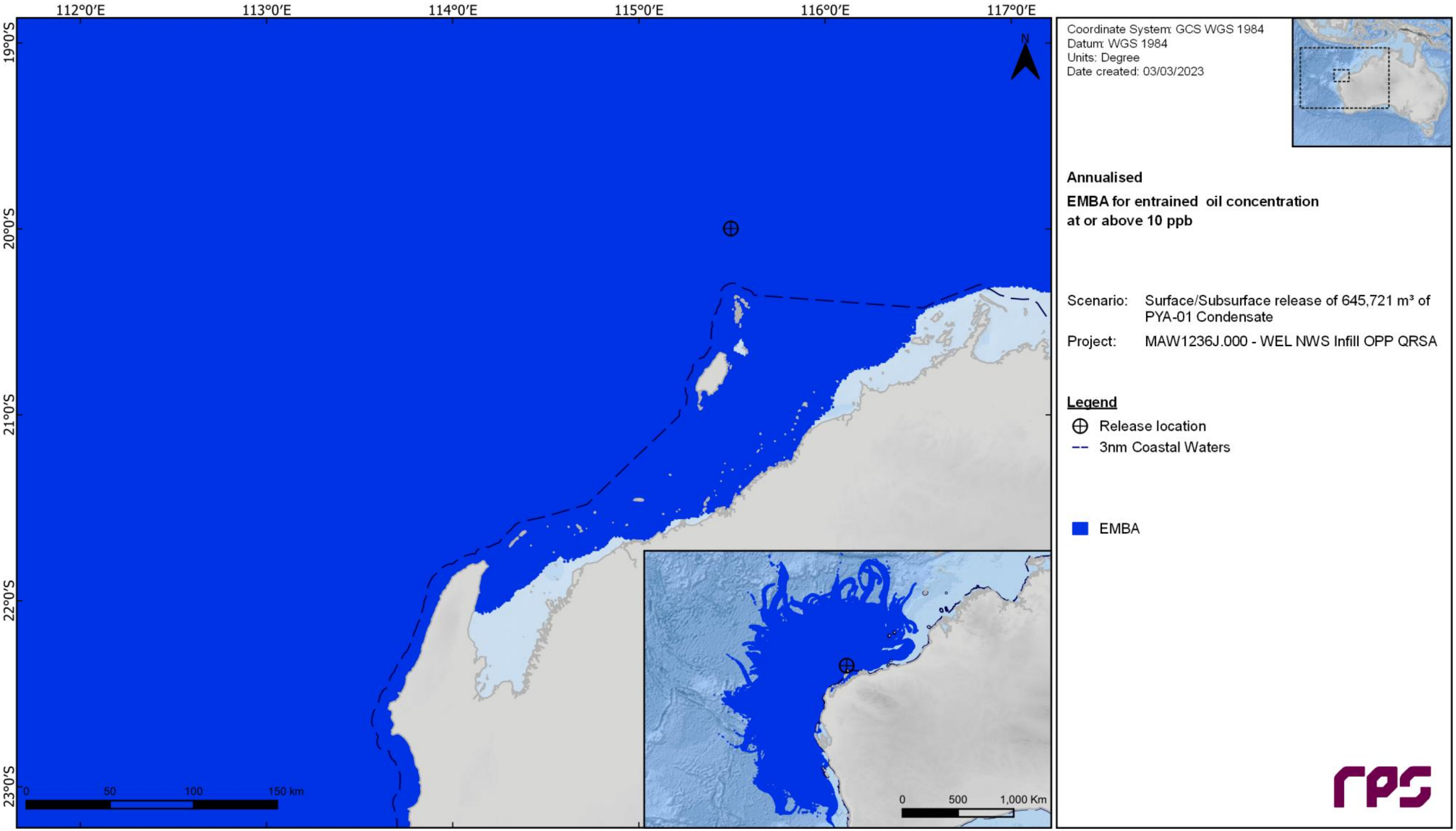


Figure 4.20 Predicted annualised EMBA of entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

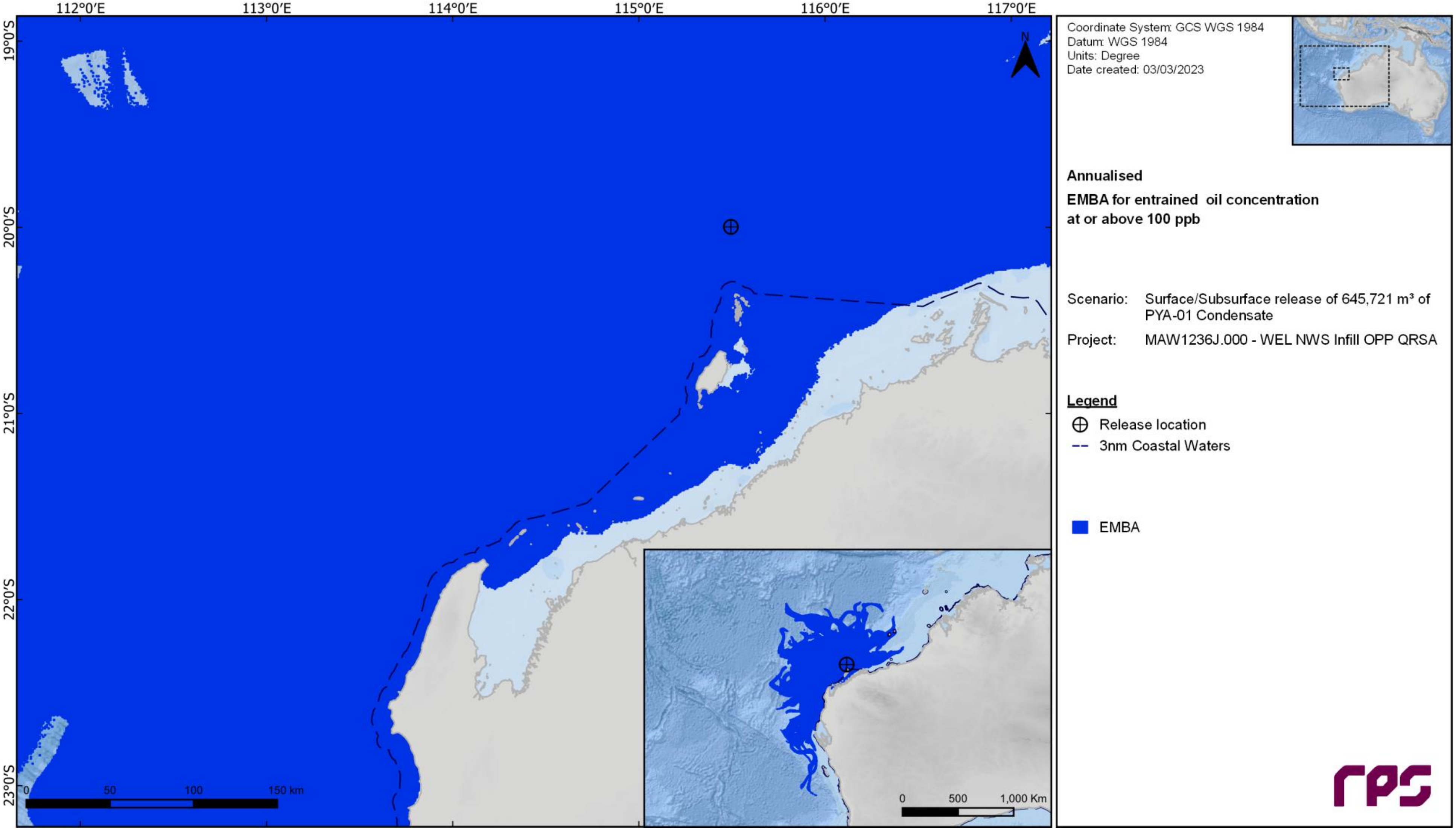


Figure 4.21 Predicted annualised EMBA of entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

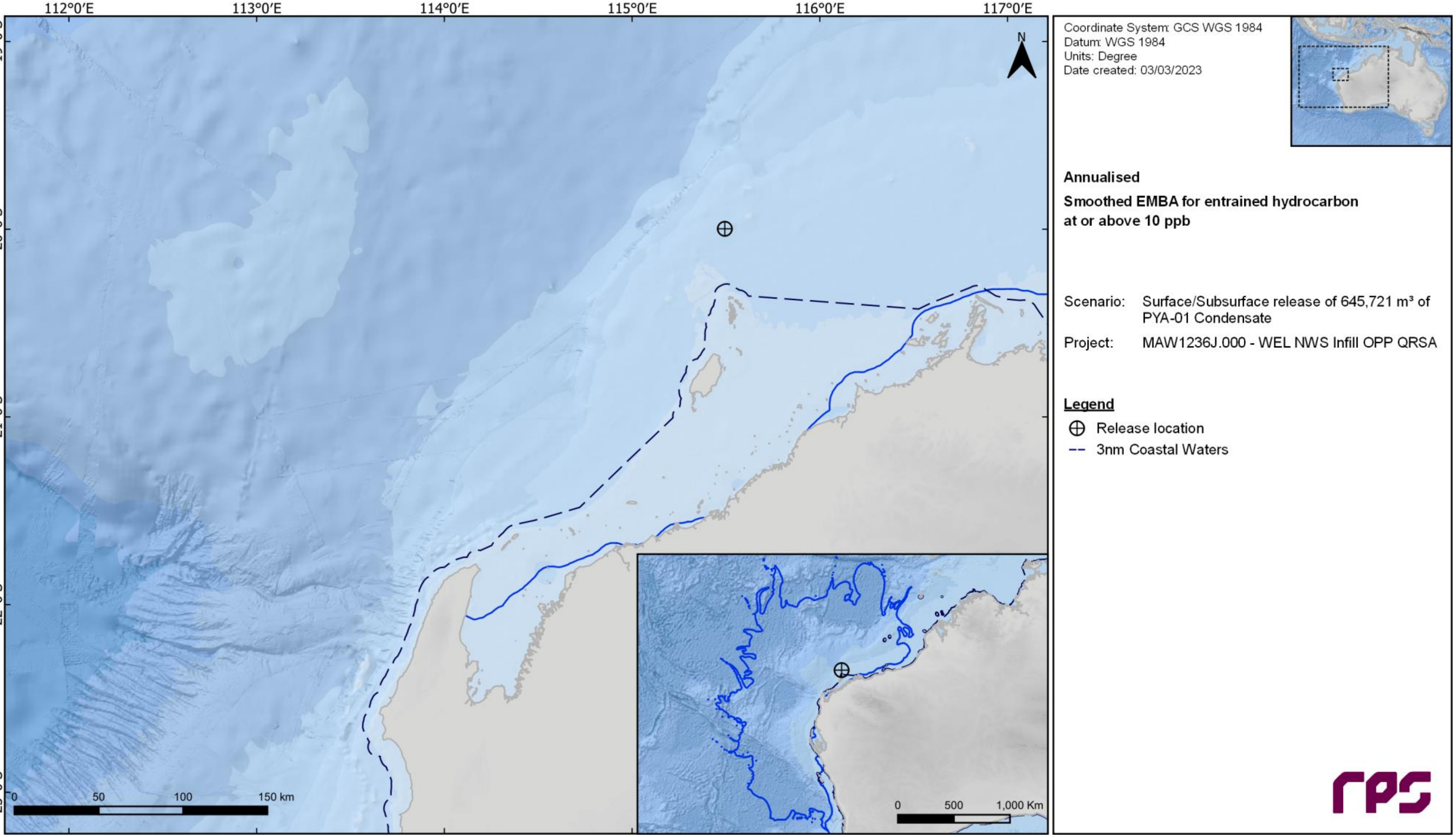


Figure 4.22 Predicted annualised smoothed EMBA of entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

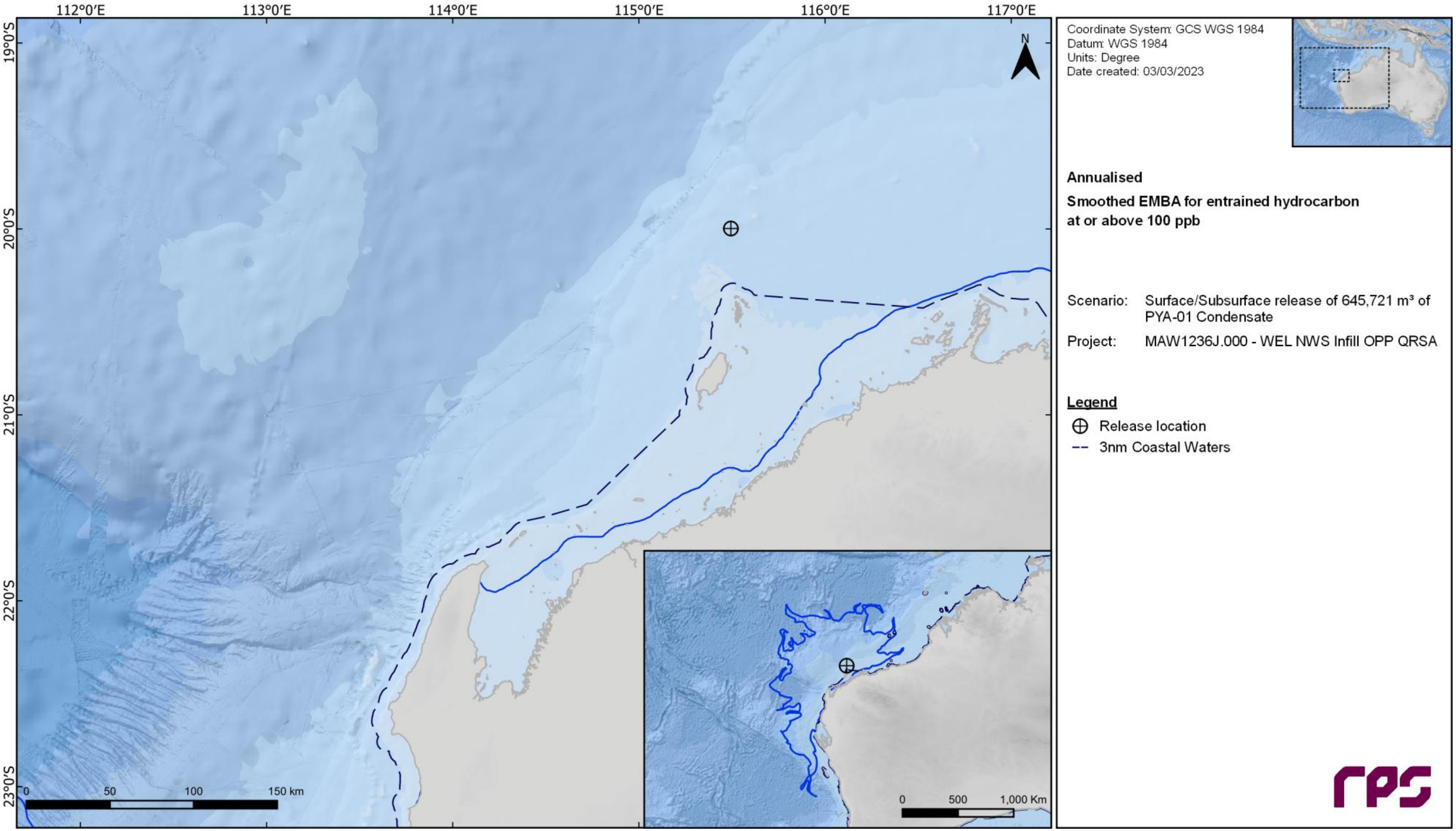


Figure 4.23 **Predicted annualised smoothed EMBA of entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

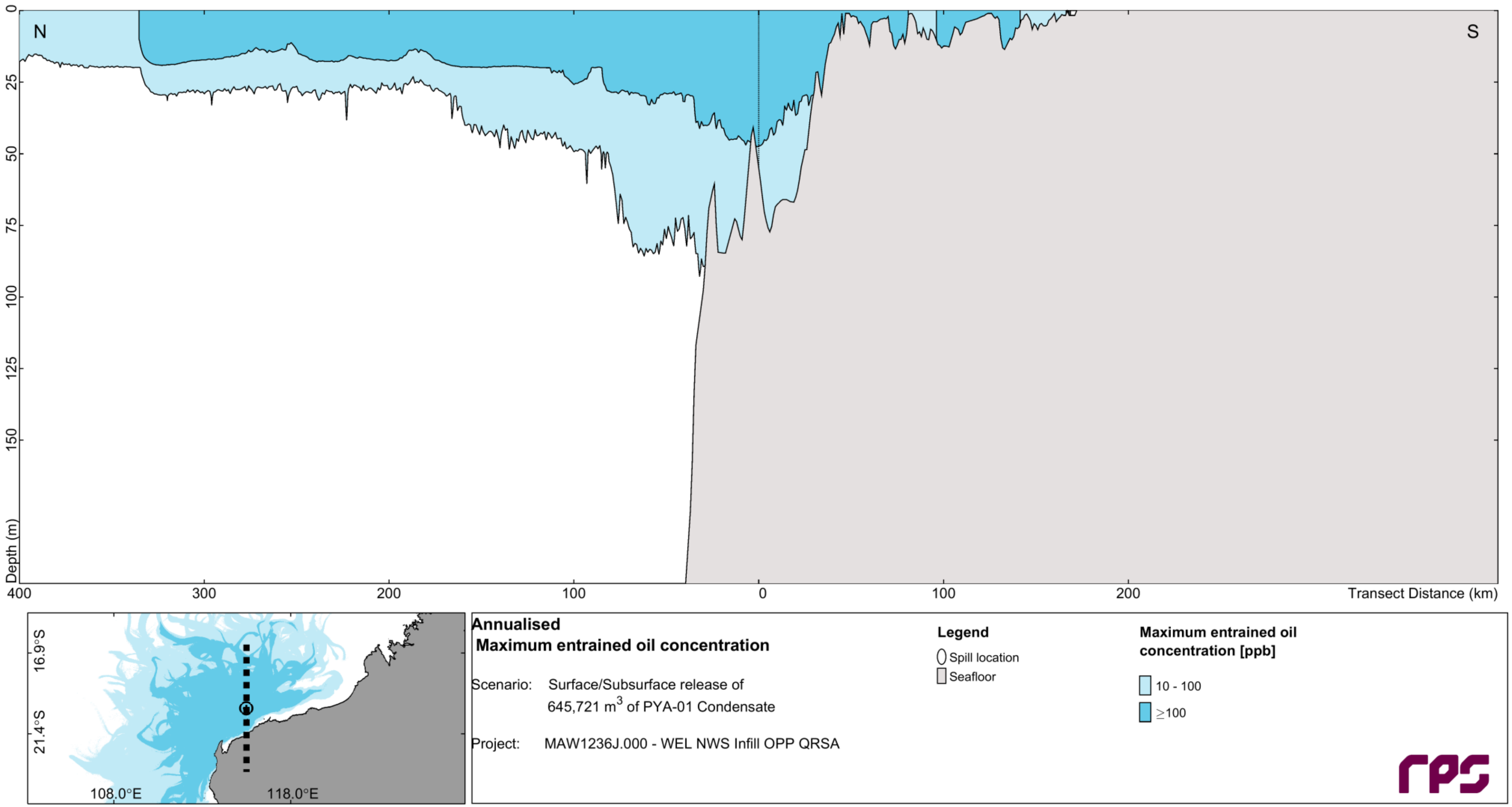


Figure 4.24 **North-to-south cross section transect of predicted annualised maximum entrained oil concentration for a Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.**

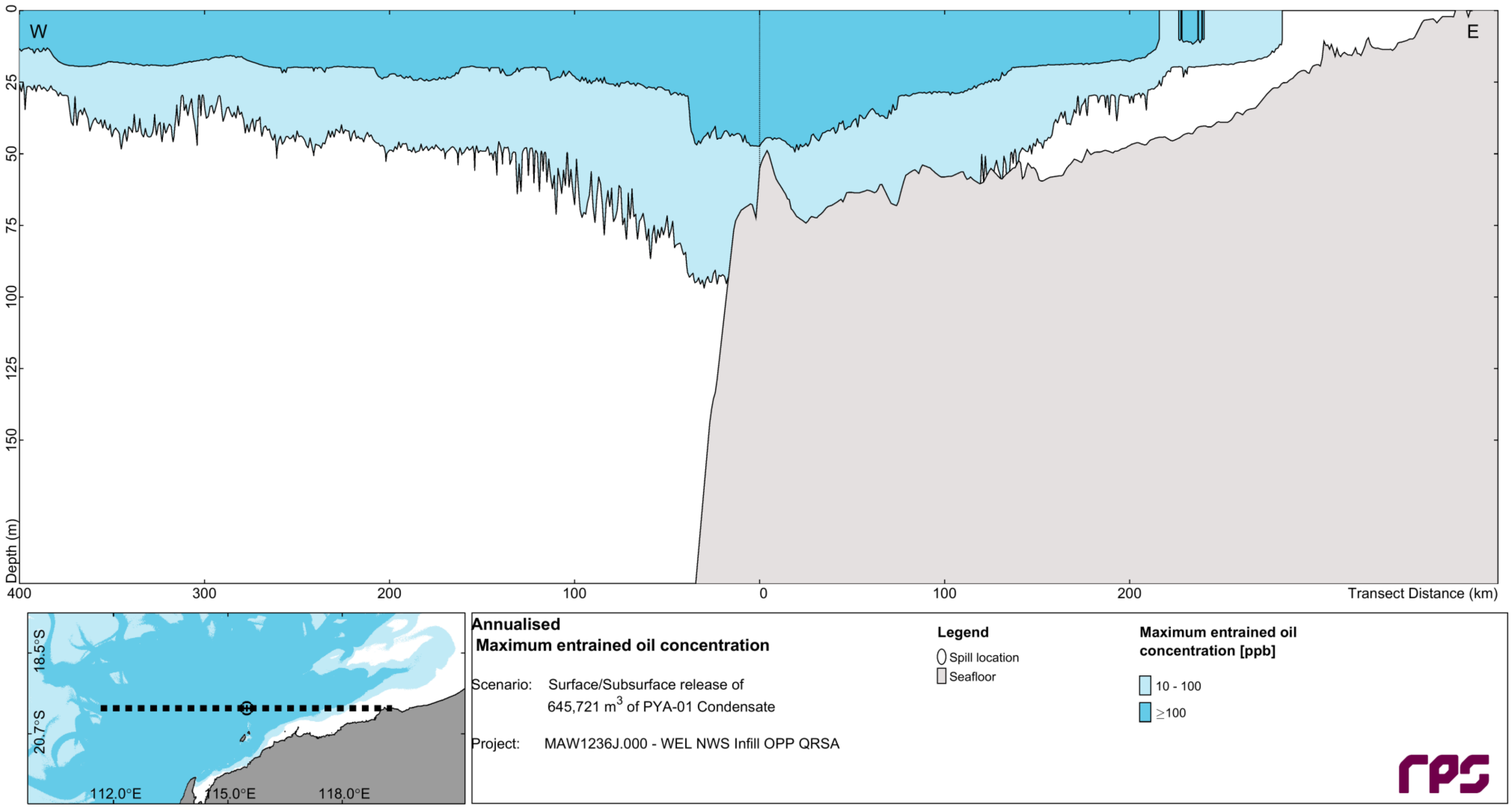


Figure 4.25 West-to-east cross section transect of predicted annualised maximum entrained oil concentration for a Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

4.2.2.3 Dissolved Aromatic Hydrocarbon

Table 4.6 Expected annualised of dissolved aromatic hydrocarbon outcomes at sensitive receptors resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

Receptors		Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Australian Marine Parks	Abrolhos MP	3	1	<1	91
	Argo-Rowley Terrace MP	6	3	3	199
	Carnarvon Canyon MP	5	1	2	81
	Dampier MP	3	<1	<1	35
	Eighty Mile Beach MP	<1	<1	<1	4
	Gascoyne MP	97	77	415	5,199
	Geographe MP	<1	<1	NC	NC
	Jurien MP	<1	<1	<1	4
	Kimberley MP	<1	<1	<1	<1
	Mermaid Reef MP	<1	<1	<1	10
	Montebello MP	100	100	8,576	28,974
	Ningaloo MP	98	78	485	6,558
	Perth Canyon MP	<1	<1	<1	4
	Shark Bay MP	16	3	7	325
	South-West Corner MP	<1	<1	<1	<1
	Two Rocks MP	<1	<1	<1	<1
Coastlines	Ashburton	<1	<1	<1	<1
	Augusta - Margaret River	<1	<1	NC	NC
	Augusta - Walpole	<1	<1	NC	NC
	Bali	<1	<1	NC	NC
	Busselton	<1	<1	NC	NC
	Cape Bruguieres	<1	<1	<1	6
	Carnamah	<1	<1	NC	NC
	Carnarvon	4	<1	2	39
	Chapman Valley	<1	<1	NC	NC
	Coorow	<1	<1	NC	NC
	Dampier Archipelago	2	<1	<1	27
	Dandaragan	<1	<1	NC	NC
	Dawesville - Bunbury	<1	<1	NC	NC
	Exmouth	74	41	124	1,236
	Exmouth Gulf South East	<1	<1	<1	2
	Exmouth Gulf West	3	1	3	144
	Geographe Bay	<1	<1	NC	NC
	Geographe Bay - Augusta	<1	<1	NC	NC

Receptors		Probability (%) of dissolved aromatic concentrations ≥ 10 ppb	Probability (%) of dissolved aromatic concentrations ≥ 50 ppb	Maximum dissolved aromatic hydrocarbon concentration (ppb) averaged over all replicate spills	Maximum dissolved aromatic hydrocarbon concentration (ppb) in the worst replicate
	Geraldton - Jurien Bay	<1	<1	NC	NC
	Gingin	<1	<1	NC	NC
	Greater Geraldton	<1	<1	NC	NC
	Harvey	<1	<1	NC	NC
	Indonesia	<1	<1	NC	NC
	Irwin	<1	<1	NC	NC
	Joondalup	<1	<1	NC	NC
	Jurien Bay - Yanchep	<1	<1	NC	NC
	Kalbarri - Geraldton	<1	<1	<1	<1
	Karratha	<1	<1	<1	<1
	Karratha-Port Hedland	<1	<1	<1	6
	Mandurah	<1	<1	NC	NC
	Mandurah - Dawesville	<1	<1	NC	NC
	Manjimup	<1	<1	NC	NC
	Middle Pilbara - Islands and Shoreline	6	1	2	51
	Nannup	<1	<1	NC	NC
	Northampton	<1	<1	<1	<1
	Northern Pilbara - Islands and Shoreline	1	<1	<1	30
	Perth Northern Coast	<1	<1	NC	NC
	Perth Southern Coast	<1	<1	NC	NC
	Rockingham	<1	<1	NC	NC
	Shark Bay	1	<1	<1	14
	Southern Pilbara - Shoreline	<1	<1	<1	<1
	Wanneroo	<1	<1	NC	NC
	Waroona	<1	<1	NC	NC
	Zuytdorp Cliffs - Kalbarri	<1	<1	<1	<1
Fish Habitat Protection Area	Abrolhos Islands	<1	<1	<1	6
	Miaboolya Beach	<1	<1	NC	NC
	Point Quobba	<1	<1	<1	2
Islands	Abrolhos Islands	<1	<1	<1	6
	Airlie Island	35	15	24	413
	Angel Island	<1	<1	<1	<1
	Ashburton Island	6	2	6	317
	Barrow Island	99	93	502	5,214
	Bedout Island	<1	<1	<1	<1
	Bedwell Island	2	<1	<1	31

Receptors	Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Bernier Island	<1	<1	<1	9
Bessieres Island	68	44	100	2,051
Bezout Island	<1	<1	NC	NC
Boodie Island	45	22	62	1,086
Cohen Island	1	<1	<1	11
Conzinc Island	<1	<1	<1	<1
Cunningham Island	1	<1	<1	21
Delambre Island	<1	<1	<1	7
Direction Island	<1	<1	<1	3
Dolphin Island	<1	<1	<1	4
Dorre Island	<1	<1	<1	10
Eaglehawk Island	<1	<1	<1	<1
East Lewis Island	<1	<1	<1	<1
Easter Group	<1	<1	<1	<1
Enderby Island	<1	<1	<1	<1
Flat Island	40	12	27	555
Fly Island	1	<1	<1	36
Garden Island	<1	<1	NC	NC
Gidley Island	<1	<1	<1	<1
Goodwyn Island	<1	<1	<1	<1
Haury Island	<1	<1	<1	4
Hermite Island	69	41	91	1,627
Keast Island	1	<1	<1	11
Kendrew Island	<1	<1	<1	5
Legendre Island	1	<1	<1	17
Locker Island	<1	<1	<1	<1
Lowendal Islands	25	8	15	515
Malus Island	<1	<1	<1	<1
Mangrove Islands	<1	<1	<1	<1
Mary Anne Group	2	<1	<1	17
Middle Island	43	19	81	2,704
Montebello Islands	81	62	153	2,039
Muiron Islands	74	56	355	4,655
North Island	<1	<1	<1	2
Observation Island	3	1	2	71
Passage Islands	6	1	3	64
Peak Island	71	40	97	1,346
Pelsaert Group	<1	<1	<1	<1
Ragnard Islands	<1	<1	<1	<1
Rivoli Islands	1	<1	<1	27
Rosemary Island	1	<1	<1	15

Receptors		Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
	Rottnest Island	<1	<1	NC	NC
	Round Island	1	<1	<1	20
	Serrurier Island	28	9	21	398
	Southern Pilbara - Islands	95	85	355	3,364
	Sunday Island	44	26	51	726
	Table Island	7	3	6	264
	Thevenard Island	54	24	56	1,131
	Tortoise Island	10	4	8	376
	Twin Island	<1	<1	<1	<1
	Wallabi Group	<1	<1	<1	2
	West Lewis Island	<1	<1	<1	<1
Marine Parks	Barrow Island MMA	99	97	590	5,491
	Barrow Island MP (State)	98	96	513	5,484
	Clerke Reef (Rowley Shoals MP)	2	<1	<1	40
	Imperieuse Reef (Rowley Shoals MP)	3	<1	<1	24
	Jurien Bay MP	<1	<1	NC	NC
	Marmion MP	<1	<1	NC	NC
	Montebello Islands MP	97	91	510	6,432
	Muiron Islands MMA	87	66	494	7,008
	Ngari Capes MP	<1	<1	NC	NC
	Ningaloo Coast WH	98	78	485	6,558
	Ningaloo MP (State)	87	69	262	3,030
	Shark Bay MR	1	<1	<1	14
	Shark Bay WH	2	1	2	76
	Shoalwater Islands MP	<1	<1	NC	NC
National Park	Cape Range	66	32	88	923
	D'Entrecasteaux	<1	<1	NC	NC
	Dirk Hartog Island	2	<1	<1	44
	Kalbarri	<1	<1	NC	NC
Nature Reserve	Bernier And Dorre Islands NR	1	<1	<1	11
	Boodie, Double Middle Islands Nature Reserve NR	50	23	92	3,196
	Great Sandy Island NR	10	2	5	121
	North Sandy Island NR	6	1	3	64
	Scott Reef NR	<1	<1	NC	NC
	Thevenard Island NR	48	24	61	1,131
	Y Island	1	<1	<1	21

Receptors		Probability (%) of dissolved aromatic concentrations ≥ 10 ppb	Probability (%) of dissolved aromatic concentrations ≥ 50 ppb	Maximum dissolved aromatic hydrocarbon concentration (ppb) averaged over all replicate spills	Maximum dissolved aromatic hydrocarbon concentration (ppb) in the worst replicate
	Boullanger, Whitlock, Favourite,Tern & Osprey Islands Nature Reserve	<1	<1	NC	NC
	Buller,Whittell & Green Islands Nature Reserve	<1	<1	NC	NC
Reefs, Shoals and Banks	Ashworth Shoal	<1	<1	<1	<1
	Assail Bank	<1	<1	<1	<1
	Australind Shoal	6	3	5	176
	Barrow Island Reefs and Shoals	9	2	5	118
	Baylis Patches	<1	<1	<1	<1
	Beagle Knoll	<1	<1	<1	<1
	Bennett Shoal	<1	<1	<1	<1
	Beryl Reef	1	<1	<1	15
	Brewis Reef	44	18	41	878
	Camplin Shoal	<1	<1	<1	<1
	Clerke Reef	2	<1	<1	31
	Clio Bank	<1	<1	<1	<1
	Cod Bank	<1	<1	<1	<1
	Combe Reef	5	<1	3	46
	Cooper Shoal	<1	<1	<1	<1
	Courtenay Shoal	<1	<1	<1	<1
	Curlew Bank	<1	<1	<1	<1
	Dailey Shoal	20	7	12	205
	Dart Shoal	<1	<1	<1	<1
	Direction Bank	<1	<1	<1	<1
	Dockrell Reef	<1	<1	NC	NC
	Eliassen Rocks	<1	<1	<1	<1
	Exmouth Reef	4	2	3	70
	Fairway Reef	1	<1	<1	26
	Fantome Shoal §	<1	<1	<1	<1
	Flinders Shoal	2	<1	<1	49
	Fortescue Reef	<1	<1	<1	<1
	Gee Bank	<1	<1	<1	<1
	Geelvink Channel Shoals	<1	<1	<1	<1
	Glennie Patches	<1	<1	<1	8
	Glomar Shoal §	21	11	95	886
	Gorgon Patch	1	<1	<1	30
	Hammersley Shoal	1	<1	<1	11
	Hastings Shoal	<1	<1	<1	<1
	Hayman Rock	<1	<1	<1	<1
	Herald Reef	<1	<1	<1	<1
	Hood Reef	1	<1	<1	15
	Imperieuse Reef	2	<1	<1	24

Receptors	Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Inner Northwest Patch	1	<1	<1	12
Koolinda Patch	<1	<1	<1	<1
Lightfoot Reef	2	<1	<1	37
Little Shoals	3	<1	<1	37
Locker Reef	<1	<1	<1	<1
Madeleine Shoals	2	<1	<1	13
Manicom Bank	<1	<1	<1	4
Mardie Rock	<1	<1	<1	<1
McLennan Bank	<1	<1	<1	<1
Meda Reef	2	<1	<1	27
Mermaid Reef	<1	<1	<1	8
Mid Reef	<1	<1	NC	NC
Montebello Shoals	77	55	155	1,833
Moresby Shoals	<1	<1	<1	4
Nares Rock	<1	<1	<1	2
Ningaloo Reef	80	55	174	3,030
North Tail Reef	<1	<1	NC	NC
North West Reef	59	34	59	473
North West Reefs	<1	<1	<1	<1
O'Grady Shoal	<1	<1	<1	<1
Otway Reef	9	2	4	93
Outtrim Patches	65	48	181	2,296
Paroo Shoal	3	2	3	124
Pearl Reef	1	<1	<1	18
Pelsaert Bank	<1	<1	<1	<1
Penguin Bank	96	79	322	2,233
Poivre Reef	62	38	101	1,945
Rankin Bank §	83	76	1,524	9,572
Ripple Shoals	20	9	16	633
Roller Shoal	<1	<1	<1	<1
Rosily Shoals	86	71	227	3,250
Saladin Shoal	2	<1	<1	29
Sand Knoll Ledge	<1	<1	NC	NC
Santo Rock	2	<1	2	49
Scott Reef South	<1	<1	NC	NC
Snapper Bank	<1	<1	<1	<1
South East Reef	<1	<1	<1	<1
South West Reef	<1	<1	<1	<1
Southwest Patch	<1	<1	<1	<1
Spider Reef	1	<1	<1	26
Stewart Shoal	<1	<1	NC	NC

Receptors	Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Sultan Reef	26	11	19	348
Taunton Reef	24	5	11	247
Tongue Shoals	1	<1	<1	19
Trap Reef	60	32	77	1,190
Tryal Rocks	100	100	1,673	8,102
Turtle Dove Shoal	<1	<1	<1	<1
Wapet Shoal	<1	<1	NC	NC
Ward Reef	<1	<1	<1	<1
Web Reef	1	<1	<1	12
Weeks Shoal	3	1	3	165
West Reef	1	<1	<1	19

NC No contact to receptor predicted for specified threshold.

