

Lord Howe Island Critical Infrastructure Project

Coastal and Marine Ecology Assessment



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Acronyms and Abbreviations

Term	Full term
AFFF	Aqueous Film Forming Foams
ANZG	Australian and New Zealand guidelines for fresh and marine water quality
BC Act	<i>Biodiversity Conservation Act 2016</i>
BCH	Benthic communities and habitats
CLM Act	<i>Contaminated Land Management Act 1997</i>
CM Act	<i>Coastal Management Act 2016</i>
CMEA	Coastal and Marine Ecological Assessment
CSSI	Critical State Significant Infrastructure
CSMF	Conservation Significant Marine Fauna
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DGVs	Default guideline values
EAC	East Australian Current
EEPL	Exotic Environmental Pest List
EIS	Environmental Impact Statement
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
FM Act	<i>Fisheries Management Act 1994</i>
IMO	International Maritime Organization
IMP	Introduced Marine Pests
IMS	Introduced Marine Species
KEF	Key Ecological Features
KTP	Key threatening process
LHI	Lord Howe Island
LHIB	Lord Howe Island Board
LHIMP	Lord Howe Island Marine Park
LoR	Limit of reporting
m	Meter
MARPOL	International Convention for the Prevention of Pollution from Ships

MEMA Act	<i>Marine Estate Management Act 2014</i>
MFO	Marine fauna observer
MNES	Matters of National Environmental Significance
NIMPIS	National Introduced Marine Pest Information System
NSW	New South Wales
PFAS	Per- and polyfluoroalkyl substances
POEO Act	<i>Protection of the Environment Operations Act 1997</i>
PSD	Particle size distribution
PTS	Permanent Threshold Shift
SEARs	Secretary's Environmental Assessment Requirements
the Project	Lord Howe Island Critical Infrastructure Program aspects relevant for development consent
TSS	Total suspended solids
TTS	Temporary Threshold Shift
WMF	Waste management facility
WWTP	wastewater treatment plan

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1. Introduction

1.1. Project description

The New South Wales (NSW) Department of Climate Change, Energy, the Environment and Water ('NSW DCCEEW' or 'Proponent'), on behalf of the Lord Howe Island Board (LHIB) proposes the construction, operation and maintenance of new marine infrastructure, cargo handling facility, biosecurity infrastructure and waste management facility on Lord Howe Island, and associated landscape and vegetation restoration.

The Proponent seeks development consent for the Project as Critical State Significant Infrastructure (CSSI) under Division 5.2, subdivision 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Project is a controlled action (2025/10188) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and will be assessed under the bilateral agreement between the NSW and Commonwealth Governments.

The Project is part of the broader Lord Howe Island Critical Infrastructure Program; however, the aspects being considered within this report comprise the construction, operation and maintenance of the following on Lord Howe Island:

- Freight handling facility which includes new and upgraded marine infrastructure (new piled vessel ramp and upgraded jetty and boat ramp), boat wash down and maintenance area, cargo loading/offloading areas, biosecurity infrastructure, adaptive reuse of the 'Old Cargo Shed' and 'Ocean View' heritage buildings, viewing area, picnic area, landscaping, retaining walls, amenities and vehicle and boat trailer parking.
- Waste management facility (WMF) upgrades which includes new storage sheds and materials processing facilities (including for organic material), wastewater treatment plant (WWTP) and waste receival area (including chemical and hazardous waste), hardstand and roads, staff office, and selective dune restoration at the existing WMF.
- Dedicated dog kennels to house detection dogs.
- Self-service fuel bowser along Old Lagoon Road.

The Project Area comprises the North Zone and the South Zone as shown in Figure 1 and Figure 2. The North Zone includes marine and land-based infrastructure, including a freight handling facility, a piled vessel ramp and biosecurity infrastructure. The South Zone includes the WMF, dog kennels and fuel bowser.

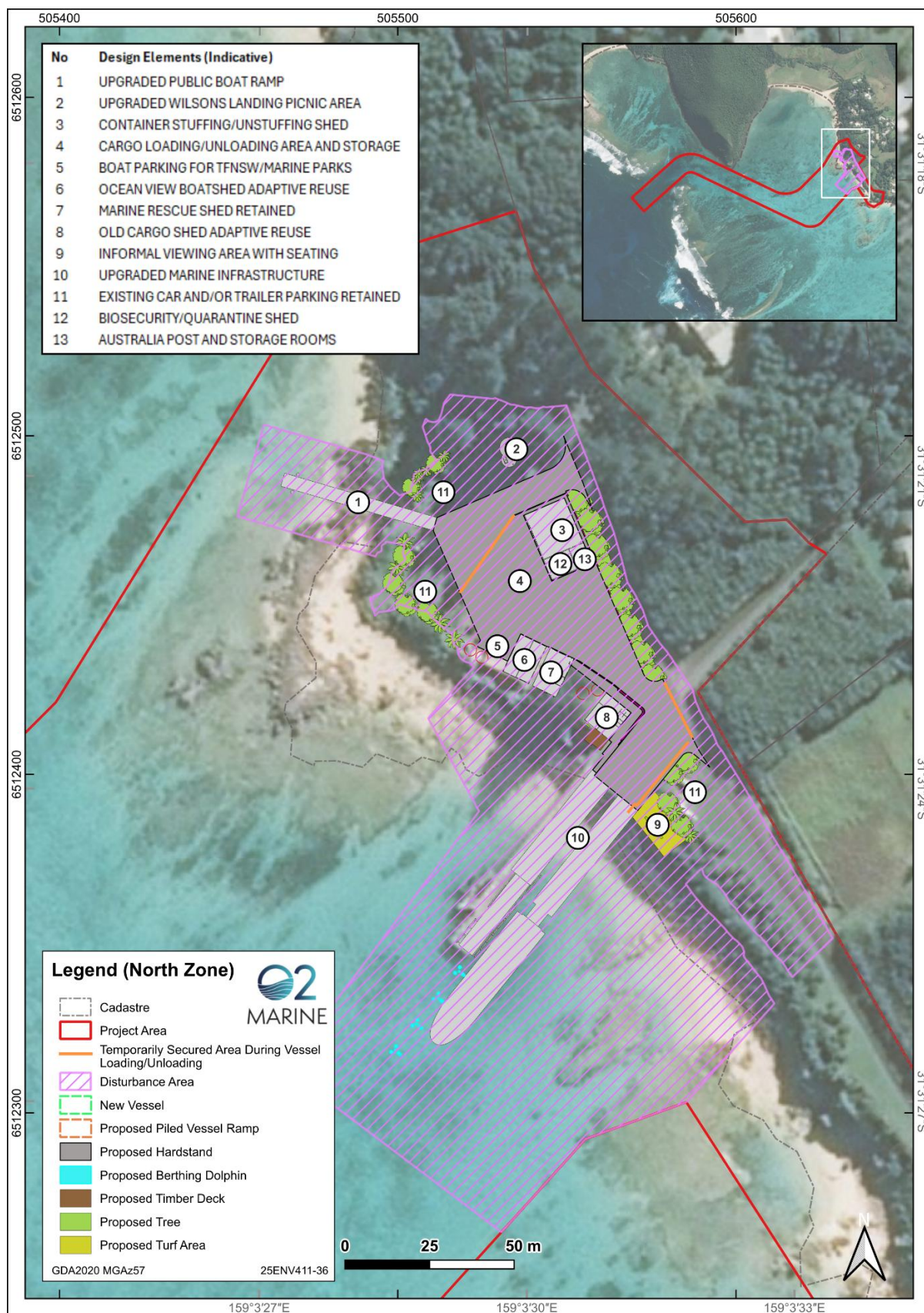


Figure 1: Project layout (North Zone)

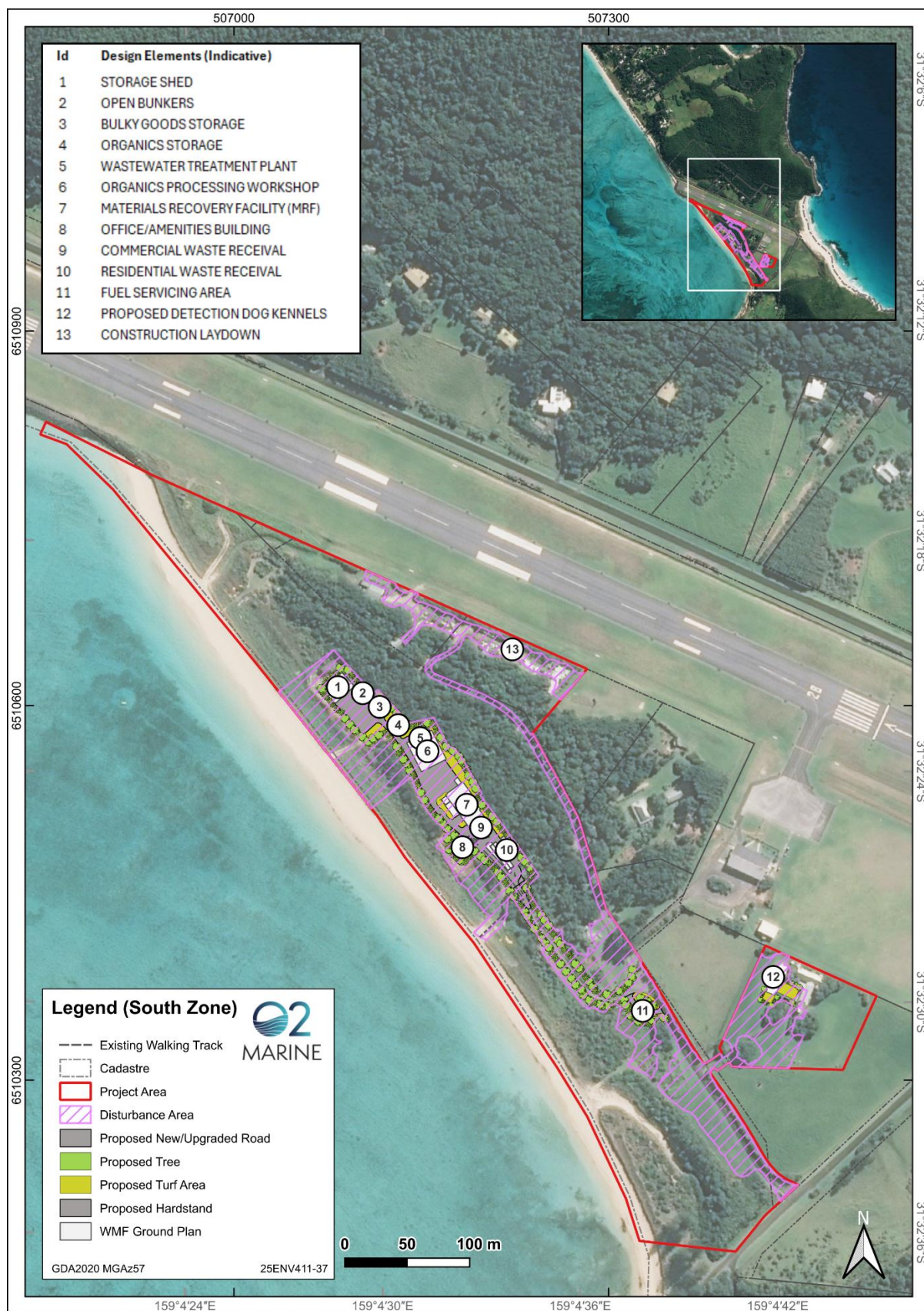


Figure 2: Project layout (South Zone)

1.2. Objectives

This document provides a Coastal and Marine Ecology Assessment (CMEA) for the aspects of the Lord Howe Island (LHI) Critical Infrastructure Project (the Project) that are the subject of the Environmental Impact Statement (EIS), for development consent as stated in Section 1.1. The CMEA includes the following tasks:

- Compile and report on data collected during coastal and marine field surveys carried out for the Project to derive baseline information to support the EIS.
- Undertake a literature review of relevant background documentation to characterise the existing coastal and marine environment to support the EIS.
- Prepare a coastal and marine ecology impact assessment which satisfies the Secretary's Environmental Assessment Requirements (SEARs) requirements (Application Number SSI-78107213: DPHI 2025).

This document addresses potential impacts to the coastal and marine environment only and does not address the terrestrial environment. This document also excludes seabirds and migratory shorebirds as this has been addressed in the Biodiversity Development Assessment Report (SLR 2025).

1.3. Document Structure

Results from baseline field surveys carried out by consultants BMT for the Project have been summarised into separate technical reports within the appendices based on the following ecological distinctions:

- Appendix A: Marine Environmental Quality
- Appendix B: Benthic Communities and Habitats
- Appendix C: Conservation Significant Marine Fauna Desktop Assessment
- Appendix D: Fish Field Study Summary

A literature review of information relevant to the existing coastal and marine environment of LHI and the Project area is provided in Section 3.

SEARs key issue 2. Biodiversity items 4 - 7 presented in Table 1 are identified as the primary requirements to be addressed within this CMEA. Item 7 involves addressing all comments relevant to coastal and marine ecology provided from the assessment undertaken in accordance with the bilateral assessment agreement between the Australian and NSW governments under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act, Amending Agreement No. 1, 2020). A summary of the items to be addressed from the EPBC Act referral (EPBC 2025/10188, SSI-78107213) relevant to coastal and marine ecology is provided in Table 2.

It is noted that thorough evaluation of items identified in item 7 correspond to many key issues identified in the SEARs which have also been considered in developing the impact assessment. Consolidation of regulatory Project risks is provided in Section 3.

Table 1: Key Issue and Requirements being addressed in this report

Key Issue and Desired Performance Outcome relevant to this Report	Specific assessment requirements	Section of report this requirement is addressed
2. Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity, compensation / or supplementary measures are assured to mitigate residual impacts of construction and operation.	4. Prepare a threatened aquatic species assessment (under Part 7A of Fisheries Management Act 1994 (FM Act)) to address whether there are likely to be any significant impacts on listed threatened species, populations or ecological communities listed under the FM Act.	Section 4.7, Appendix C
	5. Identify whether the project, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the BC Act, FM Act and the Commonwealth's EPBC Act	Section 4.7, Appendix C
	6. Assess impacts to the ecological and biological values of the Lord Howe Island Marine Park during construction and operation, including impacts to threatened species such as (but not limited to) the Black rockcod, Ballina angelfish, Elegant wrasse, Bluefish, Syngnathids, marine mammals, marine reptiles and seabirds.	Section 4
	7. Assess impacts to Matters of National Environmental Significance, in accordance with Australian government advice.	Section 4

Table 2: Matters of National Environmental Significance relevant to Coastal and Marine Ecological impacts to be addressed from the EPBC Act referral (EPBC 2025/10188, SSI-78107213)

Key Impact Activities & Protected Matters	Details of Impact Activities & Protected Matters	Section of report this requirement is addressed
There are likely to be significant impacts on World Heritage (sections 12 and 15A) and National Heritage Values of a national heritage place (sections 15B and 15C)	Construction and operation of the proposed action is likely to have significant impacts on the water quality, visual amenity, and species of conservation significance to the values of Lord Howe Island Group World Heritage Area and National Heritage Place.	Section 4.1, 4.7 Appendix C
The following matters protected under Part 3 are possibly at risk of being impacted	Black Rockcod, Black Cod, Saddled Rockcod (<i>Epinephelus daemeli</i>) – Vulnerable Whitesnout Anemonefish, McCulloch's Anemonefish (<i>Amphiprion mccullochi</i>) – Critically Endangered White Shark, Great White Shark (<i>Carcharodon carcharias</i>) – Vulnerable Leatherback Turtle (<i>Dermochelys coriacea</i>) – Endangered Green Turtle (<i>Chelonia mydas</i>) – Vulnerable Hawksbill Turtle (<i>Eretmochelys imbricata</i>) – Vulnerable Flatback Turtle (<i>Natator depressus</i>) – Vulnerable Loggerhead Turtle (<i>Caretta caretta</i>) – Endangered Giant Manta ray (<i>Mobula birostris</i>) – Migratory Bryde's Whale (<i>Balaenoptera edeni</i>) – Cetacean, Migratory	Section 4.7 Appendix C
The proposed activities may have significant impacts upon the above mentioned listed threatened species and listed migratory species via	- Clearing and modification of habitat through the removal of native vegetation and/or the clearing and levelling of sites, excavations and general construction activities. - Accidental spills, erosion and sedimentation, and dust pollution due to construction activities causing a decline in habitat quality, resulting in the long-term decline or loss of habitat and consequently, species numbers. - Construction activities, including noise, lighting and vibration impacts.	Section 3.1

Key Impact Activities & Protected Matters	Details of Impact Activities & Protected Matters	Section of report this requirement is addressed
	- Fauna mortality from vehicle/vessel strike associated with construction and/or ongoing operation. - Underwater noise from pile driving during construction, vessel usage during construction and increased vessel usage after construction. - Vehicular and vessel movements during construction and operations introducing and/or spreading weeds, pest species or pathogens, resulting in long-term decline or loss over time of habitat and consequently, species numbers. - Seabed disturbance, leading to impacts on prey species.	
The proposed activities may have significant impacts upon the World Heritage and National Heritage values of a national heritage place via:	- Reducing diversity or modifying the composition of plant and animal species in all or part of a World Heritage property. - Fragmenting, isolating or substantially damaging habitat important for the conservation of biological diversity in a World Heritage property. - Impacts on biosecurity. - Pollution into the waterways and surrounding oceanic environment during the construction and ongoing use of the proposed action. - Consumption of plastic waste material by sea birds. - Long term viability of the proposed action under climate change projections including potential threats from sea level rise and storm surge on the project infrastructure (including risk of spills/pollution on surrounding environment). - Impacts on the marine environment which are not covered in referral documentation including marine biodiversity, sea floor construction and transport of materials over a sensitive marine area.	Section 3.1
For each of the EPBC Act listed threatened species and listed migratory species impacted by the proposed action, the EIS should provide the following information:	Survey results including details of the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Commonwealth guidelines and policy statements.	Section 4.7 Appendix C

Key Impact Activities & Protected Matters	Details of Impact Activities & Protected Matters	Section of report this requirement is addressed
	• A description and quantification of habitat in the study area (including suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival, which should also be considered across life stages of species). • Information on proposed avoidance and mitigation measures to deal with the impacts of the action, and a description of the predicted effectiveness and outcomes that the avoidance and mitigation measures will achieve. • A description of the nature, geographic extent, magnitude, timing and duration of any likely direct, indirect and consequential impacts on any relevant EPBC Act listed species and communities. It must clearly identify the location and quantify the extent of all impact areas to each relevant EPBC Act listed species or communities.	
The EIS should provide the following information:	• Full assessment of impacts to the marine environment, including impacts to the sea floor and coral within the Lord Howe Island Lagoon and marine biodiversity. • Mapping demonstrating the 'bare sand zone' and the extent of the coral within the marine component of the northern project area would assist in determining if there is potential significant impacts. • Full assessment of not only threatened species but also other endemic species which are protected for World Heritage value under the EPBC Act.	Section 4 Section 2.6 Section 4.8

1.4. Policy and guidance

1.4.1. State

The following legislation, Guidelines and Plans are relevant to this assessment:

- *Environmental Planning and Assessment Act 1979*
- *Environmental Planning and Assessment Regulation 2021*
- *Lord Howe Island Act 1953*
- *Biodiversity Conservation Act 2016* (BC Act)
- *Fisheries Management Act 1994* (FM Act)
- *National Parks and Wildlife Act 1974*
- *Contaminated Land Management Act 1997* (CLM Act)
- *Coastal Management Act 2016* (CM Act)
- *Protection of the Environment Operations Act 1997* (POEO Act)
- State Environmental Planning Policy (Biodiversity and Conservation) 2021 (BC SEPP)
- *Marine Estate Management Act 2014* (MEMA Act)
- Bilateral agreement made under section 45C of the EPBC Act: Amending the Original Agreement relating to environmental assessment (Amending Agreement No. 1 2020)

Guidelines:

- State Significant Infrastructure Guidelines (DPHI 2024)
- Cumulative Impact Assessment Guidelines for State Significant Projects (DPHI 2022)
- Guidelines for developments adjacent to national parks and other reserves (NPWS 2020)
- Policy and guidelines for fish habitat conservation and management (DPI 2013)
- Threatened species test of significance guidelines (OEH 2018)
- Reducing coastal threats to marine biodiversity (DPE 2022a)
- Controlled activities – Guidelines for instream works on waterfront land (DPE 2022b)
- NSW Coastal Design Guidelines 2023 (DPE 2023)
- Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC 2006)
- Neutral or Beneficial Effect on Water Quality Assessment Guideline (WaterNSW 2022)
- Managing Urban Stormwater: Soils and construction – Volume 1 (Landcom 2004)

Plans:

- Lord Howe Island Biodiversity Management Plan (DECC 2007).
- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022).
- Operational Plan for the Lord Howe Island Marine Park (MPA 2004)
- NSW Invasive Species Plan 2023-2028 (DPI 2023)
- Lord Howe Island Local Environmental Plan 2010 (NWS 2024)

1.4.2. Commonwealth

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Biosecurity Act 2015*

Guidelines:

- EPBC Act – Environment Assessment Process (DCCEEW 2010)
- National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a)
- EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DEWHA 2008a)
- National Light Pollution Guidelines for Wildlife (DCCEEW 2023)
- Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPaC 2011)

Plans:

- Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012)
- Temperate East Marine Parks Network Management Plan (DNP 2018)
- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018)

1.4.3. Other

Guidelines:

- SA Underwater Piling Noise Guidelines (DPTI 2012)
- Great Barrier Reef Underwater Noise Guideline Discussion and Options Paper (McPherson et al 2017)
- Lord Howe Island Biosecurity - Visiting Vessels Guidelines (LHIB 2020)
- Lord Howe Island: Information for Yachts and small craft visiting Lord Howe Island World Heritage Area and Lord Howe Island Marine Park (DPI 2022).

Plans:

- Strategic Plan for the Lord Howe Island Group World Heritage Property (LHIB 2010).
- UNESCO Statement of Outstanding Universal Value Property ID: 186
- Nomination of The Lord Howe Island Group by the Commonwealth of Australia for inclusion in the World Heritage List (1981)

2. Existing Environment

2.1. Lord Howe Island Marine Park

The Lord Howe Island Marine Park (LHIMP) covers an area of approximately 480 km², located 600 km from the coast of NSW (Harasti et al. 2022). The LHIMP includes numerous ecosystems spanning a wide range of habitats and biological communities. These include estuarine ecosystems, lagoons, fringing reef, intertidal, shallow subtidal, pelagic and shelf ecosystems including coral communities. There are also slope ecosystems though these are mainly outside of the LHIMP.

The zoning plan for the LHIMP protects representative areas of these habitats in sanctuary and habitat protection zones to ensure their conservation. Indication of sanctuary and habitat protection zones near the North Zone where marine infrastructure is located is shown in Figure 3.

2.1.1. Values

In accordance with the SEARs document, the impacts need to be assessed for the values of the LHIMP. These environmental values have previously been described in Harasti et al. (2022) and will be used here. These include the following:

Physical values

- Humid and sub-tropical climate.
- Diverse and unique geomorphology.
- Unique oceanography including the eastward flow of the Eastern Australian Current (EAC) contributing to the combination of temperate and sub-tropical species found in the LHIMP.
- High water visibility and quality.

Ecological and biological values

- Numerous ecosystems spanning a wide range of habitats and biological communities.
- Southernmost records of coral reef distribution in the world.
- Macrophytes are common and diverse.
- Diverse fish assemblage.
- Marine invertebrates have a high level of diversity.
- Several threatened species and protected species and communities are supported.
- Other significant species are also supported within the LHIMP.

Existing information for each of these values have been collated in this document (Section 2). The physical environmental values of LHI do not function in isolation but are intricately interconnected, often influencing and reinforcing one another. These physical attributes are closely linked to the island's ecological and biological values, and while natural values may be reviewed individually for clarity, any assessment of associated threats should account for their interdependencies and the cumulative nature of potential impacts. Therefore, physical values have been summarised in this document to aid in understanding the potential impacts to the ecological and biological values. Potential impacts to the ecological and biological values from Project construction and operational activities have been identified in Section 3.

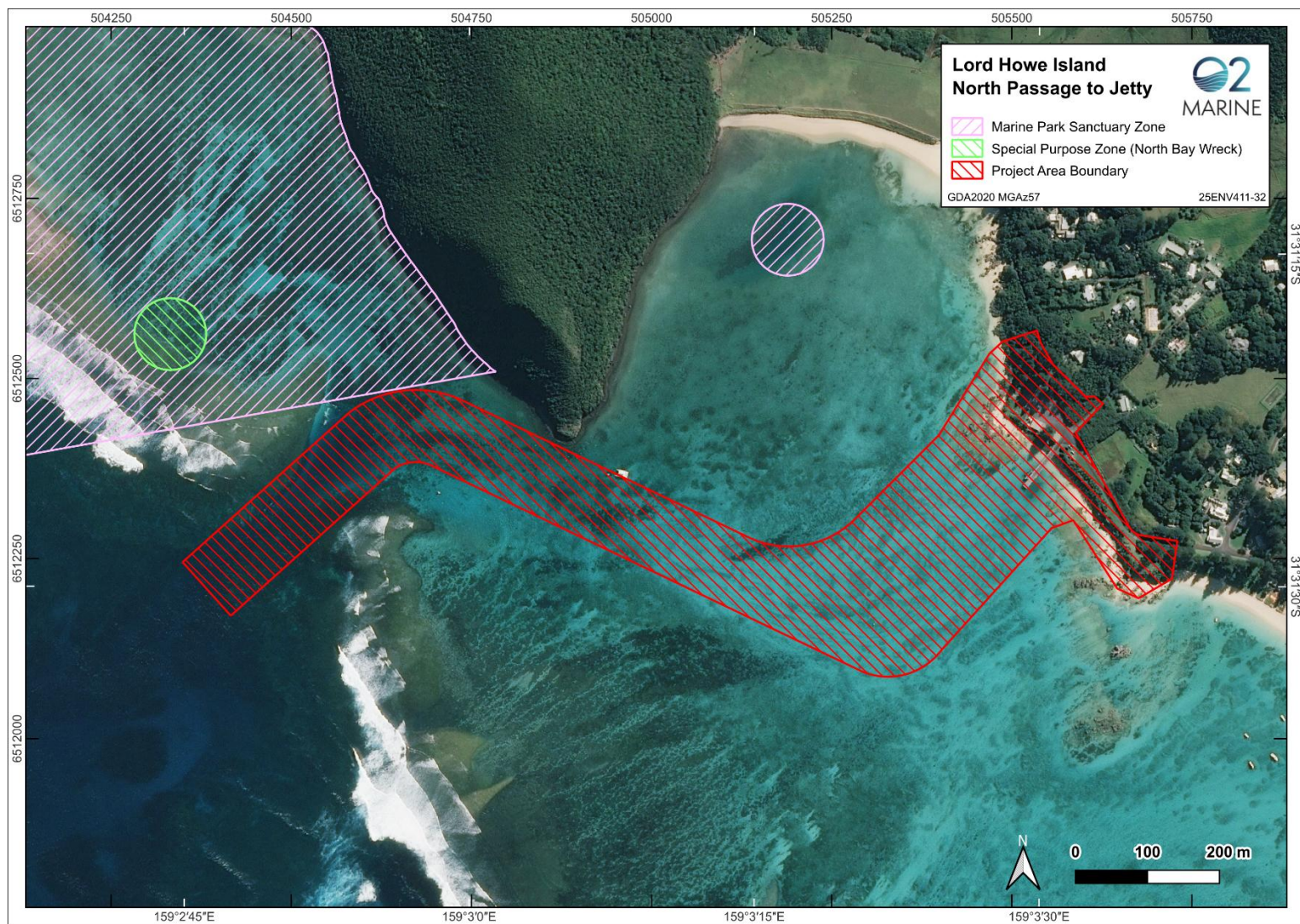


Figure 3: Sanctuary and special purpose zones near the Project area within the LHIMP

It is also noted that the LHI Group was inscribed on the World Heritage List under two of the criteria for natural values of outstanding universal significance:

- (vii) containing superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance. and
- (x) containing the most important and significant natural habitats for *in-situ* conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

Its World Heritage values relevant to the marine environment are:

- The unusual combination of tropical and temperate marine flora and fauna, including many species at their distributional limits, reflecting the extreme latitude of the coral reef ecosystems which are the southern-most true coral reefs in the world
- The diversity of marine benthic algae species, which include many endemic species
- The diversity of marine fish species including at least 500 species of which 400 are inshore species and 15 are endemic
- The diversity of marine invertebrate species, including more than 83 species of corals and 65 species of echinoderms of which 70% are tropical, 24% are temperate and 6% are endemic.

These values are also addressed in this report as they are also covered under those of the LHIMP described above.

2.1.2. Areas of conservation significance

As described above, the LHI Group is a recognised World Heritage Property, and a National Heritage Place. Adjacent and connecting to the State managed LHIMP are two Commonwealth Marine Park areas; a National Park Zone located on the east of the island and a Habitat Protection zone (Figure 4).

2.1.3. Key ecological features

Key ecological features (KEFs) are elements of the Commonwealth marine environment that are of regional importance for either a regions' biodiversity or its ecosystem function and integrity. The Protected Matters Search Tool research results showed there were two KEFs within the search area used for Matters of National Environmental Significance (MNES) (including 10 km buffer): Lord Howe seamount chain and Tasman Front and eddy field (DSEWPAC 2012).

2.2. Climate

The climate of the LHIMP has been previously summarised by Harasti et al (2022) as humid and sub-tropical. Based on data from the LHI Airport weather station from 1988 to 2025, the mean monthly maximum temperature ranges from 19 °C in winter to 26 °C in summer (BoM 2025). Mean rainfall is higher in late autumn to early winter, with a maximum monthly mean of 163 mm (June) though monthly means are at least 100 mm each month of the year. Monthly mean wind speeds are similar throughout the year with afternoon wind speeds only slightly higher than in the morning (BoM 2025). Wind direction does alter through the seasons, with wind coming from the northeast and east in summer and autumn, and from the southwest in winter and spring. The region also experiences major storms and cyclone activity with storms occurring throughout the year (Harasti et al 2022).