§ Probabilities and maximum concentrations calculated at depth of submerged feature

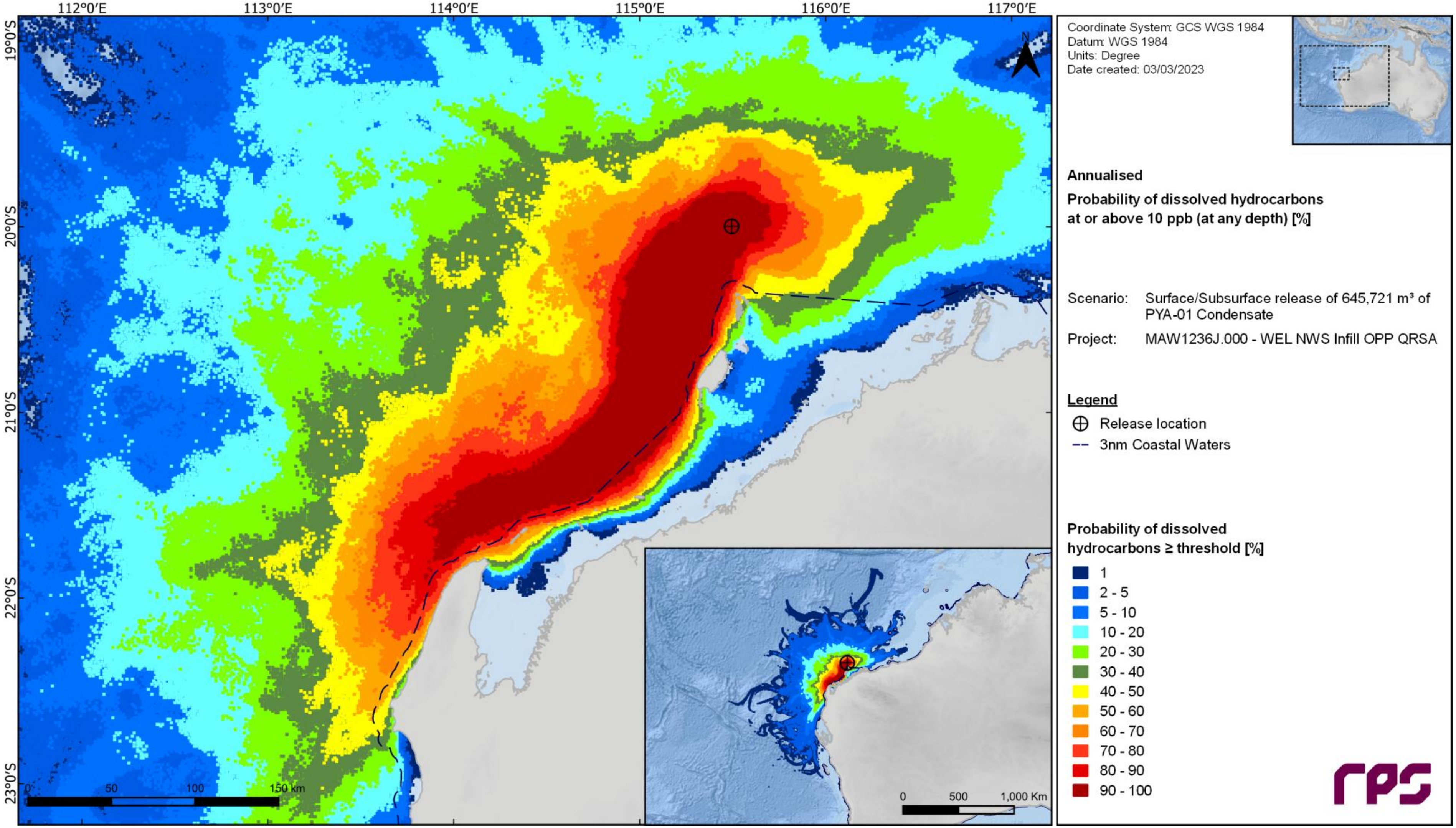


Figure 4.26 Predicted annualised probability of dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

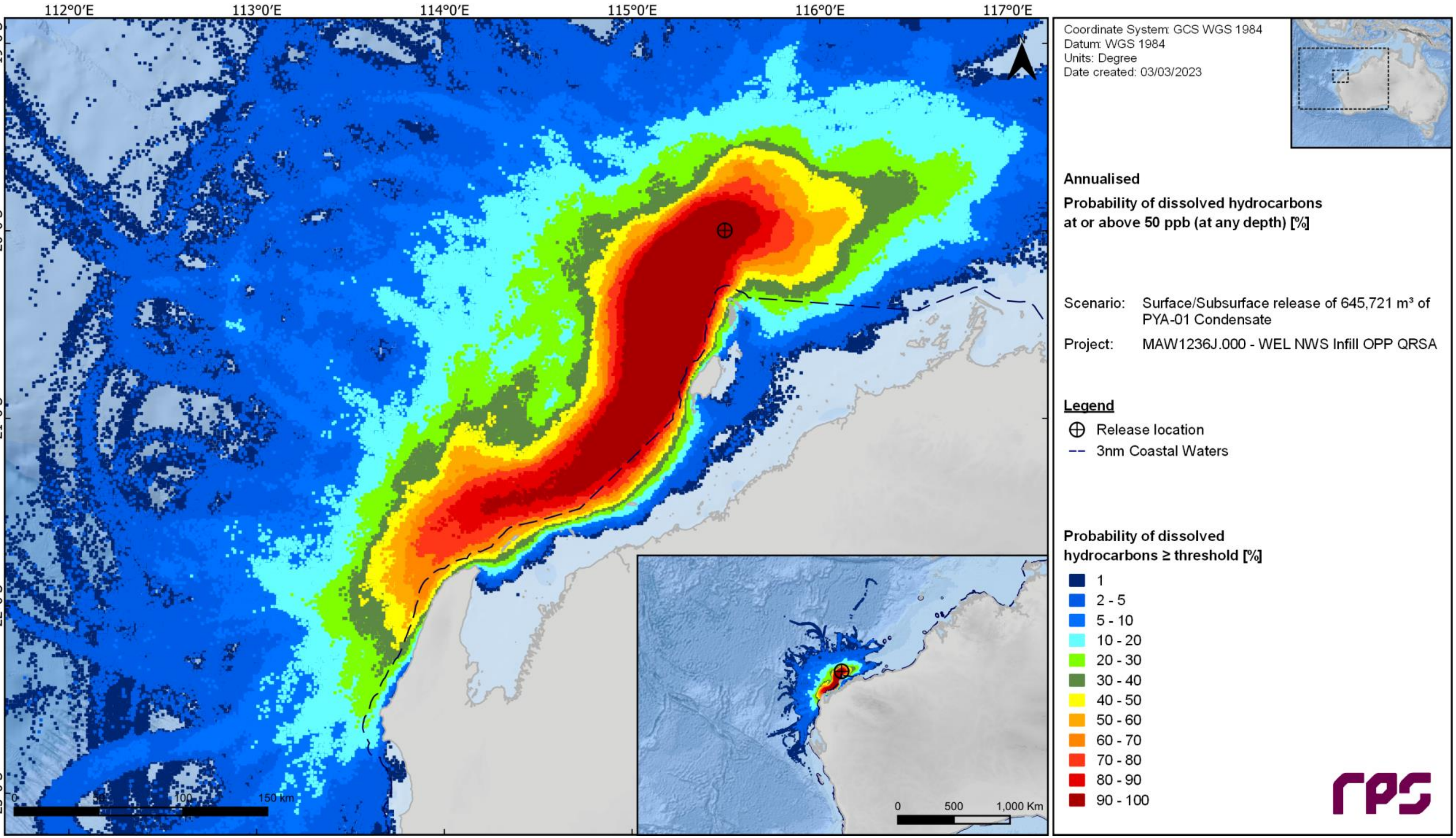


Figure 4.27 Predicted annualised probability of dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

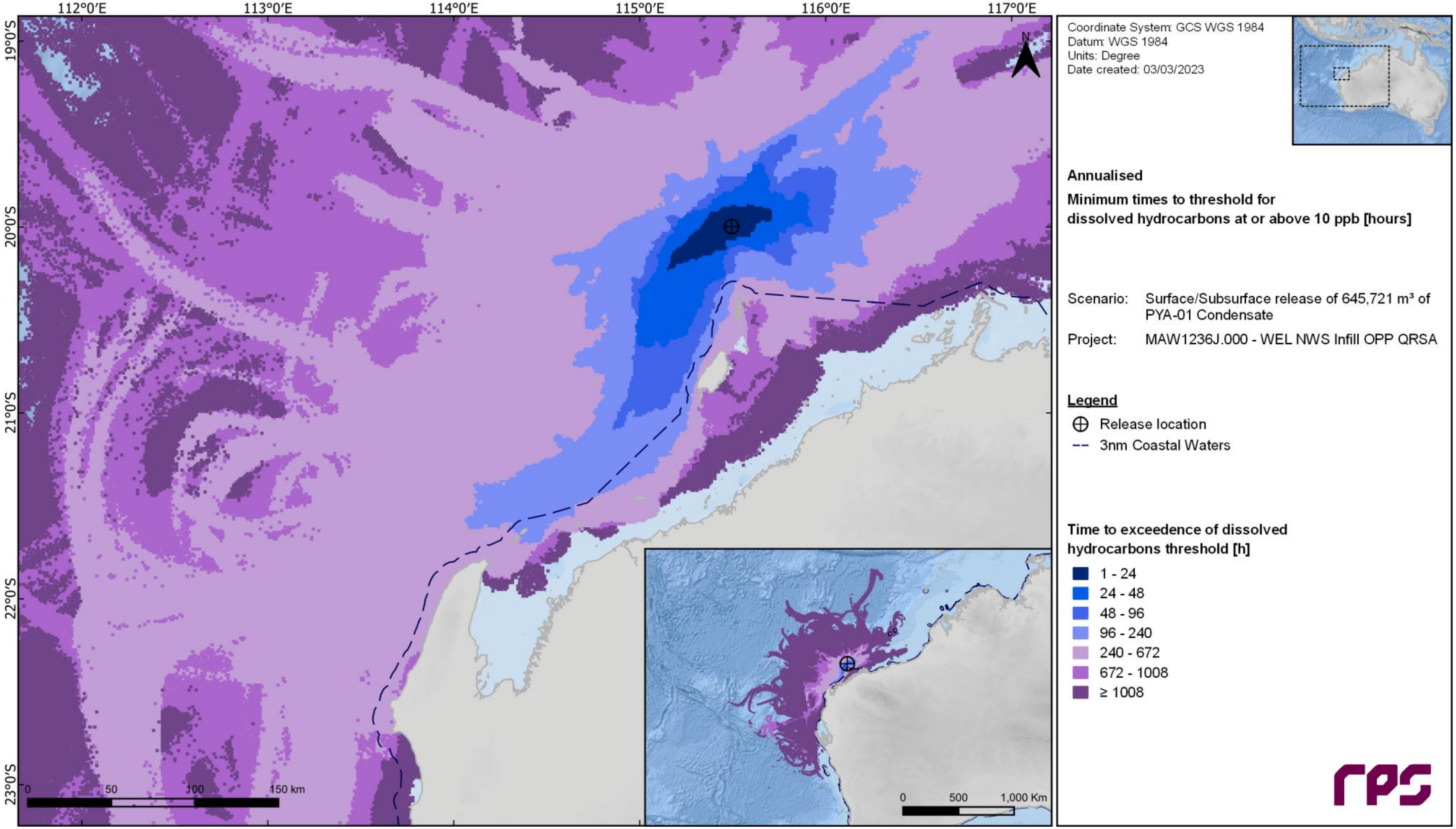


Figure 4.28 Predicted annualised minimum times to contact by dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

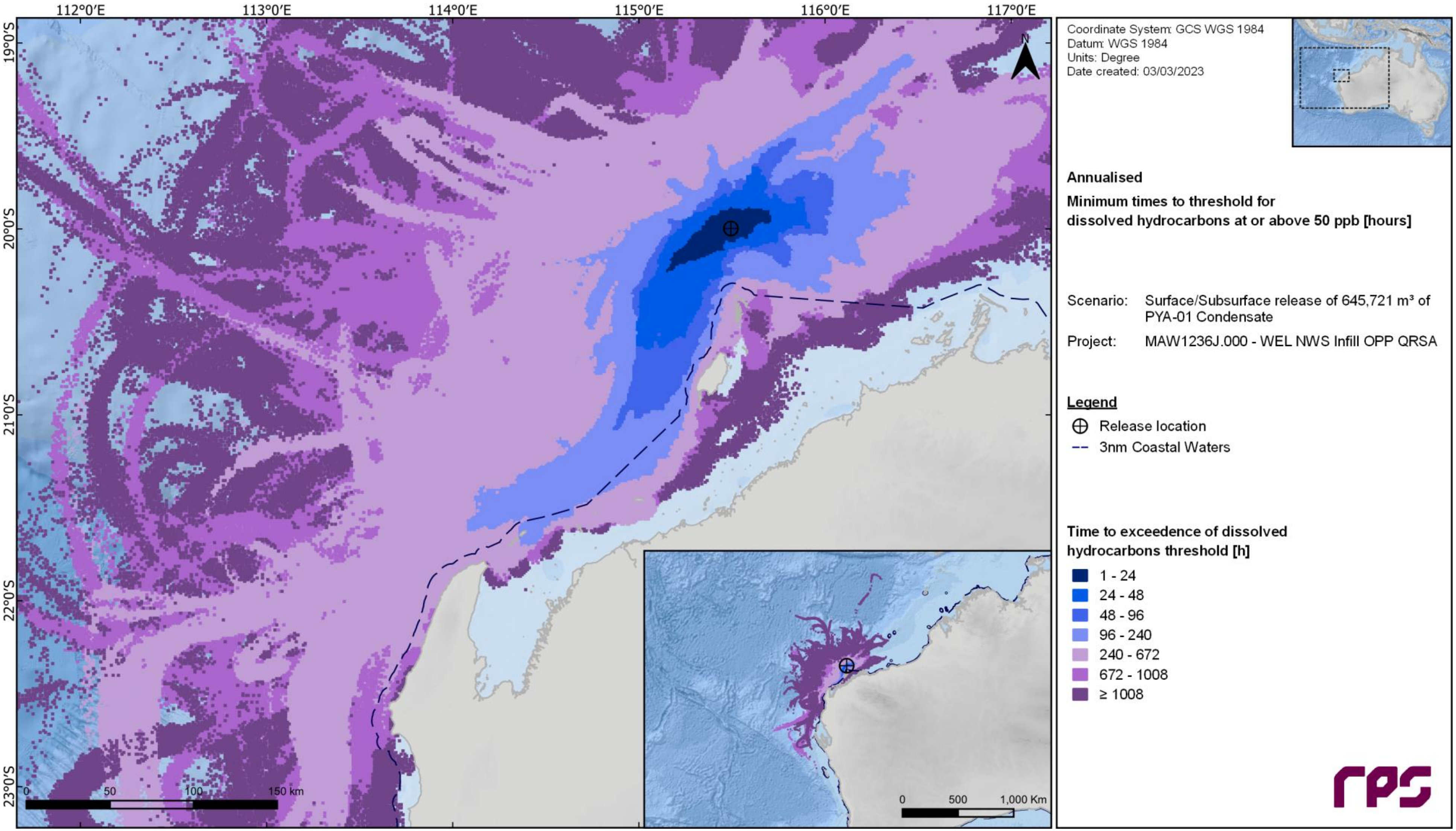


Figure 4.29 Predicted annualised minimum times to contact by dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

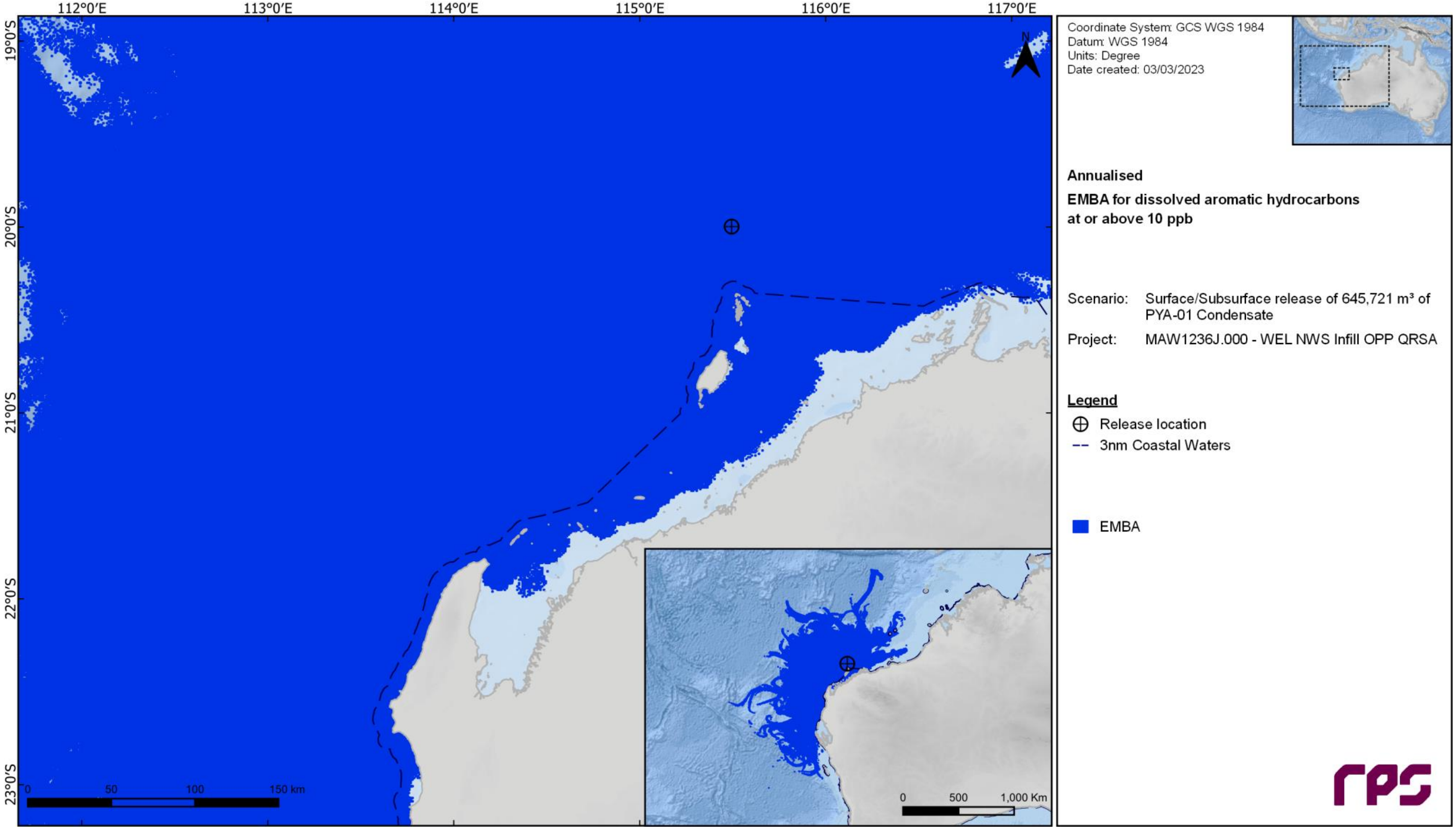


Figure 4.30 Predicted annualised EMBA of dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

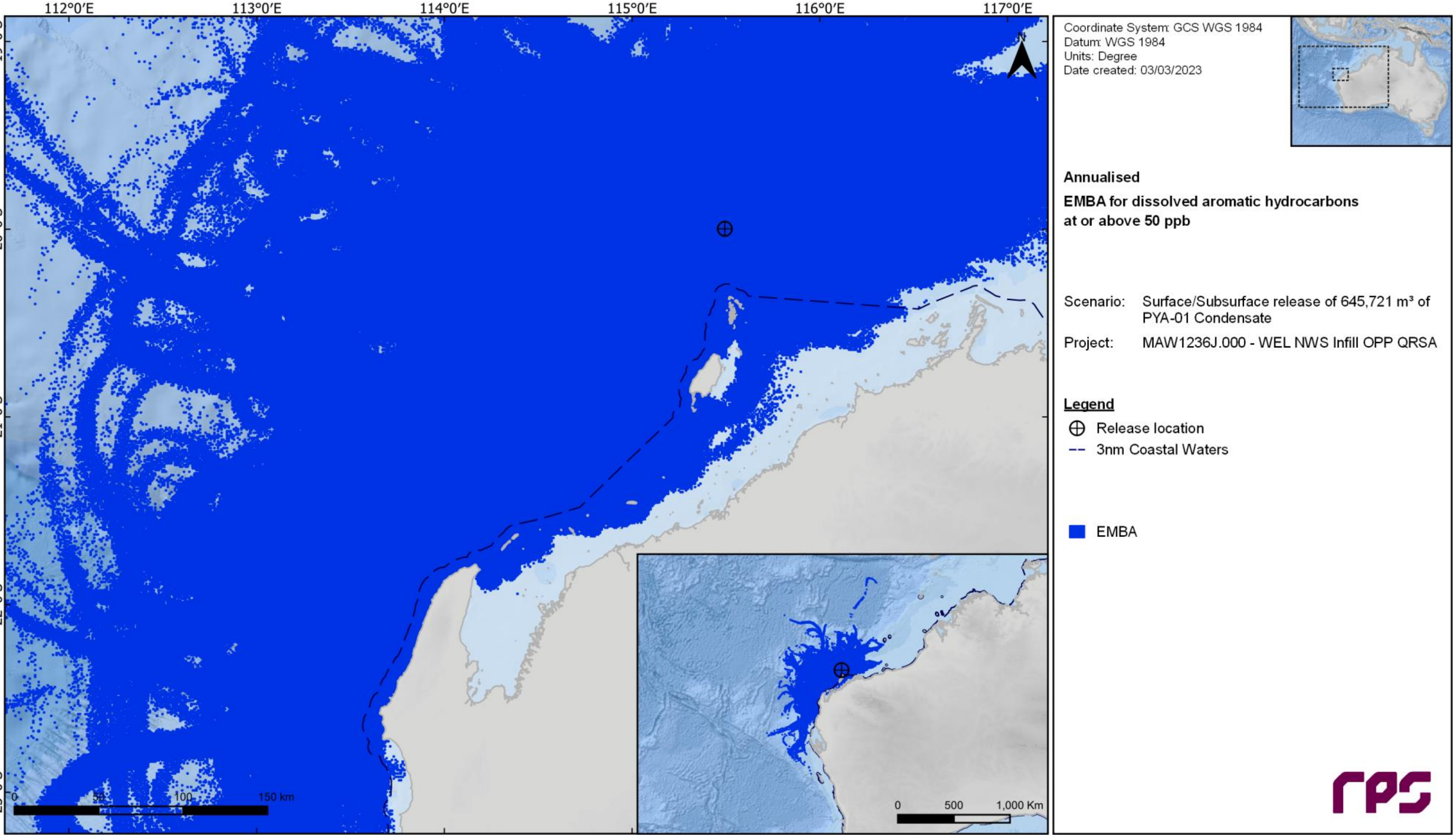


Figure 4.31 Predicted annualised EMBA of dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

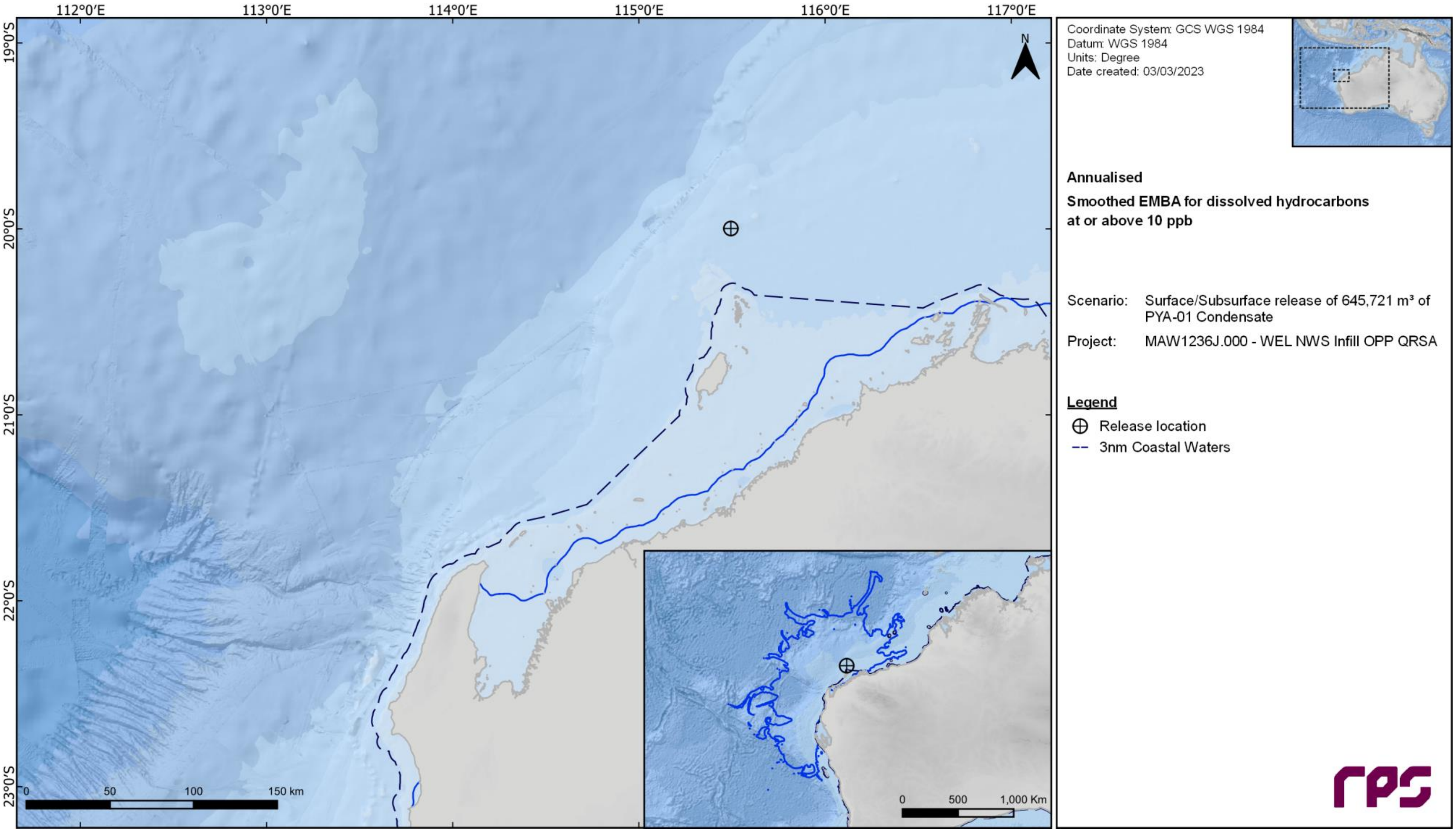


Figure 4.32 Predicted annualised smoothed EMBA of dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

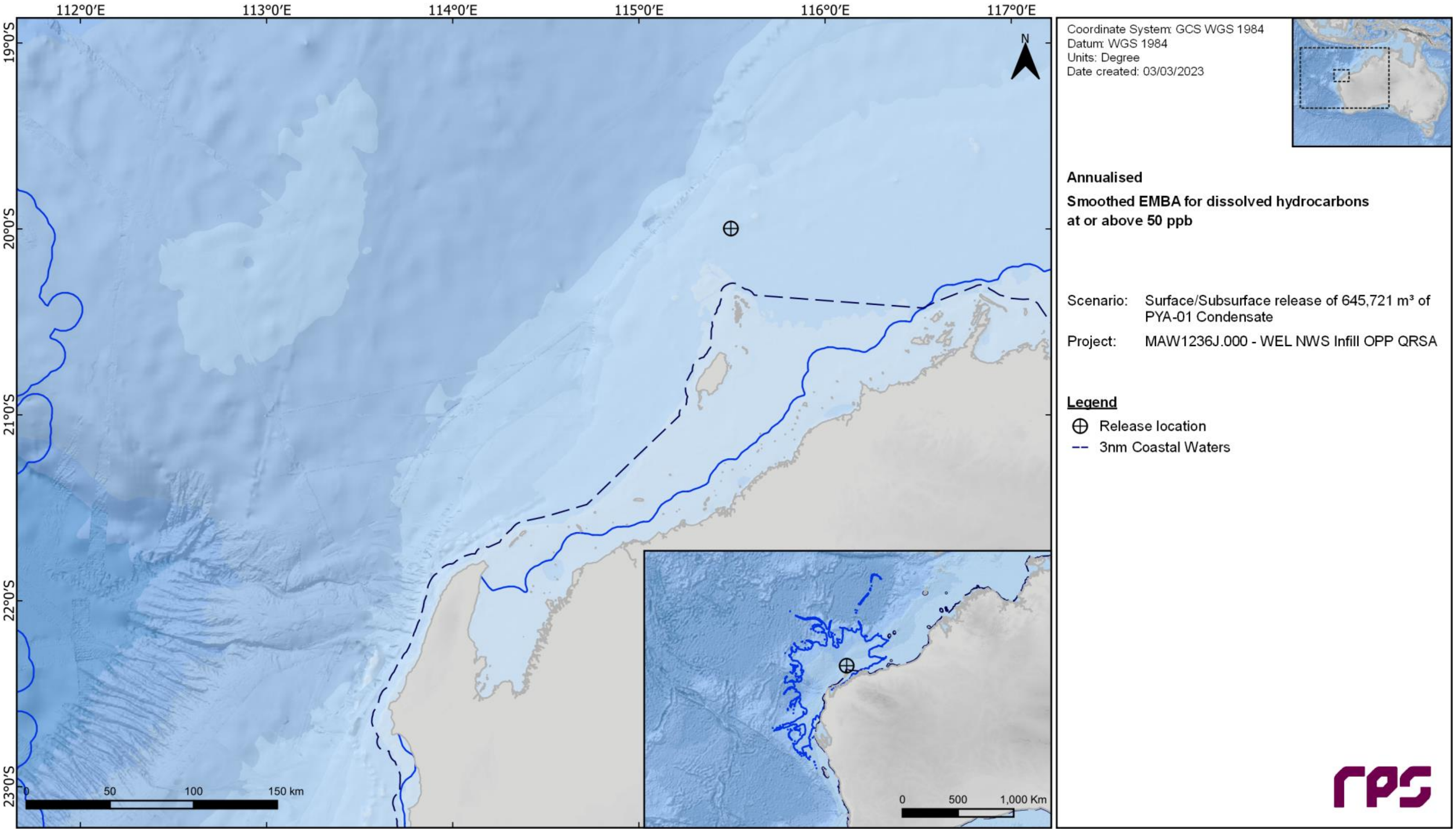


Figure 4.33 Predicted annualised smoothed EMBA of dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