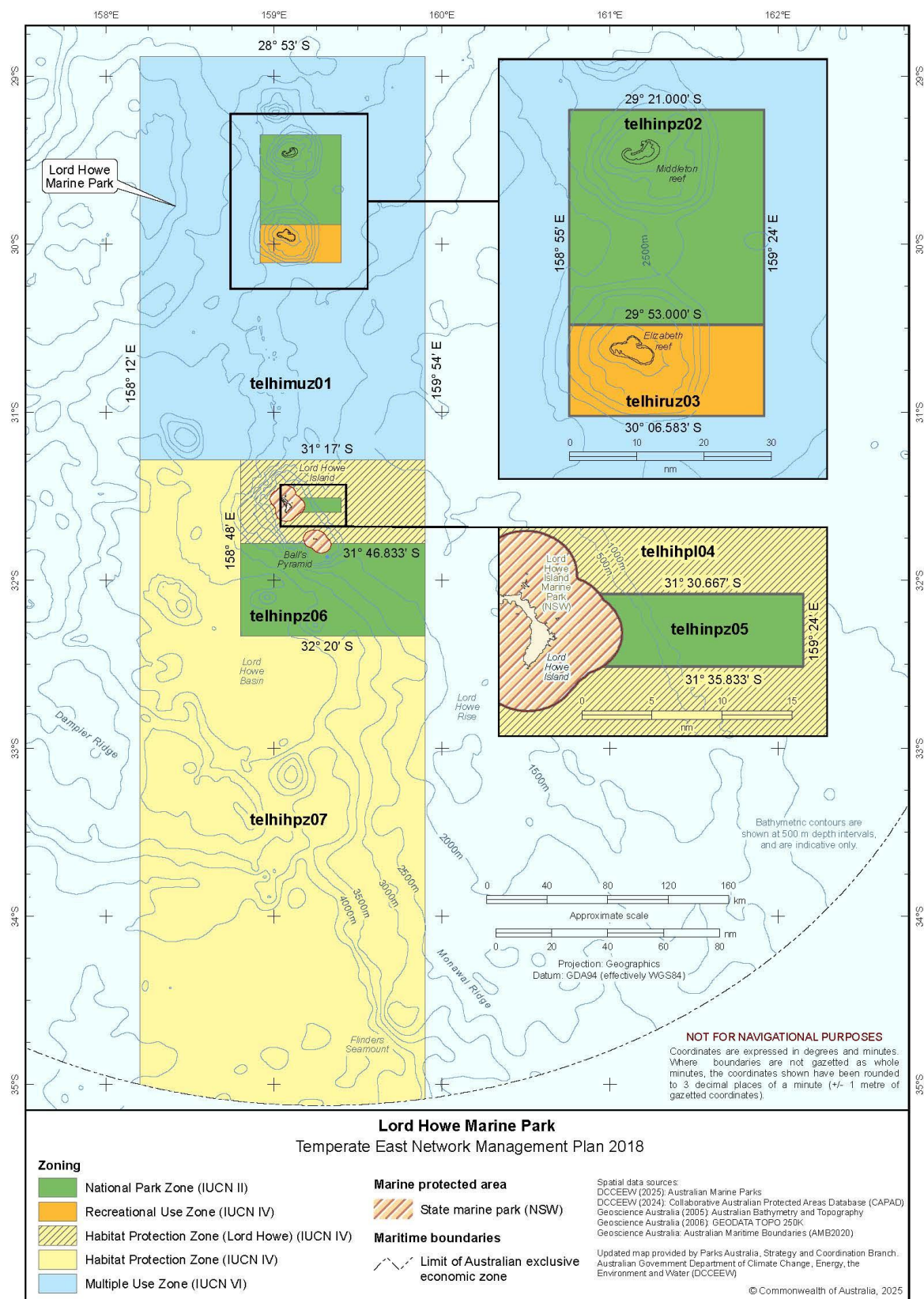


Figure 4: Protected zones within and surrounding LHI

2.3. Geology and geomorphology

LHI, as well as Balls Pyramid to the south of LHI, were formed as shield volcanoes approximately 6 to 7 million years ago as part of a chain of islands and seamounts along the Lord Howe Rise (McDougall et al 1981). Over time, the islands move northwards into warmer waters, where corals were able to form approximately 120,000 years Before Present.

On the LHI shelf, a large fossil barrier reef (155 km²) comprises approximately one-third of the 504 km² shelf. This barrier reef encircles the mid-shelf in 25 – 50 m water depth, and drill cores indicated that the upper portion is Holocene, likely forming a capping over an older reef (Harasti et al 2022). On the mid and upper shelf in 30 to 60 m depth, sedimentary basins occur, infilled with up to 25 m of carbonate sediment (Brooke et al 2010).

LHI originated as a larger volcano compared to Balls Pyramid and remains larger following the erosion over time. There is also a greater area of inner shelf bedrock and reef outcrops in shallow waters at LHI, providing more habitat for corals now and into the future with rising sea levels, while Balls Pyramid seems to have decreased in rate of growth. However, it is estimated that the modern rates of calcification at both LHI and Balls Pyramid are lower than those at higher latitude coral reefs.

2.4. Oceanography

2.4.1. Tidal regime

The coastal waters around LHI experience a mixed semi-diurnal tide, with two high and low tides of different size each day. The mean spring tide range is 1.51 m and neap tide range is 0.81 m (Harasti et al 2022). Tide predictions can also have anomalies (positive or negative changes to predicted heights), thought to be due to the East Australian Current.

2.4.2. Waves

Monthly averaged total significant wave heights vary between 1.9 m and 2.7 m (Harasti et al 2022). The largest wave heights occur over the winter months, when the swell and sea are at their highest. Swell direction is generally from the south-southwest to southeast during the year, though the sea direction varies from the east-northeast to southeast during summer and autumn, and from west-southwest to southeast during winter and spring. Swell periods are generally 9 s and sea periods are 3 to 4 seconds.

2.4.3. Currents

The main current influencing the waters around LHI is the EAC which travels south along the shelf until it turns eastward towards the Lord Howe Rise at approximately 30-40°S. This EAC bring sub-tropical waters south to LHI, and then the Tasman Front flows with subantarctic waters from the south up to meet the EAC.

2.5. Water visibility and quality

2.5.1. Physicochemical

LHI is renowned for pristine ocean water quality, supported by consistently clear, well-flushed marine conditions. Several studies have been undertaken within the area, including a recent field survey undertaken surrounding the Noth Zone in February 2025 by BMT (see Appendix A).

The monthly average sea surface temperature in the LHIMP ranges from 19.2°C in August to 24.5°C in February (CSIRO 2009). Field sampling in February 2025 by BMT (Appendix A) found water temperatures ranged between 25.0°C and 26.2°C, with an average of 25.5°C, which supports previous records, including a summer monthly average of 24.5°C (CSIRO 2009), 25.4°C (Davis *et al.* 2020), and a peak daily average of 26.8°C at Sylph's Hole in February 2019 (Moriarty *et al.* 2023). Previous abnormal increases in sea surface temperatures have also been recorded. Notably, during the 2009/2010 summer, a marine heatwave that resulted in a coral bleaching event was recorded where sea surface temperatures exceeded 28°C—approximately 2–3°C above the typical seasonal maximum for 19 consecutive weeks (Dalton *et al.* 2020 and Harrison *et al.* 2011).

Dissolved oxygen levels vary inversely with temperature, with values recorded by CSIRO (2009) ranging from a minimum of 211.2 µmol/kg (equivalent to 6.76 mg/L) in March to a maximum of 225.6 µmol/kg (7.22 mg/L) in August. Higher dissolved oxygen concentrations were recorded by Davis *et al.* (2020) with values reaching 8.61 mg/L in summer and 9.91 mg/L in winter. The field survey in February 2025 recorded dissolved oxygen in percentage, with a range of 107.5% and 125.6% at the impact sites (within the lagoon in the vicinity of the Project area) and 110.4% and 121.6% at the reference sites (deeper outside of the lagoon area), which equates to similar to Davis *et al.* (2020) though they are above the dissolved oxygen NSW guideline trigger values of between 90% and 110% (ANZG 2018).

Salinity remains relatively stable throughout the year, consistently measured between 35.6 and 35.7 PSU previously by CSIRO (2009). The February 2025 field survey found salinity was slightly higher than CSIRO (2009) with results ranging between 36.9 and 37.2 ppt across the sites.

pH data was not available from previous studies, however the field survey recorded pH ranging between 7.8 and 8.1 at the impact sites, and between 8.1 and 8.2 at the reference sites. The NSW trigger guideline value range for pH in marine waters is between 8.0 and 8.4 (ANZG 2018) which indicates some sites were below the lower trigger guideline value for the region.

Turbidity ranged between 0.1 and 7.4 NTU within the nearshore sampling sites (impact sites) and between 0 and 4.8 NTU within the reference sites further offshore. The NSW trigger guideline value for turbidity in marine waters is 0.5 NTU (ANZG 2018) indicating some sites were above the trigger guideline value for the region. However, this trigger value was developed based on one main dataset from data collected in the Sydney and Hunter regions and may not be relevant to LHI.

2.5.2. Toxicants and total suspended solids

Metals within the marine waters of LHI has been poorly studied, with no information found for this assessment. The field survey in February (Appendix A) found most metal concentrations at the two sites were below the laboratory's limit of reporting (LoR).

A study by Moriarty *et al.* (2023) in waters surrounding LHI found nitrogen levels ranged from 0.006 to 1.377 $\mu\text{mol/kg}$ (equivalent to 0.00008 to 0.019 mg/L), while phosphorus concentrations varied between 0.123 and 0.272 $\mu\text{mol/kg}$ (0.0038 to 0.0084 mg/L), reflecting natural monthly fluctuations in nutrient availability. This is likely due to the large temporal variability in the EAC flow which travels southward along the shelf edge up to 30-40°S before turning eastward towards the Lord Howe Rise.

The LHIMP Draft Management Plan (DCCEEW 2023) notes that a nutrient analysis conducted in 1994 found seawater nutrient concentrations around the island to be generally low, reflecting good water quality. However, evidence of high nutrient levels in the water table shows potential for increased nutrient levels to occur in reef sites associated with seepage or springs following heavy rainfall on the Island. The field survey by BMT (Appendix A) found these toxicants, including NH_3 , total suspended solids (TSS) and hydrocarbons were reported at low concentrations, remaining below default guideline values (DGVs) within the Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018). Similarly, nutrient parameters such as TN, NO_3^- , NO_2^- , TP, FRP, TKN, NO_x^- and Chl-a were also recorded at low concentrations, below their relevant DGVs. Therefore, recent sampling of waters around the Project area found results similar to those previously studied.

The LHIB and the NSW EPA investigated on potential per- and polyfluoroalkyl substances (PFAS) contamination as part of the State-wide PFAS Investigation Program (NSW EPA 2018), due to the historical use of PFAS-containing Aqueous Film Forming Foams (AFFF) on the Island, particularly between 1975 and 2015 at the airport and during a training event at the lagoon in 2000. Preliminary testing has detected PFAS in soil and groundwater near the airport, lagoon, and depot—locations consistent with past AFFF use. While background PFAS levels from domestic or industrial sources may also contribute, further investigations involving additional soil, sediment, and water sampling, including residential bores, are planned to determine the extent of contamination and any necessary management measures. The field survey results within the Project area found PFAS from BMT (Appendix A) were below DGVs from ANZG (2018).

2.5.3. Sediment quality

A study conducted by Haskoning (2014) determined that approximately 99% of beach and lagoon sediments within the LHI consist of carbonate material, primarily originating from the skeletal remains of marine organisms. Particle size distribution (PSD) results by BMT (Appendix A) are consistent with previous findings, indicating the area consisted of predominantly sand (mean 87%), with the next highest particle size being gravel (mean of 9.6%), and smaller amounts of clay (mean = 2.7%). In terms of sediment quality, concentrations of metals and metalloids were generally low and remained below the ANZG (2018) DGVs. Hydrocarbon levels were also reported to be low and within acceptable limits, while PFAS concentrations were below the LoR at all sampled sites.

For benthic infauna, previous information is available from Anderson *et al.* (2008) a study on the shelf surrounding LHI with 2,139 individuals from 163 taxa collected and analysed. The top three most abundant taxa across all sites were the *Maeridae* ($n = 607$), the *Kalliapseudidae* ($n = 425$), and the *Ampelisca toora* ($n = 40$). Overall low infaunal species richness was recorded across the LHIMP; however, it also revealed a high proportion of rare, previously undescribed, and potentially endemic species (Anderson *et al.* 2013). Lagoonal sediments were found to support a relatively impoverished

assemblage with a simplified trophic structure, characteristic of harsh and physically dynamic environments. In contrast, topographically elevated sites influenced by oceanic currents supported dense populations of suspension feeders and exhibited the highest levels of infaunal diversity recorded within the park (Anderson et al., 2013). These findings suggest that infaunal community composition is strongly influenced by the distribution and characteristics of sandy substrates and local oceanographic conditions, which are shaped by the island's irregular shelf morphology (Brooke et al., 2010).

The benthic infauna results by the BMT study (Appendix A) recorded a total of 452 individuals representing 39 taxa. Four indices were used to assess diversity among the microbenthic infauna samples: Margalef's species richness, Shannon's H diversity index, evenness, and dominance. ANOVA results indicated no statistically significant differences in taxonomic richness, diversity, evenness, or dominance across the surveyed sites. Overall, evenness values exceeded 0.7 and dominance values remained below 0.63, suggesting a relatively even distribution of individuals among species, with no single species dominating the assemblages. Differences in infaunal composition compared to previous studies are likely due to variation in sampling locations, as the current survey focused on more sheltered areas, while the previous study (Anderson et al 2008) included more exposed, outer coastal sites. Although the 2008 survey also reported generally low infaunal species richness across the LHI, it documented a high proportion of rare, previously undescribed, and potentially endemic species, highlighting the ecological uniqueness of the region.

2.6. Ecosystems

There is a wide range of habitats and biological communities within the LHIMP. Three estuarine systems exist on Lord Howe and stands of Mangroves are present whilst outside of the lagoon, fringing reef supports macroalgae and coral species side by side, and shallow sub-tidal reefs support diverse communities. Further afield, shelf ecosystems that include mesophotic coral communities and slope ecosystems occur outside of the LHIMP (Harasti et al.2022). Benthic habitat types within the lagoon ecosystem are presented in Figure 5.

Within the lagoon, branching coral, seagrass, solitary anemones, sand and rubble characterise the diverse habitat that supports a predominantly tropical fish assemblage, and among the highest fish and cryptic fish diversity in the LHIMP (Stuart-Smith et al 2025). This diverse habitat supports the highest biomass of benthic invertivore and corallivore fish found within the LHIMP, and is a key nursery area for endemic, threatened and protected species. Important seagrass habitats can be found in the both the northern and southern lagoon that in turn provide habitat for juvenile fish, invertebrates and provide coastal protection against erosion. Intertidal reefs in the lagoon support a diverse assemblage of invertebrates, many of which are endemic to LHIMP. However, intertidal reefs in the northern lagoon and adjacent to the existing jetty are known to support the lowest diversity of species and fewer endemics compared to other reefs in the LHIMP. In contrast, the relatively pristine Southern Lagoon sub-tidal and intertidal reefs support a high diversity of marine invertebrates (including crustaceans, sea snails, starfish and sea cucumbers, etc), many of which are endemic. For example, the Lord Howe Abalone (*Haliotis rubiginosa*) is found in greatest numbers in the southern lagoon and listed as Critically Endangered under both the NSW FM Act and IUCN Redlist.

To further understand the ecosystems and features of highest ecological value in and surrounding the Project area, a Benthic Communities and Habitat (BCH) assessment was undertaken which combined benthic habitat mapping with a targeted desktop review to define twelve discrete habitat classes across approximately 117.37 ha (Appendix B). The final BCH map prepared is shown in Figure 6.

For reporting and impact interpretation, ecosystems are separated into two habitats that reflect recognised environmental values at LHI: The Lagoon ecosystem and the Intertidal and shallow subtidal ecosystems. This structure aligns the mapping with natural exposure regimes, clarifies the distribution of corals and macrophytes (seagrass and macroalgae), and provides a practical basis for pathway and mitigation assessment.

Within the marine North Zone there has been historical seabed disturbance from operational activities. Previously disturbed areas in the Northern Lagoon and immediately surrounding marine infrastructure are presented in Figure 7 and Figure 8, respectively.

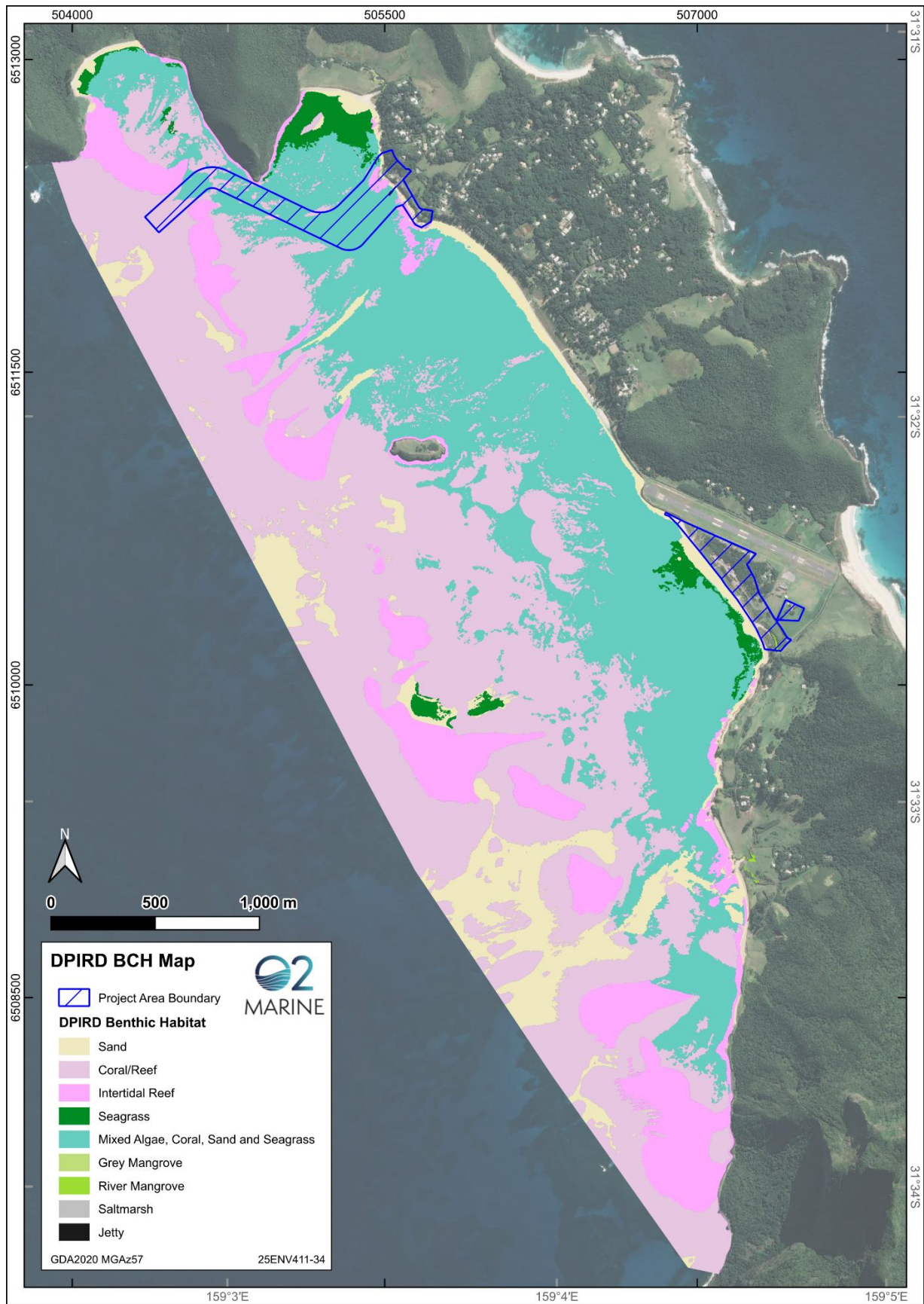


Figure 5: Mapped benthic habitats of the LHI from DPIRD

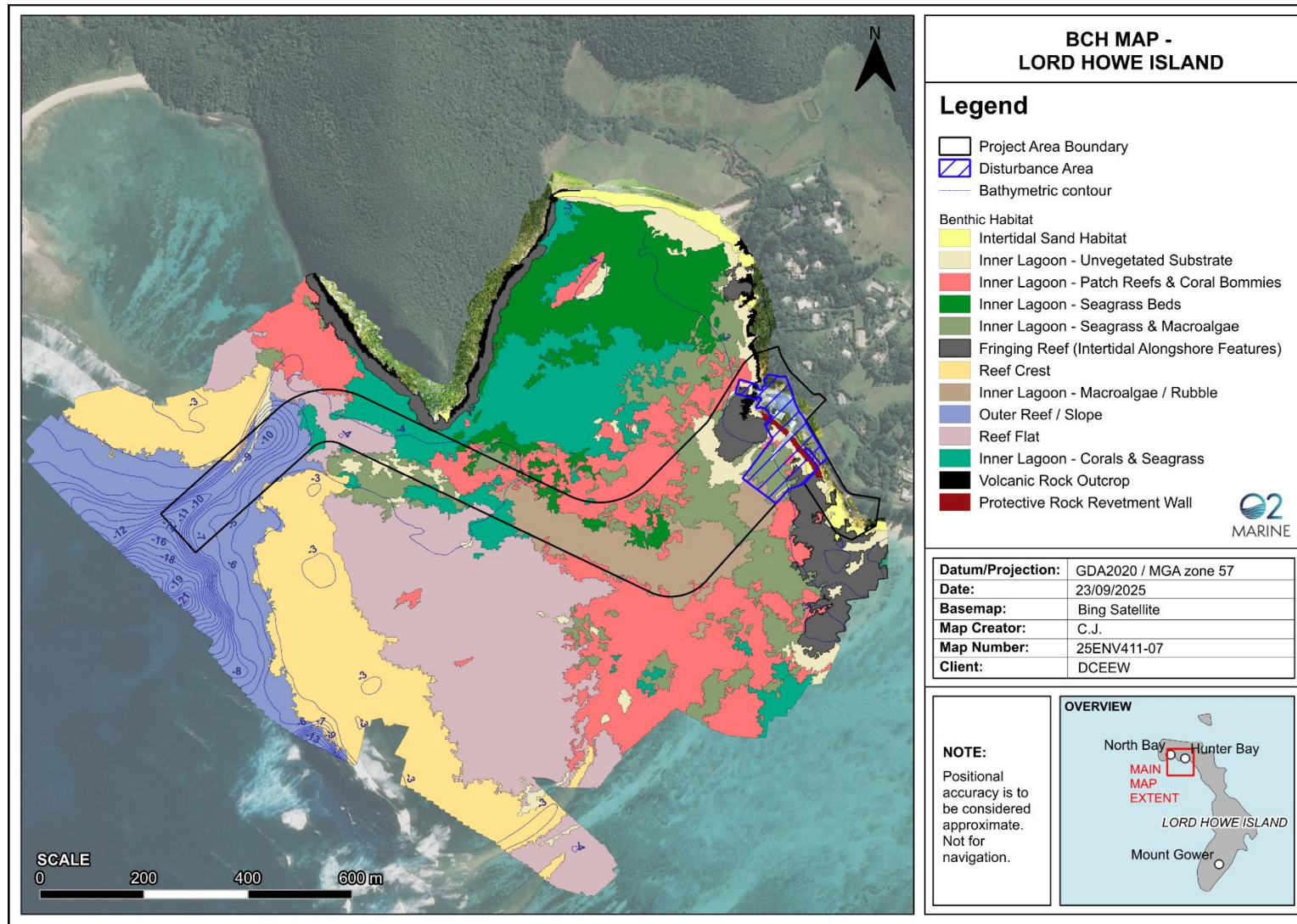


Figure 6: Benthic habitat map of the Project Area (North Zone)

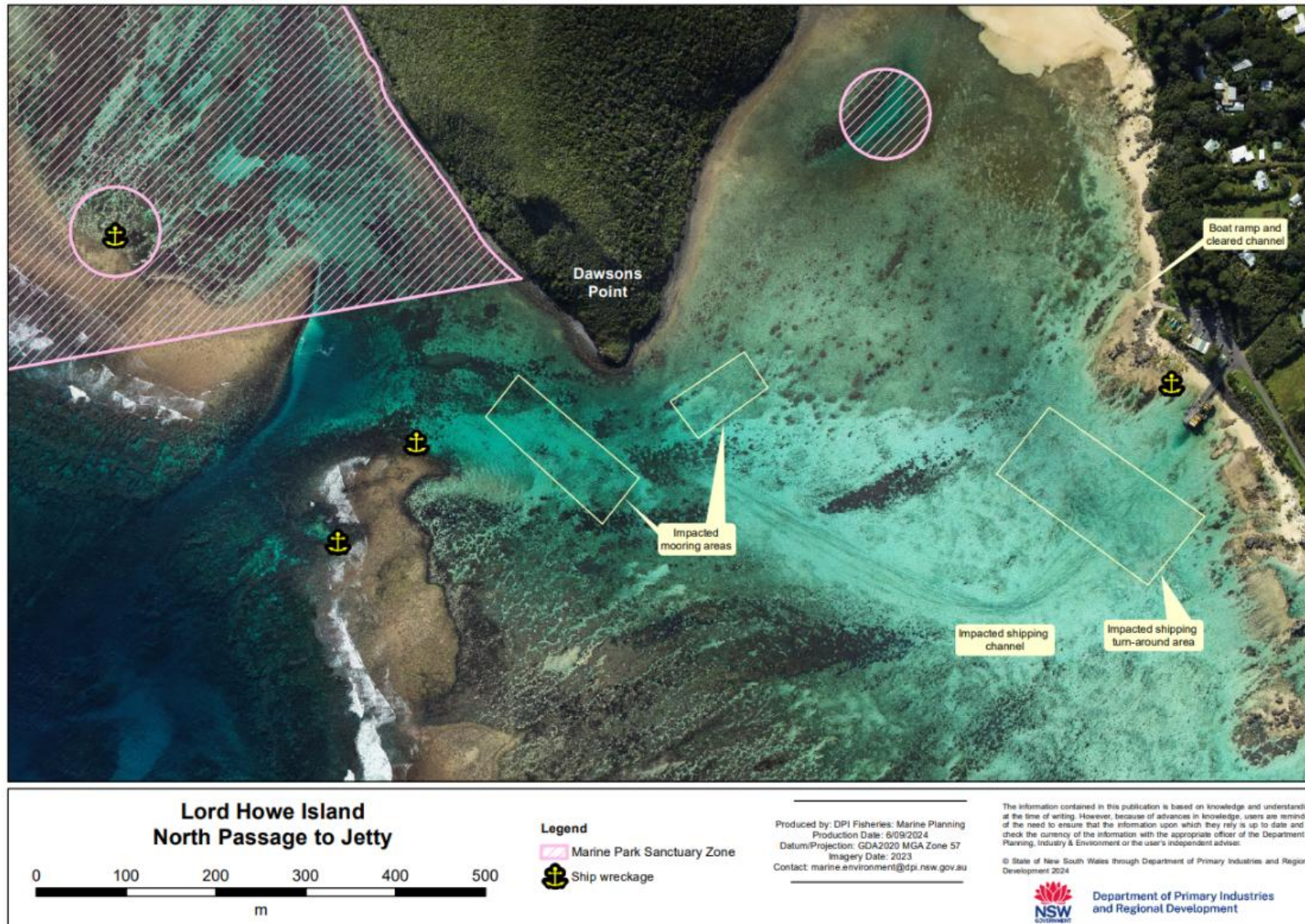


Figure 7: Previously disturbed areas in the Northern Lagoon (source: DPIRD 2024)



Figure 8: Previously impacted areas of the seafloor next to existing jetty (Source: DPIRD 2024)

2.6.1. Lagoon ecosystem

The lagoon provides habitat for a modern fringing coral reef community, among the southernmost reef systems globally, and supports at a vast number of hard coral species alongside extensive macrophyte habitats. Seagrass meadows of *Zostera muelleri* and *Halophila ovalis* stabilise carbonate sediments and provide nursery and foraging habitat for fishes and invertebrates, with macrophyte and coral patches creating fine scale refugia and feeding grounds.

The lagoon contains the majority of mapped BCH and supports a mosaic of coral, seagrass and macroalgal habitats. The Reef Flat is the most extensive class (22.03 ha, 19%) and forms a broad mid-lagoon platform with encrusting coralline and turf algal cover and scattered low-growing corals. Patch Reefs and Coral Bommies (Inner Lagoon) cover 17.81 ha (15%), comprising discrete coral structures embedded in carbonate sands and typically dominated by *Acropora* and *Porites*. The Reef Crest accounts for 17.09 ha (15%) and functions as the energetic boundary between lagoon and outer reef while remaining integral to the lagoonal fringing reef system. Mixed lagoonal habitats are also prominent: Corals and Seagrass (10.71 ha, 9%), Seagrass and Macroalgae (9.33 ha, 8%), and Seagrass Beds (9.15 ha, 8%) dominated by *Zostera muelleri* and *Halophila ovalis*. Additional classes include Macroalgae / Rubble (4.99 ha, 4%) and Unvegetated Substrate (4.20 ha, 4%). Collectively, these habitats provide nursery and foraging functions, sediment stabilisation, and fine-scale connectivity among coral and macrophyte patches.

2.6.2. Intertidal and shallow subtidal ecosystems

Intertidal reefs add shoreline protection, high biodiversity on rocky and boulder shores, and connectivity to offshore assemblages along the outer reef and slope.

Open-coast and shore-connected habitats are structured primarily by wave exposure and tidal regime. The Outer Reef / Slope covers 14.09 ha (12%), comprising consolidated volcanic or carbonate substrates with moderate coral and encrusting biota and providing connectivity to offshore environments. Fringing Reef (intertidal alongshore features) occupies 5.61 ha (5%) and is regularly exposed at low tide, supporting turf algae, encrusting invertebrates and gastropods. Intertidal soft and hard substrates are limited in extent yet remain ecologically relevant: Intertidal Sand Habitat (1.25ha, 1%) and Volcanic Rock Outcrop (1.11 ha, 1%), which contribute to shoreline buffering and niche biodiversity.

2.7. Marine invertebrates

Invertebrate communities within the LHIMP consist of tropical, temperate and endemic species due to the unique physical natural values producing a tropical to sub-temperate habitat (Harasti et al 2022). Woods (2022) studied the rocky shore habitats and found a high diversity of invertebrates, with 216 species recorded from 15,600 m² of reef habitats. Of those species, 11 % were endemic to the area (Woods 2022).

Long-term monitoring of the sub-tidal invertebrate community within the Lagoon has revealed an ecological community characterised by low abundance of most species (Stuart-Smith et al. 2025). Further to this, intertidal reefs in the northern lagoon and adjacent to the existing jetty are known to

support the lowest diversity of species and fewer endemics compared to other reefs in the LHIMP (DPIRD 2024).

In contrast, the relatively pristine Southern Lagoon sub-tidal and intertidal reefs support a high diversity of marine invertebrates (including crustaceans, sea snails, starfish and sea cucumbers, etc), many of which are endemic. For example, the Lord Howe Abalone (*Haliotis rubiginosa*) is found in greatest numbers in the southern lagoon and listed as Critically Endangered under both the NSW *Fisheries Management Act 1994* and IUCN Redlist (DPIRD 2024).

Overall, knowledge about the taxonomy and distribution of many invertebrate species remains poor and it is likely that other endemic species are vulnerable to extinction (Harasiti et al. 2022).

To support this CMEA, an invertebrate survey was undertaken along transects within and around the Project area between 26 February and 2 March 2025 by BMT (Appendix D). Invertebrate species and abundance were recorded along the same transect line as the fish and cryptic fish survey, as described in Section 2.8.2.