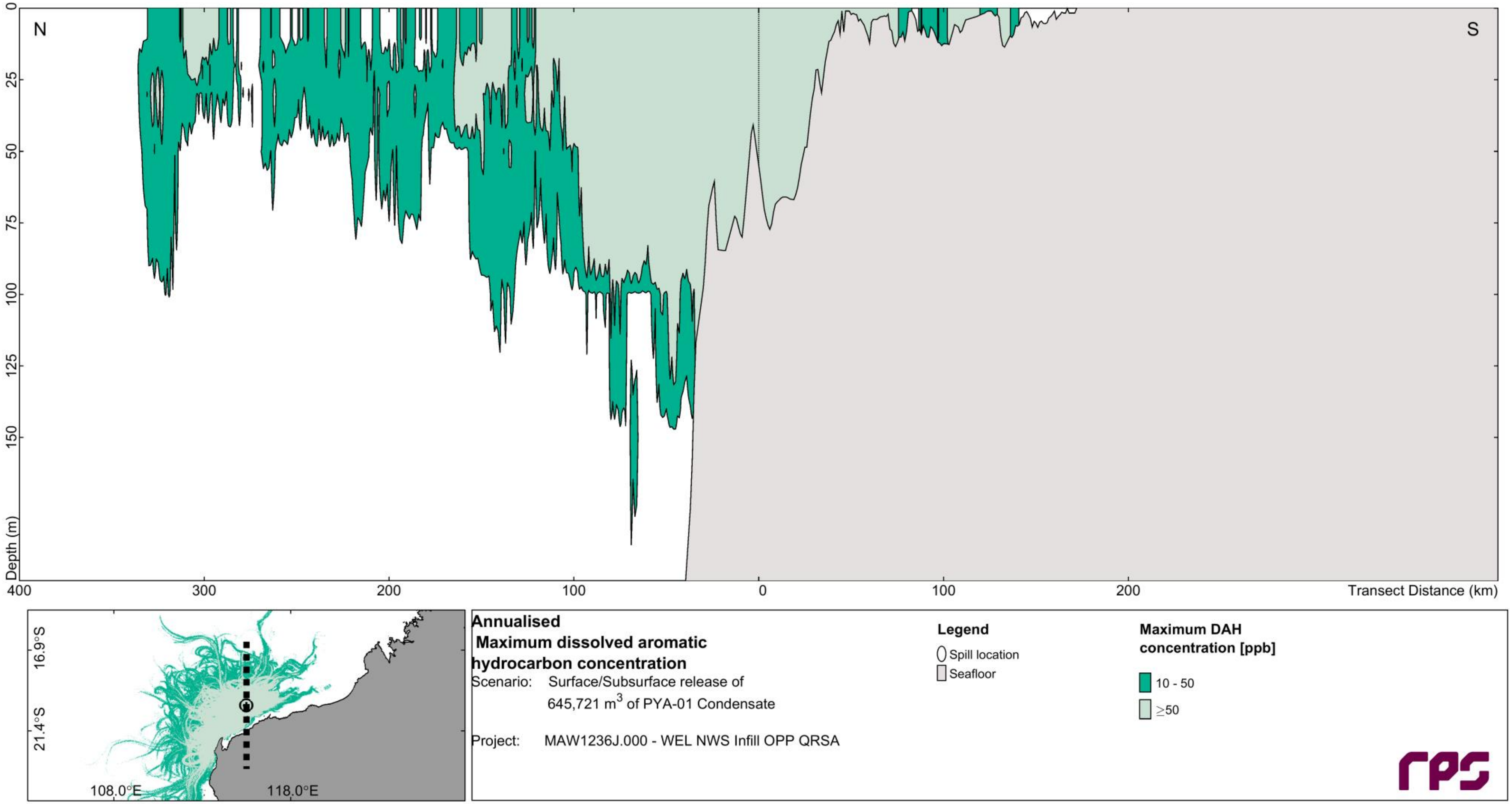


Figure 4.34 North-to-south cross section transect of predicted annualised maximum dissolved hydrocarbon concentration for a Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

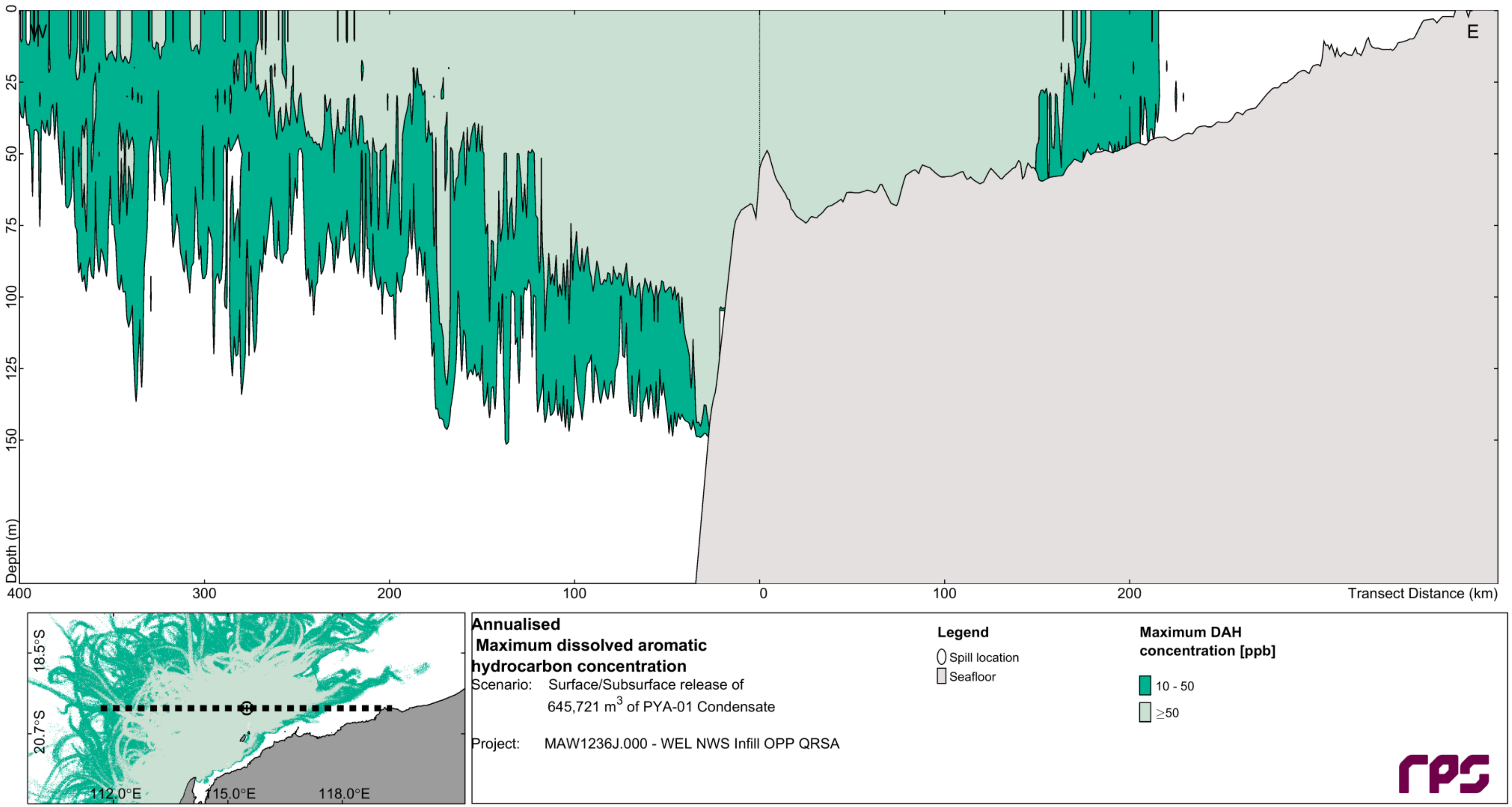


Figure 4.35 West-to-east cross section transect of predicted annualised maximum dissolved hydrocarbon concentration for a Surface/Subsurface release of 645,721 m³ of PYA-01 Condensate.

4.3 Scenario 1B: 77-day uncontrolled surface/subsurface release of 745,012 m^3 of PYA-01 Condensate

4.3.1 Overview

Scenario 1B investigated the probability of oil exposure to surrounding regions due to a 77-day surface/subsurface release of 745,012 m^3 of PYA-01 Condensate due to a loss of well integrity, 80m below the surface. Results have been separately calculated for four components:

- Floating oil.
- Floating oil that strands on shorelines.
- Oil entrained in the water column as droplets.
- Soluble, aromatic, hydrocarbons dissolved ion the water column.

4.3.1.1 Floating and Shoreline Oil

The stochastic modelling indicated a relatively restricted migration distance before floating slicks reduced below the applied thresholds. This can be attributed to rapid evaporation of a high proportion of the condensate components and the propensity of the condensate to entrain, commencing at wind speeds that occur frequently over the area. The probability contour figures for floating oil indicate a decrease in the potential drift distance for increasing concentrations. Floating oil at the 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds could potentially be found up to 385 km, 271 km, and 54 km from the spill site, respectively. (Table 4-7, Figure 4.36, Figure 4.37 and Figure 4.38).

Table 4-7 Maximum distances from the release location to zones of floating oil exposure.

Distance and direction travelled	Zones of potential sea surface exposure		
	1 g/m^2	10 g/m^2	50 g/m^2
Maximum distance travelled (km) by a spill trajectory	385	271	54
Direction of maximum travel	Southwest	Southwest	Southwest

Floating oil concentrations above 1 g/m^2 are predicted to drift over Rankin Bank and reach Tryal Rocks, both at 47% probability (Table 4.10). Floating oil concentrations above 50 g/m^2 are not predicted to contact any receptors aside from Montebello Marine Park, which has a 100% probability of contact for all assessed thresholds. This is due to the hypothetical spill site being within the boundaries of the Montebello Marine Park.

The worst-case for maximum local accumulation of oil on any surrounding shoreline was calculated at 3,133 g/m^2 on Hermite Island (Table 4.10).

The minimum times to floating oil contact with surrounding locations at 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds are depicted in (Figure 4.39 to Figure 4.41).The environments that may be affected (EMBA) by floating oil concentrations above 1 g/m^2, 10 g/m^2 and 50 g/m^2 are depicted in Figure 4.42 to Figure 4.44, with smoothed contours depicted in Figure 4.45 to Figure 4.47.

The predicted probabilities of shoreline oil concentrations above the 10 g/m^2, 100 g/m^2 and 250 g/m^2 thresholds are presented in Figure 4.48 to Figure 4.50, respectively. Shoreline oil above a concentration of 10 g/m^2 is predicted to contact Muiron Islands with 50% probability. The highest probability of shoreline oil contact above 250 g/m^2 is 4% at Peak Island.

4.3.1.2 Entrained Oil

As noted in the weathering assessments, the properties of the condensate and the release conditions are expected to favour the entrainment of condensate released under the spill scenario. Subsurface release of a larger part (90.3%) of the spill volume would result in condensate releasing and rising as entrained oil then dispersing in the surface layer as entrained droplets. Consequently, condensate that does form slicks on the surface during the initial surface release or though floating to the surface from the subsea release phase will more frequently entrain into the surface layer. The entrained plumes will then be subject to transport by prevailing currents, with reduced influence of the prevailing wind compared to floating slicks. Reduced weathering rates are also calculated for entrained oil. Hence, the entrained oil may travel larger distances than floating oil before dispersion reduces the concentration of droplets below the thresholds applied in this study, with the potential for transport into shallow or shoreline zones.

Entrained oil concentrations above 10 ppb are predicted to potentially drift up to 1,667 km from the spill site, and the maximum distance is up to 1,206 km at the 100 ppb threshold (Table 4.11, Figure 4.51, Figure 4.52).

Table 4-8 Maximum distances from the release location to zones of entrained oil exposure.

Distance and direction travelled	Zones of potential entrained oil exposure	
	10 ppb	100 ppb
Maximum distance travelled (km) by a spill trajectory	1,667	1,206
Direction of maximum travel	South	South

The probabilities of entrained oil reaching surrounding locations at the assessed are indicated are in Figure 4.51 and Figure 4.52. Entrained condensate could drift over a band that extends along a northeast to southwest axis from the hypothetical spill site, with longest trajectories of concentration towards the south, following the prevailing ocean currents.

The greatest probability of contact for entrained oil above 10 ppb is calculated at 100% for Tryal Rocks, Montebello Islands, Barrow Islands and Gascoyne Marine Park, with many other receptors having more than 90% probability of contact. The greatest probability of contact for entrained oil above 100 ppb is calculated to be 100% at Montebello Marine Park and Tryal Rocks. The worst-case entrained condensate concentration at any receptor is 85,992 ppb at Montebello Marine Park (Table 4.11).

The forecast annualised minimum times to contact, EMBA and smoothed EMBA for entrained oil at or above the 10 ppb and 100 ppb threshold are depicted in Figure 4.53 to Figure 4.58.

Cross-sectional transects of maximum entrained oil concentrations at surrounding locations, compiled from the multiple replicate simulations indicates that concentrations above 100 ppb could extend down to ~55 m depth (Figure 4.59 to Figure 4.60).

4.3.1.3 Dissolved Aromatic Hydrocarbons

Dissolved aromatic hydrocarbon concentrations above the 10 ppb and 50 ppb thresholds were calculated to potentially occur up to 1,250 km and 975 km from the spill site, respectively, (Table 4-9, Figure 4.61, Figure 4.62).

Table 4-9 Maximum distances from the release location to zones of dissolved aromatic hydrocarbon exposure.

Distance and direction travelled	Zones of potential dissolved aromatic hydrocarbon exposure	
	10 ppb	50 ppb
Maximum distance travelled (km) by a spill trajectory	1,250	975
Direction of maximum travel	Southwest	South

The probability of contact by dissolved aromatic hydrocarbon concentrations above 10 ppb is predicted to be 100% at Montebello Marine Park and Tryal Rocks. The probability of contact above 10 ppb is more than 90% for Gascoyne Marine Park, Ningaloo Marine Park, Barrow Island, Southern Pilbara Island and Penguin Bank (Table 4.12).

The maximum dissolved aromatic hydrocarbon concentration forecast at any receptor is 24,018 ppb at Montebello Marine Park.

The annualised minimum times to contact, EMBA, and smoothed EMBA for dissolved aromatic hydrocarbons at or above the 10 ppb and 50 ppb thresholds are depicted Figure 4.63 to Figure 4.68.

Cross-sectional transects of maximum dissolved aromatic hydrocarbon concentrations in the vicinity of the release site indicate that concentrations above 50 ppb could affect depth above approximately 150 m BMSL from the release site due to dissolved components entering the water column as the condensate rises from the subsea release phase (Figure 4.69 to Figure 4.70).

4.3.2 Results – Tables and Figures

4.3.2.1 Floating Oil and Shoreline Oil

Table 4.10 Expected annualised floating and shoreline oil outcomes at sensitive receptors resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Australian Marine Parks	Abrolhos MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Argo-Rowley Terrace MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Carnarvon Canyon MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dampier MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Eighty Mile Beach MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Gascoyne MP*	5	<1	<1	349	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Geographe MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jurien MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Kimberley MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Mermaid Reef MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Montebello MP*	100	100	100	1	1	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Ningaloo MP*	10	1	<1	290	847	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Perth Canyon MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Shark Bay MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	South-West Corner MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Two Rocks MP*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coastlines	Ashburton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Augusta - Margaret River	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Augusta - Walpole	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Busselton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Cape Bruguieres	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Carnarvon	<1	<1	<1	NC	NC	NC	1	<1	<1	1,461	NC	NC	0.2	13	<1	<1
	Chapman Valley	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Coorow	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Dampier Archipelago	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Dandaragan	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Dawesville - Bunbury	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Exmouth	1	<1	<1	578	NC	NC	22	3	<1	497	716	NC	11	204	2	21
	Exmouth Gulf South East	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Exmouth Gulf West	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Fremantle	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Geographe Bay	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Geographe Bay - Augusta	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Geraldton - Jurien Bay	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Gingin	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
	Greater Geraldton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Irwin	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Joondalup	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Jurien Bay - Yanchep	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Kalbarri - Geraldton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Karratha	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Karratha-Port Hedland	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Mandurah	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Mandurah - Dawesville	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Manjimup	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Middle Pilbara - Islands and Shoreline	<1	<1	<1	NC	NC	NC	3	<1	<1	1,039	NC	NC	0.8	26	<1	2
	Nannup	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Northampton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Northern Pilbara - Islands and Shoreline	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	3.4	<1	<1
	Perth Northern Coast	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Perth Southern Coast	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Port Hedland - Eighty Mile Beach	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Rockingham	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Shark Bay	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	6.4	<1	<1
	Southern Pilbara - Shoreline	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Stirling	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Wanneroo	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Waroona	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Zuytdorp Cliffs - Kalbarri	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Ashburton	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Fish Habitat Protection Area	Abrolhos Islands*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Cottesloe Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Miaboolya Beach*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Point Quobba*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Islands	Abrolhos Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2.4	<1	<1
	Airlie Island	<1	<1	<1	NC	NC	NC	8	<1	<1	386	NC	NC	2.5	77	<1	<1
	Angel Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Ashburton Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	4.5	<1	<1
	Barrow Island	4	<1	<1	189	NC	NC	14	<1	<1	479	NC	NC	5.2	62	2	9
	Bedout Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Bedwell Island	<1	<1	<1	NC	NC	NC	2	<1	<1	1,718	NC	NC	0.6	30	<1	<1
	Bernier Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.1	4.8	<1	<1
	Bessieres Island	1	<1	<1	751	NC	NC	8	<1	<1	524	NC	NC	2.6	51	<1	<1
	Bezout Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC

Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Boodie Island	<1	<1	<1	NC	NC	NC	14	<1	<1	699	NC	NC	5.2	60	<1	2
Christmas Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Cohen Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Cunningham Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Delambre Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Direction Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Dolphin Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Dorre Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.1	7.3	<1	<1
Eaglehawk Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
East Lewis Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Easter Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Enderby Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Flat Island	<1	<1	<1	NC	NC	NC	1	<1	<1	1,557	NC	NC	0.3	14	<1	<1
Fly Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Garden Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Gidley Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Goodwyn Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Haury Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Hermite Island	4	3	<1	353	360	NC	38	3	3	348	361	362	75	3,133	3	29
Keast Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Kendrew Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Legendre Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Locker Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Lowendal Islands	<1	<1	<1	NC	NC	NC	12	<1	<1	665	NC	NC	3	42	<1	2
Malus Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Mangrove Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Mary Anne Group	<1	<1	<1	NC	NC	NC	1	<1	<1	1,200	NC	NC	0.2	17	<1	<1
Middle Island	<1	<1	<1	NC	NC	NC	14	<1	<1	699	NC	NC	5.2	60	<1	2
Montebello Islands	5	3	<1	351	358	NC	38	3	3	348	361	362	75	3,133	3	29
Muiron Islands	8	<1	<1	318	NC	NC	50	8	1	253	637	751	30	296	4	44
North Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2.4	<1	<1
Observation Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Passage Islands	<1	<1	<1	NC	NC	NC	3	<1	<1	1,039	NC	NC	0.8	26	<1	<1
Peak Island	1	<1	<1	451	NC	NC	35	14	4	435	771	1,039	34	389	2	8
Pelsaert Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	2	<1	<1
Ragnard Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Rivoli Islands	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Rosemary Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Rottnest Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Round Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC

	Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
	Serrurier Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.2	9.7	<1	<1
	Southern Pilbara - Islands	4	<1	<1	219	NC	NC	35	14	4	386	435	1,039	34	389	2	8
	Sunday Island	<1	<1	<1	NC	NC	NC	14	<1	<1	658	NC	NC	5.6	88	<1	2
	Table Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Thevenard Island	<1	<1	<1	NC	NC	NC	11	1	<1	387	435	NC	4.7	124	<1	4
	Tortoise Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Twin Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Wallabi Group	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	1.2	<1	<1
	West Lewis Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
Marine Parks	Barrow Island MMA*	7	1	<1	131	1,259	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Barrow Island MP (State)*	2	<1	<1	405	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Clerke Reef (Rowley Shoals MP)	<1	<1	<1	NC	NC	NC	2	<1	<1	1,718	NC	NC	0.6	30	<1	<1
	Imperieuse Reef (Rowley Shoals MP)	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.2	4.7	<1	<1
	Jurien Bay MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Marmion MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Montebello Islands MP	12	4	<1	132	337	NC	38	3	3	348	361	362	75	3,133	3	29
	Muiron Islands MMA	9	<1	<1	258	NC	NC	50	8	1	253	637	751	30	296	4	44
	Ngari Capes MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Ningaloo Coast WH	10	1	<1	290	847	NC	22	3	<1	497	716	NC	11	204	2	21
	Ningaloo MP (State)	9	<1	<1	349	NC	NC	22	3	<1	497	716	NC	11	204	2	21
	Shark Bay MR	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	<0.1	3.3	<1	<1
	Shark Bay WH	<1	<1	<1	NC	NC	NC	1	<1	<1	2,206	NC	NC	0.2	12	<1	3
	Shoalwater Islands MP	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
National Park	Cape Range	<1	<1	<1	NC	NC	NC	17	3	<1	538	1,454	NC	11	156	2	11
	D'Entrecasteaux*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dirk Hartog Island	<1	<1	<1	NC	NC	NC	1	<1	<1	2,206	NC	NC	0.2	12	<1	2
	Francois Peron*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Kalbarri	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Leeuwin-Naturaliste*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nature Reserve	Bernier And Dorre Islands NR	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	0.1	7.3	<1	<1
	Boodie, Double Middle Islands Nature Reserve NR	<1	<1	<1	NC	NC	NC	14	<1	<1	699	NC	NC	5.2	60	<1	2
	Great Sandy Island NR	<1	<1	<1	NC	NC	NC	1	<1	<1	1,200	NC	NC	0.2	17	<1	<1
	North Sandy Island NR	<1	<1	<1	NC	NC	NC	3	<1	<1	1,039	NC	NC	0.8	26	<1	<1
	Thevenard Island NR	<1	<1	<1	NC	NC	NC	11	1	<1	387	435	NC	4.7	124	<1	4
	Y Island	<1	<1	<1	NC	NC	NC	<1	<1	<1	NC	NC	NC	NC	NC	NC	NC
	Boullanger, Whitlock, Favourite,Tern & Osprey Islands Nature Reserve*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Buller,Whittell & Green Islands Nature Reserve*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Receptors		Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
		≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Reefs, Shoals and Banks	Ashworth Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Assail Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Australind Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Barrow Island Reefs and Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Baylis Patches*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Beagle Knoll*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Bennett Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Beryl Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Brewis Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Camplin Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Clerke Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Clio Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Cod Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Combe Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Cooper Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Courtenay Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Curlew Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dailey Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dart Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Direction Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dockrell Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Eliassen Rocks*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Exmouth Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Fairway Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Fantome Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Flinders Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Fortescue Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Gee Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Geelvink Channel Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Glennie Patches*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Glomar Shoal*	3	<1	<1	332	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Gorgon Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hammersley Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hastings Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hayman Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Herald Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Hood Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Imperieuse Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Inner Northwest Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Koolinda Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Lightfoot Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Little Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Locker Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Madeleine Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manicom Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mardie Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
McLennan Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Meda Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mermaid Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mid Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Montebello Shoals*	4	3	<1	351	358	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Moresby Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nares Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ningaloo Reef*	7	<1	<1	595	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North Tail Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North West Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North West Reefs*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
O'Grady Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Otway Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Outtrim Patches*	2	<1	<1	305	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Paroo Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pearl Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pelsaert Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Penguin Bank*	2	<1	<1	315	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Poivre Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rankin Bank*	47	7	<1	44	371	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ripple Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Roller Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rosily Shoals*	1	<1	<1	333	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Saladin Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sand Knoll Ledge*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Santo Rock*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Snapper Bank*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South East Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South West Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Southwest Patch*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Spider Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stewart Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sultan Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Taunton Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Receptors	Probability (%) of films arriving at receptors at			Minimum time to receptor (hours) for films at			Probability (%) of shoreline oil on receptors at			Minimum time to receptor (hours) for shoreline oil at			Maximum local accumulated concentration (g/m²)		Maximum accumulated volume (m³) along this shoreline	
	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 1 g/m²	≥ 10 g/m²	≥ 50 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	≥ 10 g/m²	≥ 100 g/m²	≥ 250 g/m²	averaged over all replicate spills	in the worst replicate spill	averaged over all replicate simulations	in the worst replicate simulation
Tongue Shoals*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trap Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tryal Rocks*	47	9	<1	48	49	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Turtle Dove Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wapet Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ward Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Web Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Weeks Shoal*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
West Reef*	<1	<1	<1	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NC No contact to receptor predicted for specified threshold.

* Floating oil will not accumulate on submerged features and at open ocean locations. NA Not applicable

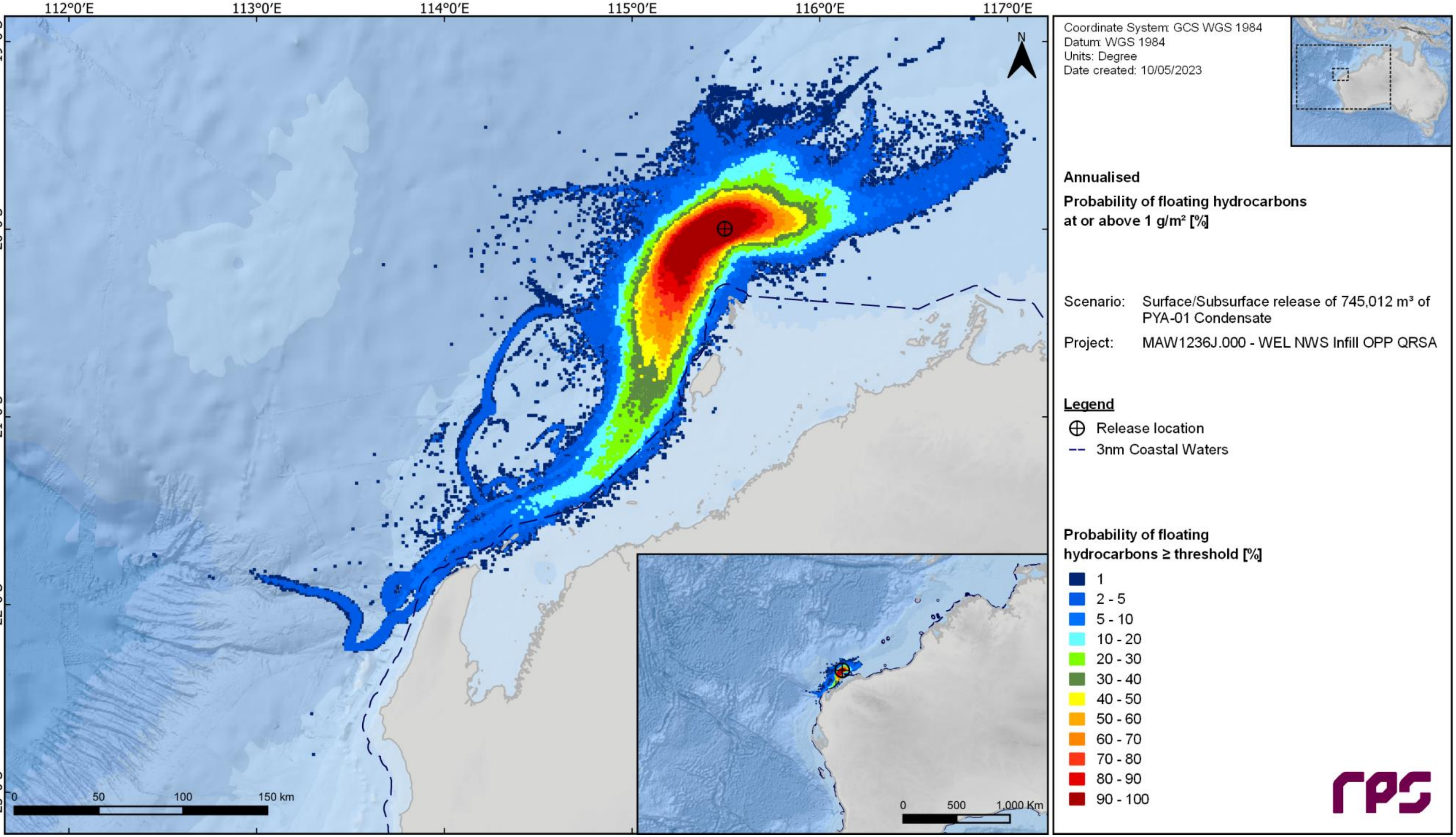


Figure 4.36 Predicted annualised probability of floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

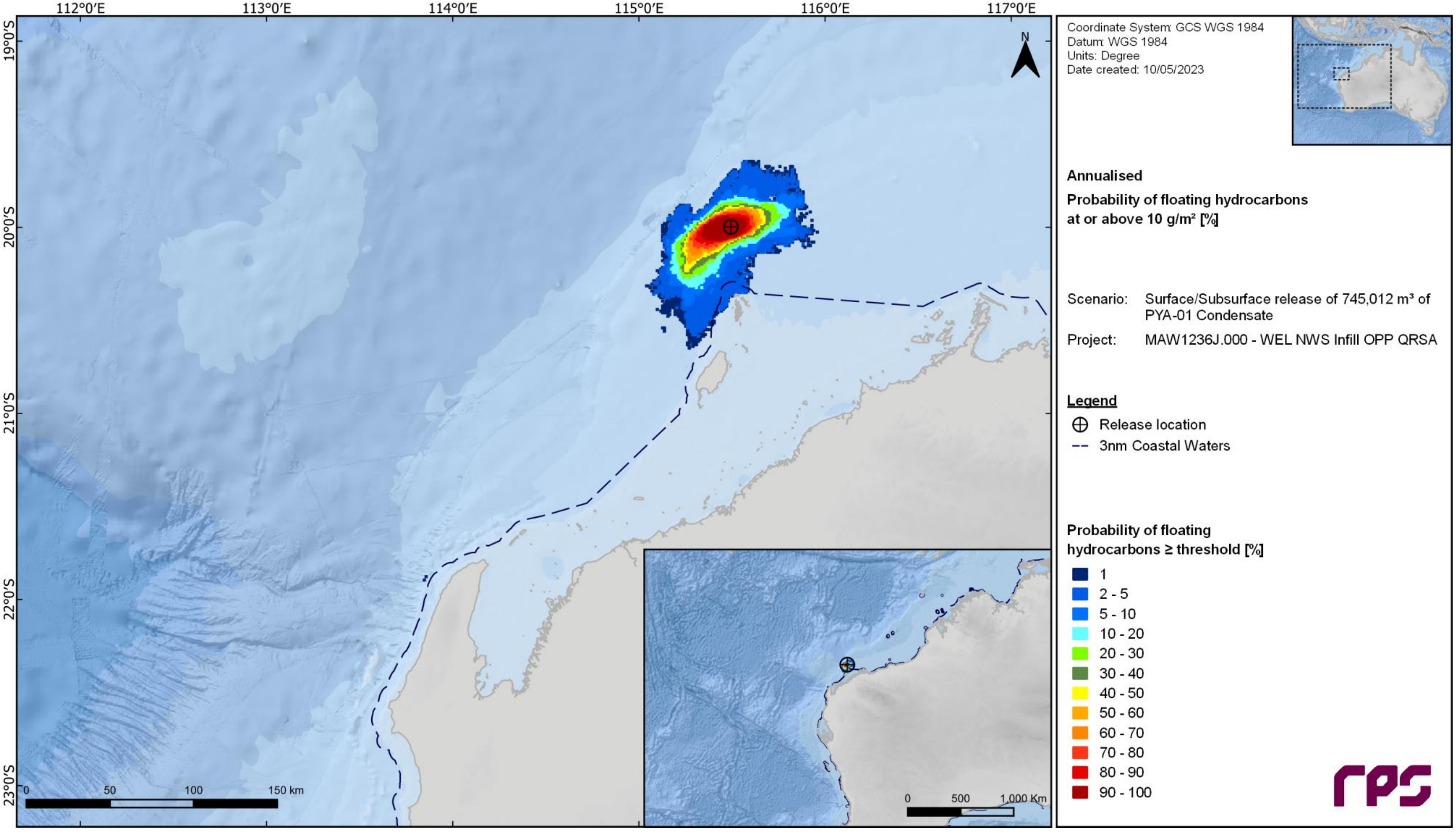


Figure 4.37 **Predicted annualised probability of floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.**