In total, 21 species of invertebrate were recorded from three phyla (Arthropoda, Echinodermata, and Mollusca) across 11 transects. No invertebrates were recorded on transects S05, S09, S10, and S12. At sites S09 and S10. The lack of mobile invertebrates is likely linked to the proximity to the existing channel and the current jetty where benthic habitat is heavily impacted by shipping movement. Vessel driven siltation, scour from vessel drawdown and controlled landings have impacted a 1 km long by 50 m wide area (50,000 m²) (DPIRD, 2024).

Species from the phylum Echinodermata were the most diverse (11 species), including eight species of sea urchin, the most abundant was the Long-spined Sea Urchin (*Centrostephanus rodgersii*) recorded at S14 (72 individuals/100 m²) and S15 (1 individuals/100 m²). Other species of urchin recorded include *Breynia australasiae*, *Diadema savignyi*, *Echinometra mathaei*, *Echinostrephus aciculatus*, *Heliocidaris tuberculata*, *Tripneustes gratilla*, and *Echinocardium* spp. (identified to genus).

Other species from the phylum include two species from the family Holothuriidae, *Actinopyga palauensis* and *Stichopus chloronotus* and 1 species from Asteroiidae, *Coscinasterias muricata*.

There were six species from the phylum Mollusca, *Astraliium rhodostomum* [species complex], *Drupella cornus*, *Flabellina* spp. (identified to genus), *Halgerda willeyi*, Pinnidae spp. (identified to genus), and *Tridacna Maxima*.

Species from the phylum Arthropoda make up the remainder of the invertebrates recorded. Individuals were separated into four groups, family (Epialtidae and Paguridae), and genus level (*Calcinus* and *Trapezia*).

Of note is a record of *Astraliium rhodostomum* [species complex] from S13 (1 individuals/100 m²). This species complex has been shown to be comprised of at least 30 geographically isolated clades, some across very small spatial scales of ~180 km (Meyer et al. 2005). Future genetic studies may identify the LHI *A. rhodostomum* population as an endemic clade.

A list of invertebrate species recorded during the baseline survey between 26 February and 2 March 2025 is provided in Appendix D.

2.8. Marine Fauna

2.8.1. Biodiversity of marine fauna

The shallow reef communities of LHI are influenced by both tropical and temperate water masses that form the Tasman Front and feature a unique combination of coral reefs typical of northern tropical regions and macroalgae and soft coral dominated reefs characteristic of sub-tropical mainland Australia. Diversity on the near-pristine, nearshore reefs is driven primarily by tropical species, whilst temperate species contribute most to biomass and abundance (Stuart-Smith et al. 2025). More than 500 species of fish and 90 species of coral have been documented.

Geographical isolation has given rise to high levels of endemism amongst algae, fishes and marine invertebrates and few islands in the world support higher levels of endemism (Rees et al. 2021).

North Bay and Lagoon Sanctuary zones provide protection to important seagrass habitats and associated species. Marine reptiles (turtles) occasionally migrate through the marine park, whilst some turtle species reside there.

Primarily occurring in the Commonwealth waters are thirty-one nationally important marine mammal species. In this marine fauna group, dolphins, whales and seals have all been observed within the marine park, although the common bottlenose dolphin is the only marine mammal species able to be sighted year-round.

Marine Mammals

Whales are rarely sighted within the LHIMP, likely because of the distance from migration routes and foraging grounds, however the humpback whale (*Megaptera novaengliae*) is the most sighted whale species. Blainville's beaked whale (*Mesoplodon densirostris*) have been documented from strandings and they are infrequently sighted as live animals by local fishers (Elridge et al 2017). The Bottlenose dolphin (*Tursiops truncatus*) and common dolphin (*Dephinus delphis*) are commonly sighted and migratory dolphins such as the spinner dolphin (*Stenella longirostris*), dusky dolphin (*Aethalodelphis obscurus*) and the pan tropical spotted dolphin (*Stenella attenuata*) are occasionally sighted. Other marine mammals such as Australia and New Zealand fur seals (*Arctocephalus pusillus* and *A. forsteri*, respectively) and leopard seals (*Hydrurga leptonyx*) are also occasionally sighted (Harasti et al. 2022).

Marine Reptiles

The most common marine reptile to occur within the LHIMP is the green turtle (*Chelonia mydas*), a resident common within the Lagoon. The hawksbill turtle (*Eretmochelys imbricate*) is also a resident species although neither the Green nor the Hawksbill turtle breed or nest within the marine park. Three rarely sighted migratory species are the flatback (*Natator depressus*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*) turtles. Sea snakes are infrequently sighted but not considered to be resident within the marine park (Harasti et al. 2022).

Marine Fishes

The habitats of the LHIMP support a highly diverse fish assemblage made up of tropical and sub-tropical species. Combined, 537 species have been recorded with the majority of those possessing broad, tropical distributions. Temperate species meanwhile represent the largest proportion of the fish biomass (Harasti et al. 2022).

Stuart-Smith et al. (2025) describes a fish assemblage composition in the context of three Ecological Communities that are distinct, the shallow reefs of the Lagoon, Algal Holes (area of shallow reef differentiated by higher cover of red foliose algae growing amongst coral colonies), Balls Pyramid and Offshore sites.

The families and species that drive the distinct differences and characterise the Ecological Communities are:

- Lagoon Ecological Community – Butterflyfish (*Chaetodon spp.*), coral associated species (example *Dascyllus spp.*), parrotfishes and damselfishes (including McCulloch's Anemonefish, *Amphiprion mccullochi*).
- Algal Holes Ecological Community – Green Moon Wrasse (*Thalassoma lutescens*), the Coral Sea Gregory (*Stegastes gascoeni*) and the Three-band Butterflyfish (*Chaetodon tricinctus*).
- Balls Pyramid Ecological Community – Damselfishes such as the One Spot Puller, *Chromis hypsilepis*, large-bodied herbivores such as *Kyphosus spp.*, species from Serranidae and the Conspicuous Angelfish (*Chaetodontoplus conspicillatus*).
- Offshore Ecological Community – Shares several species found at Balls Pyramid but with high abundance of the Bronze Bullseye (*Pempheris analis*).

The proportion of nearshore fishes that are endemic or regionally endemic is relatively high, around 4%. Genetic studies have indicated limited connectivity between LHI, Norfolk Island, Elizabeth and Middleton reefs. For example, the doubleheader wrasse (*Coris bulbifrons*), three-striped butterflyfish (*Chaetodon tricinctus*) and McCulloch's anemonefish (*Amphiprion mccullochi*) have been shown to have high levels of self-replenishment. (Harasti et al. 2022).

Important commercial species include the yellowtail kingfish (*Seriola lalandi*) that is subject to a small artisanal fishery and represents >50 % of the total fishery catch. Other targeted species include the doubleheader wrasse (*Coris bulbifrons*), species of Scorpaenidae, bluefish (*Girella cyanea*) and Spangled emperor (*Lethrinus nebulosus*).

2.8.2. Conservation Significant species

A Conservation Significant Marine Fauna (CSMF) desktop assessment has been undertaken which evaluates EPBC listed species, species with State level listings or protections and other significant species that may be present within the Project area (Appendix C). This analysis was used to determine the likelihood of occurrence for identified species and in turn, if they may be impacted by the Project. A total of 72 species of conservation significance were assessed, with 10 of these being identified as key species across the taxonomic groups of marine mammals (2), reptiles (2) and fishes (6). This also includes two key species, the doubleheader wrasse (*Coris bulbifrons*) and Galapagos shark, (*Carcharhinus galapagensis*) which are not necessarily protected under State or Commonwealth legislation but are common, iconic and/or play keystone ecological roles.

The list of key species evaluated for the Project is provided in (Table 3). Further details on these species assessments, and their ecology are detailed in Appendix C.

It is noted that while some marine fauna species identified within the SEARs (including EPBC Act comments) and listed in Section 4.7.4 may be present near LHI, the likelihood assessment undertaken

in Appendix C to identify the key species determined that impacts to population levels for these species were less likely. See the likelihood of occurrence assessment in Appendix C for further rationale.

Marine Mammals

In identifying and assessing the likelihood of occurrence for conservation significant marine mammal species, a total of 35 marine mammals were identified to occur in the 30 km broad search area surrounding LHI. Of these marine mammal species, eleven EPBC Act listed threatened species with a Known or Likely PMST rank were further considered for their conservation significance.

Ultimately, two cetaceans, Humpback whale (*Megaptera novaengliae*) and Common bottlenose dolphin (*Tursiops truncatus*) were identified as key conservation significant marine mammals for the Project.

The Humpback whale (*Megaptera novaengliae*) may be present near LHI during periods of its annual migration to tropical calving grounds between June and December annually (Andrews-Goff 2023, Seyboth 2023). Humpback whales observed at LHI are part of the East coast Australia and west Pacific humpback whale population: Breeding stock E. This breeding stock consists of three sub-populations with unique migratory paths (E1 East coast Australia, E2 New Caledonia, E3 Tonga) (IWC 2016, Seyboth 2023). While no specific tagging studies exist for LHI, it is likely that individuals from both Stock E1 (migrating to Queensland) and Stock E2 (migrating to New Caledonia) are present during migration periods (Garrigue 2015, 2020). Whilst there are limited occurrence records for Humpback whale presence at LHI, this species represents the key whale species likely to be present, and it has also been identified previously as a key marine mammal species for LHI (Harasti et al 2022).

Common bottlenose dolphins (*Tursiops truncatus*) are the most common marine mammal to be observed at LHI (Harasti et al 2022), although no specific studies have been conducted for this species at LHI, occurrence records show Bottlenose dolphins are frequently sighted, particularly in the trench to the south of the island.

Table 3: Key conservation significant species identified from both threatened and protected aquatic species list and other species and their likelihood of occurrence result.

Common Name	Scientific Name	EPBC Act	BC Act	Listing status			Likelihood of Occurrence	Species Justification
				FM Act	IUCN (non-statutory)	PMST Rank		
Bottlenose dolphin	<i>Tursiops truncatus</i>	Cetacean				May	High	This species is not listed as threatened, however is an iconic species for the island and is present year round.
Humpback whale	<i>Megaptera novaengliae</i>	Migratory Cetacean				May	High	There is limited data on humpback whale presence at LHI. However, they are likely to occur in the waters surrounding the island during both the north and south annual migrations between the periods of June-November. On the southern migration, mothers with calves are present which are particularly vulnerable to impacts during this sensitive period.
Green turtle	<i>Chelonia mydas</i>	Vulnerable Migratory Marine	Vulnerable		Endangered	Likely	High	Green turtles are listed under Cth and State legislation as a threatened species. This species is commonly sighted in the lagoon with sightings being recorded both in the Disturbance area and Northern Project boundary
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Vulnerable Migratory Marine			Critically Endangered	Likely	High	Hawksbill turtles are listed under Cth legislation as a threatened species. This species is commonly sighted in the lagoon.

Common Name	Scientific Name	EPBC Act	BC Act	Listing status			Likelihood of Occurrence	Species Justification
				FM Act	IUCN (non-statutory)	PMST Rank		
Black Rockcod	<i>Epinephelus daemeli</i>	Vulnerable		Vulnerable		Likely	High	The Black rockcod is a threatened species and present in close proximity to the Northern Project Boundary, with high number of sightings within the lagoon. Being a site attached species, the LHI lagoon, including the Northern Project boundary represent important habitat for this species.
Doubleheader wrasse	<i>Coris bulbifrons</i>				Vulnerable		High	This species is not threatened, however is an iconic species for the island and present year round. Fish surveys identified this species within the lagoon.
Elegant wrasse	<i>Anampses elegans</i>			Protected		N/A	High	Protected species under State legislation which was identified with a high number of sightings near the North Project boundary and within the lagoon.
Galapagos shark	<i>Carcharhinus galapagensis</i>				Near Threatened	N/A	High	This species is not threatened under State or Commonwealth legislation; however it has an IUCN listing status of Near Threatened. The Galapagos shark is an iconic species for LHI and represents a key species within the island's ecosystem. It is present year-round in high numbers.
LHI Abalone	<i>Haliotis rubiginosa</i>			Critically Endangered	Critically Endangered	N/A	High	Threatened endemic species under State legislation with sightings near the North Project boundary and within the lagoon. Currently under Priority Assessment by the TSSC for EPBC listing

Common Name	Scientific Name	EPBC Act	BC Act	Listing status		PMST Rank	Likelihood of Occurrence	Species Justification
				FM Act	IUCN (non-statutory)			
								status of Critically Endangered. Decision due 30/10/2025. Due to highly localised occurrence and habitat presence within the Northern Project boundary, this species is highly likely to occur.
McCulloch's Anemonefish (Whitesnout)	<i>Amphiprion mccullochi</i>	Critically Endangered		Critically Endangered		Known	High	Threatened species which is present in close proximity to the Northern Project Boundary, with high number of sightings within the lagoon

Marine Reptiles

All marine turtles are listed as threatened species in Australia, and five marine turtle species were identified within the broader search area surrounding LHI. Of these five species, two species (Green turtle *Chelonia mydas* and Hawksbill turtle *Eretmochelys imbricata*) were assessed to have a high likelihood of occurrence and represent the conservation significant marine reptiles for the Project.

Green turtles in the NSW region, including those found at LHI, are comprised of several genetic stocks. However, they are dominated by those of the southern Great Barrier Reef and New Caledonia genetic stock (Day et al 2024). During periods of foraging, Green turtles exhibit varying home-range sizes and movement patterns depending on size and location, these foraging ranges may be very small, <2 km² (Pillans et al 2021).

The Australian range of Hawksbill turtles is concentrated along the northern and eastern coastline, encompassing the Great Barrier Reef, Torres Strait, and northern Cape York Peninsula (GBRMPA 2022, DCCEEW 2025c), with sightings in more temperate waters such as NSW, indicating wide ranging movements, particularly during this species 'lost years' (the oceanic period between hatching and returning to their natal colony). This southernmost area of Hawksbill turtle habitat range in the Tasman Sea represents one of the least studied locations globally, in terms of Hawksbill turtle studies (Robinson et al 2023) and many knowledge gaps still exist regarding in-water habitats where turtles spend most of their lives (Madden et al 2025).

No turtle species have been recorded as breeding at LHI, and the island represents a key foraging area.

Marine Fish

The LHIMP supports a highly diverse fish assemblage, including at least 15 endemic fish species (Harasti et al 2022). The field surveys identified 104 species of fish, with 22 of these species being cryptic fishes. Additionally, two threatened or protected fish species were also identified during these surveys, the elegant wrasse (*Anampes elegans*) and McCulloch's anemonefish (*Amphiprion mccullochi*) (Appendix D). Additionally, the Doubleheader wrasse *Coris bulbifrons* which is IUCN listed as 'Vulnerable', was also identified, largely as sub-adult fished within the LHI lagoon.

The CSMF desktop (Appendix C) identified a total of 30 marine fishes with threatened listing status. Of these, 23 marine fish species were further identified to have either a Known or Likely presence within 20 km of LHI or be a protected species under the NSW FM Act. Ultimately, six marine fishes were identified as key species for the Project (Black Rockcod (*Epinephelus daemeli*), Doubleheader wrasse (*Coris bulbifrons*), Elegant wrasse (*Anampes elegans*), Galapagos shark (*Carcharhinus galapagensis*), Lord Howe abalone (*Haliotis rubiginosa*), and the McCulloch's anemonefish (*Amphiprion mccullochi*)). Noting that the FM Act's legislative definition of 'fish' includes a variety of other aquatic animals, including molluscs.

Black rockcod (*Epinephelus daemeli*) is one of several marine fish species that have undergone major declines in distribution and abundance and have been listed as threatened under the schedules of the NSW FM Act. This species population decline was observed as early as 1916. Black rockcod are a territorial and site attached species, with individuals often encountered persisting in the same location

or cave over time. Individual adult fish may occupy a particular cave for most of their adult life (DPI 2012, Harasti 2025).

The doubleheader wrasse (*Coris bulbifrons*) is a regionally endemic fish species with populations across southeastern Australia, including LHI, Elizabeth and Middleton Reefs, Norfolk Island, and the northern New South Wales coast. Doubleheader wrasse inhabit coral, rubble and sandy areas on coral and rocky reefs, usually above 20 m depth and is commonly by snorkellers and divers in the lagoon and offshore dive locations at LHI. Juvenile doubleheader wrasse utilise very shallow water reef habitats and have been collected from tide pools.

The Elegant wrasse (*Anampes elegans*) is naturally uncommon but geographically widespread along the eastern coast of Australia, with populations concentrated around offshore islands where they inhabit rocky and coral reefs. This species is not listed under the EPBC Act, however it is listed as a protected species under the FM Act. Adult Elegant wrasse are likely to be found in harems, with a single dominant male controlling a group of females. In the absence of a dominant male wrasse, the largest female wrasse will change sex to become the dominant male of the harem group (DPI 2006e).

The Galapagos shark (*Carcharhinus galapagensis*) is a large requiem shark that inhabits offshore and pelagic waters of the Indo–West Pacific, including Australia’s largest population of this species at Elizabeth and Middleton Reefs and the LHI Marine Park. Galapagos sharks are observed to have site fidelity, especially in islands, however, Galapagos sharks are capable of substantial movements—reported over distances exceeding 600 km from tagging locations—highlighting at least occasional long-distance dispersal behaviours (Compagno 1984). The Galapagos shark is a key indicator species for the management of the marine parks surrounding LHI (Edgar et al., 2010, Mitchell et al 2021, Harasti et al 2022).

The Lord Howe Abalone (*Haliotis rubiginosa*) is a small abalone species that is endemic to the shallow waters of the LHI Marine Park. It is a rare and cryptic species that is present under rocks, dead coral rubble and in small holes and crevices in the reef (DPI 2024). This mollusc species is also currently on the Priority Assessments List to receive Critically Endangered status under the EPBC Act. A Commonwealth determination for this assessment is due in October 2025 (DCCEEW SPRAT ID 92433). The Lord Howe Abalone has an extremely limited distribution, and its occurrence is limited to shallow reefs between the intertidal zone to 10 m deep within the LHI Marine Park, with confirmed sightings being recorded within the LHI lagoon. The species distribution is restricted to carbonate reefs around LHI, and its abundance is considered to be low (Harasti et al 2022, Woods, 2022).

McCulloch’s Anemonefish (*Amphiprion mccullochi*) is an Australian endemic species and currently listed as Critically Endangered under the EPBC Act and Fisheries Act and Vulnerable by the IUCN Red List. LHI lagoon supports approximately 75% of the remaining population and represents critical habitat for this species, and it is considered rare at its other occupied locations at Elizabeth and Middleton Reefs (TSSC 2024). Adult McCulloch’s anemonefish are dark brown to black with a whitish snout and a single white bar on the cheek that does not connect over the top of the head. The maximum size for the McCulloch’s anemonefish is 120 mm in length (TSSC 2024).

2.8.3. Introduced marine pests

No confirmed introduced marine pests (IMP) have been recorded alive in the LHIMP to date, making it one of the few pest-free ports in Australia where marine ecological baselines can still be observed (Aqenal, 2006, DPI 2020, Appendix E). However, the introduction of marine pests is a potential threat to the outstanding natural, economic and social values of the marine park, particularly during transiting from mainland Ports.

Construction vessels and equipment will originate from mainland ports which support Australia's economic growth and global trade connectivity. IMP species have been recorded at most mainland port areas in Australia and present a risk of translocation to the island. The Port Macquarie supports LHI via the *Island Trader*, a dedicated supply ship that transports essential goods such as food, fuel, and other supplies to the island on a fortnightly basis.

A review of the National Introduced Marine Pest Information System (NIMPIS) database indicated that while LHI and Port Macquarie have not recorded any IMP's listed on either the Australian Marine Pests List (MPSC 2018) or Australia's Exotic Environmental Pest List (EEPL) (DAFF 2025), a total of 14 Introduced Marine Species (IMS) were recorded at the mainland Port of Newcastle (DAFF 2025). IMS have the potential to cause ecological and amenity impacts, however, have not been declared as a pest species of national significance in Australia. The Pacific oyster, *Crassostrea gigas*, a common species in oyster aquaculture, has been observed at Port Macquarie (DAFF 2025) and as dead shells at LHI (DPI 2020). The dead shells observed at LHI were likely from human consumed and discarded product (DPI 2020).

IMS detected at the Port of Newcastle include the taxonomic groups of algae, bryozoans, cnidarians, molluscs, crustaceans and ascidians (Table 4).

The Pacific oyster, *Crassostrea gigas*, a common species in oyster aquaculture, has been observed at Port Macquarie (DAFF 2025) and as dead shells at LHI (Table 4). The dead shells observed at LHI were likely discarded product from human consumption (DPI 2020).

Due to concerns related to the invasive potential of the green alga *Caulerpa taxifolia* in cooler waters of the NSW region this species has been the focus of much research across the state (Cresse et al. 2002, DPI 2023). At LHI, *C. taxifolia* has been reported as a cryptogenic marine species in the LHI marine park, due to this species status as introduced or native at the island being unknown. However, *C. taxifolia* is probably a native algal species to LHI given historical observations of the algae at this location from the 1930's and LHI is within the native tropical/subtropical range of this species in Australian waters (noted by Stuart-Smith et al., 2015). In the LHI lagoon, there has been little net change in *C. taxifolia* coverage between 2006 to 2022 (Stuart-Smith et al., 2025). The green algae Sea grapes (*C. racemosa*) was observed during the LHI IMP survey on the jetty (Appendix E), however this species is an Australian native likely present at LHI, although it's overall abundance at this location is unknown.

Table 4: Detections of IMP's at LHI, Port Macquarie and Port of Newcastle

Organism Group	IMP Species	APMPL/EEPL/ NIMPIS				Location	
		LHI		Port Macquarie		Port of Newcastle	
Algae	Toxic dinoflagellate (<i>Alexandrium catenella</i>)	NIMPIS	Not detected	Not detected		Present	
	Toxic dinoflagellate (<i>Alexandrium minutum</i>)	NIMPIS	Not detected	Not detected		Present	
Bryozoan	Brown bryozoan (<i>Bugula neritina</i>)	NIMPIS	Not detected	Not detected		Present	
	Bryozoan (<i>Bugulina flabellata</i>)	NIMPIS	Not detected	Not detected		Present	
Cnidarian	Hydroid (<i>Coryne eximia</i>)	NIMPIS	Not detected	Not detected		Present	
	Stalked hydroid (<i>Ectopleura crocea</i>)	NIMPIS	Not detected	Not detected		Present	
	Feather Hydroid (<i>Halecium delicatulum</i>)	NIMPIS	Not detected	Not detected		Present	
	Sea thread hydroid (<i>Obelia dichotoma</i>)	NIMPIS	Not detected	Not detected		Present	
Annelid	Tubeworm (<i>Hydroides elegans</i>)	NIMPIS	Not detected	Not detected		Present	
Mollusc	Pacific oyster (<i>Crassostrea gigas</i>)	NIMPIS	Present (dead shells only)	Present		Not detected	
	Winged thecacera nudibranch (<i>Thecacera pennigera</i>)	NIMPIS	Not detected	Not detected		Present	
Crustacean	Acorn barnacle (<i>Megabalanus rosa</i>)	NIMPIS	Not detected	Not detected		Present	
Ascidian	Sea squirt (<i>Botrylloides leachii</i>)	NIMPIS	Not detected	Not detected		Present	
	Vase tunicate (<i>Ciona intestinalis</i>)	NIMPIS	Not detected	Not detected		Present	
	Solitary ascidian (<i>Styela plicata</i>)	NIMPIS	Not detected	Not detected		Present	

3. Project Risks

3.1. Pressure-Response Pathway

Impacts to coastal and marine ecology require understanding of pressure response pathways. This describes that pressures, defined here as potential construction and operational activities that alter the state of the physical environment (e.g. water quality), lead to subsequent impacts on ecology and biodiversity. Key pressures associated with the Project have been defined as key issues within the SEARs (SSI-78107213), while risks are also provided in the assessment of impacts to MNES (EPBC 2025/10188). The key risks associated with MNES are further split into impacts on threatened and listed migratory species or upon World Heritage and National Heritage values of a national heritage place. For simplicity, the pressures associated with the key risks identified through environmental regulatory processes are compiled and combined in Table 5.

It is noted that further key risks are defined under the SEARs key issue Biodiversity and MNES than the Project generated pressures identified in Table 5. Addressing the key issue Biodiversity requires evaluation of the cumulative pressures on the sensitivity of marine fauna species and their populations. Therefore, the biodiversity assessment evaluates the consequence of the cumulative pressures from Project activities, with a focus on species of conservation significance within the Project area, which are threatened species, populations or ecological communities listed under State and Commonwealth legislation. In accordance with the SEARs this includes carrying out the following requirements within this report:

- Prepare a threatened aquatic species assessment.
- Identifying Key Threatening Processes to conservation significant marine species.
- Assessment of key impacts to the ecological and biological values of the LHIMP, including impacts to threatened species such as (but not limited to) the Black rockcod, Ballina angelfish, Elegant wrasse, Bluefish, Syngnathids, marine mammals, marine reptiles and seabirds.

Assessment of potential impacts to MNES in item 7 of the SEARs also identifies requirements which involve assessment of the cumulative pressures from the Project activities:

- The proposed activities may have significant impacts upon the World Heritage and National Heritage values of a national heritage place via:
 - Reducing diversity or modifying the composition of plant and animal species in all or part of a World Heritage property.
 - Fragmenting, isolating or substantially damaging habitat important for the conservation of biological diversity in a World Heritage property.
 - Impacts on the marine environment which are not covered in referral documentation, including marine biodiversity.

3.2. Key threatening processes

Under the FM Act, the only potential key threatening process relevant to the coastal and marine aspect of the Project is:

- Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales.

The only potential key threatening process listed in the BC Act that is relevant to the Project is:

- Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments (as described in the final determination of the Scientific Committee to list the key threatening process)

Currently, 21 key threatening processes are listed under EPBC Act. Listed key threatening processes under the EPBC Act which may be considered relevant to the coastal and marine aspect for this Project include the following:

- Novel biota and their impact on biodiversity
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris
- Land clearance
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.

Table 5: Summary of pressures relevant to coastal and marine ecology identified from both the SEARs key issues and key risks to MNES identified in EPBC Act referral comments

Pressure	SEARs Key Issues	Potential Impacts EPBC: Threatened and Listed Species	Potential Impacts EPBC: World/National Heritage Values
Dust	Air Quality and Odour	Dust pollution due to construction activities causing a decline in habitat quality, resulting in the long-term decline or loss of habitat and consequently, species numbers.	Construction and operation of the proposed action is likely to have significant impacts on the water quality and visual amenity.
Accidental Spills	Contamination	Accidental spills due to construction activities causing a decline in habitat quality, resulting in the long-term decline or loss of habitat and consequently, species numbers.	Pollution into the waterways and surrounding oceanic environment during the construction and ongoing use of the proposed action.
Introduced Marine Pest Species	Hazards and Risk	Vessel movements during construction and operations introducing and/or spreading pest species or pathogens, resulting in long-term decline or loss over time of habitat and consequently, species numbers.	Impacts on biosecurity.
Underwater noise	Noise and Vibration	Underwater noise from pile driving during construction, vessel usage during construction and increased vessel usage after construction. Construction activities, including noise and vibration impacts.	
Coastal Processes/Sea Level Rise	Protected and Sensitive Lands		Long term viability of the proposed action under climate change projections including potential threats from sea level rise and storm surge on the project infrastructure (including risk of spills/pollution on surrounding environment).

Pressure	SEARs Key Issues	Potential Impacts EPBC: Threatened and Listed Species	Potential Impacts EPBC: World/National Heritage Values
Erosion & Sedimentation	Soils	Erosion and sedimentation due to construction activities causing a decline in habitat quality, resulting in the long-term decline or loss of habitat and consequently, species numbers.	
Waste	Waste	Consumption of plastic waste material	Construction and operation of the proposed action is likely to have significant impacts on the visual amenity. Pollution into the waterways and surrounding oceanic environment during the construction and ongoing use of the proposed action.
Surface and Groundwater runoff	Water - Hydrology		Pollution into the waterways and surrounding oceanic environment during the construction and ongoing use of the proposed action.
Vessel strike	Transport and traffic	Fauna mortality from vessel strike associated with construction and/or ongoing operation.	
Wastewater effluent		Vessel movements during construction and operations introducing and/or spreading pathogens, resulting in long-term decline or loss over time of habitat and consequently, species numbers.	
Terrestrial Habitat Modification		Clearing and modification of habitat through the removal of native vegetation and/or the clearing and levelling of sites, excavations and general construction activities.	
Coastal and Marine Habitat Modification	Transport and traffic	Seabed disturbance, leading to impacts on prey species.	Impacts on the marine environment: sea floor construction, transport of materials over a sensitive marine area

4. Assessment of impacts

The assessment of impacts from the Project has been based off the existing environment and values summarised in Section 2, supplemented by additional studies and reports provided in Appendix A to E. The marine construction components of the proposed development that are most likely to impact on the marine environment include works for upgraded coastal and marine infrastructure, including:

- New piled vessel ramp (to accommodate roll-on roll-off cargo) on the southern side of the existing jetty and upgrades to the existing jetty to allow for additional berthing and mooring bollards. and
- Increasing the overall dimensions of the boat ramp by approximately 8.5 m in length and 1 m in width and, installing mooring infrastructure such as breasting and mooring dolphins.

The ongoing operation of the above infrastructure, once completed, has also been included for this assessment.

The assessment of impacts is limited to the coastal and marine environment and does not address terrestrial habitats, terrestrial flora or fauna, migratory shorebirds or seabirds, sustainability, heritage, social or economic issues. It is acknowledged that as part of the proposed development there is terrestrial infrastructure and that there is potential for downstream impacts to the marine environment from construction and the ongoing operation which are assessed in other key issues. These key issues have been revisited here for complete assessment of potential impacts to the coastal and marine environment. An assessment of potential impacts, mitigation recommendations and assessment of significance of residual impacts for each identified value is provided in Sections 4.1 through to 4.8.

4.1. Water visibility and quality

Marine Park Value: High water visibility and quality.

4.1.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 6. All potential impacts to water visibility and quality that are expected attributable to construction or operations (without management or mitigation) are listed in Table 7.

Table 6: Impact criteria for water visibility and quality

Assessment	Description
Major	Significant and/or irreversible changes to water visibility and quality on a regional scale. For example, outside the inner lagoon.
Moderate	Moderate changes to water visibility and quality on a local scale. For example, within and around the inner lagoon.
Minor/ Insignificant	No impact or small, low risk changes to the values that contribute to (add value) on a local scale. For example, temporary and localised changes to water visibility and quality during construction.

Table 7: Potential impacts to water visibility and quality

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Marine Construction	Coastal/marine habitat modification Release of toxicants or nutrients to the water column due to disturbance of sediments during construction activities that disturb the seafloor.	Direct	Marine construction included works for an upgraded boat ramp and upgraded marine infrastructure.	Small localised plumes in the water column may be created by marine construction activities (e.g. driving piles into seabed, boat ramp excavations or increased vessel movements). Marine sediments in and around the Project Area have been assessed and reported (Attachment A) as having low concentration of toxicants and below ANZG (2018) DGVs.	The indicative program has marine construction extending over an eight month period.	Minor/ Insignificant
Construction	Coastal/marine habitat modification Localised increased turbidity from pile installation, vessel movements, boat ramp works.	Direct	Small localised plumes in the water column may be created by construction activities. Increase vessel activity during construction and specialised vessels requiring access to site.	Anthropogenically disturbed areas (i.e. (e.g. existing marine infrastructure or navigation channel). Particles within the sediment are also predominantly sand, which falls out of the water column quickly (as opposed to fine grade silts and clay fractions).	The indicative program has construction extending over a 14 to 20 month period. Marine construction: eight months	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Marine Construction	Accidental spills Hydrocarbon or waste spills from vessels and construction equipment resulting in water and sediment contamination	Direct	Increase vessel activity during construction. Low risk of spillage (fuels, oils and lubricants) that can pollute water in the inner lagoon.	Multiple vessels during construction. Likely to include: • Piling barge • Materials barge • Work boat/s	Marine construction: eight months	Moderate
Marine Construction	Wastewater effluent Vessel discharge of wastewater effluent into the marine environment.	Direct	Discharging effluent can cause nutrient pollution, harmful bacteria and ecosystem damage, leading to effects like algal blooms and reduced biodiversity	Possible effects likely limited to within lagoon	Marine construction: eight months	Moderate
Construction and Operations	Introduced Marine Pests Introduction of IMS and pathogens from construction and operational vessels into marine waters	Direct	Discharging ballast water introduces non-native species and microbial pathogens into new ecosystems, causing ecological, economic, and health impacts IMS and pathogens can attach to the hulls and other underwater surfaces	Possible effects likely limited to within lagoon	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			of vessels, forming a "biofilm"			
Operations	Accidental spills Diesel and oil spills, waste disposal from ongoing operations of vessel transfers	Direct	Historical evidence of diesel and oil spills and anthropogenic disturbances to water quality from supply vessel movements/ unloading	Spills of chemicals/ fuels from supply vessel could occur which affect localised area of lagoon	Operations: vessel traffic ongoing.	Moderate
Operations	Coastal/marine habitat modification Localised increased turbidity from vessel sediment resuspension	Direct	Historical evidence of sediment plumes generated from resuspension during passage through shallow navigation channel.	Localised to anthropogenically disturbed areas (i.e. (e.g. existing marine infrastructure or navigation channel).	Operations: vessel traffic ongoing.	Moderate
Construction	Accidental spills, waste, erosion/sedimentation, dust pollution, surface/groundwater runoff Pollution or increased sediments from land-based activities effecting the marine environment.	Indirect	Small accidental spills, erosion, sedimentation and dust pollution could occur during landside construction with potential for downstream impacts on the marine environment (particularly through surface or groundwater runoff).	Spills of chemicals/ fuels could occur. Increase risk of erosion, sedimentation and dust emissions during ground clearing activities.	Construction: 14 to 20 month period.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Operations	Sea level rise/ surface/groundwater runoff Flooding resulting in inundation of infrastructure with pollution potential (e.g. treatment plant, WMF)	Indirect	Pollution of marine water quality from inundation of managed facilities due to sea level rise and/or storm surge.	Possible effects likely limited to within lagoon	Operations: Following sea level rise and/or flooding event	Moderate
Operations	Surface and groundwater runoff/ Terrestrial habitat modification Pollution from contaminated surface and groundwater (i.e. boat washdown facility) and/or clearing native coastal vegetation	Indirect	Surface or groundwater runoff of pollutants from terrestrial sources and /or clearing native coastal vegetation which act as natural buffers trapping pollutants and stabilise shorelines.	Possible effects limited in extent due to likely small chronic increases in pollutants as opposed to a significant event.	Operations: Design life of new infrastructure	Moderate

4.1.1.1. Pressure Summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- Dust pollution
- Accidental spills
- Wastewater effluent
- Introduced marine pests
- Erosion and sedimentation
- Coastal Processes/Sea level rise
- Surface and Groundwater runoff
- Waste
- Terrestrial Habitat Modification
- Coastal and Marine Habitat Modification

4.1.2. Mitigation recommendations

The identification and implementation of appropriate management measures will limit the risk of the potential impacts, with recommended mitigation strategies listed in Table 8. These types of impacts can never be removed completely during construction or operation, but all potential impacts are considered as low risk and minor. The residual risk after implementation of mitigations is presented in Section 4.1.3.

Table 8: Recommended mitigation strategies to reduce potential impacts during construction and operation

Potential impact		Management Strategy (Avoidance, Minimise, Manage, Monitor, Restoration, Offsets)
Coastal/marine habitat modification Reduction in water quality from release of toxicants or nutrients due to seabed disturbance		Minimise • Restrict vessel speed in the project area. • Ensuring seabed disturbance activities only occur within the Project Area. Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring
Coastal/marine habitat modification Increased turbidity from sediment resuspension activities		Minimise: • Restrict vessel speed in the project area. • Ensuring seabed disturbance activities only occur within the Project Area. • Select construction methods which minimise turbidity resuspension. • Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring. • Tidal monitoring & consideration for activities (i.e. boat ramp on low tide, vessel movements on high tide) • Consideration of draft required for construction and operational vessels to access site and requirement for Marine Parks Permit • Marine Parks Permit required for new supply vessel (DPI 2022)

Potential impact	Management Strategy (Avoidance, Minimise, Manage, Monitor, Restoration, Offsets)
	Manage: • Works are expected to result in temporary, localised increase in turbidity, generally within 5 to 20 m from the disturbance location. • If sediment plumes are possible then silt curtains may be implemented to aid in mitigation. Monitor: • Regular inspection/ visual monitoring. • Reactive turbidity monitoring during construction if plumes of concern are observed
Accidental spills Hydrocarbon or waste spills from vessels or on land	Minimise: • Development of spill prevention and response procedures within a Construction and Environmental Management Plan and/or vessel safety management system. • Ensure all construction vessels are compliant with the International Maritime Organisation International Convention for the Prevention of Pollution from ships (MARPOL) • Development of hydrocarbon and waste handling procedure for ongoing sea freight operations • Identify storage locations and procedures for hydrocarbon and waste management. Manage: • Notify LHI Port Operations Manager (or assistant) immediately by radio as listed or telephone (02) 6563 2199 or (02) 6563 2066 if a spill occurs • Spill kit kept on site, all necessary materials for mitigation of an accidental <u>large-scale spill</u> of hydrocarbons and waste. Bunding for storage and handling (i.e. in accordance with AS1940). Monitor: • Regular inspections. • Reactive water quality monitoring in the event of a spill
Erosion/sedimentation, dust, Waste, pollution, surface/groundwater runoff.	Minimise: • Development of an erosion and sediment control plan. • Identify procedures for erosion, sedimentation and dust control. Manage: • Erosion, sedimentation control (i.e. installation of barriers and catchments systems) and dust control (i.e. water cart, sprinkler systems on unsealed surfaces and stockpiles). • Implement recommended management within relevant guidelines such as Guidelines for developments adjacent to national parks and other reserves (NPWS 2020) and Managing Urban Stormwater: Soils and construction – Volume 1 (Landcom 2004)

Potential impact	Management Strategy (Avoidance, Minimise, Manage, Monitor, Restoration, Offsets)
	Monitor: - Regular inspections. - Reactive monitoring during construction if plumes of concern are observed
Wastewater effluent Vessel discharge	Manage - All vessel sewage, including that from holding tanks and onboard treatment systems, must be deposited into approved waste collection facilities. It is illegal in NSW to discharge untreated sewage from any vessel into or onto the bank of any navigable waters. - MARPOL (International Convention for the Prevention of Pollution from Ships) is the international treaty that governs pollution prevention from commercial vessels, covering six key areas: oil, noxious liquid substances, harmful packaged substances, sewage, garbage, and air pollution.
Introduced Marine Pests Introduction of IMS and pathogens	Minimise: - Pre-inspection of construction vessels for risk of IMP including when last cleaned and antifoul applied, biofouling assessment, type of vessel, ports visited recently Manage: (Where applicable) Adhere to Australian ballast water management requirements and the International Maritime Organization's (IMO) 2011 Guidelines for the control and management of ships' ballast water and sediments to minimise the transfer of invasive aquatic species and LHIMP requirements. (Where applicable) Adhere to Lord Howe Island Biosecurity - Visiting Vessels Guidelines (LHIB 2020) - All commercial vessels to be maintained in accordance with Australian biofouling management requirements (DAFF 2023) Monitor: - Marine parks continue to undertake periodic monitoring for IMP
Sea Level Rise/ surface/groundwater runoff	Manage - Develop new infrastructure considering NSW Coastal Design Guidelines 2023 (DPE 2023) and other relevant guidelines for coastal development with suitable setback and floor heights. Monitor: - Reactive monitoring in the event of flood inundation of facilities that represent coastal risk of pollution
Surface and groundwater runoff/ Terrestrial habitat modification Downstream pollution from coastal facilities	Manage - Implement design and management recommendations within relevant guidelines such as Managing Urban Stormwater: Soils and construction – Volume 1 (Landcom 2004) - Avoid removal of coastal vegetation.

Potential impact	Management Strategy (Avoidance, Minimise, Manage, Monitor, Restoration, Offsets)
	Monitor: - Consider periodic ongoing monitoring of groundwater and surface water - Long-term monitoring of marine water and sediment quality within the marine park

4.1.3. Assessment and significance of residual impacts

The potential impacts listed in Table 7 are considered a low risk given the proposed mitigation measures recommended for construction and operation of the Project. The residual impacts to water visibility and quality are presented in Table 9. Risks are generally considered minor/insignificant (after mitigation is applied).

Table 9: Residual impacts of the Project on Water Visibility and quality

Impact	Project Phase	Assessment	Residual Impact
Coastal/marine habitat modification Release of toxicants or nutrients from sediment disturbance	Construction	Sediment sampling indicates that any sediment released into the water column is unlikely to introduce any contaminants or toxicants above the natural levels.	Minor/ Insignificant
Coastal/marine habitat modification Increased turbidity from marine construction activities	Construction	Piling and marine construction works are expected to result in temporary, localised increase in turbidity, generally within 5 to 20 m from the pile location or seabed disturbance activity	Minor/ Insignificant
Accidental Spills Hydrocarbon or waste spills from vessels.	Construction and operation	Standard procedures storage, handling and management for waste and hydrocarbons should be implemented for the duration of the Project. Spill kits and appropriate waste bins to be kept on site.	Minor/ Insignificant
Erosion and sedimentation, waste, dust pollution, surface/groundwater runoff.	Construction	Standard management of erosion and sedimentation, waste, dust pollution and surface/groundwater runoff should be implemented to minimise impacts from the landside development on the marine environment.	Minor/ Insignificant
Wastewater effluent Vessel discharge	Construction	Standard management of vessel sewage discharge for commercial vessels should be implemented to prevent impacts from vessel discharges	Minor/ Insignificant

Introduced Marine Pests	Construction and Operation	Australian and international biofouling management, ballast discharge management and LHI Biosecurity requirements should be followed to minimise the potential for the introduction of IMP.	Minor/ Insignificant
Sea Level Rise/ surface/groundwater runoff	Construction and operations	Standard management of coastal hazards applied to Project design considering appropriate setback and floor heights required to allow for sea level rise and flood events.	Minor/ Insignificant
Surface and groundwater runoff/ Terrestrial habitat modification Downstream pollution from coastal facilities	Operations	Standard management of coastal facilities such as boat wash down area to prevent pollution of the marine environment	Minor/ Insignificant

4.2. Ecosystems

Marine Park Value: Numerous ecosystems spanning a wide range of habitats and biological communities.

World Heritage Value: The unusual combination of tropical and temperate marine flora and fauna, including many species at their distributional limits, reflecting the extreme latitude of the coral reef ecosystems which are the southern-most true coral reefs in the world

4.2.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 10. Activities associated with the Project involving piling, construction and operations of the Jetty and boat ramp may have impacts to the local ecosystems within the lagoon. Landside development and coastal geomorphological changes also have the potential to impact on the local ecosystems within the lagoon. Potential impacts on the ecosystems associated with the Project that, in the absence of management or mitigation, may occur during construction or operation are listed in Table 11.

Table 10: Impact criteria for Ecosystems

Assessment	Description
Major	Permanent and/or irreversible damage to the distribution and diversity of ecosystems.
Moderate	Moderate semi-permanent changes to the distribution and diversity of ecosystems on a local scale. For example, impacts within and around the inner lagoon.
Minor/ Insignificant	No impact or small, low risk changes to the distribution and diversity of ecosystems on a local scale. For example, temporary and/ or localised changes to ecosystems during construction activities occurring within the Project Area.

Table 11: Potential impacts to ecosystems

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Marine Construction	Coastal/marine habitat modification Loss of intertidal and subtidal benthic communities due to habitat modification from construction activities	Direct	Marine construction involves upgrades to existing infrastructure and extending the marine disturbance area with direct impacts to intertidal (boat ramp) and subtidal (jetty infrastructure) habitat. Loss of benthic habitat will be permanent in the location of the piles, piled jetty ramp and mooring dolphins.	Relatively small number of piles and within Project Area. New piled ramp for roll on roll off cargo. Direct loss of habitat: • Piled ramp ~300 m² (worst case scenario covering the disturbance area of the ramp however the sea bed disturbance will be limited to the disturbance area of the piles that the ramp deck sits on) • Piled mooring dolphins ~30 m² (for 4 x triple pile moorings) • Boat ramp upgrades (design to be finalised)	The indicative program suggests marine construction extending over an eight month period.	Moderate
Construction and Operations	Coastal/marine habitat modification Loss of benthic communities from vessel grounding during construction and operation.	Direct	Increase vessel activity during construction and specialised vessels requiring access to site. New supply vessel to continue routine	Vessel activity limited to Project Area. New operational supply vessel to have shallow draft although may require more	The indicative program has construction extending over a 14 to 20 month period.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			operational sea freight service once the new piled ramp is completed.	manoeuvring to access new piled ramp.	Marine construction: eight months Operations: vessel traffic ongoing.	
Construction and Operations	Decline in water visibility and quality (see Section 4.1) from the following pressures: - Coastal/marine habitat modification - Accidental spills/ waste - Wastewater effluent or ballast water discharge - Erosion/sedimentation Dust pollution - Surface/groundwater runoff - Coastal processes/sea level rise	Indirect	Water quality decline from land and marine sources resulting in impacts to marine ecosystems. Pollutants may be toxic to marine communities. High nutrient input creates algae blooms/ eutrophication, increasing potential for harmful algae, oxygen depletion and loss of marine life. Turbidity inhibits light penetration through the water column for benthic photosynthetic biota. Waste can harm marine life through entanglement and ingestion.	Possible effects likely limited to within lagoon	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			Pathogens can cause infectious diseases. Marine fauna impacts can disrupt the food web within ecosystems.			
Construction and Operations	Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on ecosystem function and loss	Indirect	Increase in vessel traffic and increased risk of IMP for specialised vessels (e.g. barge) during construction. Translocation of IMP by supply vessel for ongoing sea freight from mainland NSW Ports. Vectors for translocation of IMP from a mainland port include biofouling on the vessel hull or ballast water transport. IMP can disrupt native habitats, outcompete or prey on native species for food and space, introduce diseases and parasites, and cause significant	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boats • Supply vessel.	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			habitat changes that reduce biodiversity			
Operations	Coastal Processes Changes to coastal process resulting in habitat modification and ecosystem impacts.	Indirect	Shoreline and coastal habitat modification with infrastructure changes could in turn impact on marine ecosystems. Revetment wall and already in place. Changes to the coastline influences hydrodynamics and sediment delivery which can result in localised changes in water temperature and smothering of nearshore reefs.	New piled ramp and boat ramp within Project Area.	Operations: Design life of new infrastructure	Minor/ Insignificant

4.2.1.1. Pressure Summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- All pressures assessed within water visibility and quality (Section 4.1), including:
 - Accidental spills/ waste
 - Wastewater effluent or ballast water discharge
 - Erosion/sedimentation
 - Dust pollution
 - Surface/groundwater runoff
- Coastal and Marine Habitat Modification
- Introduced Marine Pest Species
- Coastal Processes/Sea Level Rise

4.2.2. Mitigation recommendations

The identification and implementation of appropriate management measures will limit the risk of the potential impacts, with recommended mitigation strategies listed in Table 12. Some types of impacts can never be removed completely due to the physical disturbance during construction, but all potential impacts can be minimised. The residual risk after implementation of mitigations is presented in Section 4.2.3.

Table 12: Mitigation strategies to reduce potential impacts during construction and operation

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Coastal/marine habitat modification Loss of benthic communities due to habitat modification from construction activities	Avoidance: • • Where anchoring is required for work vessels and barges, note LHIMP anchoring restrictions for minimising the risk of anchor damage (DPI 2022) • Choosing a design option to avoid sensitive benthic habitats and minimising the disturbance area. Minimise: • Ensuring construction activities only occur within the Project Area. • Construction vessels to utilise high definition positioning systems. Manage: • Gain approval from Port Operations Managers for entry into the lagoon (DPI 2022) • Lodge application for mooring to Lord Howe Island Board at least 5 days prior to departure (DPI 2022) • Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring. • Exclusion zones to restrict shoreline access and minimise the impacts to the intertidal areas. Monitor:

	Pre-construction survey of benthic habitats that will be directly disturbed to ensure no critical ecosystems disturbed
Coastal/marine habitat modification Loss of benthic communities from vessel grounding	Minimise: - Contact Port Operations Manager for entry into the Lagoon (DPI 2022) - Vessels to be aware of shallow conditions within the lagoon, crews to be informed of operational responsibilities to ensure safe navigation and environmental protection (DPI 2022) - Ensuring construction activities/ vessel movement only occur within the Project Area with strategies to include exclusion zones to sensitive habitats. - Utilising existing impacted mooring areas (where practical) for any mooring of project vessels. - Contractors to have clearly identified areas permitted for seabed disturbance. - Consideration of draft required for construction and operational vessels to access site and requirement for Marine Parks Permit to minimise the potential for groundings and impacts to benthic communities along the navigation channel - Marine Parks Permit required for new supply vessel (DPI 2022) - Consider tidal windows for vessel movements. Manage: - Vessel Safety Management System to address prevention and response actions for grounding - Restrict vessel speed in the project area. - Install channel markers - Develop procedures for ongoing supply vessel entrance, unloading and departure Monitor: - Pre/post construction and ongoing benthic habitat surveys that will validate disturbance levels from grounding to limit further disturbance of ecosystems and recovery
Decline in water visibility and quality	see Section 4.1
Introduced Marine Pests and Translocation and establishment of IMP	Minimise: - Pre-inspection of construction vessels for risk of IMP including when last cleaned and antifoul applied, biofouling assessment, type of vessel, ports visited recently Manage: (Where applicable) Adhere to Australian ballast water management requirements and the IMO 2011 Guidelines for the control and management of ships' ballast water and sediments to minimise the transfer of invasive aquatic species and LHIMP requirements. (Where applicable) Adhere to Lord Howe Island Biosecurity - Visiting Vessels Guidelines (LHIB 2020) - All commercial vessels to be maintained in accordance with Australian biofouling management requirements (DAFF 2023)

	Monitor: Marine parks continue to undertake periodic monitoring for IMP
Coastal Processes Changes to coastal process that modify habitat and impact ecosystems	Minimise: - Identify and Implement design elements to minimise impacts to coastal processes from the marine infrastructure changes. Incorporate NSW Coastal Design Guidelines (DPE, 2023) Monitoring: - Consider ongoing monitoring for erosion, sediment movement and coastal change.

4.2.3. Assessment and significance of residual impacts

The Project will have some unavoidable direct irreversible impacts to the benthic habitat due to the placement of the piles and seabed infrastructure (i.e. new piled ramp). However, habitat mapping suggests that the most directly affected habitat types in the marine Project area is *Unvegetated Substrates* and *Lagoon Floor – Macroalgae/ Rubble*, with sparse benthic communities, therefore minimising the impacts to the ecosystem. In addition to this, the artificial structures provide opportunity for ecosystem services. The assessment of the residual impacts is presented in Table 13.

Table 13: Residual impacts of the Project on ecosystems

Impact	Project Phase	Assessment	Residual Impact
Coastal/marine habitat modification Loss of benthic communities due to habitat modification from construction activities	Construction	Seabed disturbance is limited to a small area with sparse presence of BCH. Anchoring of construction vessels to avoid sensitive areas with high coverage of BCH. Impacts are not likely to impact ecosystem diversity.	Minor/ Insignificant
Coastal/marine habitat modification Loss of benthic communities from vessel grounding	Construction and Operation	Vessel groundings have occurred in the past, however limiting construction and operation to previously impacted jetty areas, shipping channel, turning areas, mooring areas will minimise the potential for impact to ecosystems. Construction vessels will need to be evaluated for access.	Minor/ Insignificant
Decline in water visibility and quality resulting in ecosystem impacts	Construction and Operation	Residual impacts to water quality and visibility in Section 4.1 classified as 'insignificant', except for potential for accidental chemical or waste spills. Therefore, residual impacts on the ecosystem from changes in water quality will be similar.	Minor/ Insignificant

Impact	Project Phase	Assessment	Residual Impact
Introduced Marine Pests Translocation and establishment of IMP	Construction and Operation	Australian and international biofouling management, ballast discharge management and LHI Biosecurity requirements should be followed to minimise the potential for the introduction of IMP.	Minor/ Insignificant
Coastal Processes Changes to coastal process that modify habitat and impact ecosystems	Operations	Due to the existing foreshore hardening, the absence of longshore drift, and the positioning of the site between two shallow intertidal platforms, modifications to shoreline and ecosystems will likely be minimal.	Minor/ Insignificant

4.3. Corals

Marine Park Value: Southernmost records of coral reef distribution in the world.

World Heritage Value: The unusual combination of tropical and temperate marine flora and fauna, including many species at their distributional limits, reflecting the extreme latitude of the coral reef ecosystems which are the southern-most true coral reefs in the world

4.3.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 14. Activities associated with the Project involving piling, construction and operations of the Jetty and boat ramp may have impacts to the coral communities within the lagoon. Landside development and coastal geomorphological changes also have the potential to indirectly impact on the local coral communities within the lagoon. Potential impacts on the corals associated with the Project that, in the absence of management or mitigation, may occur during construction or operation are listed in Table 15.

Table 14: Impact criteria for Coral

Assessment	Description
Major	Permanent and/or irreversible damage or loss of coral communities either through smothering impacts or mechanical removal on the seabed.
Moderate	Moderate semi-permanent changes to coral communities on a local scale. For example, impacts within and around the inner lagoon.
Minor/ Insignificant	No impact or small, low risk changes to coral communities on a local scale. For example temporary and/ or localised changes to ecosystems during construction activities only occurring within the Project Area.

Table 15: Potential impacts to corals

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Marine Construction	Coastal/marine habitat modification Loss of intertidal and subtidal coral communities due to habitat modification from construction activities	Direct	Marine construction involves upgrades to existing infrastructure and extending the marine disturbance area with direct impacts to intertidal (boat ramp) and subtidal (jetty infrastructure) habitat.	Relatively small number of piles and within Project Area. No coral has been mapped in the location of the proposed marine infrastructure (Appendix B).	The indicative program suggests marine construction extending over an eight month period.	Minor/ Insignificant
Construction and Operations	Coastal/marine habitat modification Loss of Corals from vessel grounding during construction and operation.	Direct	Increase vessel activity during construction and specialised vessels requiring access to site. New supply vessel to continue routine operational sea freight service once the new piled ramp is completed.	Vessel activity to be limited to Project Area. No corals mapped in location of proposed infrastructure. However, coral communities mapped immediately adjacent to jetty and boat ramp and within the navigation channel.	The indicative program has construction extending over a 14 to 20 month period. Marine construction: eight months Operations: vessel traffic ongoing.	Moderate
Construction and Operations	Decline in water visibility and quality (see Section 4.1) from the following pressures: Coastal/marine habitat modification	Indirect	Water quality decline from land and marine sources resulting in impacts to corals.	Possible effects likely limited to within lagoon	Construction: 14 to 20 months. Marine construction: eight months	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
	Accidental spills/ waste Wastewater effluent or ballast water discharge Erosion/sedimentation Dust pollution Surface/groundwater runoff Coastal processes/sea level rise		Pollutants may be toxic to corals. High nutrient input creates algae blooms/ eutrophication, increasing potential for harmful algae, oxygen depletion and loss of coral communities. Turbidity inhibits light penetration through the water column for photosynthetic corals. Waste can harm marine life through entanglement and ingestion which can disrupt the ecological food web for coral (e.g. decline in herbivore fauna resulting in macroalgae displacement when competing for habitat) Pathogens can cause infectious diseases.		Operations: vessel traffic ongoing.	

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Construction and Operations	Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on coral	Indirect	Increase in vessel traffic and increased risk of IMP for specialised vessels (e.g. barge) during construction. Translocation of IMP by supply vessel for ongoing sea freight from mainland NSW Ports. Vectors for translocation of IMP from a mainland port include biofouling on the vessel hull or ballast water transport. IMP can disrupt native habitats, outcompete or prey on native species for food and space, introduce diseases and parasites, and cause significant habitat changes that reduce biodiversity	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boats • Supply vessel.	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing	Moderate
Operations	Coastal Processes Changes to coastal process resulting in loss of Corals.	Indirect	Shoreline and coastal habitat modification with infrastructure changes could	New piled ramp and boat ramp within Project Area.	Operations: Design life of new infrastructure.	Minor/ Insignificant

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			in turn impact on coral communities. Changes to the coastline influences hydrodynamics and sediment delivery which can result in localised changes in water temperature and smothering of nearshore reefs.			

4.3.1.1. Pressure Summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- All pressures assessed within water visibility and quality (Section 4.1), including:
 - Accidental spills/ waste
 - Wastewater effluent or ballast water discharge
 - Erosion/sedimentation
 - Dust pollution
 - Surface/groundwater runoff
- Coastal and Marine Habitat Modification
- Introduced Marine Pest Species
- Coastal Processes/Sea Level Rise

4.3.2. Mitigation recommendations

The identification and implementation of appropriate management measures limit the risk of the potential impacts, with recommended mitigation strategies listed in Table 12. Some types of impacts can never be removed completely due to the physical disturbance during construction, but all potential impacts can be minimised. The residual risk after implementation of mitigations is presented in Section 4.3.3.

Table 16: Mitigation strategies to reduce potential impacts during construction and operation

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Coastal/marine habitat modification Loss of corals from pile installation and/or disturbance to the sea floor	Avoidance: • Where anchoring is required for work vessels and barges, noting LHIMP anchoring restrictions for minimising the risk of anchor damage (DPI 2022) • Choosing a design option to avoid coral communities and minimising the design disturbance area. Minimise: • Ensuring construction activities only occur within the Project Area. • Construction vessels to utilise high definition positioning systems. Manage: • Contact Port Operations Managers for entry into the lagoon (DPI 2022) • Lodge application for mooring to Lord Howe Island Board at least 5 days prior to departure (DPI 2022) • Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring. • Exclusion zones to restrict shoreline access and minimise the impacts to the intertidal areas. Monitor: • Pre-construction survey of benthic habitats that will be directly disturbed to ensure no impact on critical benthic communities

Coastal/marine habitat modification Loss of corals from vessel grounding	Minimise: • Contact Port Operations Managers for entry into the Lagoon • Vessels to be aware of shallow conditions within the lagoon, crews to be informed of operational responsibilities to ensure safe navigation and environmental protection (DPI 2022) • Ensuring construction activities/ vessel movement only occur within the Project Area with strategies to include exclusion zones to protect benthic communities. • Utilising existing impacted mooring areas (where practical) for any mooring of project vessels. • Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring. • Consideration of draft required for construction and operational vessels to access site and requirement for Marine Parks Permit to minimise the potential for groundings and impacts to coral communities along the navigation channel • Marine Parks Permit required for new supply vessel (DPI 2022) • Consider tidal windows for vessel movements. Manage: • Vessel Safety Management System to address prevention and response actions for grounding • Restrict vessel speed in the project area. • Install channel markers • Develop procedures for ongoing supply vessel entrance, unloading and departure Monitor: • Pre/post construction and ongoing benthic surveys that will validate disturbance levels from grounding to limit further disturbance of ecosystems and recovery from historical impacts
Decline in water visibility and quality	see Section 4.1 Monitor: • Consider turbidity monitoring at benthic communities immediately adjacent to Project area boundary.
Introduced Marine Pests Translocation and establishment of IMP	Minimise: • Pre-inspection of construction vessels for risk of IMP including when last cleaned and antifoul applied, biofouling assessment, type of vessel, ports visited recently Manage: • (Where applicable) Adhere to Australian ballast water management requirements and the IMO 2011 Guidelines for the control and management of ships' ballast water and sediments to minimise the transfer of invasive aquatic species and LHIMP requirements. • All commercial vessels to be maintained in accordance with Australian biofouling management requirements (DAFF 2023) Monitor: • Marine parks continue to undertake periodic monitoring for IMP

Coastal Processes	Minimise:
Changes to coastal process that coral degradation and diversity	Identify and Implement design elements to minimise impacts to coastal processes from the marine infrastructure changes. Incorporate NSW Coastal Design Guidelines (DPE, 2023)
	Monitoring:
	Consider ongoing monitoring for erosion, sediment movement and coastal change.

4.3.3. Assessment of significance of residual impacts

The Project will have some unavoidable direct irreversible impacts to the seabed due to the placement of the piles and seabed infrastructure (i.e. new piled ramp). However, habitat mapping suggests that the most directly affected habitat types in the marine development area is *Unvegetated Substrates* and *Lagoon Floor – Macroalgae/ Rubble* with sparse benthic communities and therefore minimising the impacts to corals.

Table 17: Residual impacts of the Project on corals

Impact	Project Phase	Assessment	Residual Impact
Coastal/marine habitat modification Loss of coral communities due to habitat modification from construction activities	Construction	Seabed disturbance is limited to a small area with sparse presence of BCH and with no corals identified. Anchoring of construction vessels to avoid sensitive areas with coral cover. Impacts are therefore not likely to impact corals.	Minor/ Insignificant
Coastal/marine habitat modification Loss of coral communities from vessel grounding	Construction and Operation	Vessel groundings have occurred in the past, however limiting construction and operation to previously impacted jetty areas, navigation channel, turning areas, mooring areas will minimise the potential for impact to corals. Construction vessels will need to be evaluated for access.	Minor/ Insignificant
Decline in water visibility and quality resulting in impacts to corals	Construction and Operation	Residual impacts to water quality and visibility in Section 4.1 classified as 'insignificant', except for potential for accidental chemical or waste spills. Therefore, residual impacts on benthic habitats from changes in water quality will be similar.	Minor/ Insignificant
Introduced Marine Pests Translocation and establishment of IMP	Construction and Operation	Australian and international biofouling management, ballast discharge management and LHI Biosecurity requirements should be	Minor/ Insignificant

Impact	Project Phase	Assessment	Residual Impact
		followed to minimise the potential for the introduction of IMP.	
Coastal Processes Changes to coastal process that modify habitat and impact corals	Operations	Due to the existing foreshore hardening, the absence of longshore drift, and the positioning of the site between two shallow intertidal platforms, modifications to shoreline and coral communities will likely be minimal.	Minor/ Insignificant

4.4. Macrophytes

Marine Park Value: Macrophytes are common and diverse.