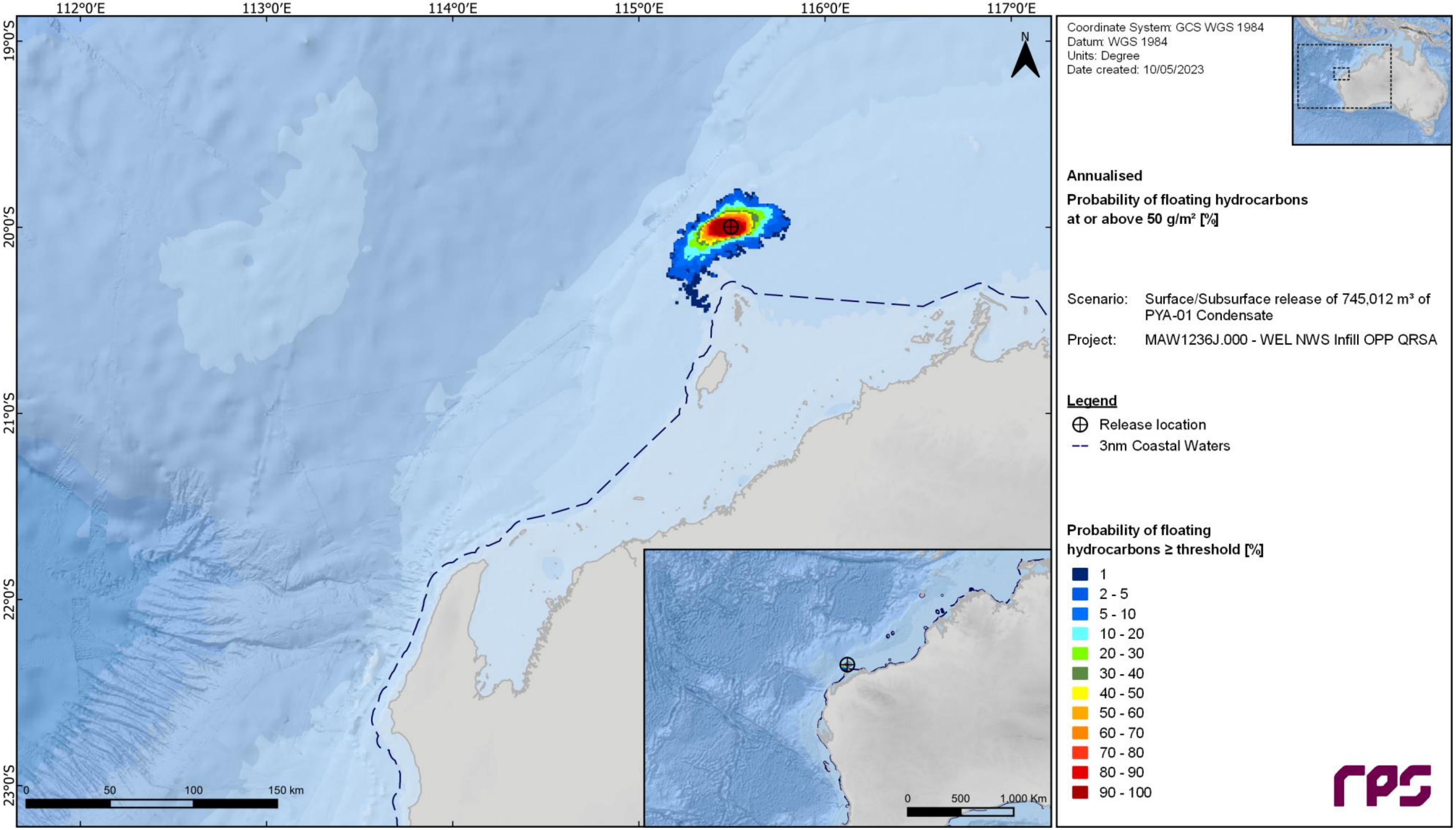


Figure 4.38 Predicted annualised probability of floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

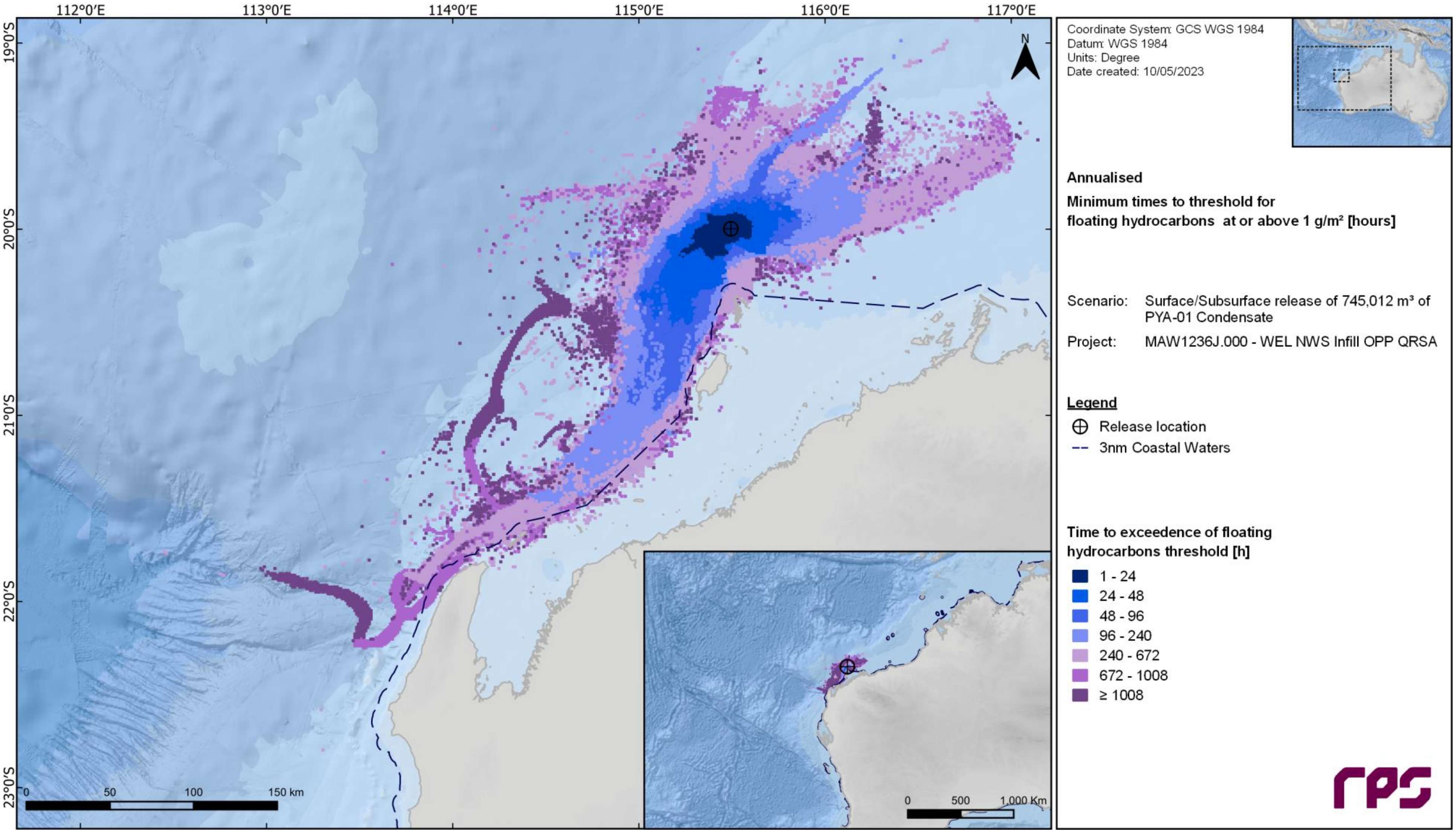


Figure 4.39 Predicted annualised minimum times to contact by floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

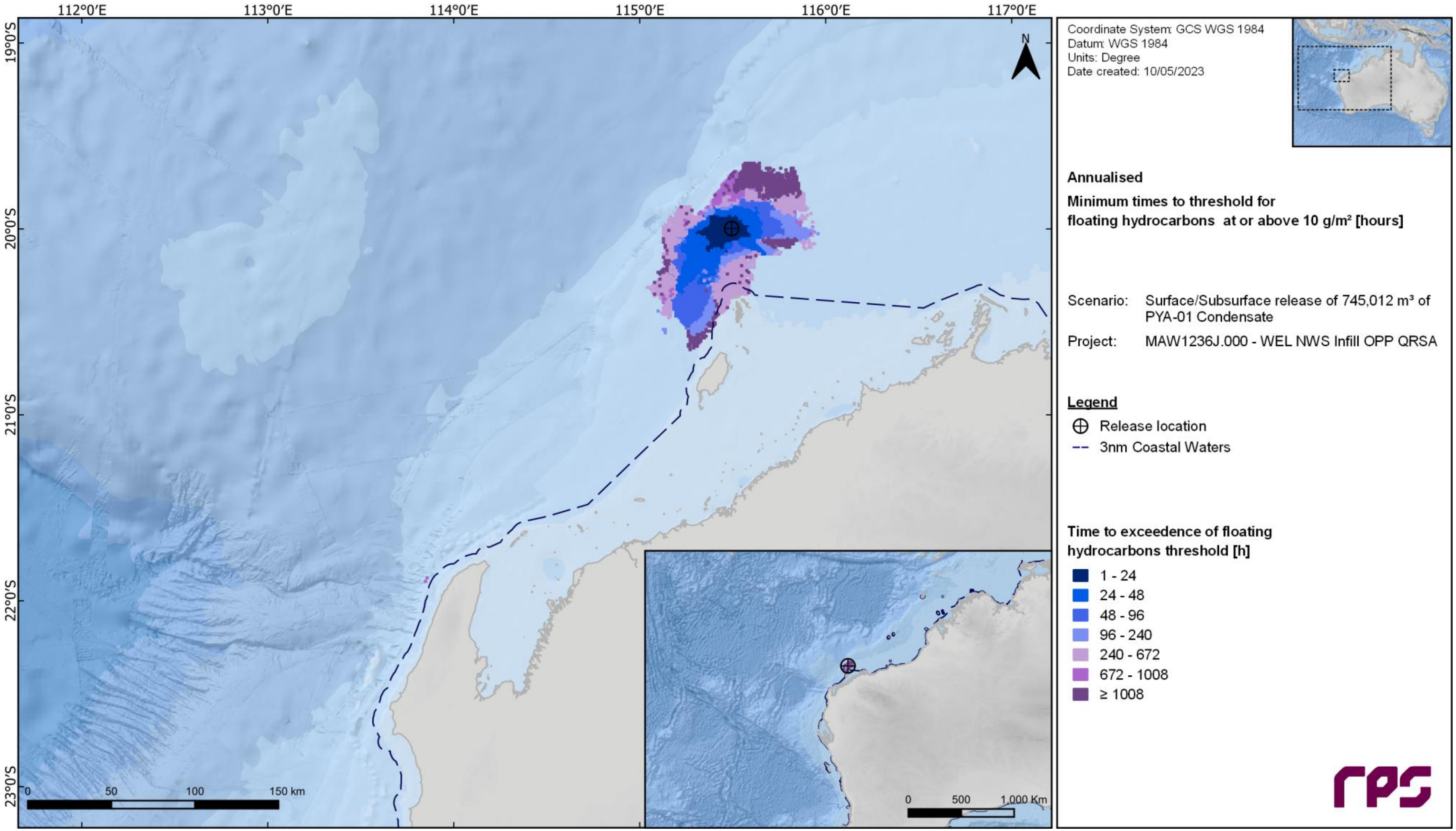


Figure 4.40 Predicted annualised minimum times to contact by floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

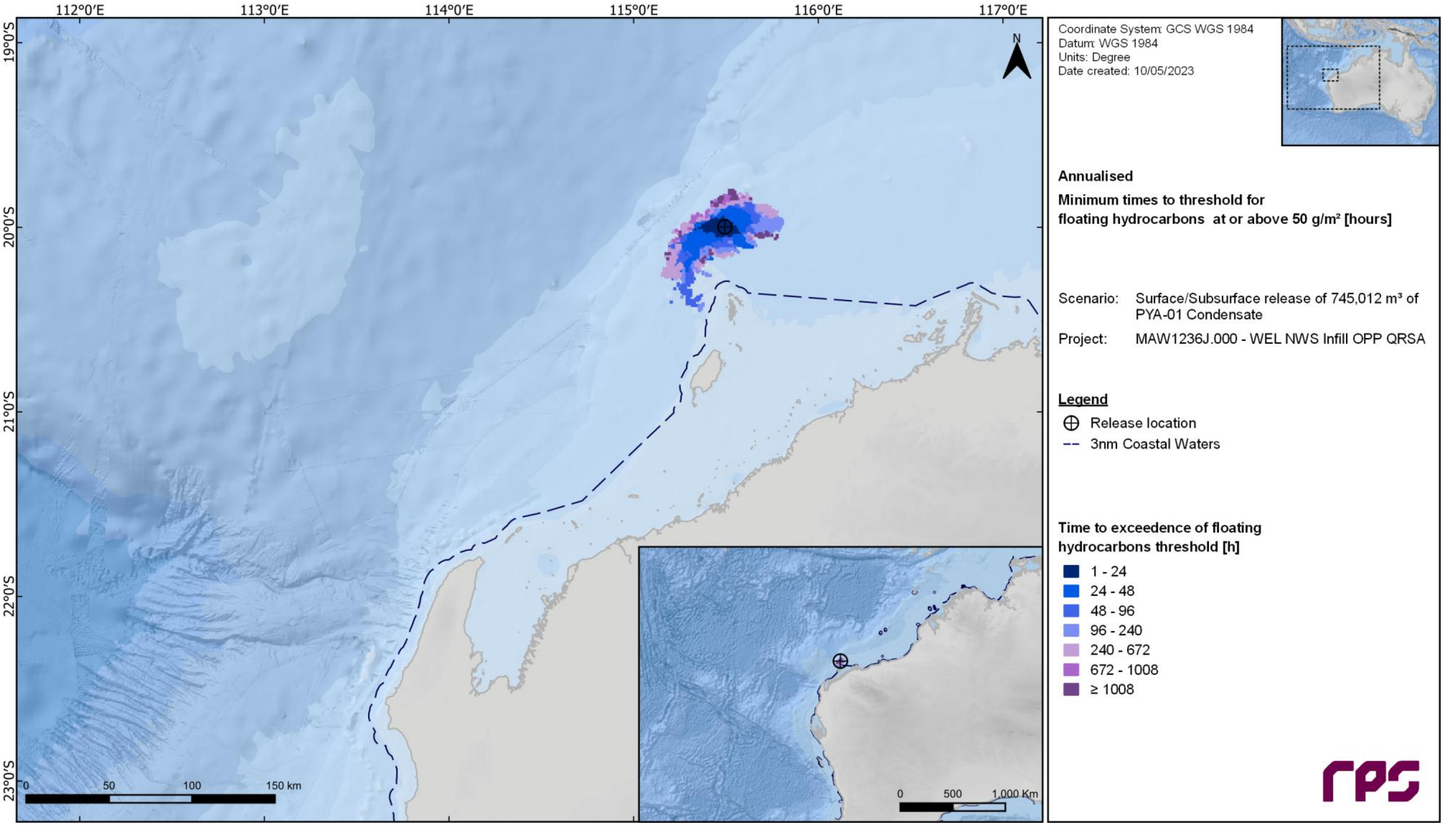


Figure 4.41 Predicted annualised minimum times to contact by floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

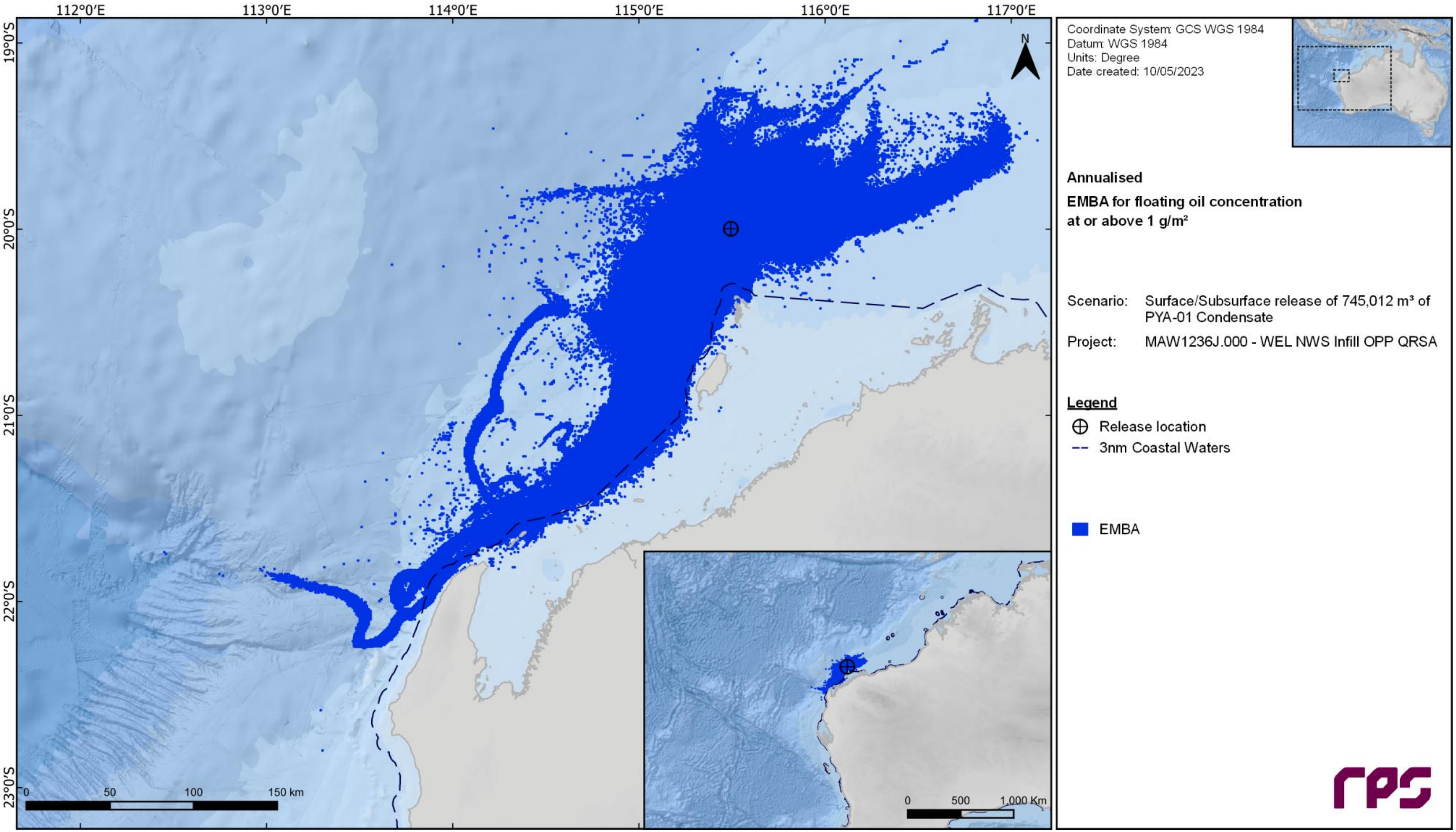


Figure 4.42 Predicted annualised EMBA of floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

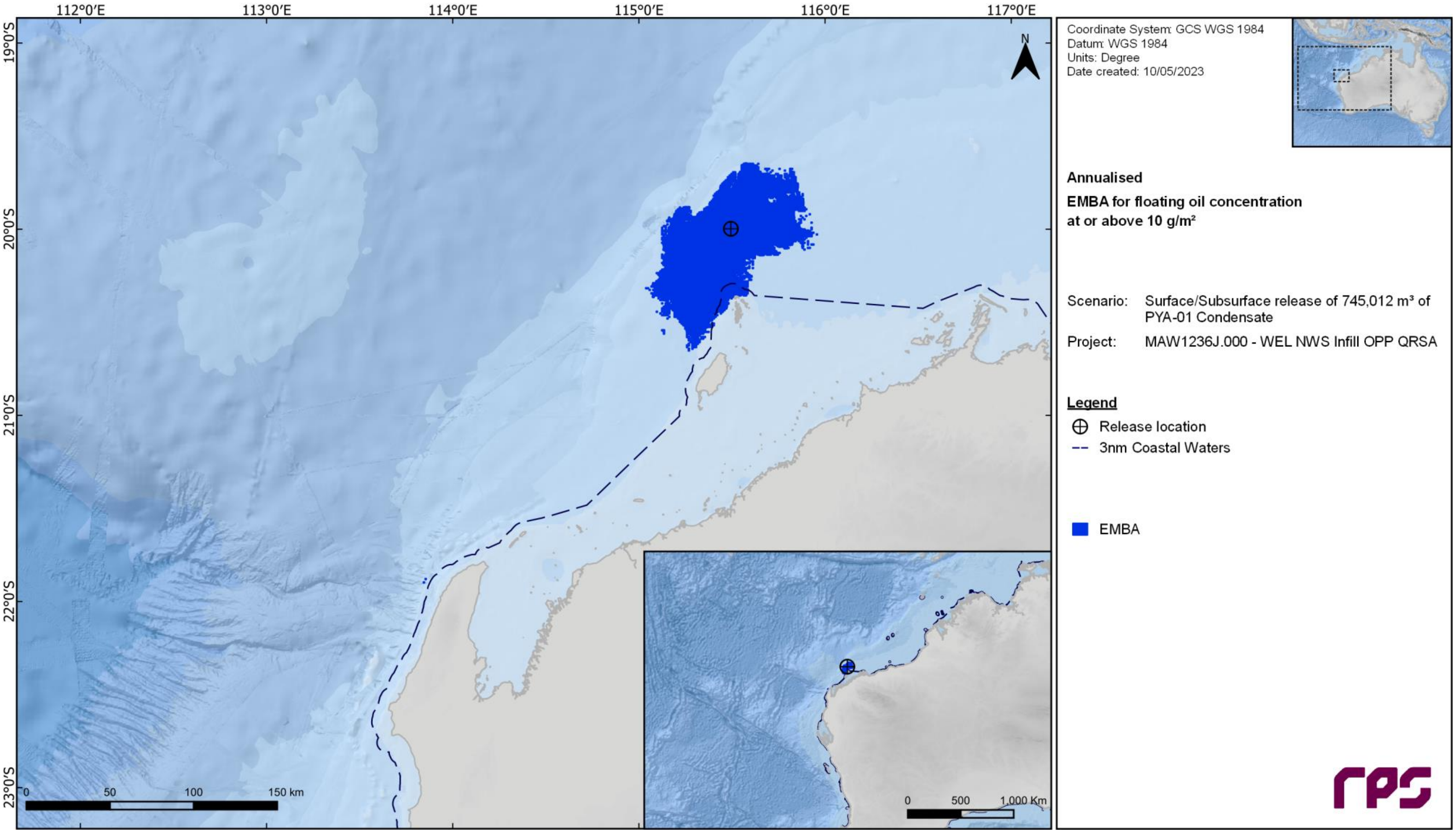


Figure 4.43 Predicted annualised EMBA of floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

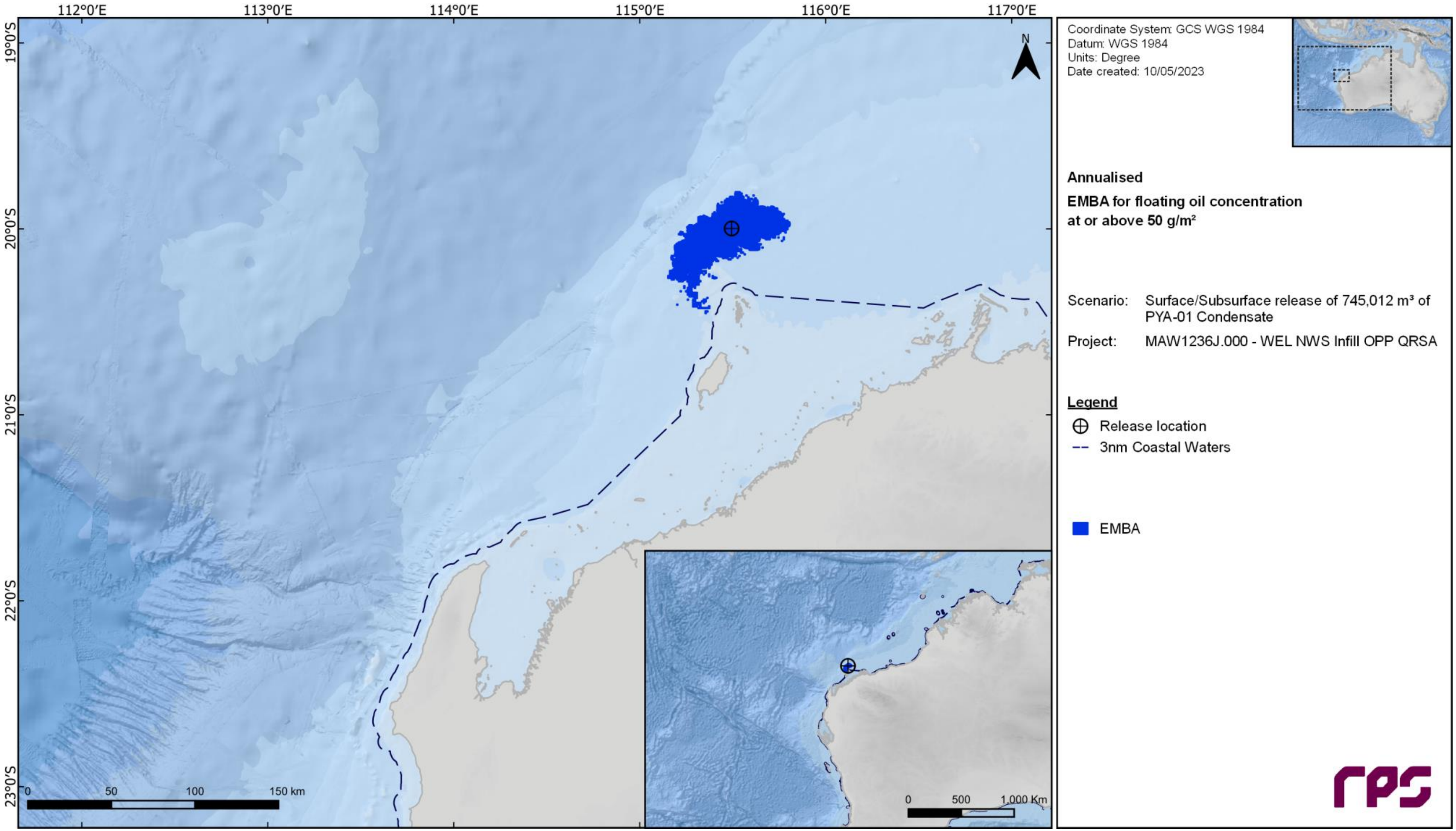


Figure 4.44 Predicted annualised EMBA of floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

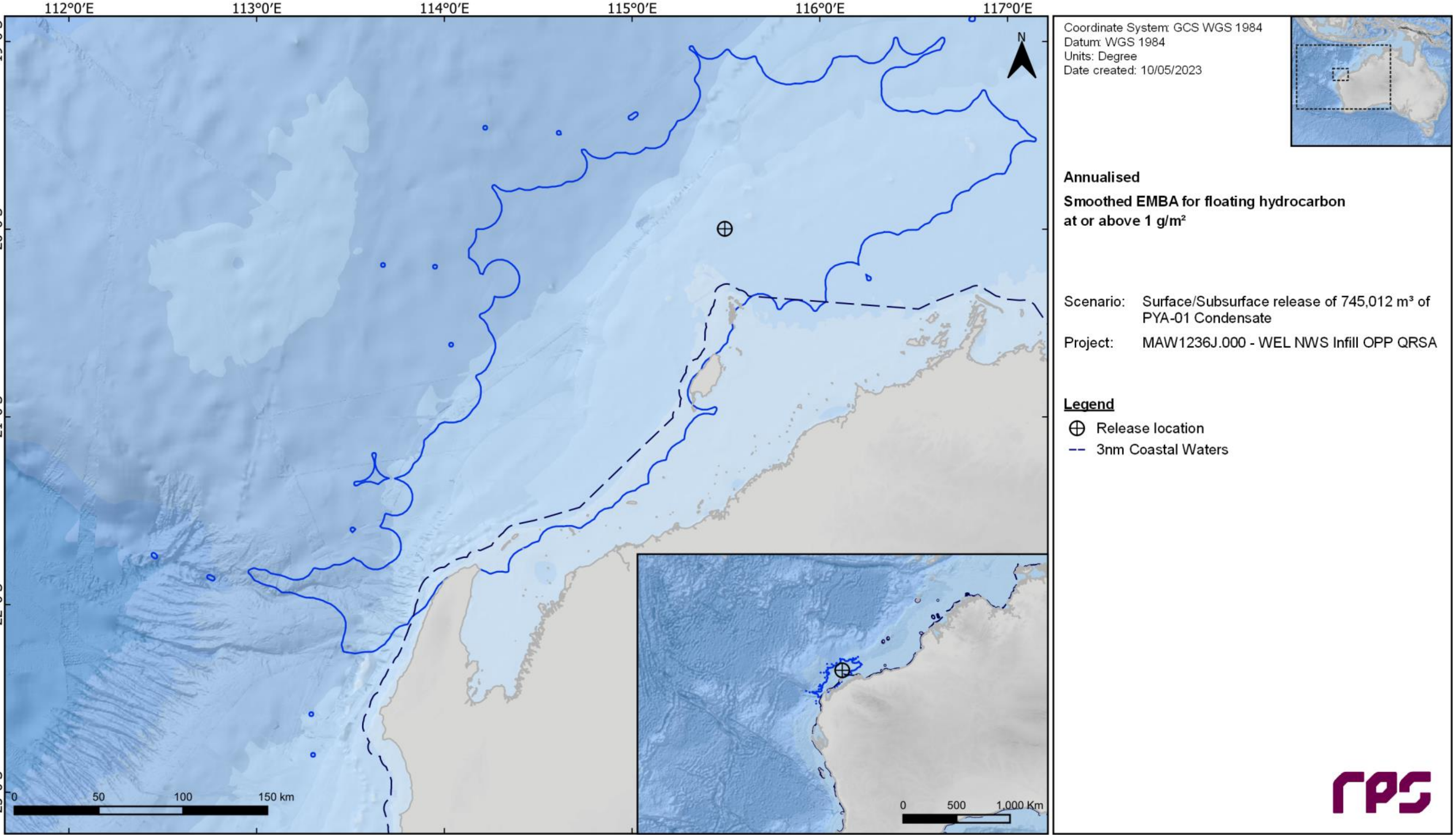


Figure 4.45 Predicted annualised smoothed EMBA of floating oil concentrations at or above 1 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

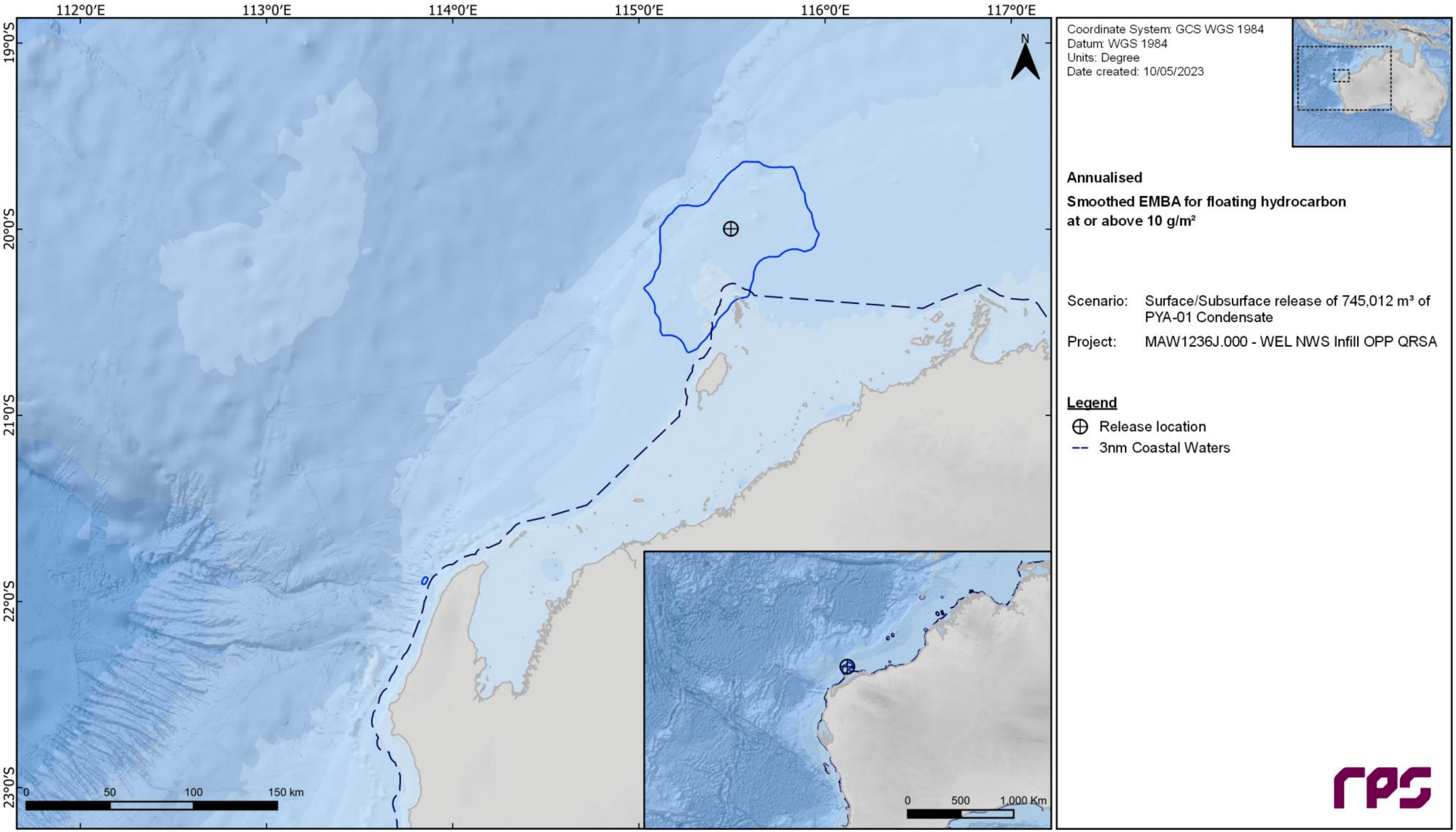


Figure 4.46 Predicted annualised smoothed EMBA of floating oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

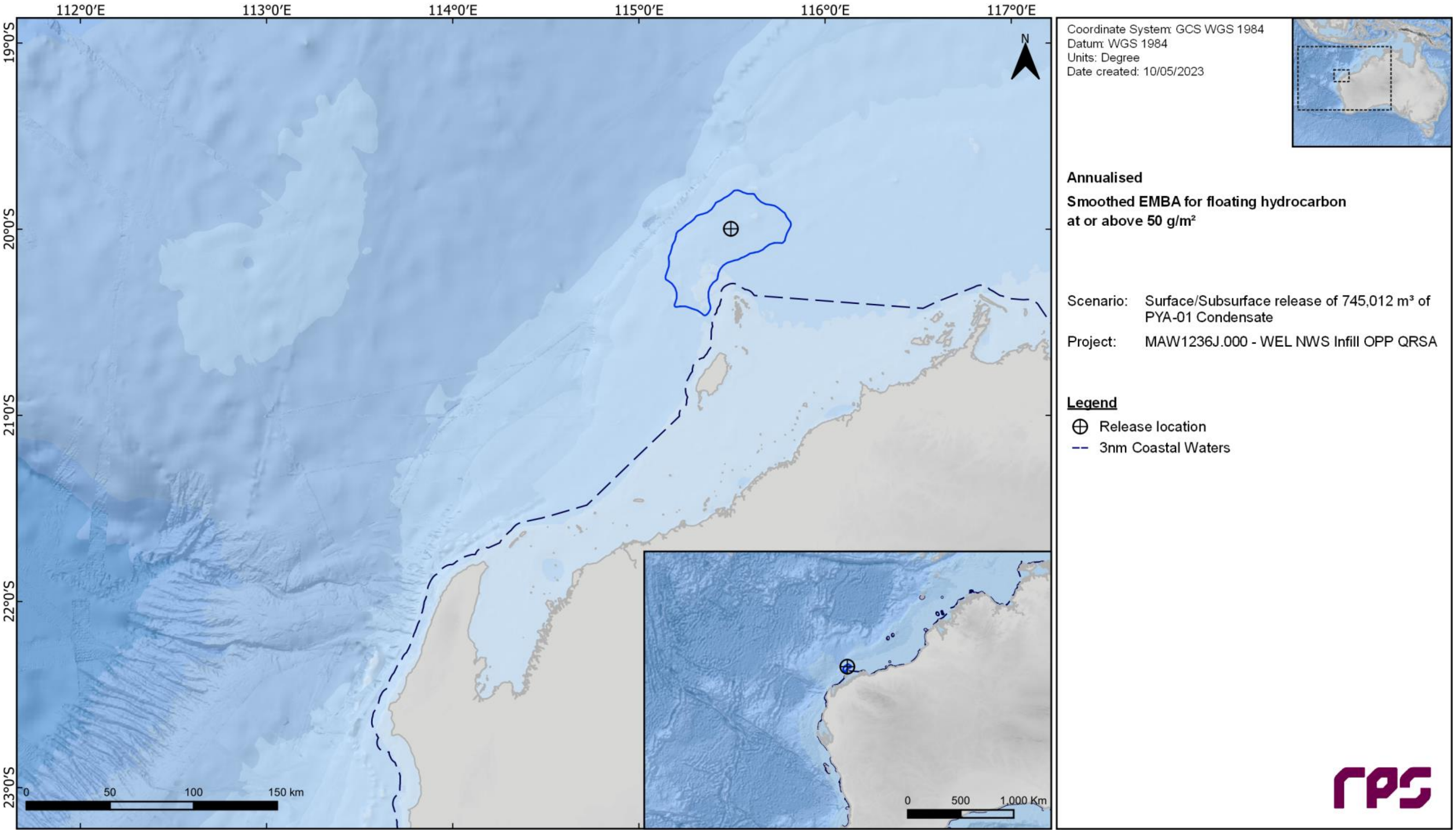


Figure 4.47 Predicted annualised smoothed EMBA of floating oil concentrations at or above 50 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

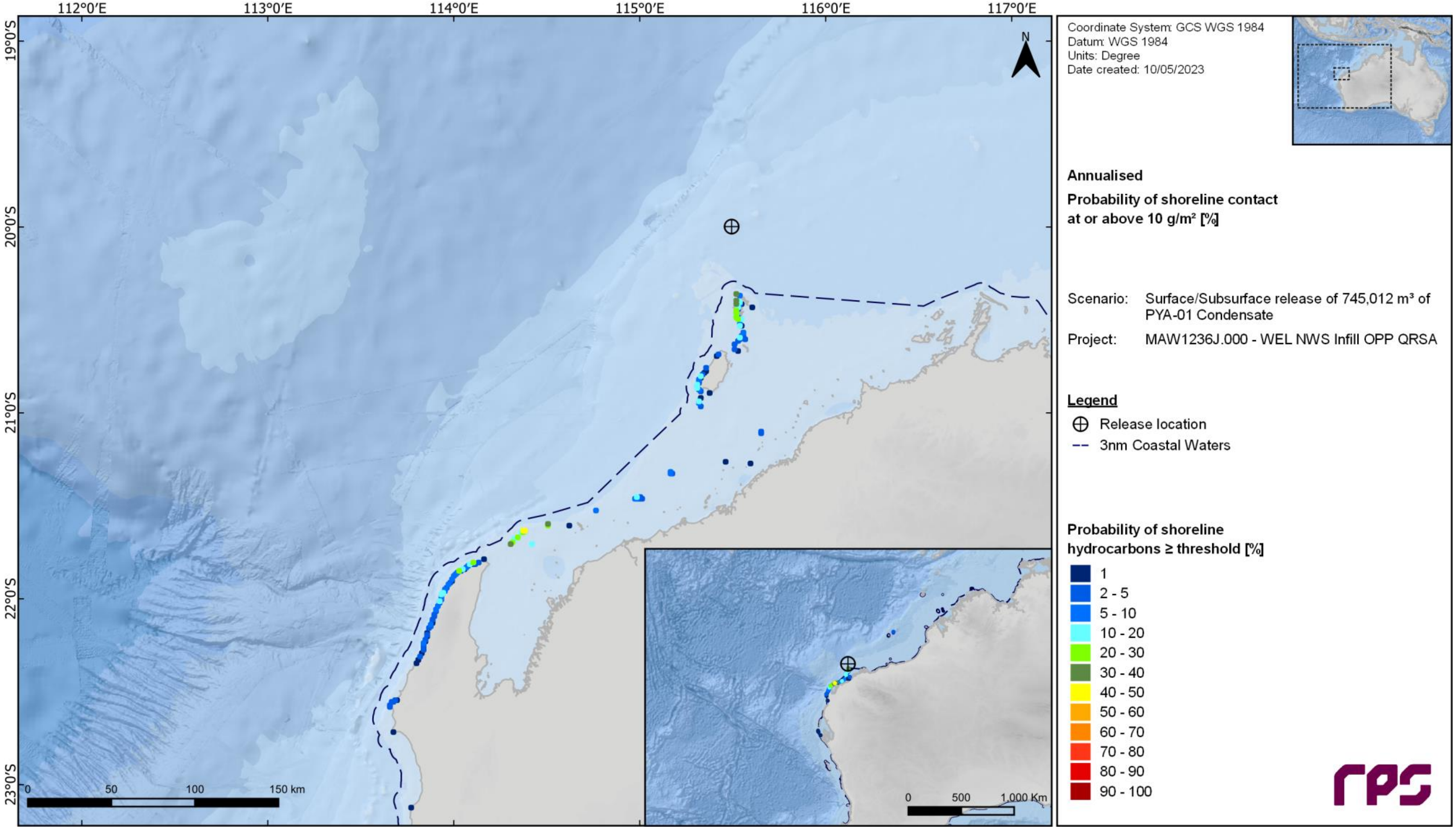


Figure 4.48 **Predicted annualised probability of shoreline oil concentrations at or above 10 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.**

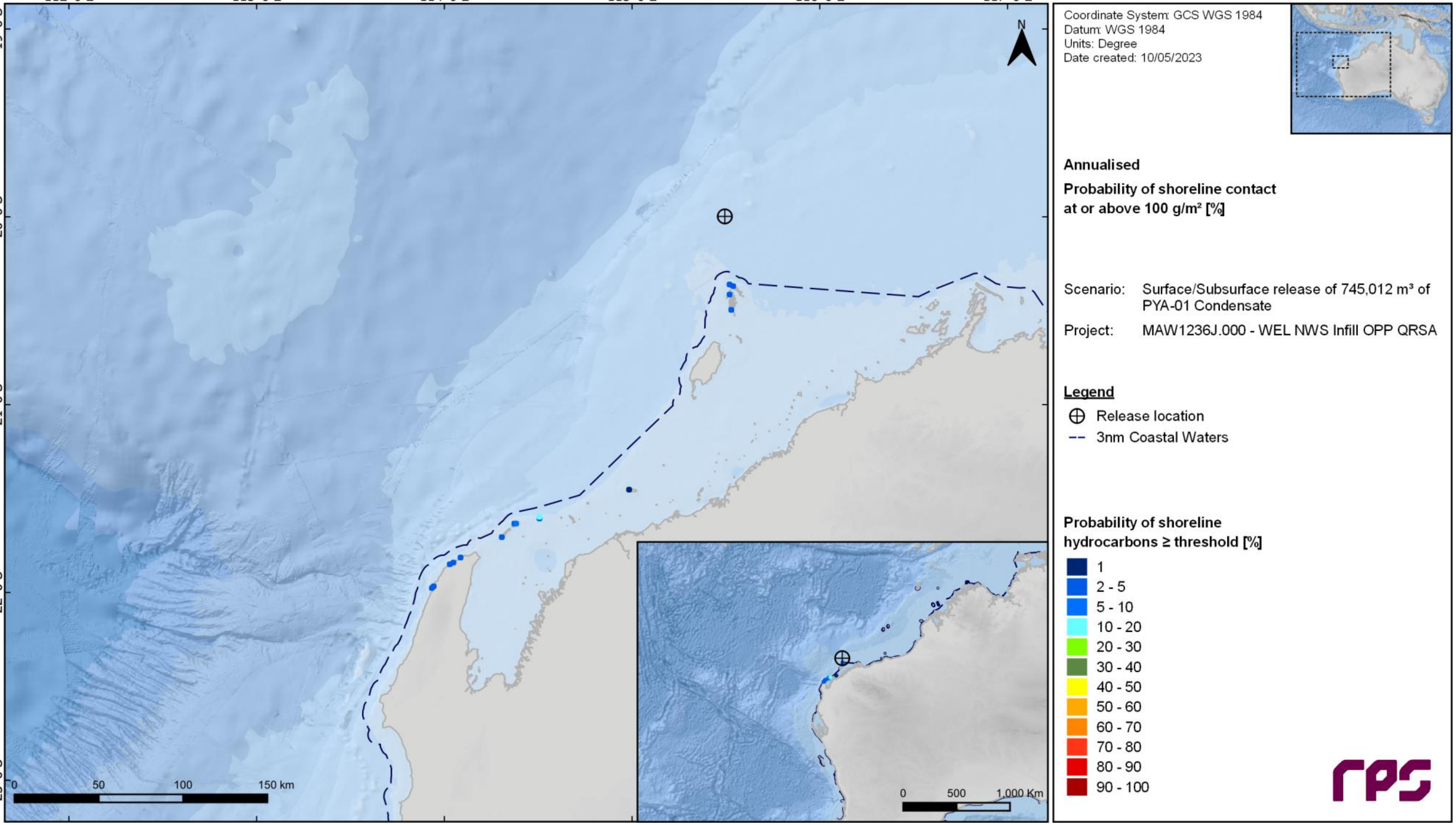


Figure 4.49 **Predicted annualised probability of shoreline oil concentrations at or above 100 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.**

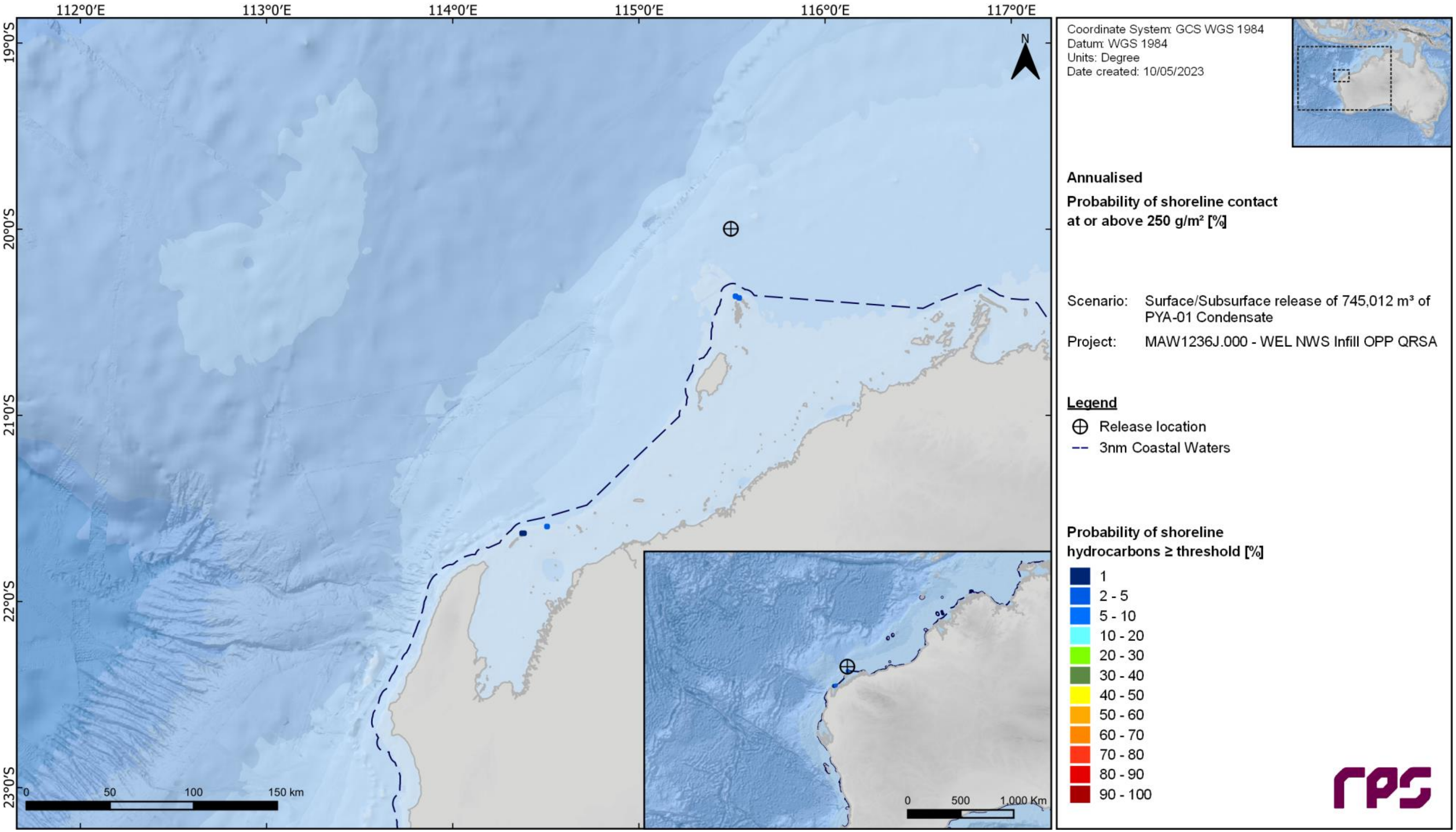


Figure 4.50 Predicted annualised probability of shoreline oil concentrations at or above 250 g/m² resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

4.3.2.2 Entrained Oil

Table 4.11 Expected annualised of entrained oil outcomes at sensitive receptors resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Australian Marine Parks	Abrolhos MP	21	3	734	868	8	218
	Argo-Rowley Terrace MP	16	7	732	771	22	799
	Carnarvon Canyon MP	29	4	824	1,222	11	170
	Dampier MP	4	<1	966	NC	2	32
	Eighty Mile Beach MP	9	<1	1,641	NC	4	75
	Gascoyne MP	100	88	247	270	2,719	14,867
	Geographe MP	<1	<1	NC	NC	<1	3
	Jurien MP	<1	<1	NC	NC	<1	9
	Kimberley MP	1	<1	2,216	NC	<1	23
	Mermaid Reef MP	2	<1	1,860	NC	2	65
	Montebello MP	100	100	1	1	42,102	85,992
	Ningaloo MP	98	80	264	267	3,079	16,910
	Perth Canyon MP	1	<1	1,517	NC	<1	68
	Shark Bay MP	56	16	693	757	43	398
	South-West Corner MP	1	<1	2,449	NC	<1	11
	Two Rocks MP	<1	<1	NC	NC	<1	5
Coastlines	Ashburton	3	<1	1,487	NC	2	46
	Augusta - Margaret River	<1	<1	NC	NC	<1	3
	Augusta - Walpole	<1	<1	NC	NC	<1	4
	Busselton	<1	<1	NC	NC	<1	2
	Cape Bruguieres	<1	<1	NC	NC	<1	5
	Carnarvon	31	8	984	1,409	28	361
	Chapman Valley	<1	<1	NC	NC	<1	2
	Coorow	<1	<1	NC	NC	<1	2
	Dampier Archipelago	4	<1	1,372	NC	2	18
	Dandaragan	<1	<1	NC	NC	<1	4
	Dawesville - Bunbury	<1	<1	NC	NC	<1	3
	Exmouth	87	69	300	338	1,110	9,189
	Exmouth Gulf South East	<1	<1	NC	NC	<1	4
	Exmouth Gulf West	50	22	441	473	47	281
	Fremantle	<1	<1	NC	NC	<1	3
	Geographe Bay	<1	<1	NC	NC	<1	2
	Geographe Bay - Augusta	<1	<1	NC	NC	<1	3

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
	Geraldton - Jurien Bay	<1	<1	NC	NC	<1	6
	Gingin	<1	<1	NC	NC	<1	4
	Greater Geraldton	<1	<1	NC	NC	<1	4
	Irwin	<1	<1	NC	NC	<1	2
	Joondalup	<1	<1	NC	NC	<1	3
	Jurien Bay - Yanchep	<1	<1	NC	NC	<1	6
	Kalbarri - Geraldton	<1	<1	NC	NC	<1	6
	Karratha	5	<1	1,360	NC	4	70
	Karratha-Port Hedland	<1	<1	NC	NC	<1	7
	Mandurah	<1	<1	NC	NC	<1	2
	Mandurah - Dawesville	<1	<1	NC	NC	<1	3
	Manjimup	<1	<1	NC	NC	<1	3
	Middle Pilbara - Islands and Shoreline	32	6	635	1,173	25	430
	Nannup	<1	<1	NC	NC	<1	2
	Northampton	<1	<1	NC	NC	<1	5
	Northern Pilbara - Islands and Shoreline	23	1	876	1,816	8	134
	Perth Northern Coast	<1	<1	NC	NC	<1	5
	Perth Southern Coast	<1	<1	NC	NC	<1	3
	Port Hedland - Eighty Mile Beach	<1	<1	NC	NC	<1	2
	Rockingham	<1	<1	NC	NC	<1	2
	Shark Bay	17	<1	1,419	NC	5	100
	Southern Pilbara - Shoreline	3	<1	1,429	NC	<1	25
	Stirling	<1	<1	NC	NC	<1	2
	Wanneroo	<1	<1	NC	NC	<1	3
	Waroona	<1	<1	NC	NC	<1	2
	Zuytdorp Cliffs - Kalbarri	<1	<1	NC	NC	<1	8
	Ashburton	3	<1	1,487	NC	2	46
Fish Habitat Protection Area	Abrolhos Islands	5	<1	1,318	NC	2	38
	Cottesloe Reef	<1	<1	NC	NC	<1	2
	Miaboolya Beach	<1	<1	NC	NC	<1	2
	Point Quobba	<1	<1	NC	NC	<1	6

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Islands	Abrolhos Islands	5	<1	1,322	NC	2	35
	Airlie Island	83	31	358	360	188	1,907
	Angel Island	<1	<1	NC	NC	<1	2
	Ashburton Island	30	<1	384	NC	11	87
	Barrow Island	99	99	119	121	1,686	6,181
	Bedout Island	<1	<1	NC	NC	<1	9
	Bedwell Island	3	2	1,675	1,694	5	200
	Bernier Island	10	<1	1,339	NC	4	65
	Bessieres Island	85	48	282	333	233	2,299
	Bezout Island	<1	<1	NC	NC	<1	3
	Boodie Island	88	59	212	352	421	3,722
	Christmas Island	<1	<1	NC	NC	<1	2
	Cohen Island	<1	<1	NC	NC	<1	6
	Cunningham Island	6	2	1,390	1,585	5	164
	Delambre Island	<1	<1	NC	NC	<1	7
	Direction Island	11	<1	966	NC	5	49
	Dolphin Island	<1	<1	NC	NC	<1	3
	Dorre Island	10	<1	1,355	NC	5	86
	Eaglehawk Island	<1	<1	NC	NC	<1	9
	East Lewis Island	<1	<1	NC	NC	<1	3
	Easter Group	<1	<1	NC	NC	<1	6
	Enderby Island	1	<1	2,504	NC	<1	12
	Flat Island	75	44	237	377	156	894
	Fly Island	<1	<1	NC	NC	2	8
	Garden Island	<1	<1	NC	NC	<1	2
	Gidley Island	<1	<1	NC	NC	<1	4
	Goodwyn Island	<1	<1	NC	NC	<1	9
	Haury Island	<1	<1	NC	NC	<1	4
	Hermite Island	88	81	222	226	748	3,422
	Keast Island	<1	<1	NC	NC	<1	6
	Kendrew Island	<1	<1	NC	NC	2	10
	Legendre Island	<1	<1	NC	NC	2	8
	Locker Island	5	<1	980	NC	3	21
	Lowendal Islands	77	45	264	324	253	2,276
	Malus Island	<1	<1	NC	NC	<1	6
	Mangrove Islands	2	<1	1,347	NC	2	31
	Mary Anne Group	24	3	635	1,227	13	235
	Middle Island	89	67	187	366	444	3,855
	Montebello Islands	95	84	134	221	959	4,495
	Muiron Islands	89	73	233	237	2,015	9,909

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
	North Island	4	<1	1,328	NC	2	25
	Observation Island	30	6	640	794	18	174
	Passage Islands	32	6	813	1,173	26	436
	Peak Island	89	58	217	223	766	7,546
	Pelsaert Group	1	<1	2,446	NC	<1	11
	Ragnard Islands	<1	<1	NC	NC	<1	5
	Rivoli Islands	<1	<1	NC	NC	<1	6
	Rosemary Island	1	<1	2,389	NC	<1	11
	Rottnest Island	<1	<1	NC	NC	<1	4
	Round Island	49	2	455	694	18	152
	Serrurier Island	69	33	250	396	93	976
	Southern Pilbara - Islands	99	91	160	162	1,770	10,938
	Sunday Island	73	56	249	250	496	2,819
	Table Island	49	4	328	457	27	470
	Thevenard Island	88	49	306	330	354	4,454
	Tortoise Island	51	4	328	457	26	359
	Twin Island	3	<1	1,368	NC	2	59
	Wallabi Group	4	<1	1,351	NC	2	25
	West Lewis Island	<1	<1	NC	NC	<1	5
Marine Parks	Barrow Island MMA	100	99	113	120	1,945	6,838
	Barrow Island MP (State)	99	98	123	125	1,500	4,819
	Clerke Reef (Rowley Shoals MP)	3	2	1,651	1,663	5	231
	Imperieuse Reef (Rowley Shoals MP)	7	2	1,342	1,560	6	225
	Jurien Bay MP	<1	<1	NC	NC	<1	6
	Marmion MP	<1	<1	NC	NC	<1	3
	Montebello Islands MP	100	97	65	102	1,926	12,120
	Muiron Islands MMA	93	79	227	231	2,592	12,202
	Ngari Capes MP	<1	<1	NC	NC	<1	4
	Ningaloo Coast WH	98	80	264	267	3,079	16,910
	Ningaloo MP (State)	94	76	267	271	2,154	15,912
	Shark Bay MR	17	<1	1,484	NC	5	100
	Shark Bay WH	22	2	1,275	1,914	8	205
	Shoalwater Islands MP	<1	<1	NC	NC	<1	2
National Park	Cape Range	85	55	408	414	798	6,271
	D'Entrecasteaux	<1	<1	NC	NC	<1	2
	Dirk Hartog Island	17	2	1,308	2,073	7	205
	Francois Peron	<1	<1	NC	NC	<1	2
	Kalbarri	<1	<1	NC	NC	<1	2

Receptors		Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
	Leeuwin-Naturaliste	<1	<1	NC	NC	<1	2
Nature Reserve	Bernier And Dorre Islands NR	11	<1	1,336	NC	5	95
	Boodie, Double Middle Islands Nature Reserve NR	91	67	187	329	512	5,217
	Great Sandy Island NR	54	15	475	777	52	812
	North Sandy Island NR	32	6	791	1,172	26	436
	Thevenard Island NR	84	49	305	330	328	4,454
	Y Island	<1	<1	NC	NC	<1	4
	Boullanger, Whitlock, Favourite,Tern & Osprey Islands Nature Reserve	<1	<1	NC	NC	<1	2
	Buller,Whittell & Green Islands Nature Reserve	<1	<1	NC	NC	<1	2
	Bernier And Dorre Islands NR	11	<1	1,336	NC	5	95
Reefs, Shoals and Banks	Ashworth Shoal	<1	<1	NC	NC	<1	4
	Assail Bank	4	<1	1,341	NC	2	20
	Australind Shoal	39	3	373	481	16	133
	Barrow Island Reefs and Shoals	51	15	475	790	50	812
	Baylis Patches	5	<1	866	NC	4	28
	Beagle Knoll	1	<1	2,490	NC	<1	11
	Bennett Shoal	<1	<1	NC	NC	<1	8
	Beryl Reef	9	<1	1,135	NC	3	32
	Brewis Reef	76	42	305	318	195	2,418
	Camplin Shoal	<1	<1	NC	NC	<1	10
	Clerke Reef	3	2	1,660	1,672	5	203
	Clio Bank	<1	<1	NC	NC	<1	4
	Cod Bank	1	<1	2,315	NC	2	21
	Combe Reef	56	25	375	387	91	623
	Cooper Shoal	<1	<1	NC	NC	<1	10
	Courtenay Shoal	<1	<1	NC	NC	<1	6
	Curlew Bank	3	<1	1,918	NC	<1	17
	Dailey Shoal	65	37	281	393	168	804
	Dart Shoal	<1	<1	NC	NC	<1	3
	Direction Bank	<1	<1	NC	NC	<1	10
	Dockrell Reef	<1	<1	NC	NC	<1	2
	Eliassen Rocks	<1	<1	NC	NC	<1	4
	Exmouth Reef	50	9	375	463	30	199
	Fairway Reef	24	<1	726	NC	8	44
	Fantome Shoal §	<1	<1	NC	NC	<1	4
	Flinders Shoal	27	3	635	1,215	15	284

Receptors	Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Fortescue Reef	3	<1	1,800	NC	2	22
Gee Bank	<1	<1	NC	NC	<1	4
Geelvink Channel Shoals	<1	<1	NC	NC	<1	6
Glennie Patches	12	<1	756	NC	4	28
Glomar Shoal §	26	<1	299	302	432	75
Gorgon Patch	12	<1	748	NC	5	51
Hammersley Shoal	<1	<1	NC	NC	<1	7
Hastings Shoal	4	<1	1,555	NC	3	44
Hayman Rock	17	<1	578	NC	6	44
Herald Reef	3	<1	1,361	NC	3	76
Hood Reef	39	3	493	885	15	113
Imperieuse Reef	6	2	1,366	1,571	5	187
Inner Northwest Patch	4	<1	780	NC	3	18
Koolinda Patch	3	<1	1,567	NC	3	40
Lightfoot Reef	24	3	854	1,250	12	232
Little Shoals	25	8	701	1,089	16	154
Locker Reef	20	<1	531	NC	7	57
Madeleine Shoals	7	<1	1,135	NC	3	21
Manicom Bank	<1	<1	NC	NC	<1	6
Mardie Rock	<1	<1	NC	NC	<1	8
McLennan Bank	13	<1	1,080	NC	4	33
Meda Reef	21	3	864	1,607	11	191
Mermaid Reef	2	<1	2,088	NC	<1	60
Mid Reef	<1	<1	NC	NC	<1	4
Montebello Shoals	95	84	147	223	932	4,463
Moresby Shoals	12	<1	946	NC	7	97
Nares Rock	8	<1	1,227	NC	4	81
Ningaloo Reef	90	72	329	335	1,447	10,474
North Tail Reef	<1	<1	NC	NC	<1	4
North West Reef	80	64	290	306	392	2,248
North West Reefs	1	<1	2,479	NC	<1	12
O'Grady Shoal	<1	<1	NC	NC	<1	9
Otway Reef	52	19	418	641	67	602
Outtrim Patches	87	68	228	233	1,438	10,686
Paroo Shoal	28	1	384	988	12	108
Pearl Reef	<1	<1	NC	NC	<1	7
Pelsaert Bank	<1	<1	NC	NC	<1	9
Penguin Bank	99	91	149	184	1,748	8,742
Poivre Reef	91	81	150	186	708	4,660
Rankin Bank §	88	76	40	41	5,270	1,955

Receptors	Probability (%) of entrained hydrocarbon concentration contact		Minimum time to receptor waters (hours) at		Maximum entrained hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 100 ppb	≥ 10 ppb	≥ 100 ppb	averaged over all replicate spills	in the worst replicate
Ripple Shoals	63	27	366	415	143	3,157
Roller Shoal	2	<1	2,444	NC	<1	14
Rosily Shoals	98	78	199	201	866	6,647
Saladin Shoal	17	<1	481	NC	6	49
Sand Knoll Ledge	<1	<1	NC	NC	<1	3
Santo Rock	32	3	408	670	14	160
Snapper Bank	<1	<1	NC	NC	<1	4
South East Reef	<1	<1	NC	NC	<1	2
South West Reef	<1	<1	NC	NC	<1	6
Southwest Patch	<1	<1	NC	NC	<1	7
Spider Reef	7	<1	793	NC	3	19
Stewart Shoal	<1	<1	NC	NC	<1	4
Sultan Reef	63	29	358	359	128	1,837
Taunton Reef	65	24	373	382	100	1,309
Tongue Shoals	10	<1	518	NC	5	40
Trap Reef	91	54	239	346	458	3,485
Tryal Rocks	100	100	47	61	3,907	11,911
Turtle Dove Shoal	<1	<1	NC	NC	<1	7
Wapet Shoal	<1	<1	NC	NC	<1	2
Ward Reef	2	<1	1,967	NC	<1	27
Web Reef	<1	<1	NC	NC	2	10
Weeks Shoal	31	<1	421	NC	13	81
West Reef	11	<1	1,150	NC	8	86

NC No contact to receptor predicted for specified threshold.