World Heritage Value: The diversity of marine benthic algae species, which include many endemic species

4.4.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 18. Activities associated with the Project involving piling, construction and operations of the Jetty and boat ramp may have impacts to the local seagrass and macroalgae communities within the lagoon. Landside development and coastal geomorphological changes also have the potential to indirectly impact on macrophytes (seagrass and macroalgae) within the lagoon. Potential impacts on macrophytes associated with the Project that, in the absence of management or mitigation, may occur during construction or operation are listed in Table 19.

Table 18: Impact criteria for macrophytes

Assessment	Description
Major	Permanent and/or irreversible loss of diversity of macrophytes either through smothering impacts or mechanical removal on the seabed.
Moderate	Moderate semi-permanent changes to macrophytes diversity on a local scale. For example, impacts within and around the inner lagoon.
Minor/ Insignificant	No impact or small, low risk changes to macrophytes on a local scale. For example temporary and/or localised changes to ecosystems during construction activities occurring within the Project Area.

Table 19: Potential impacts to macrophytes

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Marine Construction	Coastal/marine habitat modification Loss of intertidal or subtidal macrophyte communities due to habitat modification from construction activities	Direct	Marine construction involves upgrades to existing infrastructure and extending the marine disturbance area which directly impacts to intertidal (boat ramp) and subtidal (jetty infrastructure) habitat..	Relatively small number of piles and within Project Area. A section of the piled ramp and the piled mooring dolphins falls partially within an area of mapped as sparse seagrass and macroalgae habitat (Appendix B).	The indicative program has marine construction extending over an eight month period.	Moderate
Construction and Operations	Decline in water visibility and quality (see Section 4.1) from the following pressures: Coastal/marine habitat modification Accidental spills/ waste Wastewater effluent or ballast water discharge Erosion/sedimentation Dust pollution Surface/groundwater runoff Coastal processes/sea level rise	Indirect	Water quality decline from land and marine sources resulting in impacts to macrophytes. Pollutants may be toxic to macrophytes. High nutrient input creates algae blooms/ eutrophication, increasing potential for harmful algae, oxygen depletion and loss of macrophyte communities.	Possible effects likely limited to within lagoon	The indicative program has construction extending over a 14 to 20 month period. Marine construction: eight months Operations: vessel traffic ongoing.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			Turbidity inhibits light penetration through the water column for photosynthetic macrophytes. Waste can harm marine life through entanglement and ingestion which can disrupt the ecological food web for macrophytes (e.g. decline in herbivore predators resulting in decline of macrophytes) Pathogens can cause infectious diseases.			
Construction and Operations	Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on macrophytes	Indirect	Increase in vessel traffic and increased risk of IMP for specialised vessels (e.g. barge) during construction. Translocation of IMP by supply vessel for ongoing sea freight from mainland NSW Ports. Vectors for translocation of IMP from a mainland port include biofouling on the	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boats • Supply vessel	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			vessel hull or ballast water transport. IMP can disrupt native habitats, outcompete or prey on native species for food and space, introduce diseases and parasites, and cause significant habitat changes that reduce biodiversity			
Operations	Coastal Processes Changes to coastal process that result in loss of and diversity of macrophytes.	Indirect	Changes to shoreline and coastal habitat with infrastructure changes could in turn impact on macrophyte communities. Changes to the coastal geomorphology influences hydrodynamics and sediment delivery which can result in localised changes in water temperature and smothering of nearshore reefs.	New piled ramp and boat ramp within Project Area.	Operations: Design life of new infrastructure.	Minor/ Insignificant

4.4.1.1. Pressure Summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- All pressures assessed within water visibility and quality (Section 4.1), including:
 - Accidental spills/ waste
 - Wastewater effluent or ballast water discharge
 - Erosion/sedimentation
 - Dust pollution
 - Surface/groundwater runoff
- Coastal and Marine Habitat Modification
- Introduced Marine Pest Species
- Coastal Processes/Sea Level Rise

4.4.2. Mitigation recommendations

The identification and implementation of appropriate management measures limit the risk of the potential impacts. The recommended mitigation strategies for corals are also considered appropriate for macrophytes. Refer to Table 16 for recommended mitigation measures.

4.4.3. Assessment of significance of residual impacts

The Project will have some unavoidable direct irreversible impacts to the seabed due to the placement of the piles and seabed infrastructure (i.e. new piled ramp). However, habitat mapping and other reports suggests that the most directly affected habitat types in the marine Project area is highly disturbed and classified as *Unvegetated Substrates* and *Lagoon Floor – Macroalgae/ Rubble* with sparse benthic communities, and therefore minimising the impacts to macrophytes.

Table 20: Residual impacts of the Project on macrophytes

Impact	Project Phase	Assessment	Residual Impact
Coastal/marine habitat modification Loss of macrophytes and their diversity from pile installation and/or disturbance to the sea floor	Construction	Seabed disturbance is limited to a small area with sparse presence of BCH. The area has previously been used for operational and recreational vessel activities which has impacted the sea bed and associated benthos. There is sparse coverage and presence of macroalgae in the area identified for sea bed disturbance. This small area has been chosen to avoid sensitive areas with high coverage of macrophytes (seagrass and macroalgae) and the area has previously been impacted by operational activities. Impacts are therefore not likely to significantly impact on the coverage or diversity of macrophytes.	Minor/ Insignificant
Coastal/marine habitat modification	Construction and Operation	Vessel groundings have occurred in the past, however limiting construction and operation to	Minor/ Insignificant

Impact	Project Phase	Assessment	Residual Impact
Loss of macrophytes and their diversity from vessel grounding		previously impacted jetty areas, navigation channel, turning areas, mooring areas will minimise the potential for impact to corals. Construction vessels will need to be evaluated for access.	
Decline in water visibility and quality resulting in impacts to macrophytes	Construction and Operation	Residual impacts to water quality and visibility in Section 4.1 classified as 'insignificant', except for potential for accidental chemical or waste spills. Therefore, residual impacts on the ecosystem from changes in water quality will be similar.	Minor/ Insignificant
Introduced Marine Pests Translocation and establishment of IMP	Construction and Operation	Australian and international biofouling management, ballast discharge management and LHI Biosecurity requirements should be followed to minimise the potential for the introduction of IMP.	Minor/ Insignificant
Coastal Processes Changes to coastal process that modify habitat and impact macrophytes	Operations	Due to the existing foreshore hardening, the absence of longshore drift, and the positioning of the site between two shallow intertidal platforms, modifications to shoreline and macrophyte communities will likely be minimal.	Minor/ Insignificant

4.5. Fish assemblage

Marine Park Value: Diverse fish assemblage.

World Heritage Value: The diversity of marine fish species including at least 500 species of which 400 are inshore species and 15 are endemic

This section is focused on the impacts to fish diversity as a result of the Project. Impacts to conservation significant key fish species are assessed individually within Sections 4.7 and 4.8.

4.5.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 21. Key pressures on fish communities associated with Project activities include loss of benthic habitat (i.e. coral and macrophyte communities) and underwater noise. All potential impacts to the diversity of fish assemblage within the LHIMP that, in the absence of management or mitigation, may occur during construction or operations are listed in Table 22.

Table 21: Impact criteria for the significance of potential impact

Assessment	Description
Major	Significant and/or irreversible changes to fish diversity and quality over the LHIMP. Changes are likely to be permanent.
Moderate	Moderate changes to fish diversity on a local scale. For example, within and around the inner lagoon. Changes may be temporary but may not recover within 5 years, or permanent.
Minor/ Insignificant	No impact or small, low risk changes to fish diversity on a local scale. For example, changes may be temporary (recovery within 5 years) and restricted to populations within the lagoon area.

Table 22: Potential impacts to fish diversity

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of impacts
Marine Construction	Underwater Noise Injury, death or behavioural response from underwater noise during piling	Direct	Installation of piles using impact or vibratory hammer generating impulsive underwater noise. Fish species sensitivity to underwater noise is typically less than other marine megafauna, although hearing loss and chronic low-level exposure damage have been observed in some fish and larvae from underwater noise (Popper and Hawkins 2018). While fish species are typically mobile, some reef fish have small home ranges that make them vulnerable to noise disturbances (i.e. clown fish, sygnathiids).	Modelled distances for spatial extent of underwater noise levels provided by Resonate (2025). A summary of the potential distances for fish is provided in Section 4.5.1.1.	The indicative program has marine construction extending over an eight month period, however pile driving and seabed disturbance would only be a small portion of this (34 days of piling).	Moderate
Construction and Operations	Underwater Noise Injury or behavioural response from vessel generated underwater noise	Direct	Increase vessel activity during construction. Ongoing transfer of newly designed supply vessel.	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boat/s	The indicative program has construction extending over a 14 to 20 month period. Marine construction: eight months	Minor/ Insignificant

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of impacts
				Supply vessel Resonate (2025) indicate nil impacts on fish from underwater noise.	Operations: vessel traffic ongoing	
Construction and Operations	Vessel Strike Vessel strike of fish resulting in injury or death	Direct	Increase vessel activity during construction. Ongoing transfer of newly designed supply vessel.	Multiple vessels during construction and operations. Likely to include: - Piling barge - Materials barge - Work boat/s - Supply vessel	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing	Minor/ Insignificant
Construction and Operations	Decline in water quality through pollution (see Section 4.1) from the following pressures: Coastal/marine habitat modification Accidental spills/ waste Wastewater effluent or ballast water discharge Surface/groundwater runoff Sea level rise	Direct	Water quality decline from land and marine sources resulting in impacts to fish assemblage. Pollutants may be toxic to fish. High nutrient input creates algae blooms/ eutrophication, increasing potential for harmful algae and oxygen depletion leading to habitat loss and mass fish kill. Waste can harm fish through entanglement and ingestion.	Possible effects likely limited to within lagoon	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of impacts
			Pathogens can cause infectious diseases. These impacts can also disrupt the food web with potential population decline or shifts in fish species.			
Construction and Operations	Coastal/Marine Habitat Modification Loss of fish habitat within the Project area	Direct/Indirect	Loss of habitat directly or indirectly due to construction activities as well as vessel grounding during construction or ongoing operations (see Section 4.2). Some fish communities have strong associations with benthic communities such as the three stripe butterflyfish and amount of live hard coral cover (Hobbs et al 2008), or herbivores like the bluefish and large spotted surgeonfish found within macroalgal habitats (Harasti et al 2022).	Relatively small area of direct disturbance within Project Area. Vessel activity limited to within Project Area. New operational supply vessel to have shallow draft although may require more manoeuvring to access new piled ramp.	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing	Moderate
Construction and Operations	Introduced Marine Pests Translocation and establishment of IMP from	Indirect	Increase in vessel traffic and increased risk of IMP for	Multiple vessels during construction and	Construction: 14 to 20 months.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of impacts
	construction and operational vessels leading to impacts on ecosystem function and loss		specialised vessels (e.g. barge) during construction. Translocation of IMP by supply vessel for ongoing sea freight from mainland NSW Ports. Vectors for translocation of IMP from a mainland port include biofouling on the vessel hull or ballast water transport. IMP can disrupt native habitats, outcompete or prey on native species for food and space, introduce diseases and parasites, and cause significant habitat changes that reduce biodiversity	operations. Likely to include: • Piling barge • Materials barge • Work boats • Supply vessel.	Marine construction: eight months Operations: vessel traffic ongoing	
Construction and Operations	Waste Entanglement and/or ingestion of marine debris during construction and from public use of the jetty	Direct	Accidental release of unsecured items (rope, packing, general waste) into the marine environment which becomes entangled or ingested by marine fish	Increased human activity and materials handling will occur during construction period. Materials handling and activities will reduce to regular freight schedule upon project completion, although risk remains present during unloading freight.	Construction: 14 to 20 months. Marine construction: eight months Operations: vessel traffic ongoing	Moderate

4.5.1.1. Underwater noise modelling

Resonate (2015) conducted an underwater noise assessment which included the following scope:

- Overview of noise effects on marine species.
- Identification of sensitive marine fauna / hearing groups.
- Modelling of high impact construction and operational noise sources.
- Identification of physiological and behavioral impacts on identified species.
- Establishment of safe working distances for identified species in relation to the construction site.
- A risk assessment to identify if further control measures are required.

Project generated underwater noise sources include impact piling (cumulative and peak noise), vibratory piling and vessel movements during operational phase post construction. Distances modelled are determined by sensitivities of fish to risk of fatality, hearing injury separated into temporary threshold shifts (TTS) and permanent threshold shifts (PTS) and behavioural responses. Where insufficient data exist to make a recommendation for guidelines development, a subjective approach is adopted in which the relative risk of an effect is placed in order of rank at three distances from the source:

- Near: tens of meters from the source
- Intermediate: hundreds of meters from the source
- Far: thousands of meters from the source.

Fish have been separated into bony fish and elasmobranchs based on literature identifying differential sensitivities to underwater noise. Vessel movements were considered temporary non-impulsive noise which is significantly below impact thresholds that would not result in any impacts to fish (Resonate 2015). Modelled distances of impact and vibratory piling generated underwater noise sources for fish are provided in Table 23.

Table 23: Modelled distances (m) of Project generated underwater noise sources for bony fish and elasmobranchs

Hearing Group	Activity	Risk of fatality	PTS	TTS	Behavioural
Bony Fish	Impact Piling	200	700	1,900	N: High I: High F: Moderate
	Vibratory Piling	N: Low I: Low F: Low	1,800	3,350	N: High I: Moderate F: Low
Elasmobranchs	Impact Piling	200	400	1,900	N: High I: Moderate F: Low
	Vibratory Piling	N: Low I: Low F: Low	N: Moderate I: Low F: Low	N: Low I: Low F: Low	N: Moderate I: Moderate F: Low

4.5.1.2. Pressure Summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- All pressures assessed within water visibility and quality (Section 4.1), including:
 - Accidental spills/ waste
 - Wastewater effluent or ballast water discharge
 - Erosion/sedimentation
 - Dust pollution
 - Surface/groundwater runoff
- Underwater noise
- Vessel strike
- Coastal and Marine Habitat Modification
- Introduced Marine Pest Species
- Waste

4.5.2. Mitigation recommendations

The identification and implementation of appropriate management measures limit the risk of the potential impacts, with recommended mitigation strategies listed in Table 24. Some types of impacts can never be removed completely due to the physical disturbance during construction, but all potential impacts can be minimised. The residual risk after implementation of mitigations is presented in Section 4.5.3.

Table 24: Mitigation strategies to reduce potential impacts during construction and operation

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Underwater Noise Injury, death or behavioural response from underwater noise from piling	Minimise: • 30 minute pre-start, 30 minute soft-starts to slowly increase the noise intensity to allow fish to move away from the noise source • Marine piling should aim to avoid high tide where practicable. • Given Marine Fauna Observers (MFOs) are not necessarily a practical option to detect presence of fish during construction and some species are closely associated with habitat within predicted areas of impact, consider the use of bubble curtains, or other engineered solutions such as a piling sleeve or acoustic net to minimise noise propagation distance. Manage: • Prepare mitigations in an Underwater Noise Management Plan accordance with SA Underwater Piling Noise Guidelines (DPTI 2012) and Great Barrier Reef Underwater Noise Guideline Discussion and Options Paper (McPherson et al 2017) • See Safety Zones (Observation/ Potential Effect/Shutdown Zones) in Resonate (2025) for management areas relevant to piling activities for each fauna group (Figures 11 Figure 18) • Consider the use of respite days if high noise level activity (impact piling or vibratory piling) occurs on multiple successive days. • Consideration may also be afforded to timing of works to avoid important life-history periods for elasmobranch species which may utilise nearshore shallow waters as nursery area. Monitor: • Validate underwater noise predictions to ensure impacts are not greater than predicted and support management during piling activities • Consider telemetered underwater noise monitoring for real-time assessment against thresholds that can be incorporated into shut-down procedures at key locations for fish habitat • Consider pre/post monitoring targeted for key threatened species known to inhabit the predicted management zones which typically exhibit a limited home range (e.g. McCulloch's anemonefish).
Underwater Noise Injury or behavioural response from increased underwater noise from construction vessels	Minimise: • 30 minute pre-start to slowly increase the noise intensity to allow fish to move away from the noise source on departure Manage: • Restrict vessel speed in the navigation channel
Vessel Strike Vessel strike resulting in injury or death	Minimise: • Vessel use to be minimised to essential vessels only Manage: • Restrict vessel speed in the navigation channel

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Decline in water visibility and quality resulting in impacts to fish assemblage	see Section 4.1
Coastal/marine habitat modification Loss of fish habitat within the Project area	Avoidance: - Gain approval from Port Operations Managers for mooring use and entry into the lagoon - Where anchoring is required for work vessels and barges, noting LHIMP anchoring restrictions: - Vessels longer than five metres are prohibited from anchoring anywhere in the lagoon - All vessels are prohibited from anchoring in sanctuary zones, with three exclusion areas for vessels less than 10 metres long - Vessels must always aim to anchor in sand away from seagrass and coral - Vessels longer than 25 metres may anchor only in 6 designated roadstead sites – located outside the Lagoon (refer to Admiralty charts). - Vessels to be aware of shallow conditions within the lagoon, crews to be informed of operational responsibilities to ensure safe navigation and environmental protection - Choosing a design option to avoid sensitive benthic habitats and minimising the disturbance area. Minimise: - DPIRD require Port Operations Managers approval for entry into the Lagoon which will be dependent on: - Weather and sea conditions - The draft of the vessel (may exceed the safety limit for entry) - The weight of the vessel (may exceed the safe working load of the mooring systems) - The length of the vessel (vessels over 25 meters long may only anchor within one of 6 designated anchoring sites). - Ensuring construction activities only occur within the Project Area. - Construction vessels to utilise high definition positioning systems. - Consideration of draft required for construction and operational vessels to access site and requirement for Marine Parks Permit to minimise the potential for groundings and impacts to benthic communities along the navigation channel - New supply vessel design with shallower draft and Marine Parks Permit required - Consider tidal windows for vessel movements. Manage: - Vessel Safety Management System to address prevention and response actions for grounding

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
	- Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring. - Install channel markers - Exclusion zones to restrict shoreline access and minimise the impacts to the intertidal areas. - Develop procedures for ongoing supply vessel entrance, unloading and departure Monitor: - Pre/Post construction fish survey of benthic habitats that will be directly disturbed to ensure no critical ecosystems disturbed
Introduced Marine Pests Translocation and establishment of IMP	Minimise: - Pre-inspection of construction vessels for risk of IMP including when last cleaned and antifoul applied, biofouling assessment, type of vessel, ports visited recently Manage: (Where applicable) Adhere to Australian ballast water management requirements and the IMO 2011 Guidelines for the control and management of ships' ballast water and sediments to minimise the transfer of invasive aquatic species and LHIMP requirements. (Where applicable) Adhere to Lord Howe Island Biosecurity - Visiting Vessels Guidelines (LHIB 2020) - All commercial vessels to be maintained in accordance with Australian biofouling management requirements (DAFF 2023) Monitor: - Marine parks continue to undertake periodic monitoring for IMP
Waste Entanglement and/or ingestion of marine debris during construction and from public use of the jetty	Avoidance: - All waste and rubbish will be appropriately stored and managed to prevent debris and waste from entering the marine environment. Minimise: - Packaging to be removed prior to items being used within the marine environment as far as practicable

4.5.3. Assessment and significance of residual impacts

The Project will have some unavoidable direct irreversible impacts to fish communities due primarily to underwater noise generated from piling activities and potential seabed infrastructure disturbance. Additional engineering mitigations may be considered for piling activities. However, habitat mapping and other reports suggest that the most directly affected habitat types in the marine Project area is highly disturbed and classified as *Unvegetated Substrates* and *Lagoon Floor – Macroalgae/Rubble* with sparse benthic communities, which is unlikely to represent critical habitat for a high diversity of fish communities and result in significant impacts.

Table 25: Residual impacts of the Project on fish communities

Impact	Project Phase	Assessment	Residual Impact
Underwater Noise Injury, death or behavioural response from underwater noise during piling	Construction	Resonate (2025) undertook underwater noise modelling for the Project to determine the potential impacts of the piling activities on fish. Impact areas suggest fatality of bony fish within 200 m, permanent injury within 1,800 m, temporary injury up to 3,350 m and high risk of behavioural effects hundreds of metres from the source. While some mitigations can be implemented, some reef fish species have close home ranges. Distances for elasmobranch species are slightly smaller and these species are more likely to be able to move from the noise if disturbed during start-up operations. Impacts may affect individuals of a species but is unlikely to impact the diversity of fish species within the area. However, the number of endemic species within the area indicates special consideration of potential impacts and engineering mitigations may be necessary.	Moderate
Underwater Noise Injury or behavioural response from vessel generated underwater noise	Construction and operation	Modelling undertaken by Resonate (2015) indicated vessel movements were considered temporary non-impulsive noise which is significantly below impact thresholds that would not result in any impacts to fish.	Minor/ Insignificant
Vessel strike Vessel strike of fish resulting in injury or death	Construction and operation	Vessel strike likelihood is low due to the small number of vessels and the slow speeds at which they will travel through the area. Vessel strike is also generally more of a concern for large megafauna such as marine mammals and reptiles (turtles) who come to the surface to breathe. The Temperate East Marine Bioregional Plan (DSEWPac 2012) identified vessel strike as a pressure 'not of concern' for fish. Therefore vessel strike is unlikely to impact the diversity of fish species within the area.	Minor/ Insignificant
Decline in water visibility and quality resulting in impacts on fish assemblage	Construction and Operation	Residual impacts to water quality and visibility in Section 4.1 classified as 'insignificant', except for potential for accidental chemical or waste spills. Therefore, residual impacts on the	Minor/ Insignificant

		ecosystem from changes in water quality will be similar.	
Coastal/marine habitat modification Loss of fish habitat within the Project area	Construction and operation	Predicted habitat for direct loss within the disturbance area around the jetty and boat ramp is small in scale and mapped as predominantly unvegetated substrate, indicating minimal impacts on fish diversity. Indirect impacts on benthic habitats are relatively low and can be managed to prevent subsequent losses on fish diversity.	Minor/ Insignificant
Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on ecosystem function and loss	Construction and operations	Australian and international biofouling management, ballast discharge management and LHI Biosecurity requirements should be followed to minimise the potential for the introduction of IMP.	Minor/ Insignificant
Waste Entanglement and/or ingestion of marine debris during construction and from public use of the jetty	Construction and operations	Marine fish can be impacted by debris entering the marine environment potentially leading to injury or mortality, through entanglement or plastic ingestion. With all waste and debris being appropriately disposed of, stored and managed, the likelihood of waste and debris entering the marine environment can be prevented. Therefore, it is unlikely to result in reduction of the diversity of fish species.	Minor/ Insignificant

4.6. Marine invertebrates

Marine Park Value: Marine invertebrates have a high level of diversity.

World Heritage Value: The diversity of marine invertebrate species, including more than 83 species of corals and 65 species of echinoderms of which 70% are tropical, 24% are temperate and 6% are endemic.

4.6.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 26. Activities associated with the Project involving piling, construction and operations of the Jetty may have impacts to the invertebrate communities within the lagoon. Landside development and coastal geomorphological changes also have the potential to indirectly impact on the local invertebrate communities within the lagoon. Potential impacts on the invertebrates associated with the Project that, in the absence of management or mitigation, may occur during construction or operation are listed in Table 27.

Table 26: Impact criteria for invertebrates

Assessment	Description
Major	Permanent and/or irreversible loss of invertebrate diversity either through pollution impacts or mechanical removal/habitat destruction.
Moderate	Moderate semi-permanent changes to invertebrate diversity on a local scale. For example, impacts within and around the predicted area of disturbance.
Minor/ Insignificant	No impact or small, low risk changes to invertebrate diversity on a local scale. For example temporary and/ or localised changes to ecosystems during construction activities only occurring within the Project Area.

Table 27: Potential impacts to marine invertebrates

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
Marine Construction	Coastal/marine habitat modification Loss of invertebrate diversity from pile installation due to habitat modification from construction activities.	Direct	Marine construction involves upgrades to existing infrastructure and extending the marine disturbance area which directly impacts benthic habitat for marine invertebrates. There has been established shipping activities in this area for 100 years and the area around the marine infrastructure has been considered disturbed.	A section of the piled ramp and the piled mooring dolphins falls partially within an area of mapped seagrass and macroalgae that may provide habitat for invertebrates. (see calculations Table 11, map in Appendix B).	The indicative program has marine construction extending over an eight month period.	Minor/ Insignificant
Marine Construction	Underwater Noise Injury, death or behavioural response from underwater noise during piling	Direct	Installation of piles using impact or vibratory hammer generating impulsive underwater noise. Marine invertebrates are present throughout the lagoon and in close proximity to activities. Marine invertebrate sensitivity to underwater noise is typically less than other marine fauna based on not being responsive to sound pressure, but sense sound through particle motion (i.e. the physical movement of water and sediment). Sensitivity is poorly understood for	Possible effects likely limited to within lagoon.	Marine construction: eight month period. However, pile driving and seabed disturbance would only be a small portion of this (34 days of piling).	Minor/ Insignificant

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			establishing thresholds for modelling (i.e. not included in Resonate (2025), although potential impacts will be less than evaluated for other marine fauna.			
Construction and Operations	Coastal/marine habitat modification Loss of invertebrates from vessel grounding and direct habitat loss during construction and operation.	Direct	Increase vessel activity during construction. Slight change to operational activities once the new piled ramp is completed, although vessel numbers are not likely to change significantly. Intertidal reef habitat located approximately 50 m to the north west and a smaller area to the south of the existing jetty.	Vessel activity to be limited within Project Area. New operational supply barge to have shallow draft however may require more manoeuvring during use of new piled ramp.	The indicative program has construction extending over a 14 to 20 month period. Marine construction: eight months Operations: vessel traffic ongoing	Minor/ Insignificant
Construction and Operations	Decline in water visibility and quality (see Section 4.1) from the following pressures: Coastal/marine habitat modification Accidental spills/ waste	Indirect	Water quality decline from land and marine sources resulting in impacts to marine invertebrates. Pollutants may be toxic to macrophytes. High nutrient input creates algae blooms/ eutrophication, increasing potential for harmful	Possible effects likely limited to within lagoon	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
	Wastewater effluent or ballast water discharge Erosion/sedimentation Dust pollution Surface/groundwater runoff Coastal processes/sea level rise.		algae, oxygen depletion and loss of marine invertebrates. Turbidity inhibits light penetration through the water column for photosynthetic benthic fauna that provide habitat for marine invertebrates. Waste can harm marine life through entanglement and ingestion which can disrupt the ecological food web for marine invertebrates. Pathogens can cause infectious diseases.			
Construction and Operations	Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on invertebrate diversity loss	Indirect	Increase in vessel traffic and increased risk of IMP for specialised vessels (e.g. barge) during construction. Translocation of IMP by supply vessel for ongoing sea freight from mainland NSW Ports. Vectors for translocation of IMP from a mainland port include	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boats • Supply vessel	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate

Development type	Potential impacts	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impacts
			biofouling on the vessel hull or ballast water transport. IMP can disrupt native habitats, outcompete or prey on native species for food and space, introduce diseases and parasites, and cause significant habitat changes that reduce biodiversity			
Construction and Operations	Coastal processes Changes to coastal process that result in habitat modification and reduced diversity of invertebrates.	Indirect	Shoreline and coastal habitat modification with infrastructure changes could in turn impact on marine ecosystems. Revetment wall and already in place. Changes to the coastline influences hydrodynamics and sediment delivery which can result in localised changes in water temperature and smothering of nearshore reefs (invertebrate habitat).	New piled ramp and boat ramp within Project Area.	Operations: Design life of new infrastructure.	Moderate

4.6.1.1. Pressure summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- All pressures assessed within water visibility and quality (Section 4.1), including:
 - Accidental spills/ waste
 - Wastewater effluent or ballast water discharge
 - Erosion/sedimentation
 - Dust pollution
 - Surface/groundwater runoff
- Coastal and Marine Habitat Modification
- Underwater Noise
- Introduced Marine Pest Species
- Coastal Processes/Sea Level Rise

4.6.2. Mitigation recommendations

The identification and implementation of appropriate management measures limit the risk of the potential impacts. Some types of impacts can never be removed completely due to the physical disturbance during construction, but all potential impacts can be minimised. Recommended mitigation strategies for invertebrates are presented in Table 28. The Lord Howe Abalone (*Haliotis rubiginosa*) is considered a key species of conservation significance, listed as Critically Endangered under both the NSW FM Act and IUCN Redlist, found in greatest numbers in the southern lagoon. The existing management measures identified for this species identified in Section 0 will afford protection to other marine invertebrates. The residual risk after implementation of mitigations is presented in Section 4.6.3.

Table 28: Recommended mitigation measures

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Coastal/marine habitat modification Loss of invertebrate diversity from pile installation and/or disturbance to the sea floor	Avoidance: • Where anchoring is required for work vessels and barges, noting LHIMP anchoring restrictions for minimising the risk of anchor damage (DPI 2022). • Choosing a design option to avoid sensitive benthic habitats and minimising the disturbance area. Minimise: • Ensuring construction activities only occur within the Project Area. • Construction vessels to utilise high definition positioning systems. Manage: • Contact Port Operations Managers for entry into the lagoon (DPI 2022) • Lodge application for mooring to Lord Howe Island Board at least 5 days prior to departure (DPI 2022) • Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring.

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
	- Exclusion zones to restrict shoreline access and minimise the impacts to the intertidal areas. Monitor: - Pre-construction survey of benthic habitats that will be directly disturbed to ensure no critical habitats for invertebrates will be disturbed
Underwater Noise Injury, death or behavioural response from underwater noise during piling	Minimise: 30 minute pre-start, 30 minute soft-starts to slowly increase the noise intensity to allow invertebrates to move away from the noise source - Marine piling should aim to avoid high tide where practicable. - Given MFOs are not necessarily a practical option to detect presence of invertebrates during construction and some species are closely associated with habitat within predicted areas of impact, consider the use of bubble curtains, or other engineered solutions such as a piling sleeve or acoustic net to minimise noise propagation distance. Manage: - Prepare mitigations in an Underwater Noise Management Plan accordance with SA Underwater Piling Noise Guidelines (DPTI 2012) and Great Barrier Reef Underwater Noise Guideline Discussion and Options Paper (McPherson et al 2017) - See Safety Zones (Observation/ Potential Effect/Shutdown Zones) in Resonate (2025) for management areas relevant to piling activities for each fauna group (Figures 11 Figure 18) - Consideration may also be afforded to timing of works to avoid important life-history periods for key invertebrate species (e.g. Dec-Mar coral spawning which is known to coincide with reproduction of other invertebrates). Monitor: - Consider telemetered underwater noise monitoring for real-time assessment against thresholds that can be incorporated into shut-down procedures - Consider pre/post monitoring of invertebrates within the predicted management zones.
Coastal/marine habitat modification Loss of invertebrate diversity from vessel grounding	Minimise: - Contact Port Operations Managers for entry into the Lagoon - Vessels to be aware of shallow conditions within the lagoon, crews to be informed of operational responsibilities to ensure safe navigation and environmental protection (DPI 2022) - Ensuring construction activities/ vessel movements only occur within the Project Area with strategies to include exclusion zones to sensitive habitats. - Utilising existing impacted mooring areas (where practical) for any mooring of project vessels. - Contractors to have clearly identified areas permitted for seabed disturbance.