§ Probabilities and maximum concentrations calculated at depth of submerged feature

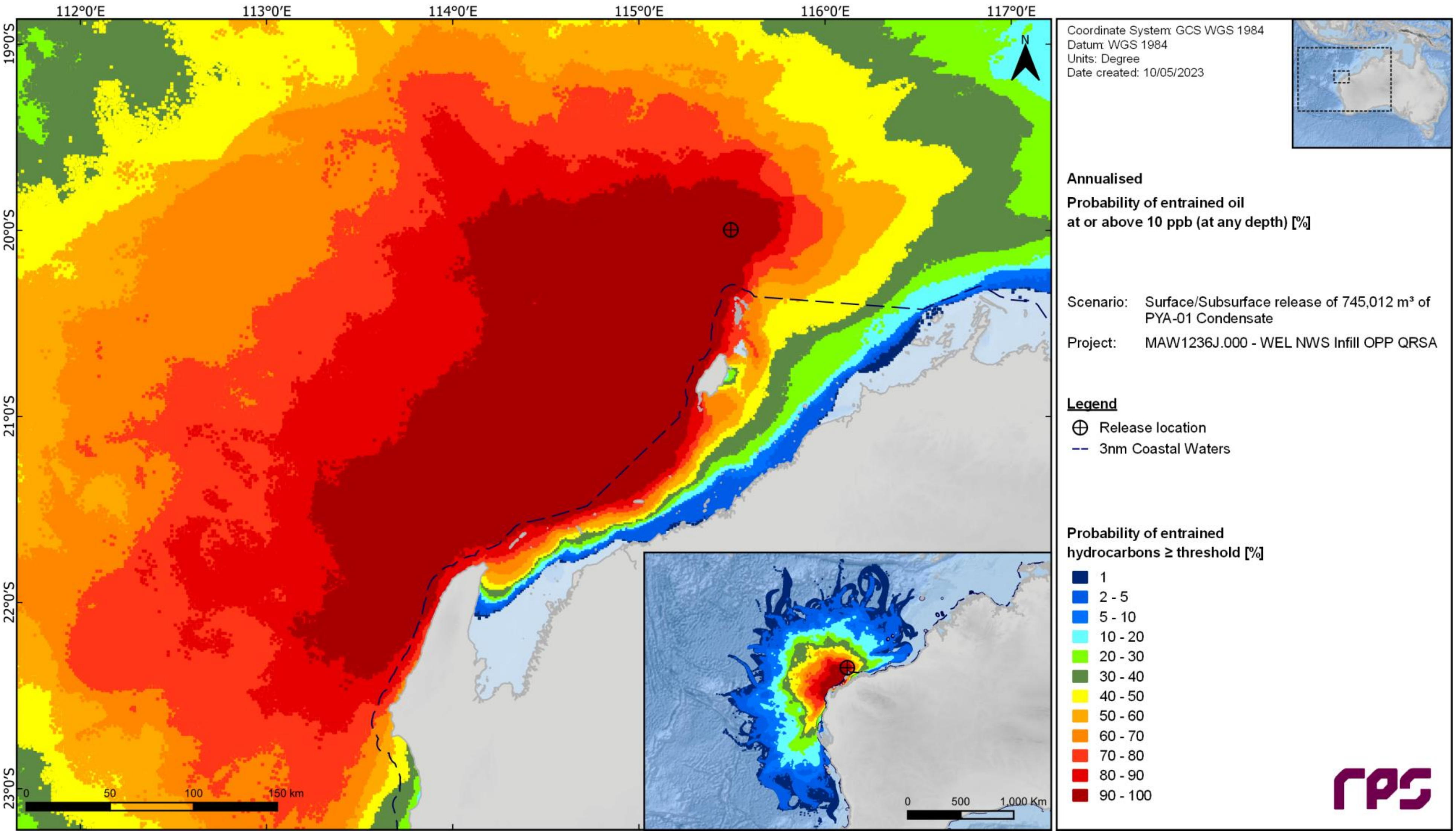


Figure 4.51 **Predicted annualised probability of entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.**

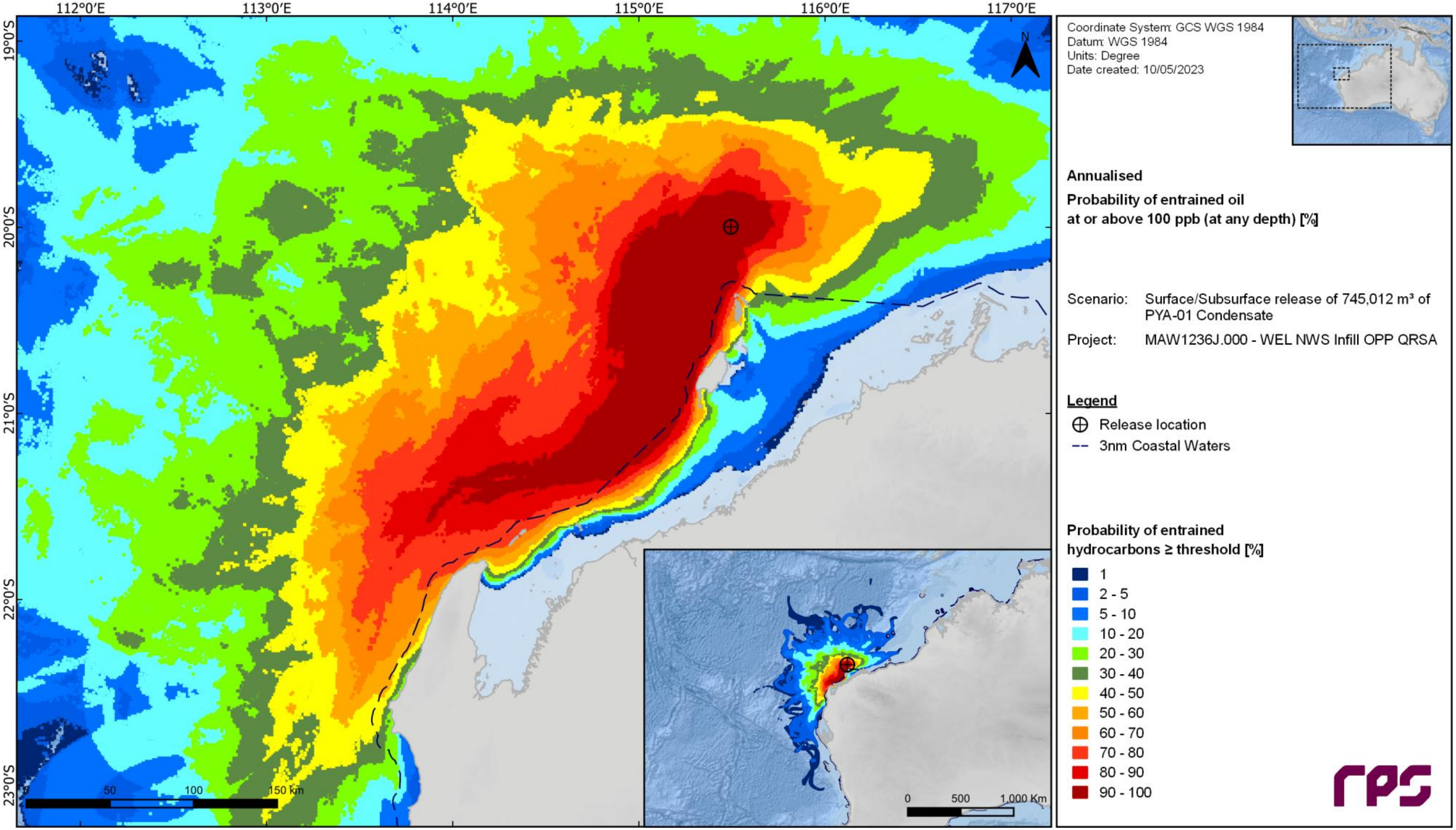


Figure 4.52 Predicted annualised probability of entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

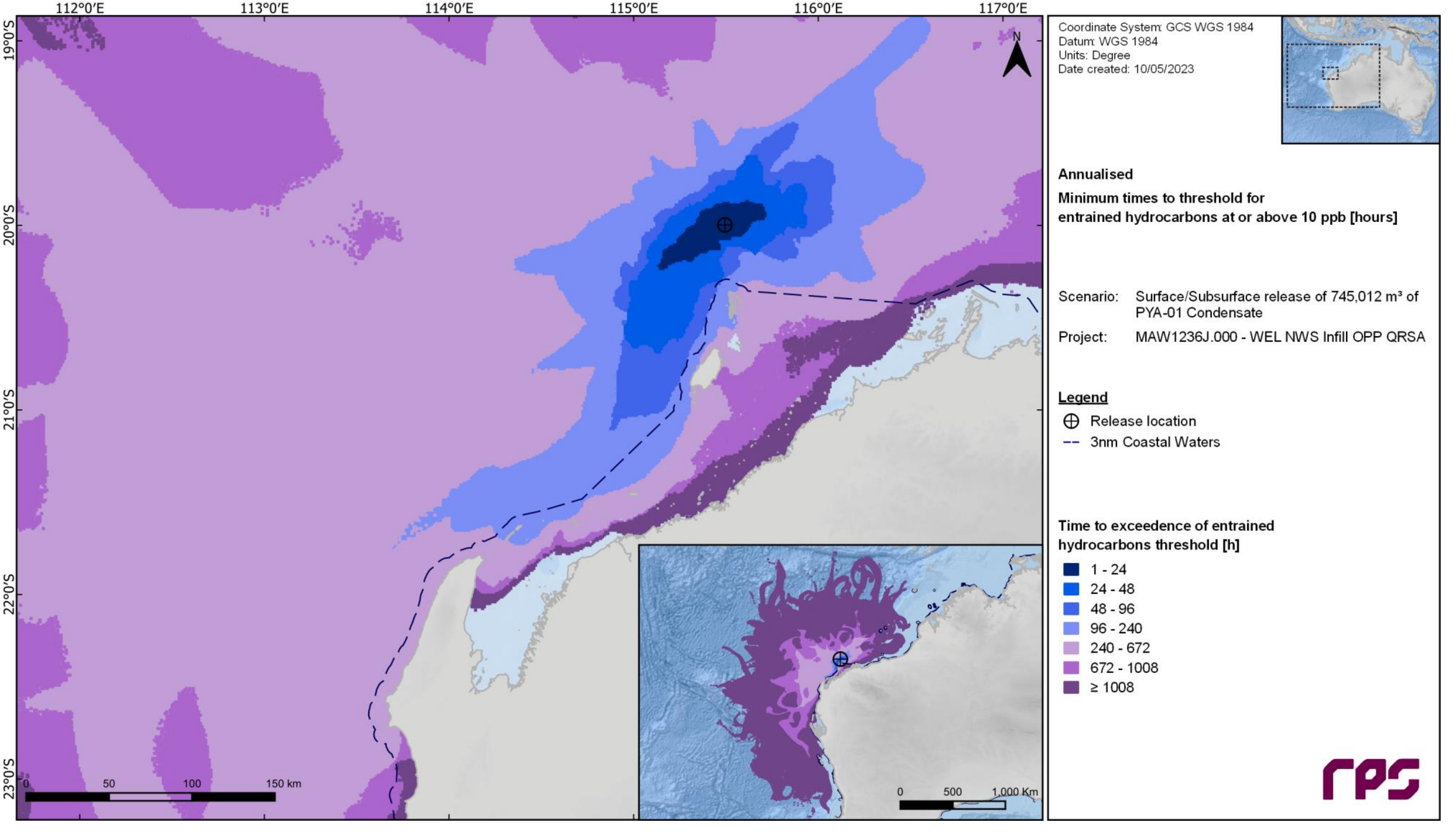


Figure 4.53 Predicted annualised minimum times to contact by entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

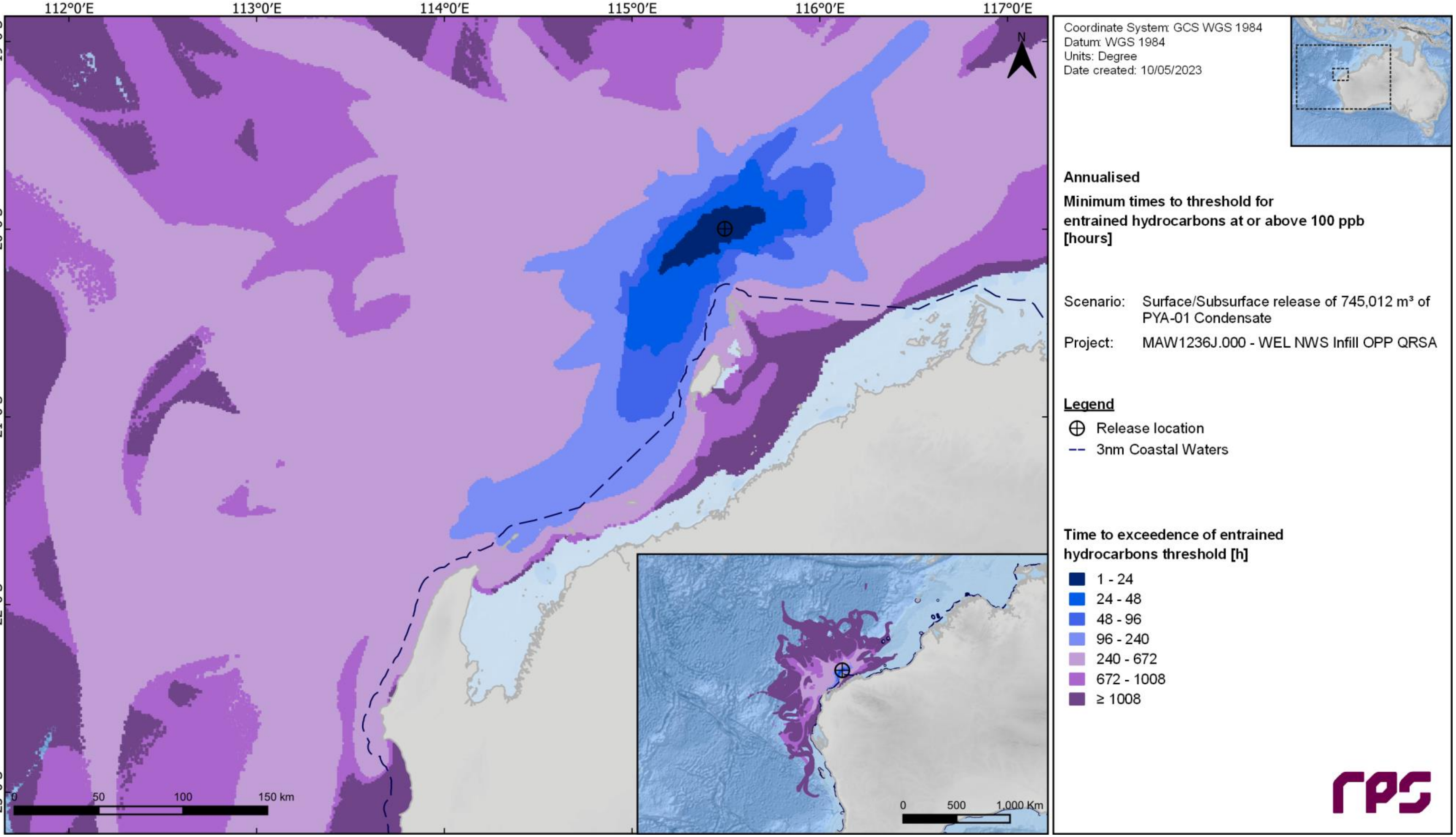


Figure 4.54 Predicted annualised minimum times to contact by entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

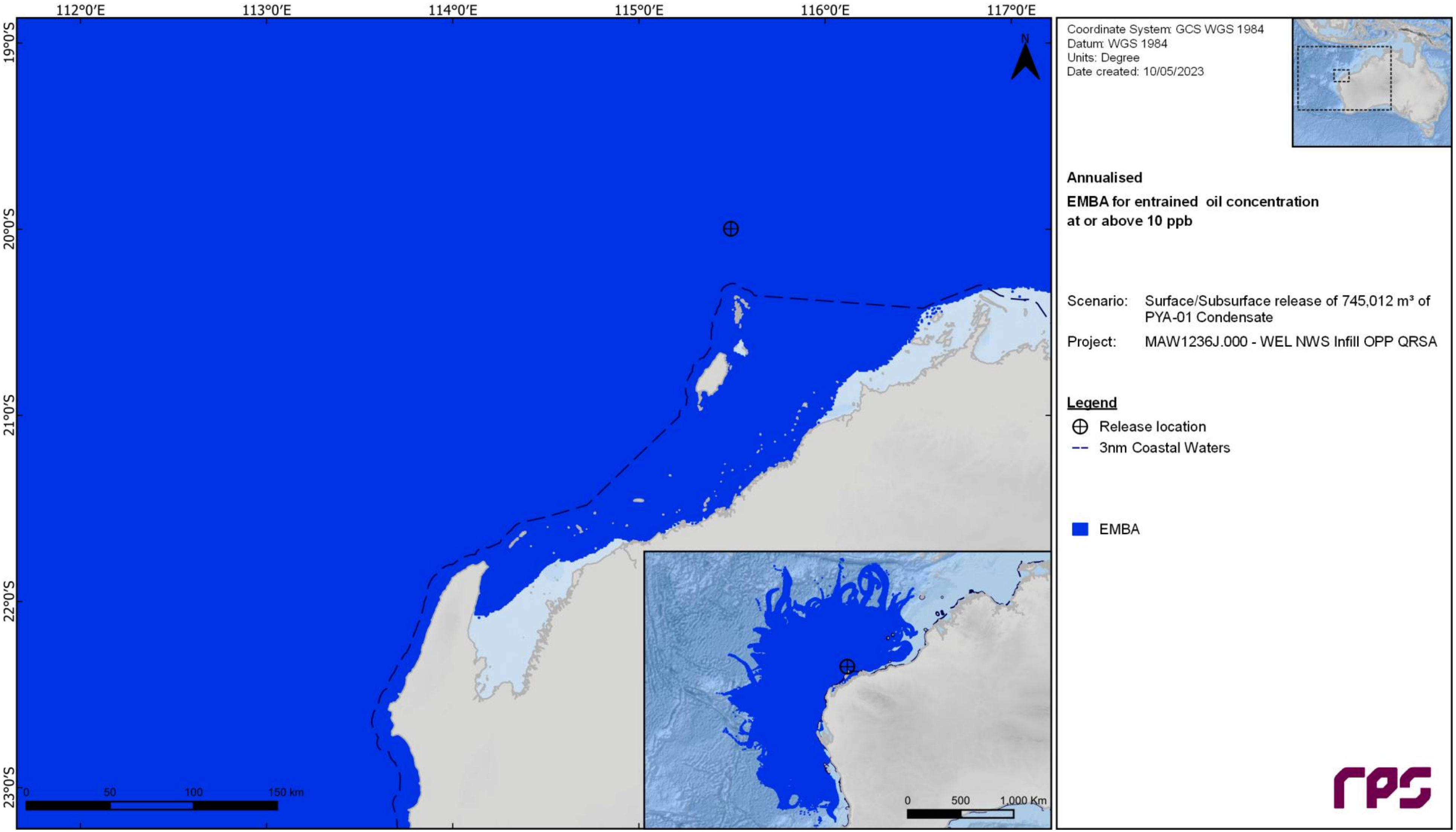


Figure 4.55 Predicted annualised EMBA of entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

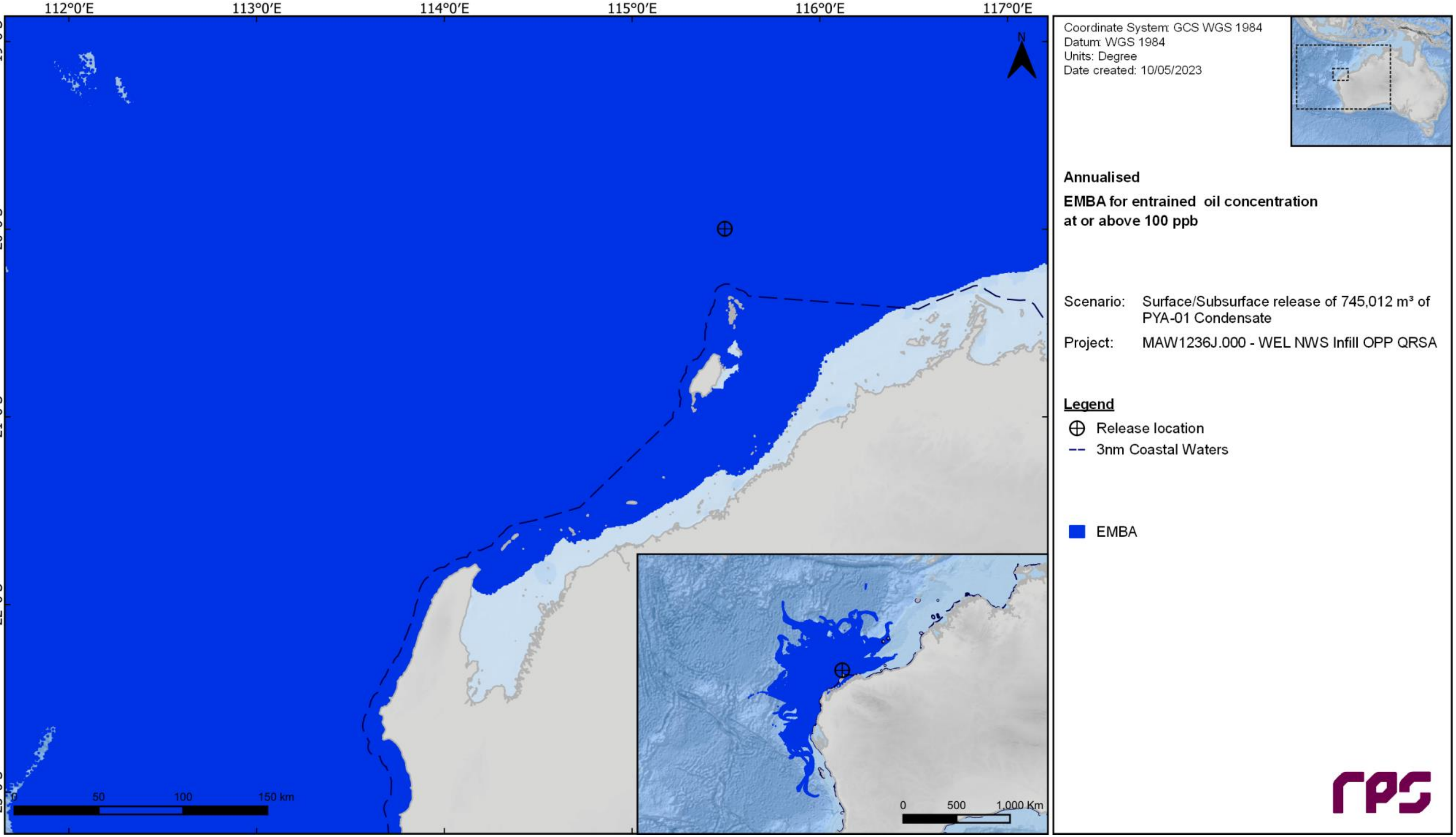


Figure 4.56 Predicted annualised EMBA of entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

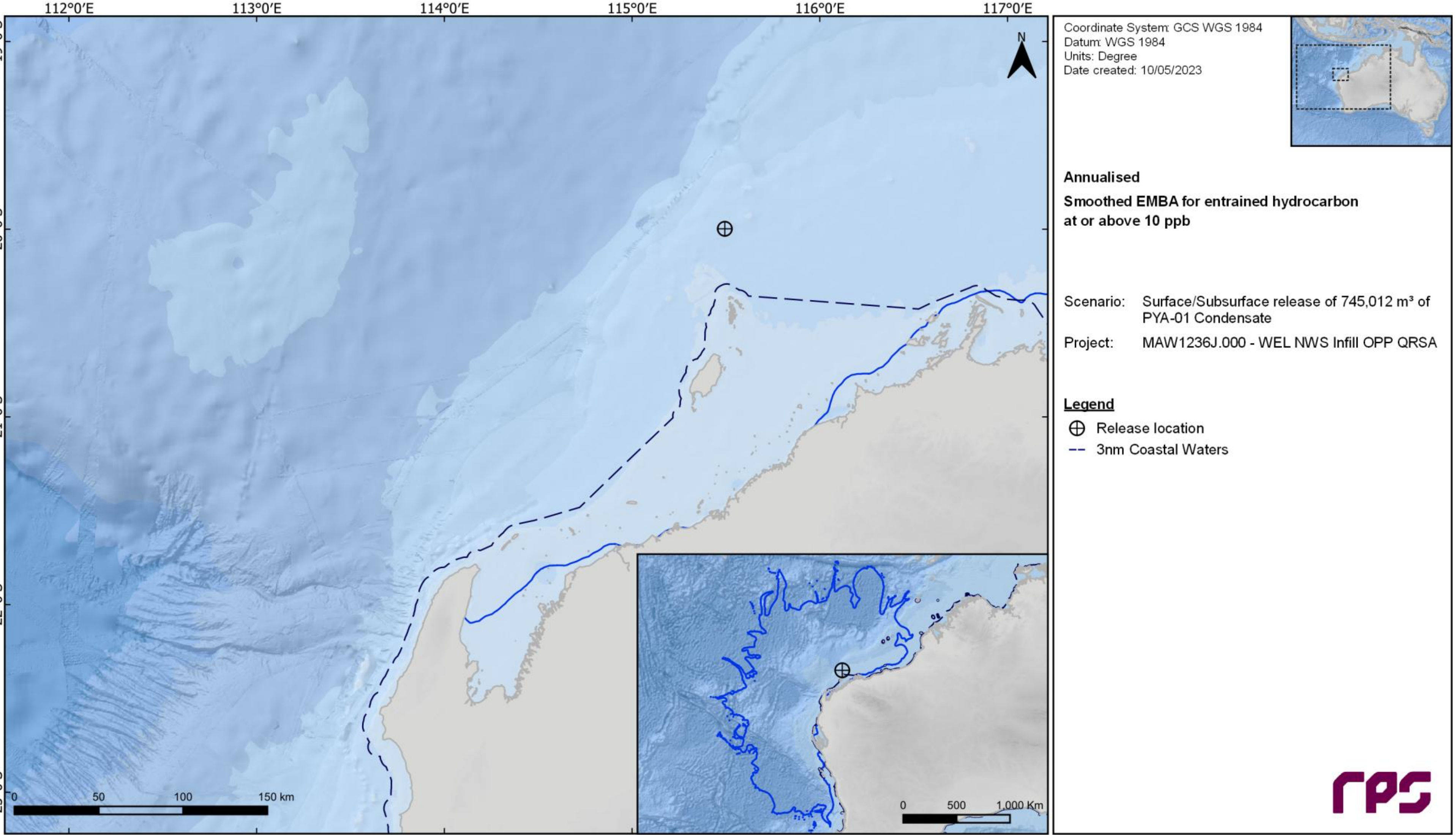


Figure 4.57 Predicted annualised smoothed EMBA of entrained oil concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

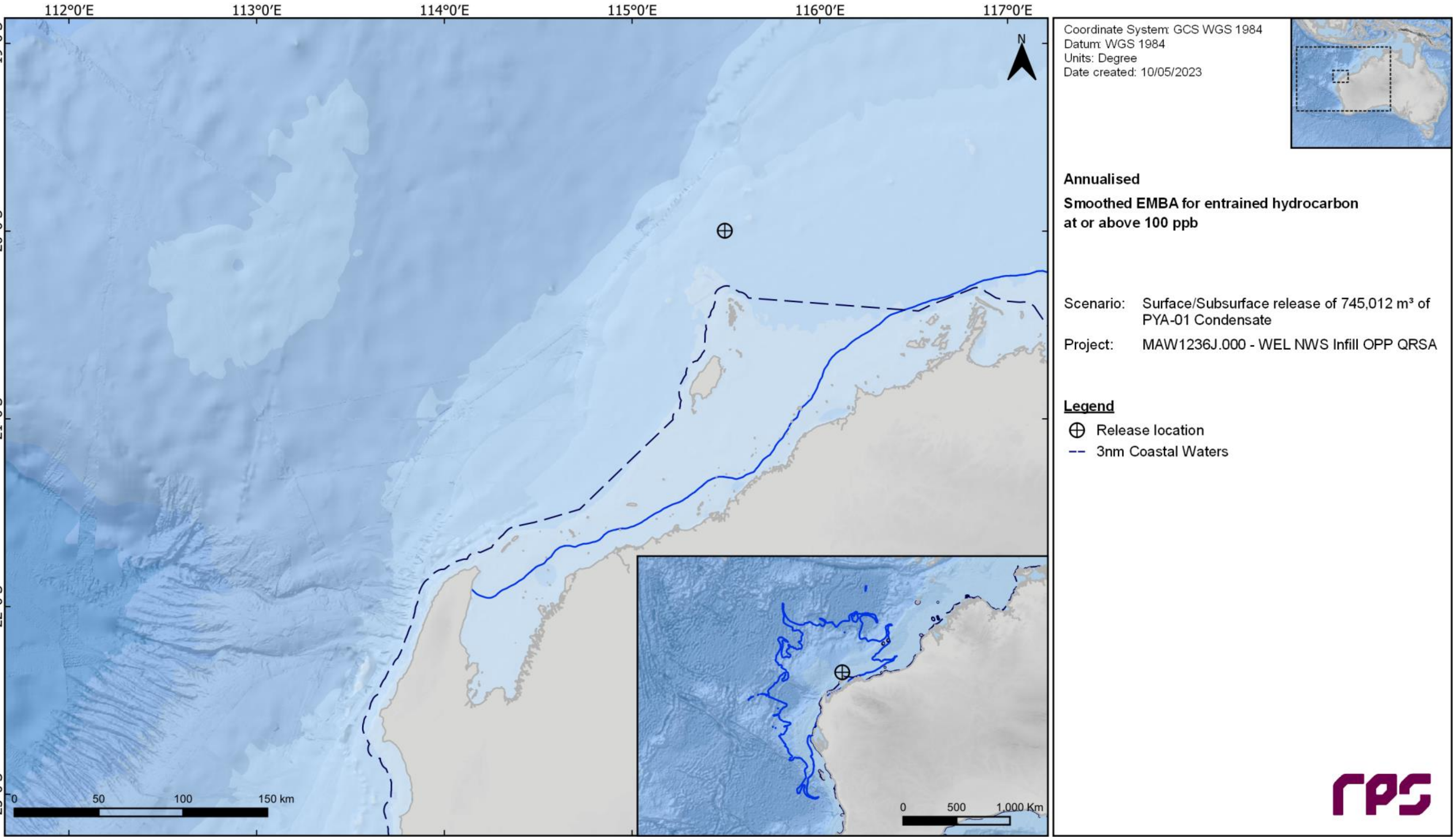


Figure 4.58 Predicted annualised smoothed EMBA of entrained oil concentrations at or above 100 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

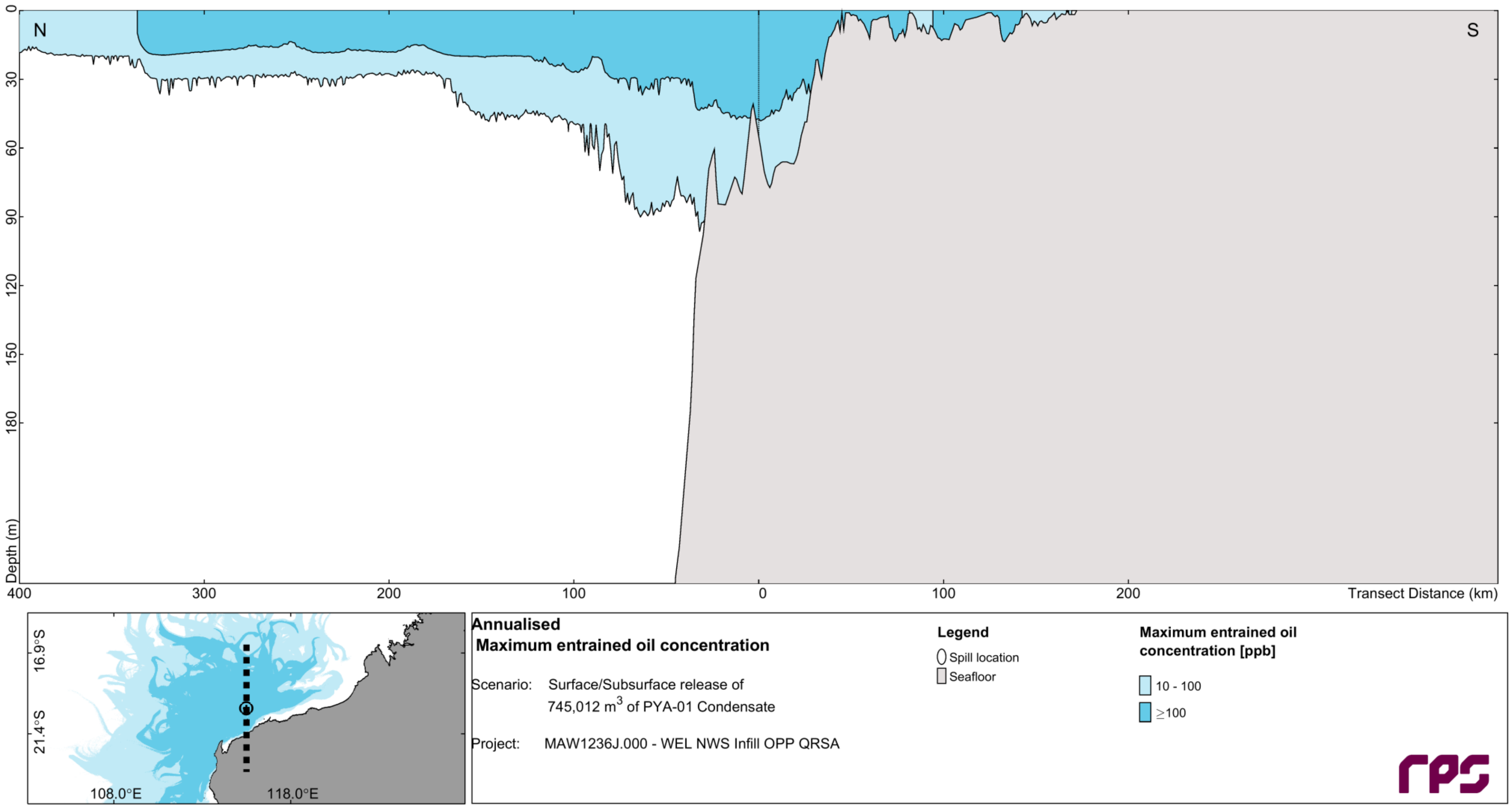


Figure 4.59 **North-to-south cross section transect of predicted annualised maximum entrained oil concentration for a Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.**

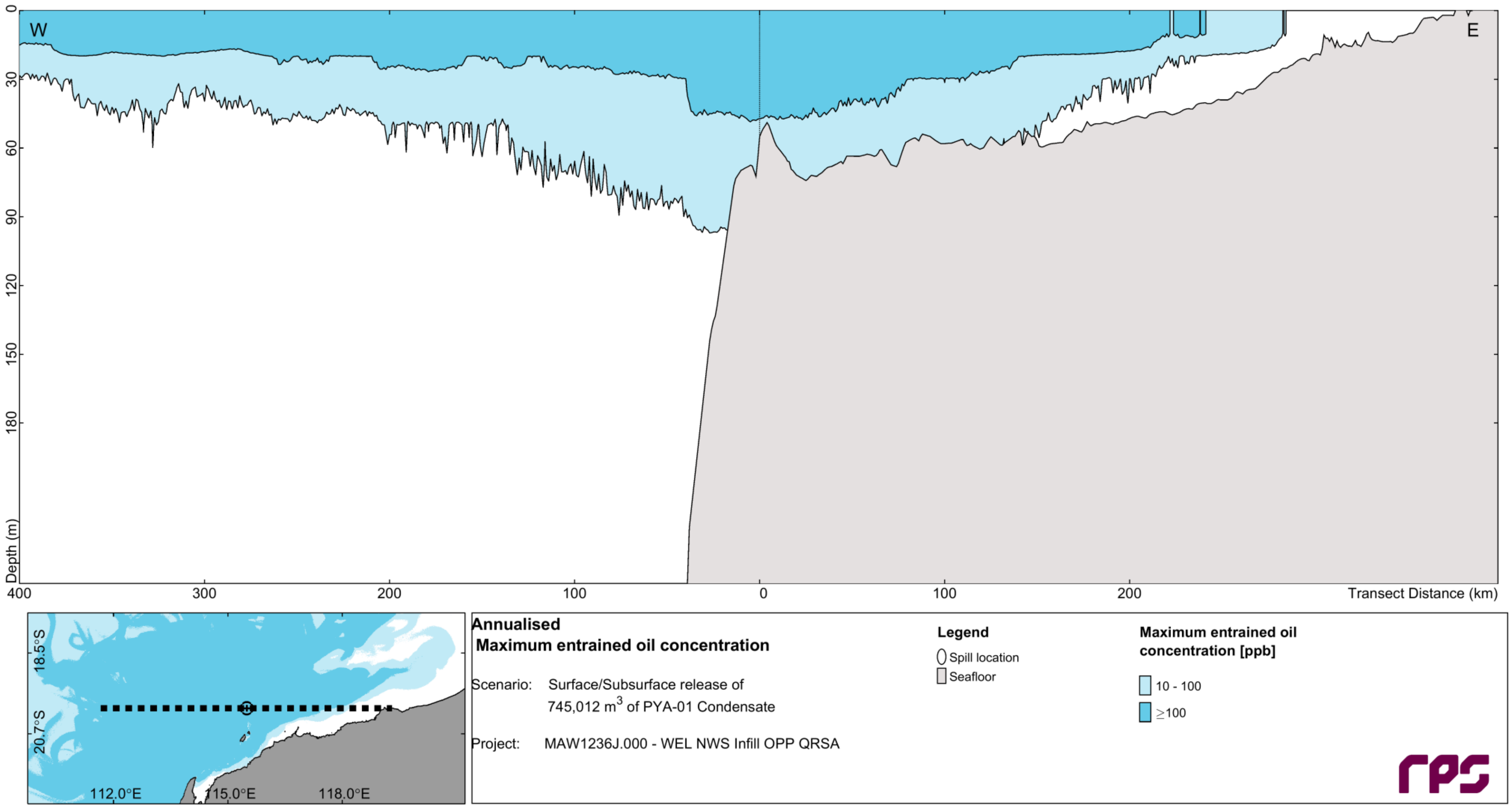


Figure 4.60 **West-to-east cross section transect of predicted annualised maximum entrained oil concentration for a Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.**

4.3.2.3 Dissolved Aromatic Hydrocarbon

Table 4.12 Expected annualised of dissolved aromatic hydrocarbon outcomes at sensitive receptors resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

Receptors		Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Australian Marine Parks	Abrolhos MP	4	1	2	128
	Argo-Rowley Terrace MP	7	3	5	280
	Carnarvon Canyon MP	7	1	2	78
	Dampier MP	3	<1	<1	41
	Eighty Mile Beach MP	<1	<1	<1	4
	Gascoyne MP	95	80	510	6,032
	Geographe MP	<1	<1	NC	NC
	Jurien MP	<1	<1	<1	<1
	Kimberley MP	<1	<1	<1	2
	Mermaid Reef MP	1	<1	<1	14
	Montebello MP	100	100	6,954	24,018
	Ningaloo MP	97	78	603	8,573
	Perth Canyon MP	<1	<1	<1	3
	Shark Bay MP	22	4	7	163
	South-West Corner MP	<1	<1	<1	<1
	Two Rocks MP	<1	<1	NC	NC
Coastlines	Ashburton	<1	<1	<1	<1
	Augusta - Margaret River	<1	<1	NC	NC
	Augusta - Walpole	<1	<1	NC	NC
	Busselton	<1	<1	NC	NC
	Cape Bruguieres	<1	<1	<1	3
	Carnarvon	6	<1	2	50
	Chapman Valley	<1	<1	NC	NC
	Coorow	<1	<1	NC	NC
	Dampier Archipelago	1	<1	<1	17
	Dandaragan	<1	<1	NC	NC
	Dawesville - Bunbury	<1	<1	NC	NC
	Exmouth	74	51	147	1,737
	Exmouth Gulf South East	<1	<1	<1	<1
	Exmouth Gulf West	12	4	8	226
	Fremantle	<1	<1	NC	NC
	Geographe Bay	<1	<1	NC	NC
	Geographe Bay - Augusta	<1	<1	NC	NC
	Geraldton - Jurien Bay	<1	<1	NC	NC

Receptors		Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
		≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
	Gingin	<1	<1	NC	NC
	Greater Geraldton	<1	<1	NC	NC
	Irwin	<1	<1	NC	NC
	Joondalup	<1	<1	NC	NC
	Jurien Bay - Yanchep	<1	<1	NC	NC
	Kalbarri - Geraldton	<1	<1	<1	<1
	Karratha	<1	<1	<1	2
	Karratha-Port Hedland	<1	<1	<1	9
	Mandurah	<1	<1	NC	NC
	Mandurah - Dawesville	<1	<1	NC	NC
	Manjimup	<1	<1	NC	NC
	Middle Pilbara - Islands and Shoreline	5	1	2	114
	Nannup	<1	<1	NC	NC
	Northampton	<1	<1	<1	<1
	Northern Pilbara - Islands and Shoreline	1	1	<1	65
	Perth Northern Coast	<1	<1	NC	NC
	Perth Southern Coast	<1	<1	NC	NC
	Port Hedland - Eighty Mile Beach	<1	<1	<1	<1
	Rockingham	<1	<1	NC	NC
	Shark Bay	1	<1	<1	13
	Southern Pilbara - Shoreline	<1	<1	<1	<1
	Stirling	<1	<1	NC	NC
	Wanneroo	<1	<1	NC	NC
	Waroona	<1	<1	NC	NC
	Zuytdorp Cliffs - Kalbarri	<1	<1	<1	<1
Fish Habitat Protection Area	Abrolhos Islands	<1	<1	<1	5
	Cottesloe Reef	<1	<1	NC	NC
	Miaboolya Beach	<1	<1	NC	NC
	Point Quobba	<1	<1	<1	<1
Islands	Abrolhos Islands	<1	<1	<1	4
	Airlie Island	35	16	31	537
	Angel Island	<1	<1	<1	<1
	Ashburton Island	3	<1	<1	22
	Barrow Island	99	95	535	3,607
	Bedout Island	<1	<1	<1	<1
	Bedwell Island	2	<1	<1	36

Receptors	Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Bernier Island	<1	<1	<1	8
Bessieres Island	63	37	90	976
Bezout Island	<1	<1	<1	<1
Boodie Island	46	22	71	1,261
Christmas Island	<1	<1	NC	NC
Cohen Island	<1	<1	<1	7
Cunningham Island	1	<1	<1	22
Delambre Island	<1	<1	<1	9
Direction Island	3	<1	<1	15
Dolphin Island	<1	<1	<1	4
Dorre Island	<1	<1	<1	10
Eaglehawk Island	<1	<1	<1	<1
East Lewis Island	<1	<1	<1	<1
Easter Group	<1	<1	<1	<1
Enderby Island	<1	<1	<1	<1
Flat Island	49	20	49	734
Fly Island	<1	<1	<1	<1
Garden Island	<1	<1	NC	NC
Gidley Island	<1	<1	<1	<1
Goodwyn Island	<1	<1	<1	<1
Haury Island	<1	<1	<1	6
Hermite Island	72	52	106	2,490
Keast Island	<1	<1	<1	6
Kendrew Island	<1	<1	<1	6
Legendre Island	<1	<1	<1	8
Locker Island	<1	<1	<1	<1
Lowendal Islands	28	13	42	1,396
Malus Island	<1	<1	<1	<1
Mangrove Islands	<1	<1	<1	<1
Mary Anne Group	3	<1	<1	15
Middle Island	49	29	79	1,533
Montebello Islands	78	66	167	2,490
Muiron Islands	84	61	545	6,732
North Island	<1	<1	<1	3
Observation Island	1	<1	<1	29
Passage Islands	5	1	3	81
Peak Island	67	42	153	3,192
Pelsaert Group	<1	<1	<1	<1
Ragnard Islands	<1	<1	<1	<1
Rivoli Islands	<1	<1	<1	<1
Rosemary Island	1	<1	<1	11

Receptors		Probability (%) of dissolved aromatic concentrations ≥ 10 ppb	Probability (%) of dissolved aromatic concentrations ≥ 50 ppb	Maximum dissolved aromatic hydrocarbon concentration (ppb) averaged over all replicate spills	Maximum dissolved aromatic hydrocarbon concentration (ppb) in the worst replicate
	Rottnest Island	<1	<1	NC	NC
	Round Island	6	1	3	73
	Serrurier Island	33	15	36	735
	Southern Pilbara - Islands	95	85	389	3,266
	Sunday Island	51	32	98	1,714
	Table Island	9	3	6	212
	Thevenard Island	51	27	84	2,081
	Tortoise Island	9	2	4	92
	Twin Island	<1	<1	<1	3
	Wallabi Group	<1	<1	<1	2
	West Lewis Island	<1	<1	<1	<1
Marine Parks	Barrow Island MMA	99	98	628	5,444
	Barrow Island MP (State)	98	96	476	3,339
	Clerke Reef (Rowley Shoals MP)	2	<1	<1	42
	Imperieuse Reef (Rowley Shoals MP)	2	<1	<1	42
	Jurien Bay MP	<1	<1	NC	NC
	Marmion MP	<1	<1	NC	NC
	Montebello Islands MP	94	92	581	7,674
	Muiron Islands MMA	91	72	593	6,902
	Ngari Capes MP	<1	<1	NC	NC
	Ningaloo Coast WH	97	78	603	8,573
	Ningaloo MP (State)	86	70	317	4,846
	Shark Bay MR	1	<1	<1	15
	Shark Bay WH	3	1	<1	64
	Shoalwater Islands MP	<1	<1	NC	NC
National Park	Cape Range	69	41	112	1,236
	D'Entrecasteaux	<1	<1	NC	NC
	Dirk Hartog Island	2	<1	<1	44
	Francois Peron	<1	<1	NC	NC
	Kalbarri	<1	<1	<1	<1
	Leeuwin-Naturaliste	<1	<1	NC	NC
Nature Reserve	Bernier And Dorre Islands NR	<1	<1	<1	10
	Boodie, Double Middle Islands Nature Reserve NR	52	30	91	1,980
	Great Sandy Island NR	11	2	4	69
	North Sandy Island NR	5	1	3	102
	Thevenard Island NR	49	27	77	1,296
	Y Island	<1	<1	<1	<1

Receptors		Probability (%) of dissolved aromatic concentrations ≥ 10 ppb	Probability (%) of dissolved aromatic concentrations ≥ 50 ppb	Maximum dissolved aromatic hydrocarbon concentration (ppb) averaged over all replicate spills	Maximum dissolved aromatic hydrocarbon concentration (ppb) in the worst replicate
	Boullanger, Whitlock, Favourite,Tern & Osprey Islands Nature Reserve	<1	<1	NC	NC
	Buller,Whittell & Green Islands Nature Reserve	<1	<1	NC	NC
	Bernier And Dorre Islands NR	<1	<1	<1	10
Reefs, Shoals and Banks	Ashworth Shoal	<1	<1	<1	<1
	Assail Bank	<1	<1	<1	<1
	Australind Shoal	4	1	2	54
	Barrow Island Reefs and Shoals	10	1	4	64
	Baylis Patches	<1	<1	<1	2
	Beagle Knoll	<1	<1	<1	<1
	Bennett Shoal	<1	<1	<1	<1
	Beryl Reef	<1	<1	<1	3
	Brewis Reef	43	25	43	418
	Camplin Shoal	<1	<1	<1	<1
	Clerke Reef	2	<1	<1	42
	Clio Bank	<1	<1	<1	<1
	Cod Bank	<1	<1	<1	<1
	Combe Reef	18	2	6	82
	Cooper Shoal	<1	<1	<1	<1
	Courtenay Shoal	<1	<1	<1	<1
	Curlew Bank	<1	<1	<1	<1
	Dailey Shoal	26	14	32	551
	Dart Shoal	<1	<1	<1	<1
	Direction Bank	<1	<1	<1	<1
	Dockrell Reef	<1	<1	<1	<1
	Eliassen Rocks	<1	<1	<1	<1
	Exmouth Reef	5	1	3	71
	Fairway Reef	<1	<1	<1	3
	Fantome Shoal §	<1	<1	<1	NC
	Flinders Shoal	4	<1	<1	38
	Fortescue Reef	<1	<1	<1	2
	Gee Bank	<1	<1	NC	NC
	Geelvink Channel Shoals	<1	<1	<1	<1
	Glennie Patches	<1	<1	<1	6
	Glomar Shoal §	22	10	68	1,076
	Gorgon Patch	1	<1	<1	22
	Hammersley Shoal	<1	<1	<1	4
	Hastings Shoal	<1	<1	<1	3
	Hayman Rock	<1	<1	<1	3
	Herald Reef	<1	<1	<1	5
	Hood Reef	1	<1	<1	11

Receptors	Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Imperieuse Reef	2	<1	<1	22
Inner Northwest Patch	1	<1	<1	12
Koolinda Patch	<1	<1	<1	5
Lightfoot Reef	2	<1	<1	20
Little Shoals	3	<1	<1	33
Locker Reef	<1	<1	<1	3
Madeleine Shoals	1	<1	<1	16
Manicom Bank	<1	<1	<1	<1
Mardie Rock	<1	<1	<1	<1
McLennan Bank	<1	<1	<1	4
Meda Reef	2	1	<1	51
Mermaid Reef	1	<1	<1	14
Mid Reef	<1	<1	NC	NC
Montebello Shoals	77	61	233	3,233
Moresby Shoals	1	<1	<1	19
Nares Rock	<1	<1	<1	5
Ningaloo Reef	78	57	226	2,689
North Tail Reef	<1	<1	NC	NC
North West Reef	56	39	101	1,242
North West Reefs	<1	<1	<1	<1
O'Grady Shoal	<1	<1	<1	<1
Otway Reef	16	3	7	142
Outtrim Patches	71	51	273	2,538
Paroo Shoal	2	<1	<1	25
Pearl Reef	<1	<1	<1	2
Pelsaert Bank	<1	<1	<1	<1
Penguin Bank	93	82	360	2,431
Poivre Reef	65	46	164	2,609
Rankin Bank §	84	79	1,649	9,231
Ripple Shoals	23	7	19	590
Roller Shoal	<1	<1	<1	<1
Rosily Shoals	81	65	254	3,094
Saladin Shoal	<1	<1	<1	7
Sand Knoll Ledge	<1	<1	NC	NC
Santo Rock	2	1	2	106
Snapper Bank	<1	<1	NC	NC
South East Reef	<1	<1	NC	NC
South West Reef	<1	<1	NC	NC
Southwest Patch	<1	<1	<1	<1
Spider Reef	<1	<1	<1	8
Stewart Shoal	<1	<1	NC	NC

Receptors	Probability (%) of dissolved aromatic concentrations		Maximum dissolved aromatic hydrocarbon concentration (ppb)	
	≥ 10 ppb	≥ 50 ppb	averaged over all replicate spills	in the worst replicate
Sultan Reef	25	11	17	306
Taunton Reef	25	11	18	275
Tongue Shoals	1	1	<1	67
Trap Reef	61	31	111	1,572
Tryal Rocks	100	100	1,803	14,334
Turtle Dove Shoal	<1	<1	<1	<1
Wapet Shoal	<1	<1	NC	NC
Ward Reef	<1	<1	<1	<1
Web Reef	<1	<1	<1	<1
Weeks Shoal	4	<1	2	34
West Reef	1	<1	<1	18

NC No contact to receptor predicted for specified threshold.

§ Probabilities and maximum concentrations calculated at depth of submerged feature

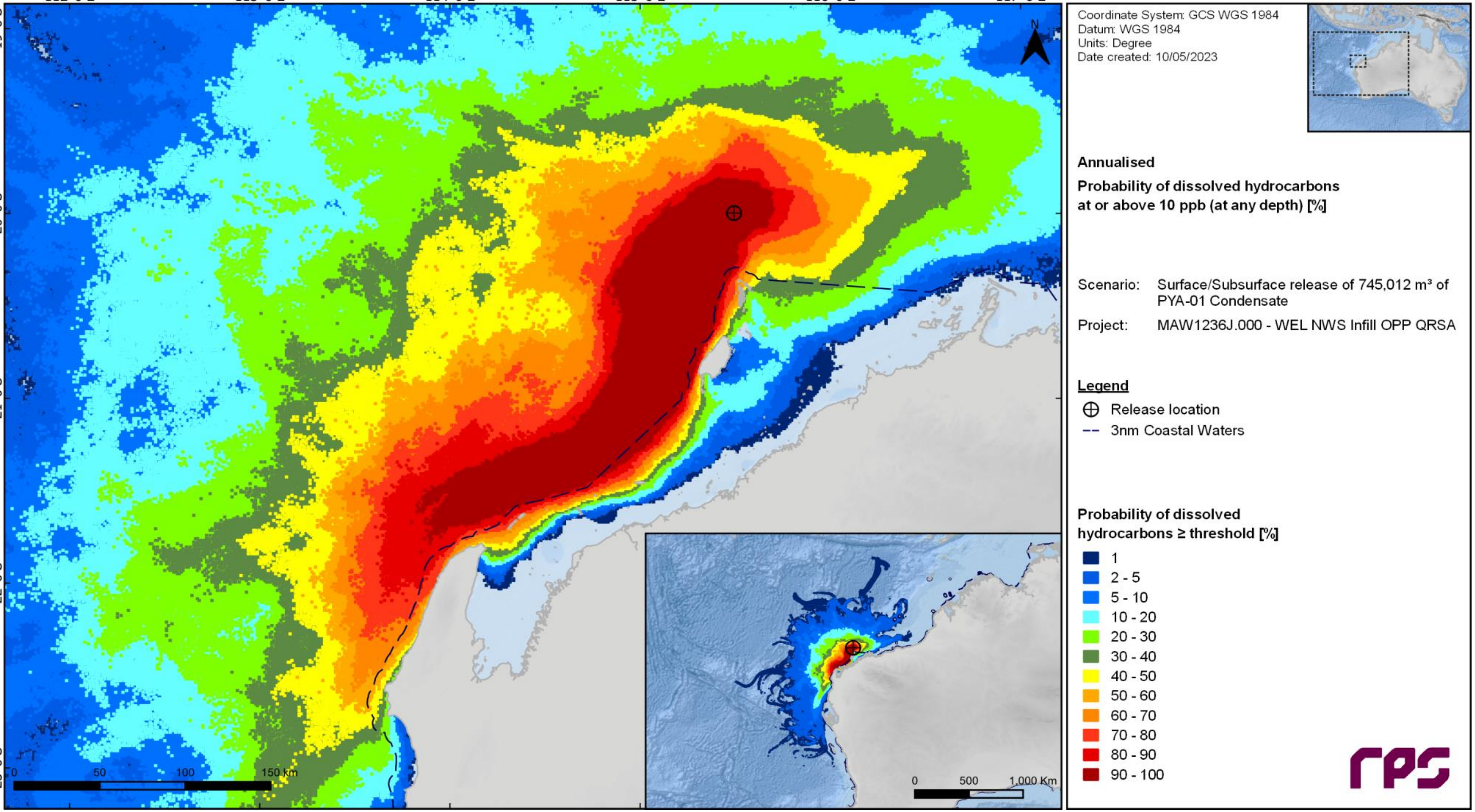


Figure 4.61 Predicted annualised probability of dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

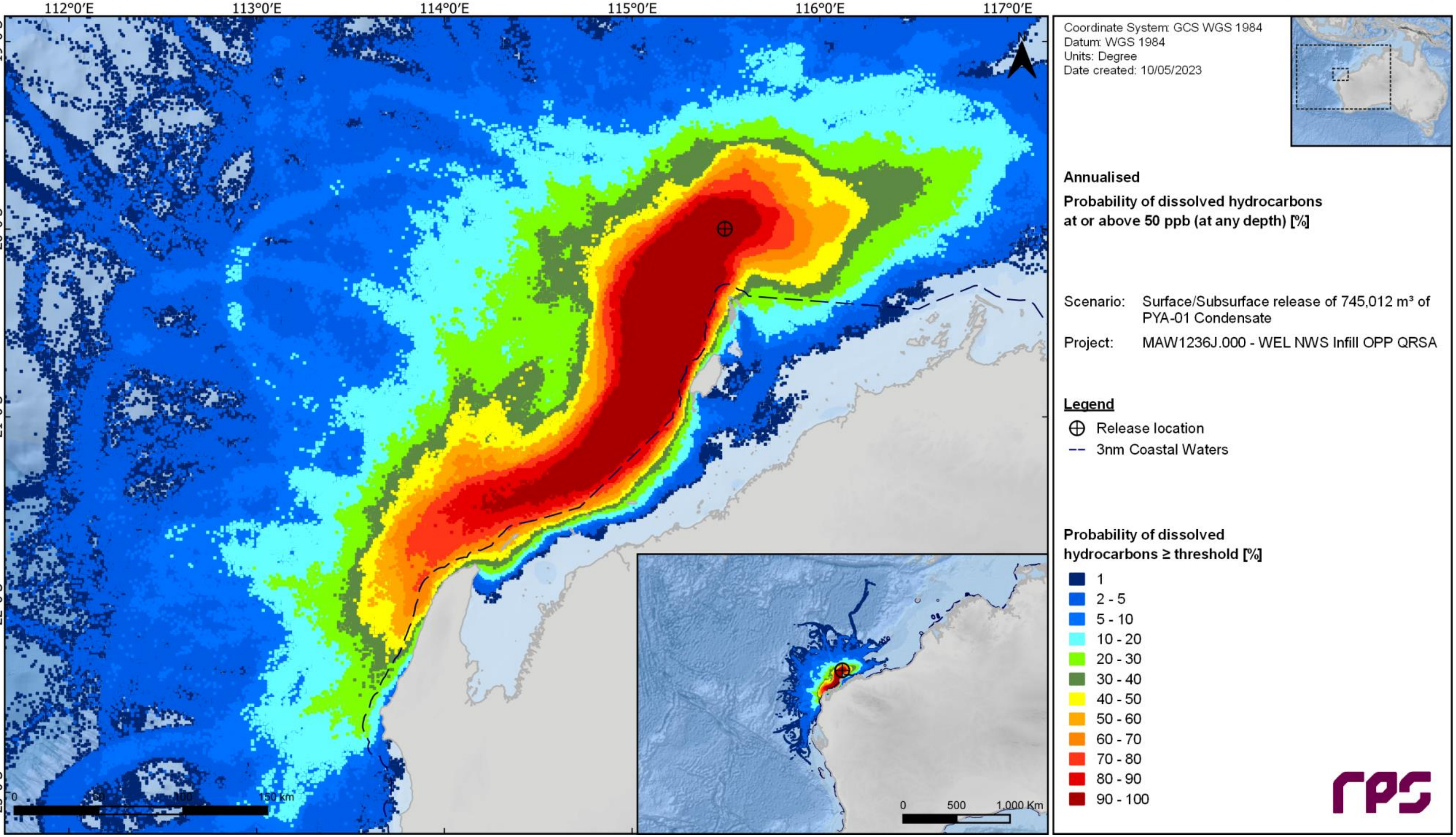


Figure 4.62 Predicted annualised probability of dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

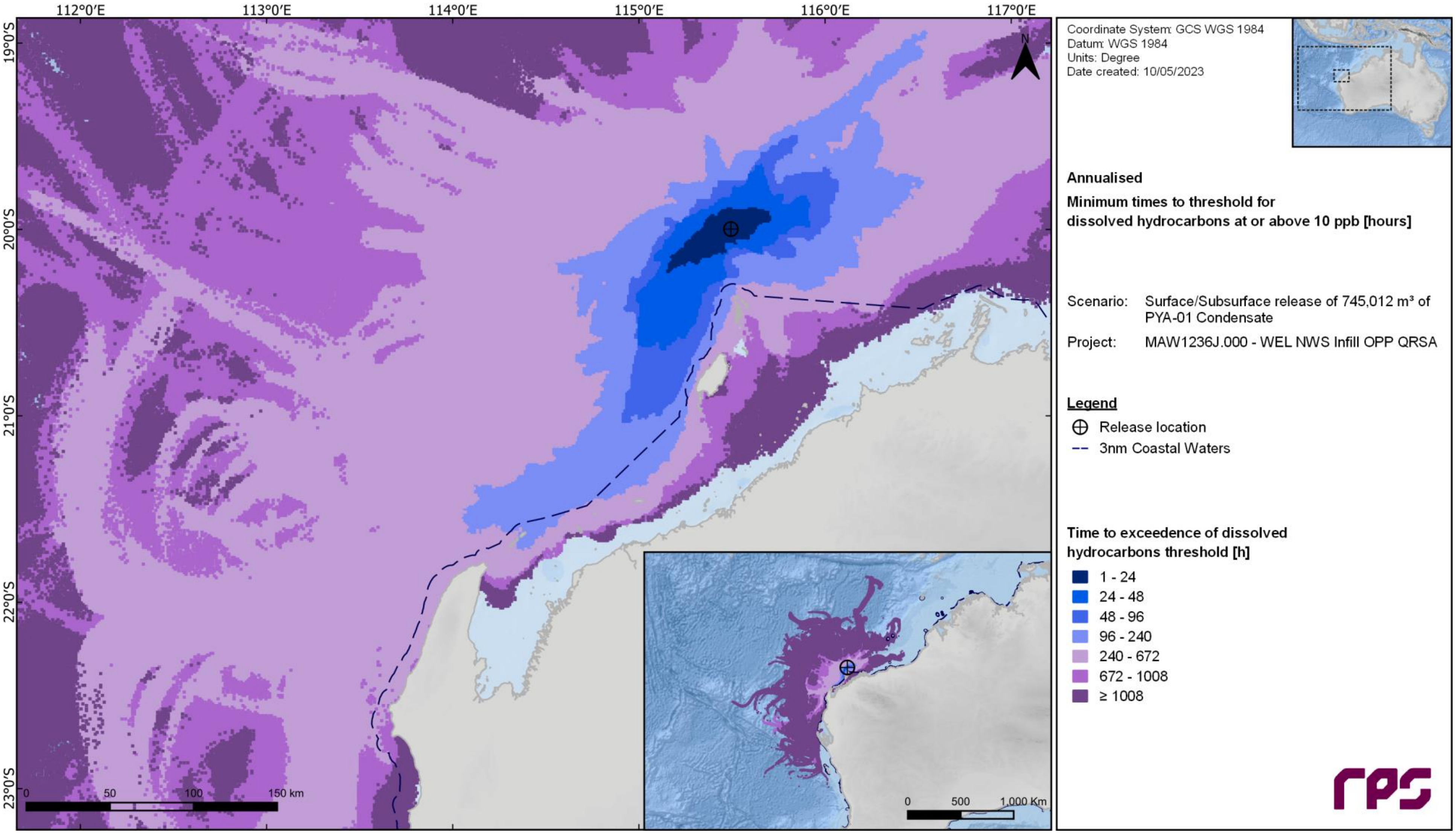


Figure 4.63 Predicted annualised minimum times to contact by dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