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
	- Consideration of draft required for construction and operational vessels to access site and requirement for Marine Parks Permit to minimise the potential for groundings and impacts to benthic communities along the navigation channel - Marine Parks Permit required for new supply vessel (DPI 2022) - Consider tidal windows for vessel movements. Manage: - Vessel Safety Management System to address prevention and response actions for grounding - Restrict vessel speed in the project area. - Install channel markers - Develop procedures for ongoing supply vessel entrance, unloading and departure Monitor: - Pre/post construction and ongoing benthic habitat surveys that will validate disturbance levels from grounding to limit further disturbance of ecosystems and recovery
Decline in Water Quality	see Section 4.1
Introduced Marine Pests Translocation and establishment of IMP	Minimise: - Pre-inspection of construction vessels for risk of IMP including when last cleaned and antifoul applied, biofouling assessment, type of vessel, ports visited recently Manage: (Where applicable) Adhere to Australian ballast water management requirements and the IMO 2011 Guidelines for the control and management of ships' ballast water and sediments to minimise the transfer of invasive aquatic species and LHIMP requirements. (Where applicable) Adhere to Lord Howe Island Biosecurity - Visiting Vessels Guidelines (LHIB 2020) - All commercial vessels to be maintained in accordance with Australian biofouling management requirements (DAFF 2023) Monitor: - Marine parks continue to undertake periodic monitoring for IMP
Coastal Processes Changes to coastal processes leading to altered suitability of habitats	Minimise: - Identify and Implement design elements to minimise impacts to coastal processes from the marine infrastructure changes. Incorporate NSW Coastal Design Guidelines (DPE, 2023) Monitoring: - Consider ongoing monitoring for erosion, sediment movement and coastal change.

4.6.3. Assessment of significance of residual impacts

The Project will have some unavoidable direct irreversible impacts to the seabed due to the placement of the piles and seabed infrastructure. However, habitat mapping suggests that the most directly affected habitat types in the marine Project area is *Unvegetated Substrates and Lagoon Floor – Macroalgae/ Rubble*, which is unlikely to represent critical habitat for a high diversity of marine invertebrates and result in significant impacts.

Table 29: Residual impacts of the Project on macrophytes

Impact	Project Phase	Assessment	Residual Impact
Coastal/marine habitat modification Loss of invertebrate diversity from pile installation and/or disturbance to the sea floor	Construction	Seabed disturbance is limited to a small area with sparse presence of BCH. Anchoring of construction vessels to avoid sensitive areas with high coverage of BCH. Impacts are not likely to impact invertebrate diversity.	Minor/ Insignificant
Underwater Noise Injury, death or behavioural response from underwater noise during piling	Construction	Predicted underwater noise impacts on invertebrates were not modelled in Resonate (2025), although sensitivity is lower than other marine fauna and generally poorly understood for establishing thresholds. Marine invertebrates sense sound through particle motion rather than sound pressure, so the potential for impacts are considered low.	Minor/ Insignificant
Coastal/marine habitat modification Loss of invertebrates and their diversity from vessel grounding	Construction and Operation	Vessel groundings have occurred in the past, however limiting construction and operation to previously impacted jetty areas, shipping channel, turning areas and mooring areas will minimise the potential impact on invertebrate diversity. Construction vessels will need to be evaluated for access.	Minor/ Insignificant
Decline in water visibility and quality resulting in reduced invertebrate diversity	Construction and Operation	Residual impacts to water visibility and quality in Section 4.1 classified as 'insignificant', except for potential for accidental chemical or waste spills. Therefore, residual impacts on the ecosystem from changes in water quality will be similar.	Minor/ Insignificant
Introduced Marine Pests Translocation and establishment of IMP	Construction and Operation	Australian and international biofouling management, ballast discharge management and LHI Biosecurity requirements should be followed to minimise the potential for the introduction of IMP.	Minor/ Insignificant

Impact	Project Phase	Assessment	Residual Impact
Coastal Processes Changes to coastal process that modify habitat and impact invertebrate diversity	Operations	Due to the existing foreshore hardening, the absence of longshore drift, and the positioning of the site between two shallow intertidal platforms, modifications to shoreline and invertebrate diversity will likely be minimal.	Minor/ Insignificant

4.7. Threatened and Protected species

Marine Park Value: Several threatened species and protected species and communities are supported.

World heritage criterion for outstanding universal significance: containing the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

This section has been developed to assess the cumulative impacts to threatened and protected species as per previous sections, although includes an additional subsection 4.7.3 where individual key species are evaluated in accordance with the Matters of National Environmental Significance Significant impact guidelines 1.1 (DotE 2013), with consideration also to the Threatened Species Test of Significance Guidelines (OEH 2018) and the Threatened Species assessment guidelines (NSW DPI 2008).

4.7.1. Potential impacts

Potential impacts have been assessed according to the categories identified in Table 30. Potential impacts to the threatened and protected species within the LHIMP that, in the absence of management or mitigation, may occur during construction or operations are listed in Table 31. These have been based on the key risks that were previously identified for threatened species and listed migratory species in the Assessment Notes for the Project by DCCEEW (2025).

Table 30: Impact criteria for significance of potential impact

Assessment	Description
Major	Significant and/or irreversible changes to the population of key conservation significant species, including delays to the recovery of threatened species.
Moderate	Temporary impacts to the population of key conservation significant species, however does not impact the long-term recovery.
Minor/ Insignificant	No impact or small, low risk changes to key conservation significant species. For example, temporary impacts to individuals of the species that will not impact at a population level.

Table 31: Potential impacts to Marine Mammals

Development type	Potential impact	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impact
Marine Construction	Underwater Noise Injury, death or behavioural response from underwater noise from piling	Direct	Installation of piles using impact or vibratory hammer generating impulsive underwater noise. Underwater noise can propagate and travel large distances; therefore potential impacts to marine fauna can be widespread. The severity of impacts from underwater noise is dependent on the sound's duration, amplitude, and frequency, the distance between the sound source, marine species present and the sensitivity of the marine species to the site-specific combination of these factors (Salgado Kent et al. 2016).	Modelled distances for spatial extent of underwater noise levels provided in Resonate (2025). A summary of the potential distances for fish, mammals or reptiles is provided in Section 4.7.1.1.	The indicative construction program has marine construction extending over an eight month period, however pile driving and seabed disturbance would only be a small portion of this (34 days of piling).	Major
Construction and Operations	Underwater Noise Injury or behavioural response from increased underwater noise from construction vessels	Direct	Increase vessel activity during construction. Ongoing transfer of newly designed supply vessel.	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge	The indicative program has construction extending over a 14 to 20 month period.	Minor/ Insignificant

Development type	Potential impact	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impact
				• Work boat/s • Supply vessel Resonate (2025) indicate nil impacts on all marine fauna from vessel generated underwater noise.	Marine construction: eight months Operations: vessel traffic ongoing	
Construction and Operations	Vessel Strike Vessel strike of marine fauna resulting in injury or death	Direct	Increase vessel activity during construction. Ongoing transfer of newly designed supply vessel.	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boat/s • Supply vessel	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate
Marine Construction and Operations	Decline in water quality through pollution (see Section 4.1) from the following pressures: Coastal/marine habitat modification Accidental spills/ waste Wastewater effluent or ballast water discharge	Direct	Water quality decline from land and marine sources resulting in impacts to threatened and protected species. Pollutants may be toxic to marine fauna. High nutrient input creates algae blooms/ eutrophication, increasing potential for harmful	Possible effects likely limited to within lagoon	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate

Development type	Potential impact	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impact
	Surface/groundwater runoff Sea level rise		algae and oxygen depletion leading to habitat loss and mass fish kill. Waste can harm marine fauna through entanglement and ingestion. Pathogens can cause infectious diseases. These impacts can also disrupt the food web with potential population decline or shifts in marine fauna.			
Marine Construction and Operations	Coastal/Marine Habitat Modification or loss of critical habitat for marine fauna.	Indirect/Indirect	Loss of marine fauna habitat directly or indirectly due to construction activities as well as vessel grounding during construction or ongoing operations (see Sections 4.2, 4.3 and 4.4).	Relatively small area of direct disturbance within Project Area. Vessel activity limited to within Project Area. New operational supply vessel to have shallow draft although may require more manoeuvring to access new piled ramp.	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate

Development type	Potential impact	Impact type (direct/indirect)	Context of assessment	Extent	Duration	Significance of potential impact
Construction and Operations	Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on ecosystem function and loss	Indirect	Increase in vessel traffic and increased risk of IMP for specialised vessels (e.g. barge) during construction. Translocation of IMP by supply vessel for ongoing sea freight from mainland NSW Ports.	Multiple vessels during construction and operations. Likely to include: • Piling barge • Materials barge • Work boats • Supply vessel	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate
Construction and Operations	Waste Entanglement and/or ingestion of marine debris during construction and from public use of the jetty	Direct	Accidental release of unsecured items (rope, packing, general waste) into the marine environment which becomes entangled or ingested by marine fauna.	Increased amount of human activity and materials handling will occur during construction period. Materials handling and activities will reduce to regular freight schedule upon project completion, although risk remains present during unloading of freight.	Construction: 14 to 20 months. Marine construction: eight months Operations: vessels: traffic ongoing.	Moderate

4.7.1.1. Underwater Noise Modelling

Resonate (2025) conducted an underwater noise assessment as described in Section 4.5.1.1.

Project generated underwater noise sources include impact piling (cumulative and peak noise), vibratory piling and vessel movements during operational phase post construction. Distances modelled were determined by sensitivities of fish, marine mammals and reptiles to risk of fatality, hearing injury, either TTS or PTS, and behavioural responses. Where insufficient data exists to make a recommendation for guidelines development, a subjective approach is adopted in which the relative risk of an effect is placed in order of rank at three distances from the source:

- Near: tens of meters from the source
- Intermediate: hundreds of meters from the source
- Far: thousands of meters from the source.

Fish were separated into bony fish and elasmobranchs, mammals were separated into low (whales) and high (dolphins) frequency cetaceans, while reptiles were represented by marine turtles. These classifications are based on literature identifying differential sensitivities to underwater noise. Vessel movements were considered temporary non-impulsive noise which is significantly below impact thresholds that would not result in any impacts to any marine fauna (Resonate 2015). Modelled distances of impact and vibratory piling generated underwater noise sources for fish are provided in Table 32.

Table 32: Modelled distances (m) of Project generated underwater noise sources for bony fish and elasmobranchs

Hearing Group	Relevant Species	Activity	Risk of fatality	PTS	TTS	Behavioural
Bony fish	Black rockcod Doubleheader wrasse Elegant wrasse Lord Howe Abalone McCulloch's anemonefish Sygnathids	Impact Piling	200	700	1,900	N: High I: High F: Moderate
		Vibratory Piling	N: Low I: Low F: Low	1,800	3,350	N: High I: Moderate F: Low
Elasmobranchs	Galapagos shark	Impact Piling	200	400	1,900	N: High I: Moderate F: Low
		Vibratory Piling	N: Low I: Low F: Low	N: Moderate I: Low F: Low	N: Low I: Low F: Low	N: Moderate I: Moderate F: Low
Low frequency cetaceans	Humpback whale	Impact Piling	-	2,000	4,800	6,600
		Vibratory Piling	-	800	2,650	>10,000
High frequency cetaceans	Bottlenose dolphin	Impact Piling	-	750	1,400	5,000
		Vibratory Piling	-	500	1,000	>10,000
Marine turtles	Green turtle	Impact Piling	-	600	1,100	3,400
	Hawksbill turtle	Vibratory Piling	-	300	700	5,000

4.7.1.2. Pressure summary

These potential impacts are related to the following pressures identified in Table 5 which relate to key issues identified in both the SEARs and EPBC Act referral comments:

- All pressures assessed within water visibility and quality (Section 4.1), including:
 - Accidental spills/ waste
 - Wastewater effluent or ballast water discharge
 - Erosion/sedimentation
 - Dust pollution
 - Surface/groundwater runoff
- Underwater Noise
- Vessel Strike
- Coastal and Marine Habitat Modification
- Introduced Marine Pest Species
- Waste

4.7.2. Mitigation recommendations

The identification and implementation of appropriate management measures limit the risk of the potential impacts, with recommended mitigation strategies listed in Table 33. Some types of impacts can never be removed completely due to the physical disturbance during construction, but all potential impacts can be minimised. The residual risk after implementation of mitigations is presented in Section 4.7.3.

Table 33: Mitigation strategies to reduce potential impacts during construction and operation

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Underwater Noise Injury, death or behavioural response from underwater noise from piling	Avoidance: • Consideration of ecological windows of threatened species for piling activities such as humpback whale migration (May-November) and/or McCulloch's anemonefish spawning (November-March) • Piling to occur during day light hours only to enable effective marine fauna observing and offer night time respite for marine fauna from noise. Minimise: • 30-minute pre-start, 30-minute soft-start, shut-down, and low-visibility conditions to be applied. • Marine piling should aim to avoid high tide where practicable. • Consider the use of respite days if high noise level activity (impact piling or vibratory piling) occurs on multiple successive days. • Consider the use of bubble curtains, or other engineered solutions such as a piling sleeve or acoustic net to minimise noise propagation distance. Manage:

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
	• Prepare mitigations in a Underwater Noise Management Plan accordance with SA Underwater Piling Noise Guidelines (DPTI 2012) and Great Barrier Reef Underwater Noise Guideline Discussion and Options Paper (McPherson et al 2017) • See Safety Zones (Observation/ Potential Effect/Shutdown Zones) in Resonate (2025) for management areas relevant to piling activities for each fauna group (Figures 11 Figure 18). • Dedicated MFOs during piling activities and trained MFOs for remaining marine construction program Monitor: • Validate underwater noise predictions to ensure impacts are not greater than predicted and support management during piling activities • Consider telemetered underwater noise monitoring for real-time assessment against thresholds that can be incorporated into shut-down procedures at key locations for fish habitat • Consider pre/post monitoring targeted for key threatened species known to inhabit the predicted management zones which typically exhibit a limited home range (e.g. McCulloch's anemonefish).
Underwater Noise Injury or behavioural response from increased underwater noise from construction vessels	Avoidance: • Avoid construction works during sensitive times such as McCulloch's anemonefish spawning (November-March) • Marine construction to occur during day light hours only to enable effective marine fauna observing. Minimise: • 30 minute pre-start to slowly increase the noise intensity to allow fish to move away from the noise source on departure • Development of and adherence to vessel caution and approach zones to avoid impacts from both noise and vessel strike • Trained MFOs on vessels to ensure vessels are adhering to the caution and approach zones Manage: • Restrict vessel speed in the navigation channel
Vessel Strike Vessel strike of marine fauna resulting in injury or death	Minimise: • Vessel movements to occur during day light hours (where practical) • The Project will be completed using a small number of small vessels (e.g. a tender and/or a barge). • Development of and adherence to vessel caution and approach zones to avoid impacts from both noise and vessel strike • Trained MFOs on vessels to ensure vessels are adhering to the caution and approach zones Manage: • Restrict vessel speed in the navigation channel

Potential impact		Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
Decline in water visibility and quality resulting in impacts to threatened and protected marine fauna		see Section 4.1
Coastal/marine Habitat Modification	Habitat	Avoidance: - Gain approval from Port Operations Managers for mooring use and entry into the lagoon - Where anchoring is required for work vessels and barges, noting LHIMP anchoring restrictions: - Vessels longer than five metres are prohibited from anchoring anywhere in the lagoon - All vessels are prohibited from anchoring in sanctuary zones, with three exclusion areas for vessels less than 10 metres long - Vessels must always aim to anchor in sand away from seagrass and coral - Vessels longer than 25 metres may anchor only in 6 designated roadstead sites – located outside the Lagoon (refer to Admiralty charts). - Choosing a design option to avoid sensitive benthic habitats and minimising the design disturbance area. Minimise: - DPIRD require Port Operations Managers approval for entry into the Lagoon which will be dependent on: - Weather and sea conditions - The draft of the vessel (may exceed the safety limit for entry) - The weight of the vessel (may exceed the safe working load of the mooring systems) - The length of the vessel (vessels over 25 meters long may only anchor within one of 6 designated anchoring sites). - Vessels to be aware of shallow conditions within the lagoon, crews to be informed of operational responsibilities to ensure safe navigation and environmental protection - Ensuring construction activities only occur within the Project Area. - Construction vessels to utilise high definition positioning systems. - Consideration of draft required for construction and operational vessels to access site and requirement for Marine Parks Permit to minimise the potential for groundings and impacts to benthic communities along the navigation channel - New supply vessel design with shallower draft and Marine Parks Permit required

Potential impact	Management Strategy (Avoidance, Minimisation, Manage, Monitor, Restoration, Offsets)
	- Consider tidal windows for vessel movements. Manage: - Vessel Safety Management System to address prevention and response actions for grounding - Contractors to have clearly identified areas permitted for seabed disturbance. i.e. for piling and anchoring. - Install channel markers - Exclusion zones to restrict shoreline access and minimise the impacts to the intertidal areas. - Develop procedures for ongoing supply vessel entrance, unloading and departure Monitor: - Pre/Post construction fish survey of benthic habitats that will be directly disturbed to evaluate critical ecosystems disturbed
Introduced Marine Pests Introduction and establishment of invasive marine species from construction equipment and vessels	Minimise: - Pre-inspection of construction vessels for risk of IMP including when last cleaned and antifoul applied, biofouling assessment, type of vessel, ports visited recently Manage: (Where applicable) Adhere to Australian ballast water management requirements and the IMO 2011 Guidelines for the control and management of ships' ballast water and sediments to minimise the transfer of invasive aquatic species and LHIMP requirements. (Where applicable) Adhere to Lord Howe Island Biosecurity - Visiting Vessels Guidelines (LHIB 2020) - All commercial vessels to be maintained in accordance with Australian biofouling management requirements (DAFF 2023) Monitor: - Marine parks continue to undertake periodic monitoring for IMP
Waste Entanglement and/or ingestion of marine debris during construction and from public use of the jetty	Avoidance: - All waste and rubbish will be appropriately stored and managed to prevent debris and waste from entering the marine environment. Minimise: - Packaging to be removed prior to items being used within the marine environment as far as practicable - Minimise the amount of unnecessary packaging at the construction site - Where possible construction equipment to be assembled prior to arriving at site to reduce amount of waste the entering the construction site.

4.7.3. Assessment of significance of residual impacts

The Project will have direct impacts to threatened and protected marine fauna due primarily to underwater noise generated from piling activities, with particular risk to some fish species which are present within the effect area and have a limited home range. The residual impacts of pressures on threatened and protected species after mitigation are summarised in Table 34. Further assessment on the significance of potential impacts to each key threatened and protected species identified from the desktop assessment are provided in Section 4.7.3. Other pressures are not predicted to present a significant risk of impact to threatened and protected species.

Table 34: Residual impacts of the Project on threatened and protected species

Impact	Project Phase	Assessment	Residual Impact
Underwater Noise Injury, death or behavioural response from underwater noise during piling	Construction	Resonate (2025) undertook underwater noise modelling for the Project to determine the potential impacts of the piling activities on fish. Impact areas suggest fatality of bony fish within 200 m, permanent injury within 1,800 m, temporary injury up to 3,350 m and high risk of behavioural effects hundreds of metres from the source. While some mitigations can be implemented, some reef fish species such as the McCulloch's anemonefish which are common within effect zones and have close home ranges. The marine park sanctuary zone Sylphs Hole within the permanent auditory injury zone which has historically recorded protected and conservation significant species such as McCulloch's anemonefish and Doubleheader wrasse. The potential for population effects on some fish species is considered plausible. The risk for other key species, such as mammals, reptiles and elasmobranchs, is considered slightly lower, despite larger effect zones, based on likely being able to move from the noise if disturbed, while for air breathing species MFOs and management can be applied during activities. Mitigations should consider avoidance of activities during critical ecological windows for key species (see Table 15 Appendix C). Impacts may affect individuals of a species but is unlikely to impact populations within the area. The number of endemic species within the area indicates special consideration of potential impacts and engineering mitigations for piling activities may be necessary.	Moderate
Underwater Noise Injury or behavioural response from vessel generated underwater noise	Construction and operation	Modelling undertaken by Resonate (2015) indicated vessel movements were considered temporary non-impulsive noise which is significantly below impact thresholds that would not result in any impacts to marine fauna.	Minor/ Insignificant
Vessel Strike Vessel strike of fish resulting in injury or death	Construction and operation	Vessel strike likelihood is low due to the small number of vessels and the slow speeds at which they will travel through the area. The Temperate East Marine Bioregional Plan (DSEWPac 2012) identified vessel strike as a pressure of concern for the green turtle,	Minor/ Insignificant

Impact	Project Phase	Assessment	Residual Impact
		hawksbill turtle and 'not of concern' for elasmobranchs, larger cetaceans i.e. whales) and fishes. Laist (2001) determined vessel speeds >10knots significantly increases the risk of vessel collision with marine megafauna. Reduced speeds provide greater reaction time and therefore restricting vessel speeds during construction activities would also decrease the likelihood of vessel strike. Therefore, if vessel speed can be managed, vessel strike is unlikely to impact threatened and protected species within the area.	
Accidental Spills Hydrocarbon spills from vessels and construction equipment resulting in fish injury or death	Construction and operation	Hydrocarbon spill is identified as 'potential concern' for turtle and dolphin species and 'less concern' for bony fishes and other cetaceans (whales) and sharks (DSEWPaC 2012). A spill can affect all levels of marine life including both the physical health of species directly, including mortality, as well as their habitat or food source. Standard procedures for storage, handling and management of hydrocarbons should be implemented for the duration of the Project. Spill kits and appropriate waste bins to be kept on site. With suitable management in place, cumulative impacts from hydrocarbon spills are not anticipated to impact threatened and protected species.	Minor/ Insignificant
Coastal/marine Habitat Modification Loss of fish habitat within the Project area	Construction and operation	Predicted habitat for direct loss within the disturbance area around the jetty and boat ramp is small in scale and mapped as predominantly unvegetated substrate, indicating minimal impacts on fish diversity. Indirect impacts on benthic habitats are relatively low and can be managed to prevent subsequent losses on threatened and protected species.	Minor/ Insignificant
Introduced Marine Pests Translocation and establishment of IMP from construction and operational vessels leading to impacts on ecosystem function and loss	Construction and operations	Australian and international biofouling management requirements should be followed to minimise the potential for the introduction of IMP.	Minor/ Insignificant
Waste	Construction and operations	Marine fauna can be impacted by debris entering the marine environment potentially leading to injury or mortality, through entanglement or plastic ingestion. Marine debris is identified	Minor/ Insignificant

Impact	Project Phase	Assessment	Residual Impact
Entanglement and/or ingestion of marine debris during construction and from public use of the jetty		as a pressure 'of potential concern' for turtle and dolphin species and of 'less concern' for shark and fish species (DSEWPaC 2012). With all waste and debris being appropriately disposed of, stored and managed, the likelihood of waste and debris entering the marine environment can be prevented. Therefore, it is unlikely to result in impacts to threatened and protected species.	

4.7.4. Significance of impacts for key threatened and protected species

A significance assessment has been undertaken on key threatened and protected species identified in the desktop assessment (Appendix C), with consideration of appropriate Commonwealth and State threatened species guidelines (DotE 2013, OEH 2018, NSW DPI 2008). It is noted that DCCEEW and DPHI identified several other species that may be impacted by the Project during review of referral documents, including:

- Ballina angelfish
- Bluefish
- White shark
- Giant manta ray
- Bryde's whale
- Flatback turtle
- Loggerhead turtle
- Leatherback turtle

The desktop assessment (Appendix C) found these species may be present near LHI, although the likelihood assessment determined impacts to population levels for these species were less likely. See the likelihood of occurrence assessment in Appendix C for further rationale. However, it is noted that individual significance assessments have been provided for key species within the same phyla groups (both threatened and Other conservation significant species), which provide an assessment and mitigation measures that are also relevant and protect these species.

4.7.4.1. Fish

4.7.4.1.1. Black rockcod

Black rockcod (*Epinephelus daemeli*) are a threatened species and is listed a 'Vulnerable' under both State and Commonwealth legislation, this species has experienced population pressure for most of the last century. Both adult and juvenile Black rockcod are present at LHI, with adults preferring deeper offshore waters, becoming site attached to a chosen location beneath caves and overhangs. Juveniles and sub-adults are mobile in shallow coastal waters, such as the LHI lagoon.

Table 35: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Black rockcod are present year round at LHI, including inside the lagoon habitat. Adult Black rock cod prefer deeper reef waters and within the lagoon, highly mobile juveniles and sub-adults are present. The juvenile cohort which may be present within the lagoon may be temporarily disturbed during construction by underwater noise from both piling and increased vessel movements. While some individual Black rockcod may be impacted by these construction activities, it is unlikely that long term population decline will result from the temporary construction activity.

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	Adult Black rock cod prefer to settle in deeper waters, utilising caves and overhangs and become site attached to their chosen settlement location. Within the lagoon, highly mobile juveniles and sub-adults are present. Project activities are within an area previously modified for the use of marine freight services and it is unlikely the new action will reduce the area of occupancy for this species.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats, although fragmentation has not already occurred. This Project is not likely to increase this risk. Populations are mobile, with juveniles and sub-adults moving within and out of the lagoon, and adults being site attached in a single location once settled. Therefore the small infrastructure would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	The lagoon area represents a key habitat for juvenile and sub-adult Black rock cod, which are yet to select a deeper water location for settlement. The area within the lagoon in which the proposed activities will take place, has been previously modified for the same purpose. Therefore there is no increase in the risk for habitat modification to affect survival of this species.
Will the action disrupt the breeding cycle of an important population?	Possible	Black rockcod continue to experience population decline despite decades of legislative protections and all populations of this species are considered important. They are a protandrous hermaphrodite – appearing first as female before transitioning to male sex at maturity and ~100 cm in length. This means the smaller individuals within the lagoon are likely female fishes, with the ability to contribute to egg production once sexually mature. Additionally, spawning aggregations form for this species, however specifics of these formations remains a knowledge gap. This female juvenile/sub-adult size class is highly mobile with the ability to move away from temporary disturbance. However impacts from underwater noise may possibly disrupt breeding behaviours in individual fishes within the Shutdown Zone for fish with swim bladders if piling occurs during sensitive times.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the	Unlikely	The area within the lagoon in which the proposed activities will take place, has been previously modified for the same purpose. Therefore there is no increase in the risk for habitat modification to affect survival of this species.

Significant Impact Criteria	Likelihood of Impact	Justification
extent that the species is likely to decline?		
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline
Will the action interfere substantially with the recovery of the species?	Unlikely	During construction activities, piling will lead to an increase in underwater noise. Black rock cod are at risk of impacts from this increased noise if they are present within the zones of impact and may include behavioural change, injury or death. However, adopting the mitigation measures as recommended in Section 4.7.2 will reduce this risk. Juvenile and sub-adult Black rock cod are present and utilise the shallow water habitat within the lagoon. The inner lagoon and headland areas are located within the Shutdown Zone for Fish with swim bladders which is 1,900 m from the source as modelled and proposed by Resonate (Resonate 2025).

4.7.4.1.2. Elegant wrasse

Elegant wrasse (*Anampes elegans*) is a protected species under the NSW FM Act, however they are not listed as threatened under State or Commonwealth legislation. This uncommon species is present at LHI within the lagoon and has been recognised as a contributing species to LHI's biodiversity and an iconic species within the LHIMP.

Table 36: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Elegant wrasse are present year round at LHI, including inside the lagoon habitat. This species is uncommon, but has a wide distribution across its range. Elegant wrasse are often found as groups of fishes consisting of a single large male leading a harem of juvenile and female fishes. These groups are highly mobile, with the ability to move away from disturbances, but are potentially impacted by increased underwater noise during construction from both piling and additional vessel movements. . Although some individual fishes present within

Significant Impact Criteria	Likelihood of Impact	Justification
		the lagoon may be temporarily disturbed during construction long term impacts to the LHI population of Elegant wrasses are unlikely.
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	Elegant wrasse are an uncommon species but are widely distributed across its known range, which extends from coastal mainland NSW across to New Zealand. The Project activities are unlikely to affect the wider area of occupancy for this species.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats, although fragmentation has not already occurred. This Project is unlikely to increase this risk. Populations are mobile, with harem groups of fishes moving within and outside of the lagoon. Therefore the small infrastructure would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	This species utilises coral and algae habitats, where their prey of molluscs and crustaceans are foraged by scraping the surface of these substrates. Although these habitats are present within the Project area, the area affected by proposed activities has been previously modified for the purpose of supporting marine freight services and therefore it is unlikely that the risk of adverse effects on critical habitat will be increased.
Will the action disrupt the breeding cycle of an important population?	Unlikely	Larger adults of this species tend to occupy deeper waters outside of the lagoon area, and these individuals represent the key breeding stock for the population. Juveniles and small sub-adults are likely to be females as this species is a protandrous hermaphrodite, with a fish being born female and changing sex to male when environmental conditions allow (i.e. loss of an existing dominant male). Breeding occurs during the summer months, and with the key breeding stock being located in deeper waters outside of the lagoon area, temporary behavioural disturbance resulting from construction activities is unlikely to cause any effects to breeding success at the population level.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The area within the lagoon in which the proposed activities will take place, has been previously modified for the same purpose. Therefore there is no increase in the risk for habitat modification to affect survival of this species.

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline
Will the action interfere substantially with the recovery of the species?	Unlikely	Elegant wrasse are not threatened, and therefore there is no recovery plan for the species. The Project is located within preferred habitat for the species, with the species sighted within the lagoon. Temporary construction works may have the potential for impacts to individuals of the species, however mitigation measures would minimise this risk. Operations would not increase the risk of impacts to the species. Therefore this Project is unlikely to affect the recovery of the species.

4.7.4.1.3. Lord Howe abalone

Table 37: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Lord Howe abalone is a threatened species, endemic to LHI. This rare and cryptic species is present under rocks, dead coral rubble and in small holes and crevices in the reef. It occurs in these habitats in several locations around LHI, with a few sightings within the lagoon. More numerous sightings occur in bays on the east of the island. Construction activities may temporarily disturb some individuals, but long term population decrease is unlikely.
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	Shallow intertidal reefs at LHI are the only area of occupancy for this species. The proposed activities are within an area previously modified for the use of marine freight services and it is unlikely the new action will reduce the area of occupancy for this species.
Will the action fragment an existing important	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats, and this Project will not increase this risk. There is a single population of Lord Howe

Significant Impact Criteria	Likelihood of Impact	Justification
population into two or more populations?		abalone, and the Project will not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	Lord Howe abalone are present under rocks, dead coral rubble and in small holes and crevices in the reef. Although these habitats are present within the Project area, the area affected by proposed activities has been previously modified for the purpose of supporting marine freight services. It is unlikely that the risk of adverse effects on critical habitat will be increased. Shallow intertidal habitat immediately outside the Project area represents the habitat in which this species has been historically recorded.
Will the action disrupt the breeding cycle of an important population?	Unlikely	Characteristics of reproductive ecology for the Lord Howe abalone are unknown, it is assumed this species reproduces sexually. Due to the higher occurrence of this species on the eastern side of LHI, it is not expected the breeding cycle will be disturbed by proposed activities.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The area within the lagoon in which the proposed activities will take place, has been previously modified for the same purpose. There is no increase in the risk for habitat modification to affect survival of this species, however it's habitat may be temporarily disturbed during construction activities.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline
Will the action interfere substantially with the recovery of the species?	Unlikely	The Lord Howe abalone is Critically Endangered under the FM Act, and current on the 2025 Priority Assessments list for Critically Endangered status under the EPBC Act. As such, there is no current Conservation Advice or Recovery Plan for this species. However, the main threats to the Lord Howe abalone are warming ocean temperatures, ocean acidification and habitat modification. The Project activities are taking place within a location previously modified for the

Significant Impact Criteria	Likelihood of Impact	Justification
		same purpose, therefore there is not an increase in the risk of habitat modification affecting this species presence.