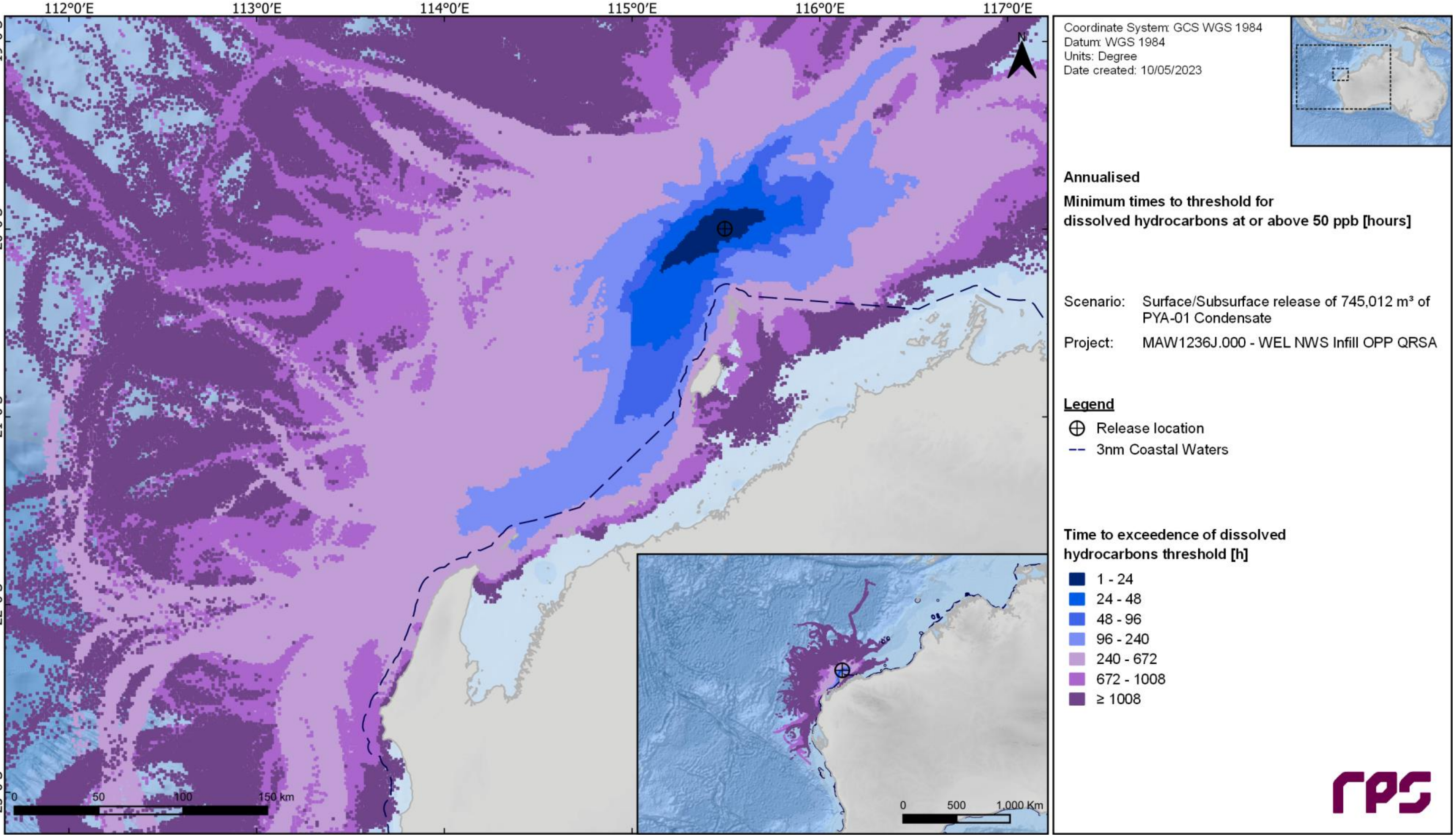


Figure 4.64 Predicted annualised minimum times to contact by dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

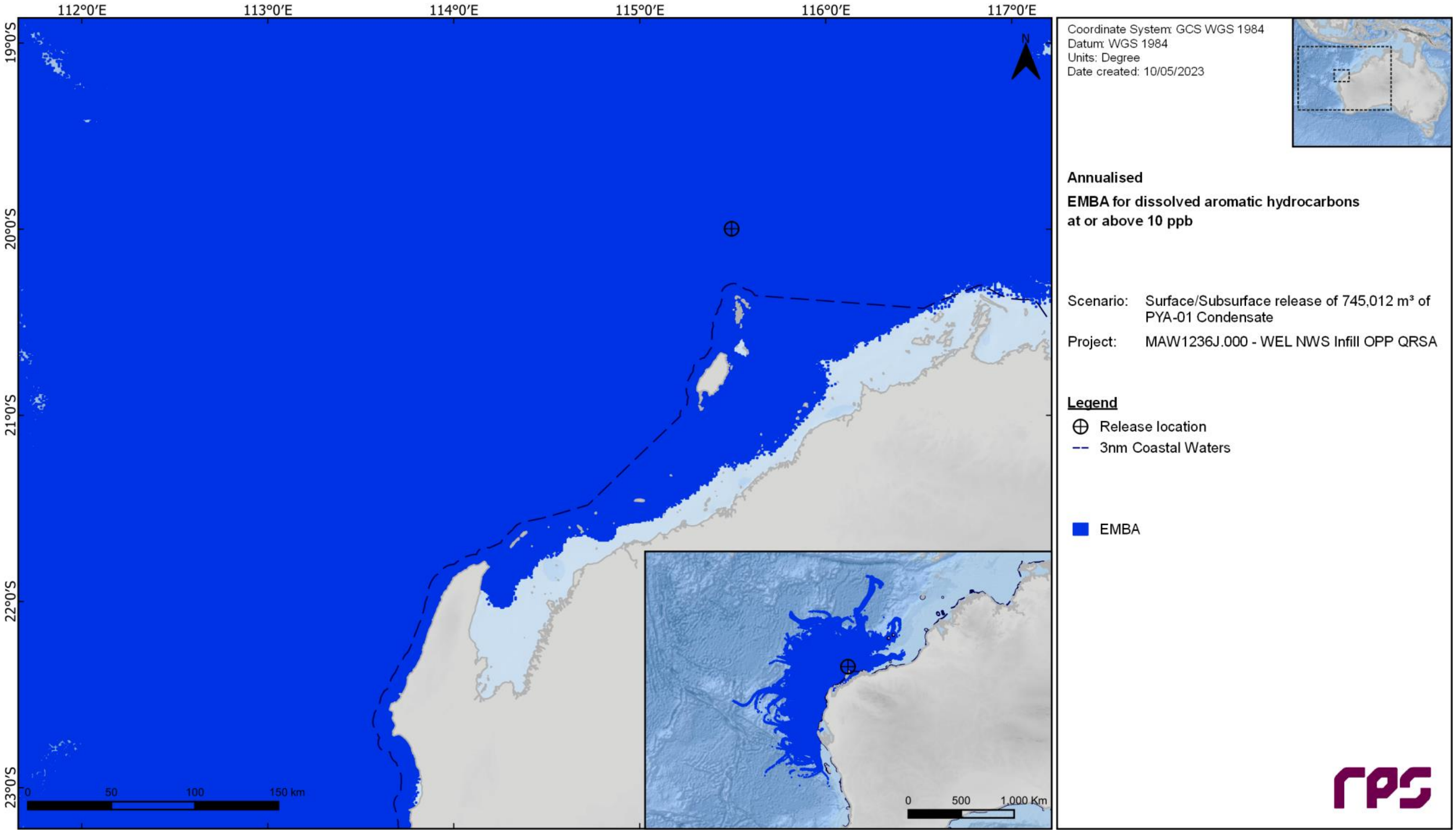


Figure 4.65 Predicted annualised EMBA of dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

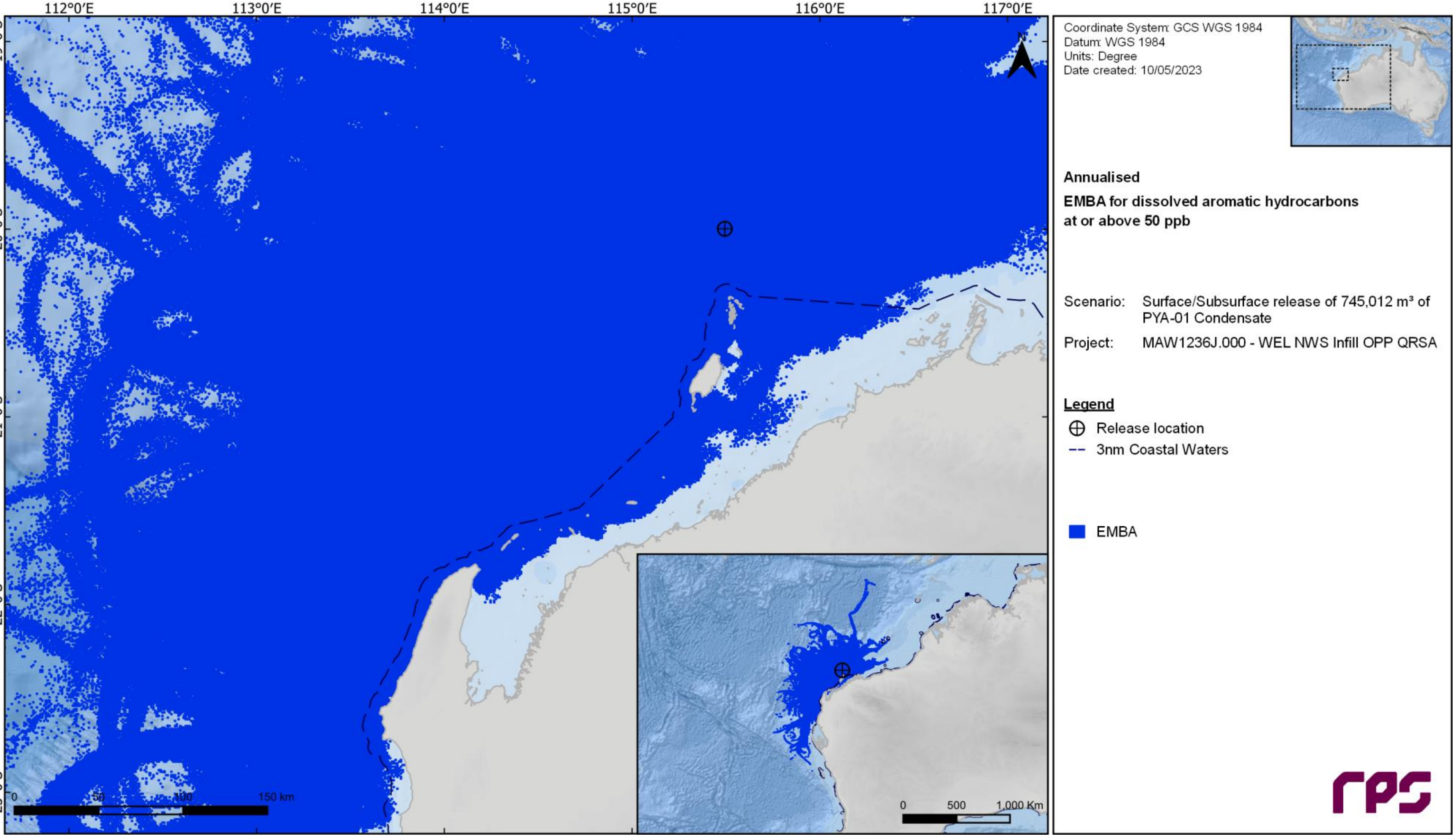


Figure 4.66 Predicted annualised EMBA of dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

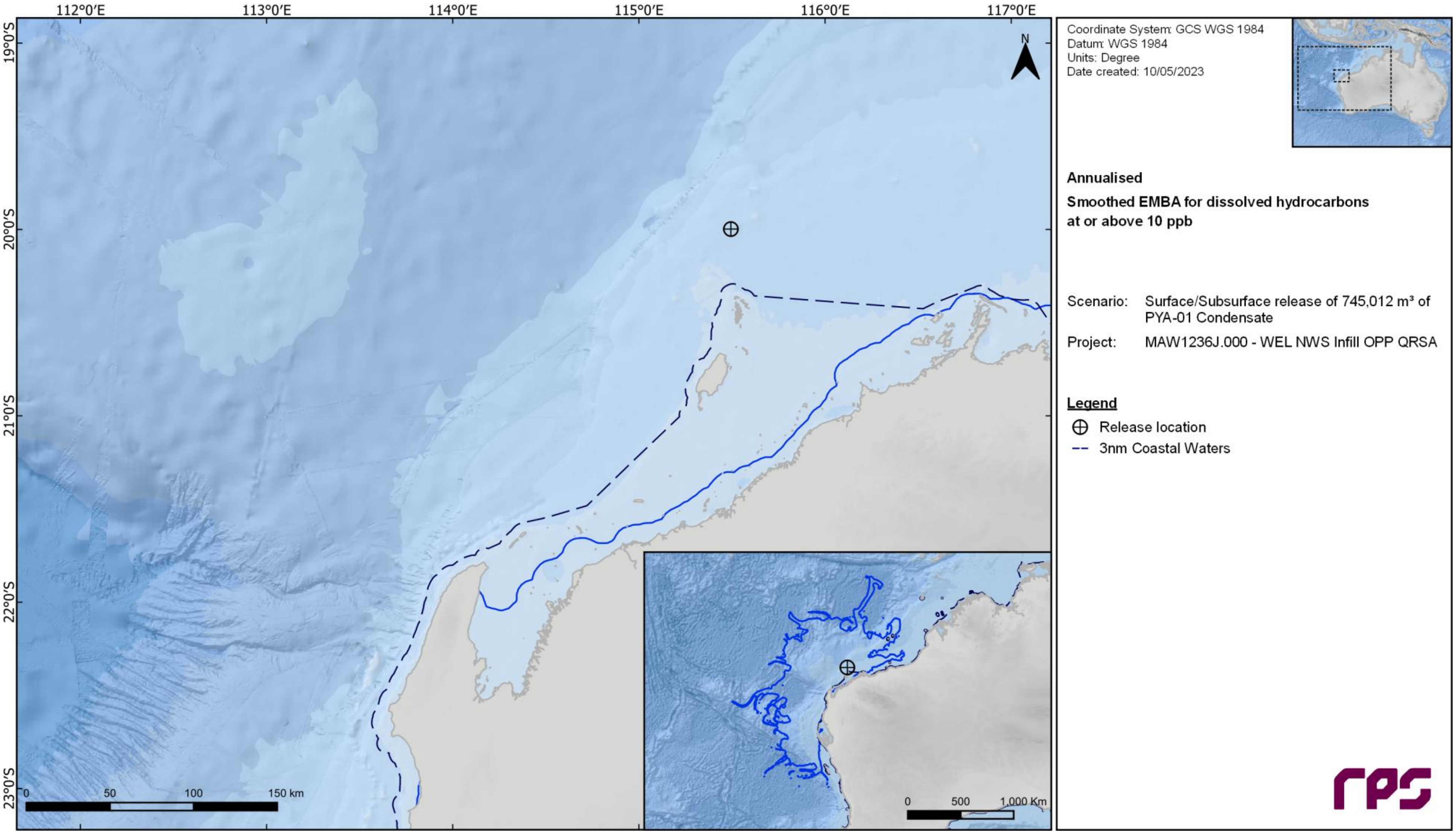


Figure 4.67 Predicted annualised smoothed EMBA of dissolved aromatic hydrocarbon concentrations at or above 10 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

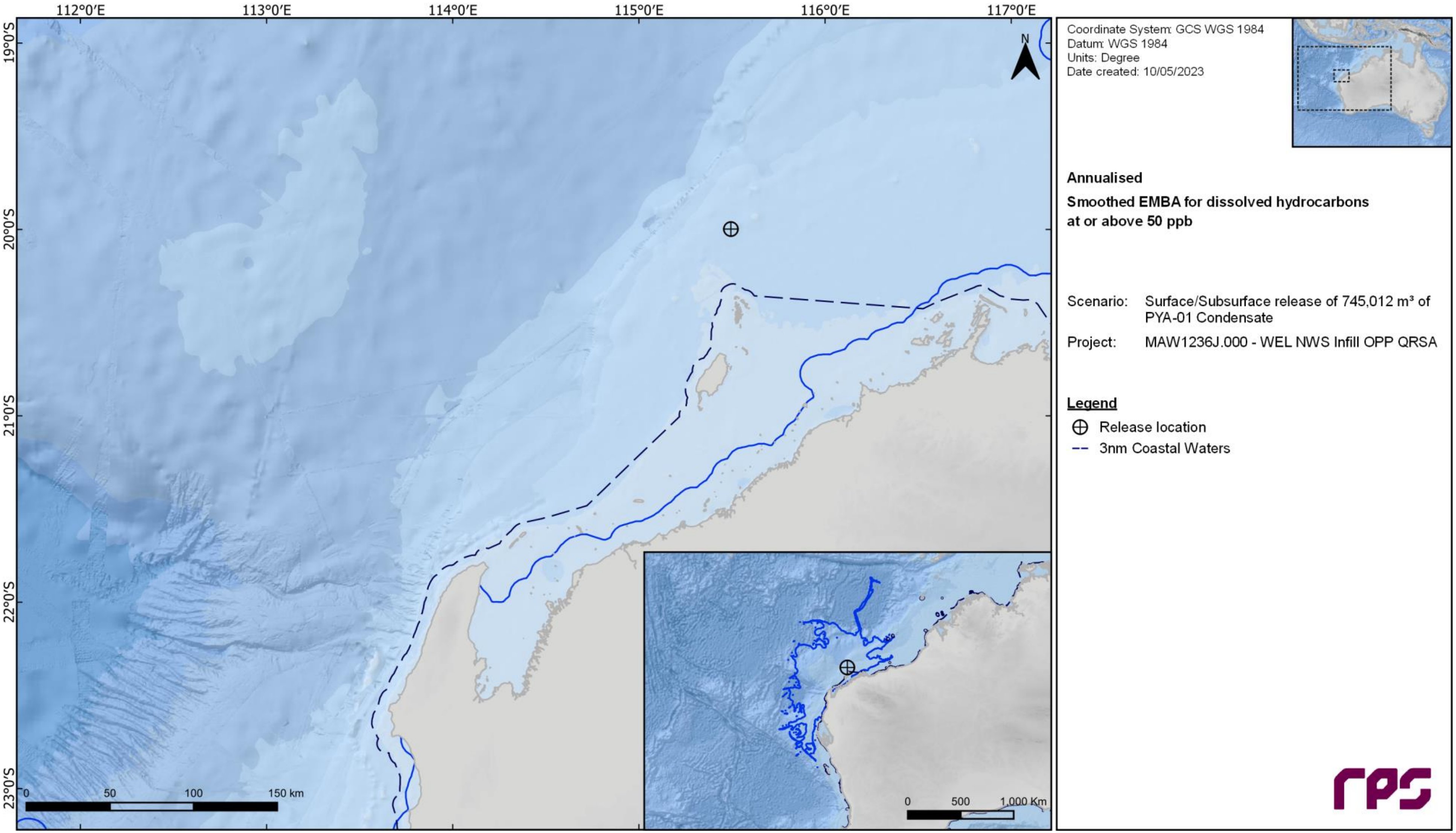


Figure 4.68 Predicted annualised smoothed EMBA of dissolved aromatic hydrocarbon concentrations at or above 50 ppb resulting from Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

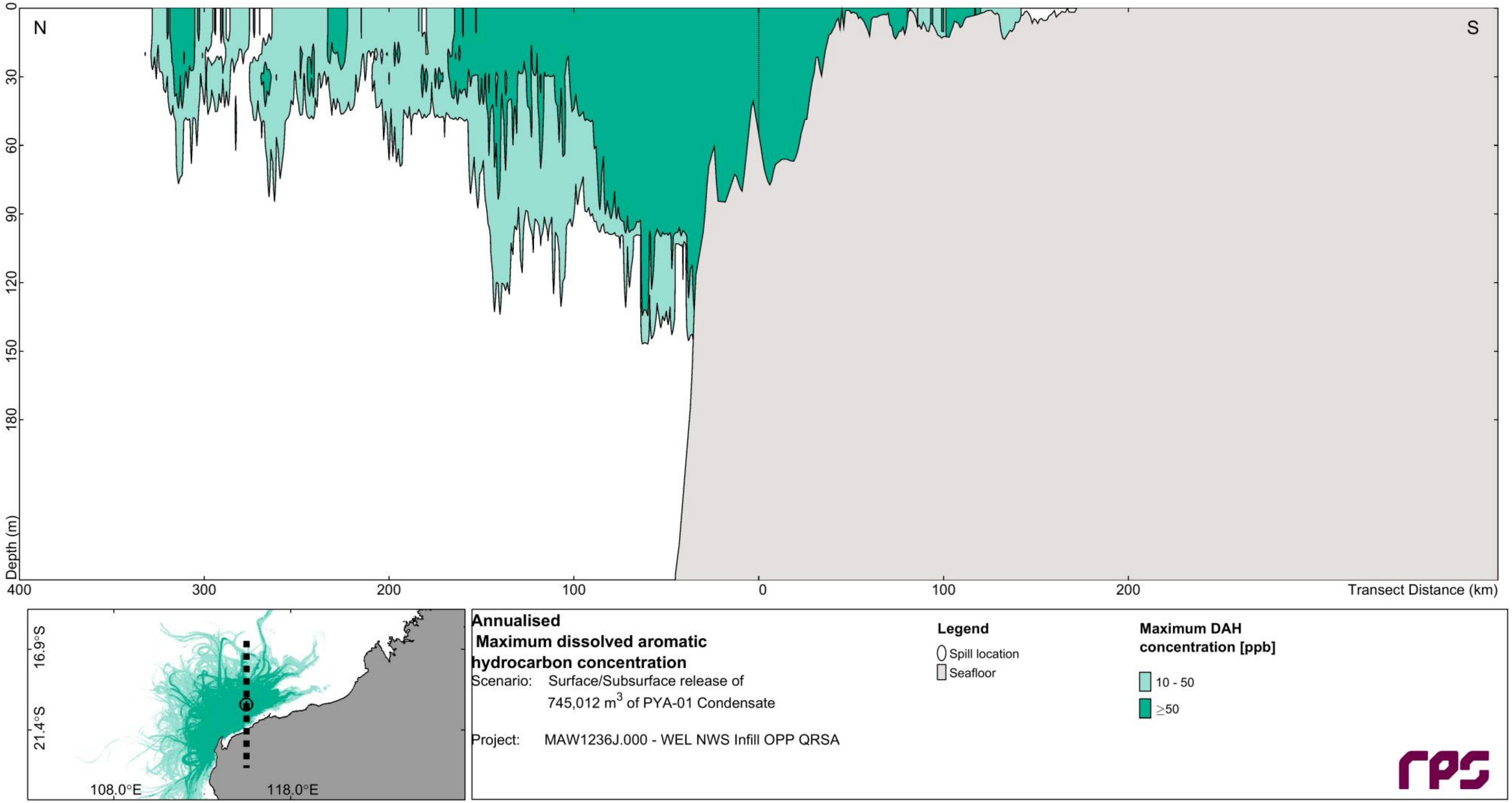


Figure 4.69 North-to-south cross section transect of predicted annualised maximum dissolved hydrocarbon concentration for a Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

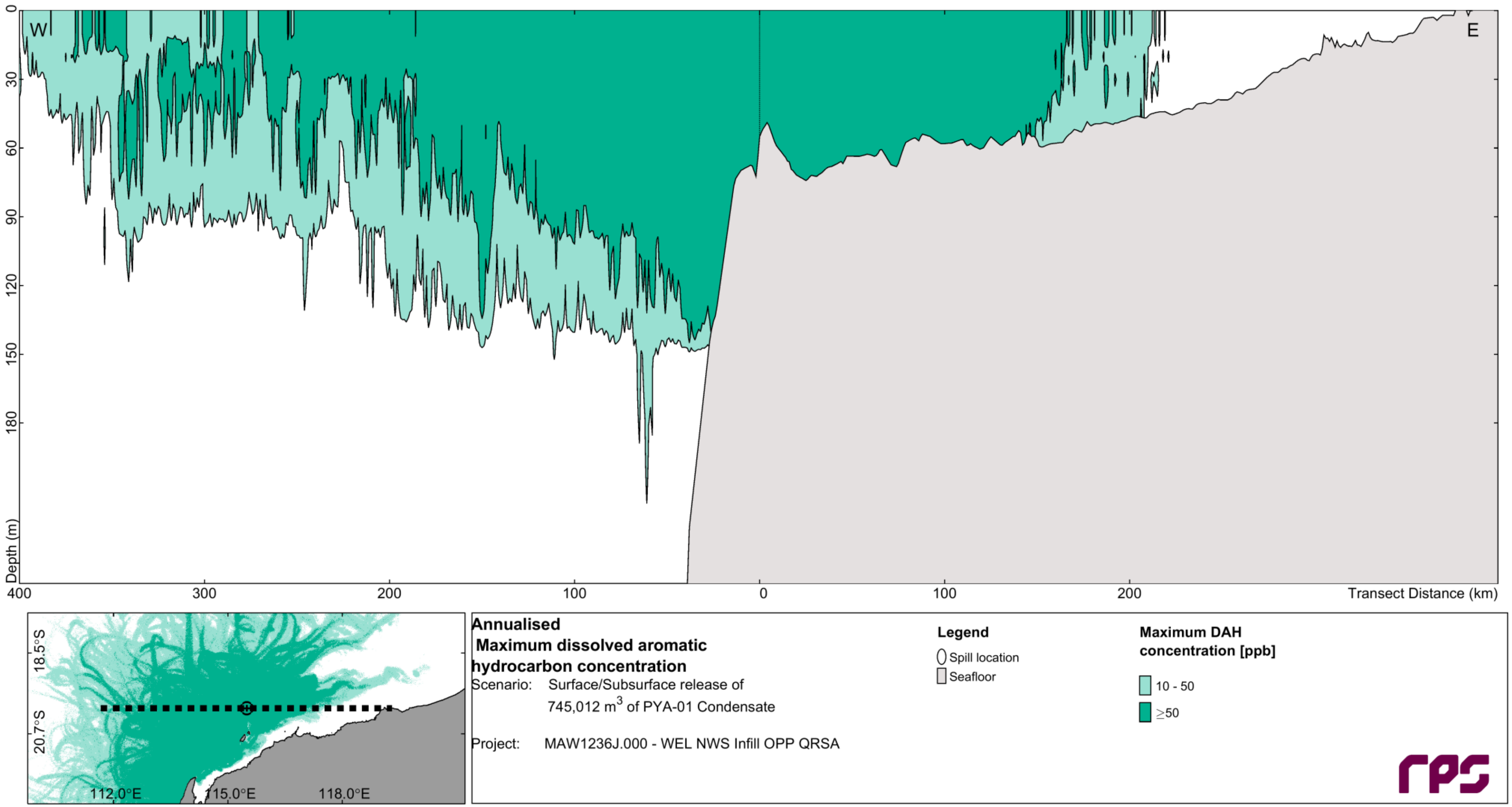


Figure 4.70 West-to-east cross section transect of predicted annualised maximum dissolved hydrocarbon concentration for a Surface/Subsurface release of 745,012 m³ of PYA-01 Condensate.

5 INPUTS TO FINANCIAL ASSURANCE CALCULATIONS

Table 5-1 summarises inputs to NOPSEMA's Environment Assessment Policy (N-04750-PL1347) and Financial Assurance Guideline (N-04730-GL1381) that requires estimates for the worst-case volume of oil accumulating on shorelines.

Table 5-1 Inputs for estimating level of financial assurance for both scenarios, based on the worst-case prediction of oil volume washed ashore (shoreline impact) at concentrations at or above 100 g/m^2.

Scenario	Hydrocarbon Type	Total Spill Volume (m^3)	Oil Volume Washed Ashore (Worst-Case Simulation) (m^3)
Scenario 1A	Condensate	645,721	66
Scenario 1B	Condensate	745,012	66

6 CONCLUSIONS

The main findings of this study are as follows:

Metocean Influences

- Large-scale drift currents will have a significant influence on the trajectory of any oil spilled at the modelled release sites, irrespective of the seasonal conditions. The prevailing drift currents will determine the trajectory of oil that is entrained beneath the water surface.
- Interactions with the prevailing wind will provide additional variation in the trajectory of spilled oil that is afloat at the surface.
- Marked variation in the prevailing drift current and wind conditions will be expected over the duration of a multi-week simulation. This will be expected to increase the spread of hydrocarbon during any single event as well as the range of trajectories that could occur.

Oil Characteristics and Weathering Behaviour

- PYA-01 condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi-volatile components. In favourable evaporation conditions, about 48% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); up to a further 19% could evaporate within the first 24 hours (180 °C < BP < 265 °C); and a further 30% should evaporate over several days (265 °C < BP < 380 °C).
- Physical entrainment will slow down the evaporation of the condensate.
- The aromatic content of the oil is approximately 3%. Dissolution of these water-soluble components will occur from below the surface slicks, and from the entrained droplets generated by wave mixing and released subsea.

Summary of Stochastic Assessment Results

Scenario 1A: 77-day uncontrolled surface/subsurface release of 645,721 m^3 of PYA-01 Condensate

- As the hypothetical spill site is located within Montebello Marine Park, the probabilities of contact for all thresholds tested for floating oil, entrained oil and dissolved hydrocarbons is 100%.
- The combination of low viscosity and high volatility of the condensate is expected to limit the distance that visible films will occur from the source. Floating oil concentrations equal to or greater than the 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds could potentially be found, in the form of slicks, up to 395 km, 270 km and 51 km from the spill site, respectively.
- Floating oil concentrations for thresholds $\geq$ 50 g/m^2 are not predicted to contact any receptors aside from Montebello Marine Park.
- Shoreline oil concentrations for threshold $\geq$ 250 g/m^2 are predicted to contact Peak Island and Southern Pilbara Islands at a 4% probability.
- The worst-case accumulated concentration is predicted as 1,302 g/m^2 at Muiron Island. Up to 44 m^3 of oil was calculated to arrive on any shoreline section over the duration of an event.
- A large proportion of released condensate should entrain. Entrained oil concentrations $\geq$ 10 ppb and 100 ppb thresholds are predicted to be found up to 1,666 km and 1,202 km from the spill site, respectively.
- The greatest probabilities of contact by entrained oil concentrations at $\geq$ 10 ppb threshold are predicted at 100% for Tryal Rocks, Montebello Islands, Barrow Islands and Gascoyne Marine Park.
- At the higher threshold of 100 ppb, Montebello Marine Park is calculated to have 100% probability of contact while Barrow Island is calculated to have 99% probability.

- The maximum entrained oil concentration forecast for any receptor is predicted to be 84,164 ppb at Montebello Marine Park.
- Dissolved aromatic hydrocarbon concentrations $\geq$ 10 ppb and 50 ppb thresholds are predicted to be found up to around 1,286 km and 955 km from the spill site, respectively.
- The greatest probabilities of contact by dissolved aromatic hydrocarbon concentrations $\geq$ 10 ppb are predicted at 100% for Montebello Marine Park and Tryal Rocks. Receptors Gascoyne Marine Park, Ningaloo Marine Park, Barrow Island, Southern Pilbara Island and Penguin Bank all have probabilities of contact more than 90%.
- The worst maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 28,974 ppb at Montebello Marine Park.

Scenario 1B: 77-day uncontrolled surface/subsurface release of 745,012 m^3 of PYA-01 Condensate

- The combination of low viscosity and high volatility of the condensate is expected to limit the distance that visible films will occur from the source. Floating oil concentrations equal to or greater than the 1 g/m^2, 10 g/m^2 and 50 g/m^2 thresholds could potentially be found, in the form of slicks, up to 385 km, 271 km and 54 km from the spill site, respectively.
- Floating oil concentrations for thresholds $\geq$ 50 g/m^2 are not predicted to contact any receptors aside from Montebello Marine Park.
- Shoreline oil concentrations for threshold $\geq$ 250 g/m^2 are predicted to contact Peak Island and Southern Pilbara Islands at a 4% probability.
- The worst-case accumulated concentration is predicted as 3,133 g/m^2 at Muiron Island. Up to 44 m^3 of oil was calculated to arrive on any shoreline section over the duration of an event.
- A large proportion of released condensate should entrain. Entrained oil concentrations $\geq$ 10 ppb and 100 ppb thresholds are predicted to be found up to 1,667 km and 1,206 km from the spill site, respectively.
- The greatest probabilities of contact by entrained oil concentrations $\geq$ 10 ppb threshold are predicted at 100% for Tryal Rocks, Montebello Islands, Barrow Islands and Gascoyne Marine Park.
- At higher threshold of 100 ppb, Montebello Marine Park and Tryal Rocks is calculated to have 100% probability of contact.
- The maximum entrained oil concentration forecast for any receptor is predicted to be 85,992 ppb at Montebello Marine Park.
- Dissolved aromatic hydrocarbon concentrations $\geq$ 10 ppb and 50 ppb thresholds are predicted to be found up to around 1,250 km and 975 km from the spill site, respectively.
- The greatest probabilities of contact by dissolved aromatic hydrocarbon concentrations $\geq$ 10 ppb are predicted at 100% for Montebello Marine Park and Tryal Rocks. Receptors Gascoyne Marine Park, Ningaloo Marine Park, Barrow Island, Southern Pilbara Island and Penguin Bank all have probabilities of contact more than 90%.
- The worst replicate of maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 24,018 ppb at Montebello Marine Park.
- As the hypothetical spill site is located within Montebello Marine Park, the probabilities of contact for all thresholds tested for floating oil, entrained oil and dissolved hydrocarbons is 100%.

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