4.7.4.1.4. McCulloch's anemonefish

Since the publication of Harasti et al (2022) the McCulloch's anemonefish (*Amphiprion mccullochhi*) has been listed as critically endangered under the EPBC Act and is considered a threatened species which is present at LHI. Previously, this species was considered by Harasti et al (2022) as one of the "other significant species" and placed within that value, although is now considered as a threatened or protected species.

Table 38: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Likely	McCulloch's anemonefish are a site attached reef fish, and occurs only in symbiosis with bubbletip anemones. The shallow waters of the LHI lagoon support 75% of the McCulloch's anemonefish population (TSSC 2024). Individual fishes and their host anemones situated within the Project boundaries are likely to be impacted. Additionally it is possible impacts may be realised for fishes outside of the Project boundary, but within the 1900 m Shutdown Zone for fishes with swim bladders due to the propagation of underwater noise. Temporary increased underwater noise from piling may have permanent impacts on individuals of this species due to their close proximity to the work. Mitigation measures are recommended in Section 4.7.2, however loss of individuals may still be possible. As the population is already decreasing, this may lead to longer recovery time
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	This species is site attached, and dependent on chosen host anemone. The shallow waters of the LHI lagoon support 75% of this species population. The area of occupancy is extremely limited, however proposed activities occur in an area previously modified for the same purpose, therefore the risk of further reduction in occupancy area is unlikely.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats, and this Project will not increase this risk. The main population of McCulloch's anemonefish is found within the LHI lagoon, two other populations are present at the nearby Elizabeth and

Significant Impact Criteria	Likelihood of Impact	Justification
		Middleton Reefs. The Project will not impact connections within these population groups.
Will the action adversely affect habitat critical to the survival of the species?	Possible	The lagoon supports a significant proportion of this species remaining populations, and its critical habitat of bubbletip anemone hosts. There are numerous sightings within the Project area and in very close proximity to the Northern boundary. Loss of anemone's could also result from decrease in water quality caused by construction activities, pollution and marine debris, although the primary risk to McCulloch's anemonefish is underwater noise. Adopting the mitigation measures as recommended in Section 4.7.2 will reduce this risk.
Will the action disrupt the breeding cycle of an important population?	Possible	McCulloch's anemonefish breed during the summer months, between December-March. There is a short reproductive cycle, with eggs being laid on the host anemone, before hatching into larval fish and settling in an anemone in ~30 days. There are potential impacts of larval loss due to impacts of pressure waves associated with underwater noise. Temporary increased underwater noise from piling may have permanent impacts on individuals of this species due to their close proximity to the work. Mitigation measures are recommended in Section 4.7.2, however loss of individuals may still be possible. As the population is already decreasing, this may lead to longer recovery time
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The area within the lagoon in which the proposed activities will take place, has been previously modified for the same purpose. There is no increase in the risk for habitat modification to affect survival of this species, however it's habitat may be temporarily disturbed during construction activities.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action interfere substantially with the recovery of the species?	Possible	There is no Recovery Plan in place for this species, due to a highly localised distribution and sound understanding of the threats this species faces. The conservation actions needed are well understood. Temporary increased underwater noise from piling may have permanent impacts on individuals of this species due to close proximity to the work. Mitigation measures are recommended in Section 4.7.2, however loss of individuals may still be possible. As the population is already decreasing, this may lead to longer recovery time.

4.7.4.1.5. Sygnathids

Due to cryptic nature of seahorses, sea dragons and pipefishes, there are few specific studies to determine the ecological traits at a species level which creates ecological uncertainty for their presence and use of habitats. The sygnathid group of threatened marine fishes is considered at the family taxonomic level due to their ecological traits being broadly similar. Further, management implications are similar for all bony fishes and may be applied to all marine (bony) fishes. Species which May occur in the LHIMP include Booth's pipefish (*Halicampus boothae*), Duncker's pipehorse (*Solegnathus dunckeri*), Kellogg's seahorse (*Hippocampus kelloggi*), Lord Howe pipefish (*Cosmocampus howensis*) and the White's seahorse (*Hippocampus whitei*).

Table 39: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Possible	Sygnathids are a cryptic marine fish, and occurs in areas in low numbers. The shallow waters of the LHI lagoon with its variety or coral, seagrass and algal habitats support numerous individuals of several sygnathid species. Individual sygnathids situated within the Project boundaries, may be impacted and unable to move away to avoid impacts due to their weak swimming ability. Additionally it is possible impacts may be realised for sygnathids outside of the Project boundary, but within the 1900 m Shutdown Zone for fishes with swim bladders due to the propagation of underwater noise. Temporary increased underwater noise from piling may have permanent impacts on individuals of this species due to their close proximity to the work and cryptic nature disguising their presence.. Mitigation measures are recommended in Section 4.7.2, however loss of individuals may still be possible. Recovery may take longer due to low fecundity in sygnathids.

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	The disturbance area is small, adjacent to existing infrastructure. However sygnathids are a cryptic species, often occurring unnoticed in an area. Further, limited information on populations exists and there is uncertainty regarding the importance of LHI sygnathid populations.. The identified sygnathid species are distributed in other locations, and their wider area of occupancy is unlikely to be affected.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats, although fragmentation has not already occurred. This Project is unlikely to increase this risk. Sygnathids tend to have a small dispersal range due to weak swimming ability reducing their capacity to move away from noisy or disturbed areas to avoid impacts. While individuals may be impacted, fragmentation of the wider populations is unlikely to occur.
Will the action adversely affect habitat critical to the survival of the species?	Possible	The habitats of corals, seagrass and algae within the lagoon supports the survival of several sygnathid species with some sightings recorded near the Project area. A decrease in habitat quality could result from decrease in water quality caused by construction activities, pollution and marine debris. Adopting the mitigation measures as recommended in Section 4.7.2 will reduce this risk of habitat loss for sygnathids.
Will the action disrupt the breeding cycle of an important population?	Possibly	Sygnathids generally breed during the summer months, with males brooding up to 200 eggs which hatch into live young. There may be multiple reproductions during each breeding season. Despite high reproductive activity and parental care, few larvae survive to adulthood. Given the low fecundity of this group of marine fishes. it is possible that temporary disturbance from underwater noise from piling and increased vessel movements or temporary disturbance to habitats will disrupt the breeding cycle for sygnathids. Implementing the mitigation measures in Section 4.7.2 will reduce the risk of potential impacts for sygnathids.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The area within the lagoon in which the proposed activities will take place, has been previously modified for the same purpose. There is no increase in the risk for habitat modification to affect survival of sygnathids, however it's habitat may be temporarily disturbed during construction activities. Hydrocarbon spills and marine debris may decrease habitat quality, however implementing the management controls in Section 4.7.2 will reduce this risk for sygnathids.

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline
Will the action interfere substantially with the recovery of the species?	Unlikely	A Recovery Plan is in place for White's seahorse, however LHI is outside the known locations for occurrence of this species. No sightings of White's seahorse at LHI were recorded during database searches. The Project is located within preferred habitat for the species, with sightings for other syngnathids identified being recorded within the lagoon. Temporary construction works may have the potential for impacts to individuals of the species, however mitigation measures would minimise this risk. Operations would not increase the risk of impacts to the species. Therefore this Project is unlikely to affect the recovery of the species.

4.7.4.2. Mammals

4.7.4.2.1. Bottlenose dolphin

The bottlenose dolphin (*Tursiops truncatus*) has a local population of unknown size but is known to be residents of the waters surrounding LHI throughout the year (Harasti et al 2022). They are most sighted offshore, in the deeper waters between LHI and Balls Pyramid, though they can be seen occasionally within the lagoon where the Project is located.

Table 40: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	The resident bottlenose dolphins are usually found to the south east of LHI, in deeper waters, though they are occasionally found in the lagoon Modelling outputs in 4.7.1.1 present effect zones indicating high frequency cetaceans may be impacted by underwater noise from piling however mitigation measures recommended in Section 4.7.2 will ensure this risk is minimised and the residual risk is not considered to be significant.

Significant Impact Criteria	Likelihood of Impact	Justification
		Threats and pressures of potential concern identified in DSEWPac (2012) include chemical, nutrient and light pollution, marine debris, underwater noise, human presence, collision with vessels. Activities associated with the operations of the Project will not increase the risk of any of these pressures, as the number of vessel trips are not expected to increase post construction. The Island Trader currently has a 10 kn speed limit, reducing this to 8 kn upon entry to the channel and lagoon will further reduce collision risk. Pollution risk will likely remain the same. Therefore it is unlikely that operations would lead to a long-term decrease in the size of the bottlenose dolphin population.
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	The Project area is a small area adjacent to areas already developed Main area of occupancy for bottlenose dolphins is to the south of LHI, away from the North and South Project boundaries, although this species may enter the lagoon at times. The Project is not occurring within the main occupancy area.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats and this Project will not increase this risk. Populations are transient, moving within and out of the lagoon, and therefore the small infrastructure would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	The lagoon area, particularly the shallow areas around the Project area, are not the preferred habitat of the bottlenose dolphin. It is also not critical habitat for the population.
Will the action disrupt the breeding cycle of an important population?	Unlikely	Construction activities such as piling should be undertaken with the mitigation measures recommended in Section 4.7.2 to ensure no dolphins are present within areas where they may be impacted by piling noise. Breeding is unlikely to occur within the lagoon area, with the species preferring to be in the deeper waters which is away from the piling activities. Therefore they are also unlikely to be within the zones throughout their life cycle, including breeding.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The bottlenose dolphins around LHI prefer the deeper waters where they feed on the schools of fish and squid present there. Therefore, their prey species and their preferred habitat are both outside of the Project area. Therefore the species is not likely to decline as a result of the Project.
Will the action result in invasive species that are harmful to a vulnerable	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of

Significant Impact Criteria	Likelihood of Impact	Justification
species becoming established in the vulnerable species' habitat?		invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline
Will the action interfere substantially with the recovery of the species?	Unlikely	Bottlenose dolphins are not threatened, and therefore there is no recovery plan for the species. The Project is also not located within preferred habitat for the species, with the species only occasionally sighted within the lagoon. Temporary construction works may have the potential for impacts to individuals of the species, however mitigation measures would minimise this risk. Operations would not increase the risk of impacts to the species. Therefore this Project is unlikely to affect the recovery of the species.

4.7.4.2.2. Humpback whale

The humpback whale (*Megaptera novaengliae*) is present at LHI during it's annual northern and southern migrations from its Antarctic feeding grounds to warmer tropical breeding grounds. Outside of the migration period, this species is unlikely to be impacted by project related activities. However, when present this species is particularly susceptible to impacts from underwater noise, and slow travelling mothers and calves are potentially at greater risk of vessel strike.

Table 41: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Humpback whales are likely to be migrating past LHI during their southern and northern migrations, with their southern migration most likely leading to the species being closer to the island. LHI is within the migration BIA for the species and waters within Lord Howe Marine Park are noted as being an important migratory pathway for this species. . The construction piling activities have the potential to cause impacts to humpback whales, however adopting the mitigation measures recommended in Section 4.7.1.1, including avoiding sensitive ecological windows and not piling when the species are more likely to be present in the LHI waters, then this Project is unlikely to lead to any long-term decrease in the population size of the species.

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	The shallow lagoon is not the preferred habitat of the humpback whale, and will not reduce the area of occupancy of the species. It is however within the migration BIA for the species, and therefore humpback whales may be migrating past the island and through waters impacted by underwater noise generated from project activities.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats where fragmentation may have already occurred, and this Project will not increase this risk. Populations are migratory along known oceanic pathways and are unlikely to enter the shallow waters of the lagoon. As the disturbance area is within the lagoon and small in spatial area, infrastructure development would not impact connectivity for this population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	The shallow lagoon is not the preferred habitat of the humpback whale, and this habitat is not critical for the survival of the species. Therefore it is unlikely the Project will have this impact.
Will the action disrupt the breeding cycle of an important population?	Unlikely	The construction piling activities have the potential to cause impacts to humpback whales, however adopting the mitigation measures recommended in Section 4.7.2, including avoiding sensitive ecological windows and not piling when the species are more likely to be present in the LHI waters, will mitigate disruption to breeding or any other important life cycle stage for the species.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The lagoon is not preferred habitat of the humpback whale, as they are more likely to be in deeper waters off the coast of the island, travelling past during their southern/northern migrations. The Project's disturbance area is highly unlikely to impact the habitat of the humpback whale or its prey species.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action interfere substantially with the recovery of the species?	Unlikely	Project pressures on humpback whales at LHI include underwater noise (resulting in hearing impairment, organ damage, communication interference, elevated stress levels and/or avoidance of important habitat), vessel strike, entanglement in lobster pot lines and marine debris (TSSC 2022). Neonate calves are particularly vulnerable to vessel strikes as they have limited swimming and diving abilities and low breath-hold capacity (Irvine and Salgado 2018). The construction piling activities have the potential to cause impacts to humpback whales, however adopting the mitigation measures recommended in Section 4.7.2, including avoiding sensitive ecological windows and not piling when the species are more likely to be present in the LHI waters, will help mitigate impact to humpback whale individuals. Vessel strike risk is very low within the Project area, as it is mostly within the lagoon and not primary habitat for humpback whales.

4.7.4.3. Reptiles

4.7.4.3.1. Green turtle

Many sightings of the Green turtle (*Chelonia mydas*); occur within the lagoon and around LHI. The species is considered resident at LHI, with increased sightings during the summer months, and the area within the lagoon is used for foraging and resting.

The existing infrastructure currently poses a risk to green turtles, as evident by previous harming of a turtle due to a collision with a barge. However, the new infrastructure will enable a newer barge with a shallower hull to access the island and therefore reduce this risk.

Table 42: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Green turtles foraging at LHI largely consist of the non-breeding juvenile and sub-adult cohort <20 years of age and individuals move on to their next life history stage of breeding, transiting oceanic waters to return to their natal colony. The juvenile/sub-adult cohort of Green turtles are unlikely to be significantly impacted by project activities and it is therefore unlikely long term population decline will result.
Will the action reduce the area of occupancy of an	Unlikely	The disturbance area is small, adjacent to existing infrastructure. It is unlikely that the loss of area will reduce the area of occupancy of the Green turtle.

Significant Impact Criteria	Likelihood of Impact	Justification
important population of the species?		
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitat and this Project will not increase this risk. Populations are transient, moving within and out of the lagoon, and therefore the small disturbance area would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	Seagrass beds in the inner lagoon located adjacent to the Northern Project boundary are a significant foraging site for Green turtles. However, these foraging areas are not directly impacted by the Project activities. Two patches of seagrass located within the Project Area are foraged by green turtles, however this habitat is unlikely to be impacted as it is outside the disturbance area. The Sylphs Hole Sanctuary Zone also represents important habitat for turtles temporarily impacted by underwater noise activities.
Will the action disrupt the breeding cycle of an important population?	Unlikely	Green turtle nesting has not been observed at LHI, with known nesting sites for this species being located on the southern Great barrier Reef in mainland Australia.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	All seagrass habitats are outside of the Project's disturbance area. There are two patches of seagrass used by Green turtles for foraging identified within the Project Area. These seagrass patches are adjacent to a main foraging area located at the inner lagoon outside the Project Area and unlikely to be impacted. Population level decline caused by loss of access to foraging areas is unlikely.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline
Will the action interfere substantially with the recovery of the species?	Unlikely	During construction activities, piling will lead to an increase in underwater noise. Green turtles are at risk of impacts from this increased noise if they are swimming within effect zones and may include behavioural change, injury or death. However, adopting the mitigation measures as recommended in

Significant Impact Criteria	Likelihood of Impact	Justification
		Section 4.7.2 will reduce this risk. Green turtles are known to forage over areas of seagrass and algae located within the lagoon and close to the Project area. The foraging area within the inner lagoon is located within the Shutdown Zone as modelled and proposed by Resonate (2025) identified in Section 4.7.1.1. Piling activities are to be managed in accordance with a construction environmental management plan. During operations, there is no increase in the vessel use of the infrastructure or the risk of collision with boats and other marine traffic, being entangled in fishing gear and marine debris and oil spills. A shallower hull design for the new barge will further reduce the risk of vessel strike. Therefore, the Project is unlikely to interfere substantially with the recovery of the species.

4.7.4.3.2. Hawksbill turtle

Frequent sightings of Hawksbill turtles (*Eretmochelys imbricata*) have been recorded within the lagoon and around LHI, although hawksbill turtles are slightly less common than green turtles. Hawksbill turtles are also considered to be resident at LHI and the area within the lagoon is used for foraging and resting.

Table 43: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Hawksbill turtles foraging at LHI largely consist of the sub adult and adult cohort, which recruit to reef areas after the juvenile period in the open ocean. Breeding takes place in the northern Coral Sea, with individuals transiting oceanic waters to return to their natal colony from foraging grounds. The sub-adult/adult cohort of Hawksbill turtles are unlikely to be significantly impacted by project activities and it is therefore unlikely long term population decline will result.
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	The disturbance area is small, adjacent to existing infrastructure. It is unlikely that the loss of area will reduce the area of occupancy of the hawksbill turtle.
Will the action fragment an existing important	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats and this Project will not increase this risk. Populations are transient, moving within

Significant Impact Criteria	Likelihood of Impact	Justification
population into two or more populations?		and out of the lagoon, and therefore the small infrastructure would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	Patch reef and coral bommies used by hawksbill turtles for foraging will not be impacted by the proposed activities. These patch reef and coral bommie areas located at the inner lagoon, headland and inside the Project Area. While there is some historical evidence of grounding disturbance on these habitats, it is unlikely population level decline will occur from any Project impact as this habitat type is present throughout the lagoon and on the eastern side of the island, where hawksbill turtles have also been sighted. The Sylphs Hole Sanctuary Zone represents important habitat for turtles temporarily impacted by underwater noise activities.
Will the action disrupt the breeding cycle of an important population?	Unlikely	Hawksbill turtle nesting has not been observed at LHI, with known nesting sites for this species being located in the northern Coral Sea. Foraging adults are likely to leave LHI for breeding, transiting oceanic waters to return to nesting beaches. This breeding cycle is unlikely to be impacted by project activities.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	Habitat loss will be minimal. A small area of patch reef and coral bommie used by hawksbill turtles for foraging overlaps the Project Area, although no impacts are predicted outside the disturbance area. These patch reef and coral bommie habitats are also located adjacent to the Northern Project boundary located at the inner lagoon and headland. It is unlikely that loss of habitat from the disturbance area will cause population level decline.. as habitat used by hawksbill turtles is present as other locations within the lagoon and hawksbill turtles have also been observed in these other areas.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action interfere substantially with the recovery of the species?	Unlikely	During construction activities, piling will lead to an increase in underwater noise. Hawksbill turtles are at risk of impacts from this increased noise if they are swimming within the zones of impact and may include behavioural change, injury or death. However, adopting the mitigation measures as recommended in Section 4.7.2 will reduce this risk. Hawksbill turtles are known to forage over areas of patch reef located within the lagoon, near the headland and inside the Project area. The inner lagoon and headland areas are located within the Shutdown Zone as modelled and proposed by Resonate (2025) identified in Section 4.7.1.1. Piling activities are to be managed in accordance with a construction environmental management plan. During operations, there is no increase in the vessel use of the infrastructure or the risk of collision with boats and other marine traffic, being entangled in fishing gear and marine debris and oil spills. A shallower hull design for the new barge will further reduce the risk of vessel strike. Therefore, the Project is unlikely to interfere substantially with the recovery of the species.

4.8. Other conservation significant species

Marine Park Value: Other significant species are also supported within the LHIMP.

Other species are those that are not listed as threatened but are still significant for the ecology and biodiversity of LHI. Potential impacts, mitigation recommendations, and assessment and significant residual impacts for other conservation significant species are the same as those assessed in Section 4.7 (subsections 4.7.1, 4.7.2 and 4.7.3, respectively). Therefore, these findings have not been replicated here. The relevant information can be found in the following tables:

- Potential impacts: Table 30
- Mitigation recommendations: Table 33
- Assessment and significance of residual impacts: Table 34

However, assessment on the significance of potential impacts to other key conservation significant species identified from the desktop assessment are provided in Section 4.8.1.

4.8.1. Significance of impacts for other key conservation significant species

Similar to Section 4.7, individual key species are evaluated in accordance with the Matters of National Environmental Significance Significant impact guidelines 1.1 (DotE 2013), with consideration also to the Threatened Species Test of Significance Guidelines (OEH 2018) and the Threatened Species assessment guidelines (NSW DPI 2008).

4.8.1.1. Fish

Two fish species are evaluated as other key conservation significant species:

- Doubleheader wrasse
- Galapagos shark

Harasti et al (2022) identifies the following “other significant species” within the LHIMP:

- White shark
- Tiger shark
- Silky shark
- Shortfin mako shark
- Blue shark

The desktop assessment (Appendix C) found these additional species may be present near LHI, although the likelihood assessment determined impacts to population levels for these species were less likely. See the likelihood of occurrence assessment in Appendix C for further rationale. However, it is noted that individual significance assessments have been provided for key species within the same phyla groups (i.e. elasmobranch), which provide an assessment and mitigation measures that are also relevant and protect these species.

4.8.1.1.1. Doubleheader wrasse

Doubleheader wrasse (*Coris bulbifrons*) has a geographically isolated population at LHI, which is evident by a rare recessive genetic trait of a pied colouration, which is distinct from the dominant trait in the general population of being steely blue in colour. This assessment focuses on this sub-population.

Table 44: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Possible	Underwater noise generated by piling activities have the potential to impact the species, causing injury or possible death to fish within effect zones modelled by Resonate (2025) and distances provided in Section 4.7.1.1. Mitigation measures provided in Section 4.7.2 will help reduce impacts. There is the possibility of loss of individuals of the species if they are unable to exit the management zones, however this is unlikely to have a population level effect. Piling will also only be temporary within a short time frame. There is unlikely to be direct loss of the doubleheader wrasse due to vessel strike, hydrocarbon/ waste spill or loss of habitat as a result of the Project.
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	The doubleheader wrasse inhabit coral, rubble and sandy areas on coral and rocky reefs, and commonly seen by snorkellers and divers within these habitats within the lagoon. Habitat mapping suggests that the most directly affected habitat types in the marine Project area is <i>Unvegetated Substrates and Lagoon Floor – Macroalgae/ Rubble</i> , with sparse benthic communities. Therefore, it is possible this species may be present, although a small area of disturbance of marginal habitat is unlikely to influence the distribution of the species. However, fish may temporarily relocate due to underwater noise generated during piling activities.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats and this Project will not increase the risk. The species is transient, moving within and out of the lagoon, and therefore the small infrastructure would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	The doubleheader wrasse inhabit coral, rubble and sandy areas on coral and rocky reefs, and commonly seen by snorkellers and divers within these habitats within the lagoon. Habitat to be disturbed is classified as <i>Unvegetated Substrates and Lagoon Floor – Macroalgae/ Rubble</i> , with sparse benthic communities. The Sylphs Hole Sanctuary Zone represents the nearest important habitat temporarily impacted by underwater noise activities which contains high biodiversity.
Will the action disrupt the breeding cycle of an important population?	Unlikely	The doubleheader wrasse is a protogynous hermaphrodite, changing from female to male over its life span and females generally breed earlier in life, before becoming male, and populations are male-dominated. Piling activities will be

Significant Impact Criteria	Likelihood of Impact	Justification
		temporary, and is unlikely to impact on the life cycle of the species, including the breeding cycle as it will not specifically impact juvenile or adults of the species.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	As described above, the Project infrastructure will not cause a loss of coral or reef where the doubleheader wrasse inhabits. Therefore it is unlikely that the species would decline due to a loss in habitat as a result of the Project.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline

4.8.1.1.2. Galapagos shark

The Galapagos shark (*Carcharhinus galapagensis*) has distinct populations, including one at LHI which is separate from the population between Elizabeth and Middleton Reefs (DEWHA 2008; O2 Marine 2025). Evidence indicates the LHI population is older and more genetically resilient than the latter population, though both have healthy population densities compared to other populations globally (O2 Marine 2025).

Table 45: Assessment of significant residual impacts

Significant Impact Criteria	Likelihood of Impact	Justification
Will the action lead to a long-term decrease in the size of an important population of a species?	Unlikely	Adult Galapagos sharks are more likely to reside in deeper waters, offshore from LHI. Juveniles may be found within the lagoon near the Project area, however they are unlikely to be impacted by vessel strike, hydrocarbon/ waste spill or loss of habitat as a result of Project activities. Increased underwater noise caused by piling activities have the potential to impact the species, causing injury or possible death to individuals within the effect zones modelled by Resonate (2025) and distances provided in Section 4.7.1.1. However, mitigation measures as given in Section 4.7.2 will minimise these impacts and the Galapagos sharks are likely to swim away from the noise to deeper areas. Piling will also be temporary, lasting

Significant Impact Criteria	Likelihood of Impact	Justification
		only for a short time and therefore increased underwater noise impacts would also be temporary.
Will the action reduce the area of occupancy of an important population of the species?	Unlikely	The Project will only impact very small areas of <i>Unvegetated Substrates and Lagoon Floor – Macroalgae/ Rubble</i> , with sparse benthic communities at the shore and will not reduce the area of occupancy of the Galapagos shark.
Will the action fragment an existing important population into two or more populations?	Unlikely	The proposed marine construction activities will occur in areas of already disturbed habitats and this Project will not increase this risk. Galapagos sharks are transient, moving within and out of the lagoon over large distances, and therefore the small infrastructure would not impact connections within the population.
Will the action adversely affect habitat critical to the survival of the species?	Unlikely	Galapagos sharks travel long, wide distances, including within the lagoon and further from LHI. The Galapagos shark is not threatened and there is no identified habitat critical to its survival. The Project will also be undertaken within an already disturbed area in a small area of the lagoon, and habitat is not likely to be lost.
Will the action disrupt the breeding cycle of an important population?	Unlikely	Juveniles are most likely to be within the lagoon, and if they are impacted then there may be an impact to the adult population. However, the only potential impact to the sharks would be increased underwater noise, which would be temporary in nature during piling works. Other impacts are already a risk due to the current operations, and no incidents have been recorded previously to the breeding cycle.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Unlikely	The Project is located within an area where operations and infrastructure already occur, and therefore the quality of the habitat is unlikely to change from the current condition. The Project is unlikely to impact habitat for the species and therefore is also unlikely to decrease the population.
Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?	Unlikely	No invasive species have been recorded at LHI from historical activities being undertaken in the area. Invasive species are also not a key threatening process for this species. The risk of invasive species can be managed and therefore impacts to this species are unlikely to be significant.
Will the action introduce disease that may cause the species to decline?	Unlikely	Introduced disease is not a key threatening process for this species. The Project is therefore unlikely to introduce disease that may cause the species to decline

5. Conclusion

The primary requirements to be addressed within this CMEA are described in the Supplementary SEARs key issue 2. Biodiversity, items 4 - 7 presented in Table 1. Item 7 involves addressing all comments relevant to coastal and marine ecology in Table 2 provided from the assessment undertaken under the EPBC Act.

Key pressures to the coastal and marine environment that were evaluated in this study to address all comments raised from the referral advice for assessment relevant to both State and Commonwealth legislation included:

- Dust
- Accidental spills
- Introduced marine pests
- Underwater noise
- Coastal processes/sea level rise
- Erosion and sedimentation
- Waste
- Surface and groundwater runoff
- Vessel strike
- Wastewater effluent
- Terrestrial habitat modification
- Coastal and marine habitat modification

5.1. Threatened Species Aquatic Assessment

A threatened species aquatic assessment has been undertaken as described under Part 7A of the FM Act. Details of the desktop assessment to identify key conservation significant marine fauna species, including their ecology and sensitivity to disturbances, is provided in Appendix C. Evaluation of the pressures and cumulative impacts on these species is provided in Sections 4.7 and 4.8.

The key risk to threatened species under the FM Act is underwater noise generated from piling activity. The findings indicate that significant impacts on McCulloch's anemonefish (*Amphiprion mccullochi*), listed as critically endangered under the FM Act, is possible with regular sightings within predicted effect zones defined by Resonate (2025) to 1,900 m for impact piling and 3,350 m for vibratory piling. Impacts on the species would cause permanent or temporary injury, or possible death to fish within 200 m.

The shallow waters of the LHI lagoon support 75% of this species population and impacts could result in population level effects. This reef fish species has a symbiotic relationship with bubbletip anemones and therefore has a limited home range, meaning little management can be implemented during construction activities to mitigate predicted impacts (i.e. fish are less likely to be deterred from soft-start noise). Similar impacts may be applicable for any fish species present within effect zones that exhibit a limited home range, such as Syngnathid species (Booth's Pipefish, Lord Howe Pipefish) also protected under the FM Act. The number of endemic species within the area indicates special

consideration of mitigation and management actions beyond what would normally be considered standard procedure for piling activities including:

- Engineering solutions to minimise noise propagation distance (e.g. bubble curtains, piling sleeve or acoustic net)
- Telemetered underwater noise monitoring program at targeted sites/distances where threatened species are known and can be incorporated into management and shutdown procedures.
- Targeted fish pre/post monitoring program to validate impacts detected for key threatened species known to inhabit the predicted management zones which typically exhibit a limited home range (e.g. McCulloch's anemonefish).

Engineering mitigations would also be effective for reducing potential impacts on other marine fauna (i.e. mammals, reptiles, elasmobranchs), although potential for impacts on these species are considered slightly lower, despite larger effect zones, based on ability to move from the noise if disturbed, while for air breathing species MFOs and management can be applied during activities.

The risk from remaining Project pressures on listed threatened species, populations or ecological communities listed under the FM Act was classified to be Minor/ Insignificant with modern standard mitigation and management actions applied to Project activities.

5.2. Key Threatening Processes

Potential KTPs identified to be relevant to the coastal and marine aspects of the Project include:

- FM Act
 - Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales.
- BC Act
 - Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments
- EPBC Act
 - Novel biota and their impact on biodiversity
 - Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris
 - Land clearance
 - Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.

While the pressures have been evaluated, none of the processes identified result in impact levels on this Project that could be considered justifying classification as a KTP.

5.3. LHIMP Ecological and Biological Values

An assessment of impacts to the ecological and biological values of the LHIMP was undertaken and a descriptive summary of residual impacts and the cumulative impact classification is provided in Table. It is noted that a separate assessment was undertaken on the physical value High water visibility and quality as in many cases this would determine the level of impact risk on ecological and biological values.

Assessment of the cumulative impacts from the Project, assuming appropriate mitigations in place, against the water quality value, as well as ecological and biological values, were typically classified as “minor/insignificant”. Findings for Fish, Threatened and protected species, as well as Other significant species values, were classified as Moderate. The primary risk to these species is underwater noise generated from piling activity as described in Section 5.1. While impacts to fish diversity and threatened classification align to specific species (McCulloch's anemonefish, Syngnathid), the Doubleheader wrasse as a key ‘Other significant species’ is also prominent within the lagoon and while they may have a larger home range, the range of juveniles is poorly understood and potentially vulnerable. The high number of endemic species of fish within the area, combined with a small home range of some reef species and their vulnerability to population level effects, indicates special consideration of mitigation and management actions for piling activities may be required beyond standard procedures to minimise potential impacts.

Cumulative impacts associated with ongoing operations of the Project were considered “minor/insignificant” with appropriate management.

5.4. Impacts to MNES

The values of the LHIMP closely align with World Heritage and National Heritage values relevant to the marine environment and have therefore been covered under the existing assessment undertaken in Section 5.3, including evaluation of water visibility and quality, as well as species of conservation significance to the values of the Lord Howe Island Group World Heritage Area and National Heritage Place.

The assessment was undertaken for each threatened and listed species under the NSW BC Act and the EPBC Act potentially impacted by the Project and provides baseline survey results, description of habitat in the study area, advice on avoidance and mitigation measures and description of direct and indirect impacts. Key risks associated with the Project from a Commonwealth perspective were considered within the list of pressures evaluated during the process.

Similar to Section 5.3, the McCulloch's anemonefish is listed as Critically endangered, while Syngnathid species also listed, under the EPBC Act. These species are at risk of not meeting significance criteria due to modelled predicted impacts of underwater noise from piling activities without implementation of engineering mitigations that are beyond standard procedures. This finding is not only relevant to populations of these species, but also to values associated with marine biodiversity and the reduction of the composition of animal species in part of a World Heritage property.

Table 46: Residual impacts for each of the LHI environmental values

LHIMP values	Residual impacts assessment	Cumulative Impact
High water visibility and quality	No evidence of anthropogenic disturbance on marine environmental quality was identified during baseline surveys and within existing literature, which is therefore considered to be in pristine condition. The risk of toxicant release through disturbance of sediments is low due to low toxicant concentrations within sediments. Temporary, localised increases in turbidity may occur during construction activities, generally within 5 to 20 m from seabed disturbance activity, which is highly unlikely to exceed any light or sedimentation thresholds for photosynthetic benthic organisms (i.e. no ecological effect other than temporary visual observation of plume). Discharge of treated or untreated sullage from vessels will be regulated by international, national and state laws to prevent pollution. The proximity of the project area to ecologically sensitive areas demand procedures for storage, handling and management for waste and hydrocarbons be implemented to minimise and manage the risk of accidental spills into the marine environment during construction and operations. Land-based construction and coastal activities should also be effectively managed to prevent downstream effects to the marine environment. In addition, design planning for coastal infrastructure will consider appropriate coastal hazard guidance for mitigating sea level rise and flooding risks which could introduce pollution into the marine environment.	Minor/ Insignificant
Numerous ecosystems spanning a wide range of habitats and biological communities. Southernmost records of coral reef distribution in the world Macrophytes are common and diverse Marine invertebrates have a high level of diversity	The proposed installation of marine infrastructure is unlikely to impact significantly on any of the ecosystems or their communities at the Island, due to the small area of the disturbance within an area of previous disturbance and existing infrastructure. Vessel groundings have occurred in the past, however all vessels will be evaluated for access which will be limited to previously impacted jetty areas, shipping channel, turning areas, mooring areas, which will minimise the potential for impact to ecosystems. Residual impacts to all pressures associated with water quality have been classified as Minor/ Insignificant, indicating no impact to ecosystems through a water quality cause-effect pathway provided pressures are effectively managed. Australian and international biofouling and ballast water management requirements should be followed to minimise the potential for the translocation of IMP.	Minor/ Insignificant

LHIMP values	Residual impacts assessment	Cumulative Impact
	Due to the existing foreshore hardening, the absence of longshore drift, and the positioning of the site between two shallow intertidal platforms, modifications to shoreline and ecosystems will likely be minimal.	
Diverse fish assemblage Several threatened species and protected species and communities are supported Other significant species are also supported within the LHIMP	Underwater noise generated from piling activities has been modelled by Resonate (2015) predicting spatial effect zones of fatality, permanent or temporary injury, masking or behavioural responses. The possibility of significant impacts is present for McCulloch's anemonefish (<i>Amphiprion mccullochi</i>), listed as critically endangered under the FM Act and EPBC Act, predicting fatality within 200 m and injury zones extending to 1,900 m for impact piling and 3,350 m for vibratory piling. These impacts could result in population level effects due to limited home range characteristics and limited population distribution. Similar impacts may be applicable for any fish species present within effect zones that exhibit a limited home range, such as Syngnathid species (Booth's Pipefish, Lord Howe Pipefish) also protected under the FM Act and EPBC Act. Impact risk is also present on locally relevant iconic species such as the Doubleheader Wrasse (<i>Coris bulbifrons</i>). Additional mitigation and management actions than standard procedures are recommended involving engineering solutions to minimise noise propagation distance, telemetered underwater noise monitoring during construction activities and targeted fish pre/post monitoring. The potential for impacts from piling underwater noise on other marine fauna (i.e. mammals, reptiles, elasmobranchs) are considered acceptable, despite larger effect zones in some cases, based on the ability of the species to move away from the noise if disturbed, while for air breathing species MFOs and management can be applied during activities. It is recommended that appropriate management and mitigation actions are developed and provided in a construction environmental management plan which may include avoiding sensitive times of the year for certain species, including migration and reproduction periods. However, modelling undertaken by Resonate (2015) indicated temporary non-impulsive noise generated by vessel movements were considered significantly below impact thresholds that would not result in any impacts to marine fauna. Vessel speeds within the navigation channel and jetty should be managed to ensure they minimise the risk of vessel strike. The potential for a hydrocarbon spill to result in direct toxic effects on marine fauna is considered Minor/ Insignificant, corresponding with management and mitigation measures identified to maintain water quality. Further, impacts to	Moderate

LHIMP values	Residual impacts assessment	Cumulative Impact
	critical habitat for marine fauna, translocation of IMP or shoreline coastal process modification are considered Minor/Insignificant with appropriate mitigations implemented as identified for protecting ecosystems.	

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Appendix A. Marine Environmental Quality Survey Summary

Appendix A. Marine Environmental Quality Survey Summary

A marine environmental quality (MEQ) survey, involving the collection of water and sediment quality measurements, was undertaken to support the Coastal and Marine Ecology Assessment for the Lord Howe Island Critical Infrastructure Project. The survey was undertaken by BMT in March 2025 in accordance with a sampling plan designed by BMT and approved by DCCEEW. The data collected during the survey was provided to O2 Marine for analysis and interpretation. This report provides a summary of the baseline MEQ data collected to support approvals for the Lord Howe Island Critical Infrastructure Project.

1. Methods

MEQ data was collected by BMT from 26 to 28 March 2025. The MEQ survey was conducted in accordance with the accepted sampling plan designed by BMT and approved by DCCEEW. This sampling plan was not available at the time of the preparation of this report to include further details on methods, such as water depths of sampling or specific sampling equipment used. Briefly, sampling methods for MEQ included the following:

- Physicochemical profiles
- Water samples for laboratory chemical assessment
- Sediment samples for laboratory chemical assessment
- Sediment samples for analysis of microbenthic infauna

The sampling location coordinates and a summary of sampling indicators collected from each location is provided in Table A1 and locations presented in Figure A1. In summary, the number of sites for each collection method included:

- 25 sites for water physicochemical profile (16 impact sites & nine reference sites)
- two sites for chemical water quality
- five sites for chemical sediment quality
- eight sites for benthic infauna.

Table A1: Sample location details for MEQ sampling

Site ID	Lat.	Long.	Sampling Date	Others
Water quality sites				
W1	-31.5241	159.0579	26 March 2025	N/A
W2	-31.5235	159.0483	26 March 2025	Triplicate taken here
Water physicochemical profile (Impact sites)				
WP1	-31.524	159.0583	27 March 2025	N/A
WP 2	-31.5241	159.0578	27 March 2025	N/A
WP 3	-31.5249	159.0576	27 March 2025	N/A
WP 4	-31.5257	159.0557	27 March 2025	N/A
WP 5	-31.5252	159.0544	27 March 2025	N/A

Site ID	Lat.	Long.	Sampling Date	Others
WP 6	-31.5246	159.0532	27 March 2025	N/A
WP 7	-31.5235	159.0508	27 March 2025	N/A
WP 8	-31.5231	159.0492	27 March 2025	N/A
WP 9	-31.5226	159.057	27 March 2025	N/A
WP 10	-31.5219	159.0574	27 March 2025	N/A
WP 11	-31.5222	159.0568	27 March 2025	N/A
WP 12	-31.5213	159.0546	27 March 2025	N/A
WP 13	-31.5206	159.0549	27 March 2025	N/A
WP 14	-31.5198	159.0553	27 March 2025	N/A
WP 15	-31.5248	159.0581	27 March 2025	N/A
WP 16	-31.5256	159.0585	27 March 2025	N/A
Water physicochemical profile (Reference sites)				
WP ref1	-31.5313	159.0601	27 March 2025	N/A
WP ref2	-31.5322	159.0604	27 March 2025	N/A
WP ref3	-31.5307	159.0621	27 March 2025	N/A
WP ref4	-31.5216	159.0492	27 March 2025	N/A
WP ref5	-31.5214	159.0485	27 March 2025	N/A
WP ref6	-31.522	159.0481	27 March 2025	N/A
WP ref7	-31.5245	159.0467	27 March 2025	N/A
WP ref8	-31.5251	159.0459	27 March 2025	N/A
WP ref9	-31.5254	159.0463	27 March 2025	N/A
Sediment quality and benthic infauna sites				
S1	-31.5233	159.0545	26 March 2025 27 March 2025	Sediment quality sampled Benthic infauna sampled Duplicate taken here
S2	-31.5254	159.0561	26 March 2025 27 March 2025	Sediment quality sampled Benthic infauna sampled
S3	-31.5267	159.0573	26 March 2025 28 March 2025	Sediment quality sampled Benthic infauna sampled
S4	-31.5263	159.055	26 March 2025 28 March 2025	Sediment quality sampled Benthic infauna sampled
S5	-31.5236	159.0569	26 March 2025 28 March 2025	Sediment quality sampled Benthic infauna sampled
S6	-31.5237	159.0511	28 March 2025	Only benthic infauna sampled
S7	-31.5227	159.0495	28 March 2025	Only benthic infauna sampled
S8	-31.5219	159.0571	28 March 2025	Only benthic infauna sampled

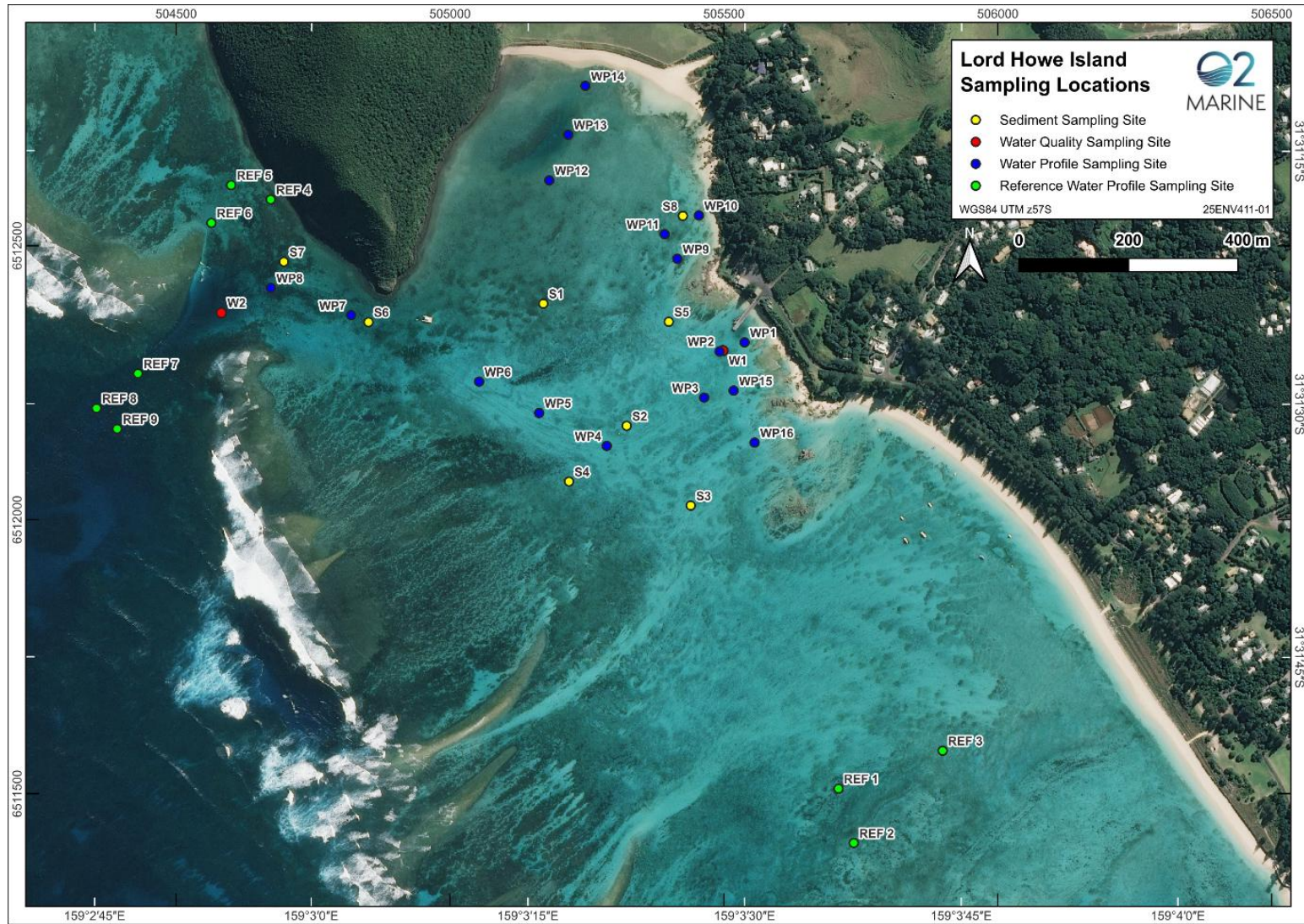


Figure A1: Sampling locations

1.1. Physicochemical profiling

Water physicochemical profiling was conducted in accordance with the accepted sampling plan designed by BMT and approved by DCCEEW. The following parameters were collected:

- Conductivity (EC)
- Salinity
- Temperature
- pH
- Dissolved Oxygen (DO)
- Turbidity.

1.2. Water sampling

Water samples were collected in accordance with the accepted sampling plan designed by BMT and approved by DCCEEW. Triplicate samples (i.e. three separate samples taken at the same location) were collected at W2 to determine within site variability. Additionally, two rinsate samples were collected.

All samples were transported to the laboratories in eskies with accompanying chain of custody (COC) forms. All water samples were handled, stored and transported in accordance with standards defined in the BMT sampling plan.

Water samples were sent to laboratories for analysis of the following parameters:

- Total Suspended Solids (TSS)
- Total Recoverable Hydrocarbons (TRH) and Total Petroleum Hydrocarbons (TPH)
- Benzene, Toluene, Ethylbenzene, Xylene & Napthalene (BTEXN)
- per- and poly-fluoroalkyl substances (PFAS)
- Polycyclic Aromatic Hydrocarbons (PAH)
- Total Metals (Al, Sb, As, Be, B, Cd, Cr, Co, Cu, Fe, Mn, Mo, Ni, Se, Ag, Hg, Pb, Sn & Zn)
- Nutrients (TN, TP, TKN, NH_3 , NO_3^- , NO_2^- , NO_x)
- Chlorophyll (a) (Chl-a)

All laboratory analyses were conducted by ALS Environmental Pty Ltd (ALS), a laboratory accredited by the National Association of Testing Authorities (NATA Accreditation No. 825). Comprehensive quality assurance and quality control (QA/QC) testing of samples was undertaken in accordance with their respective NATA accreditation and include testing of laboratory control samples, method blanks, matrix spikes and laboratory duplicates (where applicable).

1.3. Sediment quality

Sediment quality samples were collected, handled, and stored in accordance with the BMT sampling plan. A photograph was taken and notes collected on visual appearance and any key features. The sediment samples were taken from eight locations. A field duplicate was collected at sampling location S1 for field quality control.

Five sediment samples (S1 - S5) were sent to laboratories for analysis of the following parameters:

- Particle Size Distribution (PSD)
- TRH and TPH
- BTEXN
- PFAS
- Metals (Al, Sb, As, Cd, Cr, Co, Cu, Fe, Mn, Hg, Ni, Pb, Se, Ag, V & Zn)
- Total Organic Carbon (TOC).

1.4. Benthic infauna

Benthic infauna sampling was also undertaken at eight sediment sampling locations, with three replicates collected at each location (giving 24 samples in total). The benthic infauna samples were sieved, preserved and shipped in accordance with standards accepted by the receiving laboratory where they were sorted and identified to the lowest taxonomic resolution possible.

2. Data analysis

2.1. Physicochemical profiling

The following analysis (including QA/QC) was undertaken of the physicochemical profile data:

- Data trimming was conducted to remove data points occurring outside the range of 0.5 m below the surface (except for WP9, where all data collected from WP9 were obtained at depths of less than 0.5 m below the water surface).
- Manual QC checks were conducted to remove erroneous entries.
- A median value of the profile was calculated for each parameter at each location.

The median physicochemical values were compared against default guideline values (DGVs) from ANZG (2018). DGVs from the Manning Shelf were adopted for this analysis, which is the coastal section of the Central Eastern Shelf Province from the Temperate East Marine Bioregion. It is noted that Lord Howe Province is recognised as a Provincial bioregion under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) framework within the same bioregion, although DGVs have not been allocated under ANZG (2018) to this Province.

2.2. Water sampling

Laboratory results for contaminants (i.e. metals, hydrocarbons) and nutrients in water samples were listed in tables and compared against DGVs from ANZG (2018). Several forms of the contaminant exist for arsenic and chromium, where the most conservative (i.e. lowest) values were used for assessment purposes. Physical and chemical stressor DGVs adopted from the Manning Shelf were used for nutrient and Chl-a parameters (as per Section 2.1).

Comprehensive QA/QC testing of samples was undertaken by ALS laboratory in accordance with NATA accreditation, including testing of laboratory control samples, method blanks, matrix spikes and laboratory duplicates (where applicable). Analysis of field QA/QC triplicate samples involved calculation of the Relative Standard Deviation (RSD) where 50% difference was applied to indicate an acceptable limit.

2.3. Sediment quality

Laboratory results for contaminants (i.e. metals, hydrocarbons) were listed in tables and compared against DGVs from ANZG (2018) to determine contaminant risk of marine sediments within the study area. Summary statistics (i.e. mean, median, maximum, minimum) were calculated across sites and compared to DGVs. Where concentrations were recorded below the limit of reporting (LOR), the value of the LOR was halved for statistical calculations.

The PSD of sediment samples were taken from all eight locations with three replicates at each location (i.e. 24 samples in total). The distribution was classified in accordance with the International Scale (ISO 14688-1: 2017) which categorises the following size ranges: Clay (<2 µm), Silt (2-60 µm), Sand (0.06-2.00 mm), Gravel (2.00-60.0 mm) and Cobbles (>6 cm). The PSD is presented graphically showing the proportional distribution of the grain sizes in the samples.

Similar to Water sampling (Section 2.2), NATA accredited QA/QC testing was undertaken by the laboratory, while analysis of field QA/QC duplicate samples involved calculation of the relative percentage difference (RPD) where 35% difference was applied to indicate an acceptable limit.

2.4. Benthic infauna

For the analysis of sediment samples for benthic infauna, diversity indices that measure species diversity and richness provide information about community composition. Indices that measure species dominance and evenness across sample sites provide information about ecosystem function and health. Indices suitable for providing information relevant to diversity, richness and evenness include:

- Margalef's index to assess the species richness
- Shannon's-H index to assess the species diversity
- Evenness index to assess evenness within samples
- Dominance-D to assess taxon dominance within the sample.

Multivariate cluster and multidimensional scaling (MDS) analyses has been conducted. The multivariate analysis will reveal natural groupings of sample sites based on those with similar faunal and community composition. This can be used to interpret patterns of biodiversity and characterise the infauna communities within the study area.

3. Results

Detailed results provided from the laboratory are presented in the Appendices as follows:

- ALS laboratory water quality results – Appendix A.1
- ALS laboratory water quality (quality control) report – Appendix A.2
- ALS laboratory sediment quality results – Appendix A.3
- ALS laboratory sediment quality (quality control report) – Appendix A.4

Chain of Custody (CoC) forms for all samples collected on the survey are provided in Appendix A.5 and sediment sample photographs are presented in Appendix A.6.

3.1. Physicochemical profiling

Median values of physical and chemical stressors calculated for each site are presented in Table A2. A summary of the results are as follows:

- Impact sites:
 - Temperature values ranged between 25.0 and 26.2°C. This was warmer than Manning Shelf DGVs, with 20th and 80th percentiles for summer ranging from 21.7 to 24.8°C.
 - DO was supersaturated ranging between 107.5 and 125.6% and well above minimum DGVs for surface and bottom waters of Manning Shelf at 82% and 73%, respectively.
 - EC values ranged between 55.7 and 57.2 mS/cm.
 - Salinity values ranged between 36.9 and 37.1 psu, above DGVs for surface and bottom waters of Manning Shelf of 35.5 psu and 35.3 psu, respectively.
 - pH values ranged between 7.8 and 8.1. Two sites (WP1 and WP2) recorded pH values slightly below the DGV lower limit. However, the overall median pH value was within the DGV range.
 - Turbidity values ranged between 0.1 and 7.4 NTU. Eleven sites exceeded the DGV for NSW, although turbidity generally remained very low (i.e. <3 NTU), with only two sites (WP12 and WP13) recording clear signs of solid concentrations in the water column.
- Reference sites typically recorded data reflective of the impact sites:
 - Temperature values ranged between 25.1 and 25.5°C within range of impact sites.
 - DO saturation ranged between 110.4 and 121.6% within the range of impact sites.
 - EC values ranged between 55.6 and 56.5 mS/cm comparable to impact sites.
 - Salinity values ranged between 36.8 and 37.2 psu comparable to impact sites.
 - pH values ranged between 8.1 and 8.2, which is in the upper range of the impact sites. Impact sites WP1 and WP2 exhibit concentrations notably lower (± 0.2) than the range of values from reference sites.
 - Turbidity values ranged between 0 and 4.8 NTU within range of impact sites.

The median values of all physical and chemical stressors recorded at both reference and impact sites were generally comparable. DO saturation and pH were slightly higher at the reference sites, whereas turbidity was marginally higher at the impact sites.

Table A2: Median values for physical and chemical stressors.

Site ID	Temp	DO	EC	Salinity	pH	Turbidity
Unit	°C	% Saturation	mS/cm	Psu	-	NTU
DVG	21.7 – 24.8°C	73 - 82% ¹	--	35.3 – 35.5	8.0 - 8.4 ²	0.5
Impact Sites						
WP1	25.6	117.2	56.2	36.9	7.8	0.9
WP2	25.3	119.1	55.9	36.9	7.9	1.7
WP3	25.2	116.3	55.8	36.9	8.0	0.9
WP4	25.1	120.8	55.7	36.9	8.0	1.7
WP5	25.0	117.5	55.8	37.0	8.0	1.4
WP6	25.2	119.8	55.8	36.9	8.0	0.1
WP7	25.3	113.1	55.9	36.9	8.0	0.5
WP8	25.0	115.0	55.8	37.0	8.0	0.1
WP9	25.9	117.1	56.9	37.1	8.1	2.3
WP10	26.1	115.9	56.8	37.0	8.0	0.5
WP11	26.0	113.2	56.8	37.0	8.0	2.4
WP12	26.0	125.6	57.0	37.1	8.1	7.4
WP13	25.7	107.5	56.4	36.9	8.0	4.6
WP14	26.2	114.6	57.2	37.1	8.1	1.8
WP15	25.5	116.9	56.4	37.1	8.1	2.3
WP16	25.2	114.6	56.0	37.0	8.1	0.3
Median	25.4	116.6	56.1	37.0	8.0	1.5
Average	25.5	116.5	56.3	37.0	8.0	1.8
Maximum	26.2	125.6	57.2	37.1	8.1	7.4
Minimum	25.0	107.5	55.7	36.9	7.8	0.1
Reference Sites						
WPref1	25.2	115.4	56.1	37.1	8.1	1.5
WPref2	25.5	121.6	56.2	37.0	8.1	2.7
WPref3	25.4	120.5	56.1	37.0	8.1	4.8
WPref4	25.5	121.5	56.5	37.2	8.1	1.3
WPref5	25.3	131.0	56.0	36.9	8.1	0.2
WPref6	25.5	139.5	56.3	37.0	8.2	3.0
WPref7	25.4	129.7	56.0	36.9	8.1	0.1
WPref8	25.2	121.6	55.8	36.9	8.1	0.0
WPref9	25.1	110.4	55.6	36.8	8.1	0.0
Median	25.4	121.6	56.1	37.0	8.1	1.3
Average	25.3	123.5	56.1	37.0	8.1	1.5
Maximum	25.5	139.5	56.5	37.2	8.2	4.8
Minimum	25.1	110.4	55.6	36.8	8.1	0.0

¹ Converted DO % saturation values using relevant temperature, atmospheric pressure and salinity from summer DGVs in mL/L units for surface and bottom waters of the Manning Shelf mesoscale bioregion

² DGVs for pH and turbidity are extracted from ANZECC & ARMCANZ (2000) Section 8.2.2.1 Trigger values for NSW

3.2. Water sampling

3.2.1. Toxicants and total suspended solids

Results for toxicants and TSS in water samples from the two sites are presented in Table A3. Detailed results from laboratory are provided in Appendix A.1.

Key findings are summarised below:

- Arsenic, boron, and molybdenum were detected above the LOR at both W1 and W2 sites, while iron was detected only at the W1 site. Remaining metal concentrations were reported below the LOR. However, all results were reported below ANZG (2018) DVGs.
- Ammonia was reported below LOR.
- TSS was reported below LOR.
- Hydrocarbons BTEXN, TRH, TPH and PAH were reported below LOR at all sample sites.
- PFAS was reported below LOR at all sample sites.

3.2.2. Nutrients and Chlorophyll-a

Results for nutrients in water are presented in Table A4. Detailed results provided from laboratory in Appendix A.1.

Key findings are summarised below:

- Concentrations for NO_2^- , TP, FRP and Chl-a were either reported very low or below the LOR. It is noted that the DGV for Chl-a is also below the LOR, although concentrations were low regardless.
- TN, TKN, NO_3^- and NO_x^- were detected at low concentrations from both W1 and W2 sites, while NO_3^- remains below the DVG.

Table A3: Result on toxicants in water

Site ID		Al	Sb	As (III)	As (V)	Be	B	Cd	Cr (III)	Cr (VI)	Co	Cu	Fe	Pb	Mn	Mo	Ni	Se	Ag	Sn	Zn	Hg	Ammonia (NH ₃)	TSS
LOR Unit		5	0.5	0.5	0.1	100	0.2	0.5	0.2	1	5	0.2	0.5	0.1	0.5	2	0.1	5	5	0.005	5	0.5	5	5
		µg/L																						mg/L
Level of protection (% species)	99%	9	ID	ID	ID	ID	ID	0.7	7.7	0.14	0.005	0.3	ID	2.2	ID	ID	7	ID	0.8	ID	3.3	0.1	500	ID
	95%	37	ID	ID	ID	ID	ID	5.5	27	4.4	1	1.3	ID	4.4	ID	ID	70	ID	1.4	ID	8	0.4	910	ID
	90%	72	ID	ID	ID	ID	ID	14	49	20	14	3	ID	6.6	ID	ID	200	ID	1.8	ID	12	0.7	1200	ID
	80%	160	ID	ID	ID	ID	ID	36	91	85	150	8	ID	12	ID	ID	560	ID	2.6	ID	21	1.4	1700	ID
Low Reliability Marine Guideline Trigger Value		--	270	2.3	4.5	0.13	5,100	--	--	--	--	--	--	--	80	23	--	3	--	10	--	--	--	0.5
W1		<5	<0.5	1.7		<0.1	4860	<0.2	<0.5		<0.2	<1	11	<0.2	<0.5	7.7	<0.5	<2	<0.1	<5	<5	<0.005	<10	<5
W2		<5	<0.5	1.8		<0.1	3960	<0.2	<0.5		<0.2	<1	<5	<0.2	<0.5	7.5	<0.5	<2	<0.1	<5	<5	<0.005	<10	<5

Low Reliability Marine Guideline Trigger Value of Sb, As(III), As(V), Be, B, Mn, Mo, Se and Sn are extracted from 'Detailed descriptions of chemicals' of the ANZG (2018) guidelines.

Low Reliability Marine Guideline Trigger Value of TSS is extracted from ANZECC & ARMCANZ (2000) Section 8.2.2.1 Trigger values for NSW.

Table A4: Chlorophyll- α and nutrient concentrations.

Site ID	Total Nitrogen (TN)	Total Kjeldahl Nitrogen (TKN)	Nitrite (NO ₂ ⁻)	Nitrate (NO ₃ ⁻)	Oxides of Nitrogen (NO _x ⁻)	Total Phosphorus (TP)	Filterable Reactive Phosphorus (FRP)	Chlorophyll- α (Chl- α)
LOR	0.01	0.01	0.002	0.002	0.002	0.005	0.001	1
DVGs	-	-	-	1.012	-	-	-	0.814
W1	0.16	0.14	<0.002	0.015	0.015	<0.005	<0.001	<1
W2	0.19	0.17	<0.002	0.019	0.019	<0.005	<0.001	<1

3.2.3. QA/QC

The QA/QC results from ALS laboratory are presented in Appendix A.2. A summary of the results is provided below:

- All laboratory blanks are below the LOR
- All laboratory control samples are within acceptable limits
- All laboratory duplicate samples are within acceptable limits
- All matrix spike samples are within acceptable limits, except for two analytes (TN and TP) reported outside the recommended laboratory acceptance criteria

Laboratory QA/QC results indicate that the holding times for several analytes, including NO_2^- , NH_3 , NO_3^- , TN, TP, FRP, and Chl-a from both W1 and W2, were exceeded by three days.

Procedures for field QA/QC sampling involving the collection and analysis of triplicate and rinsate samples set out in the approved BMT Sampling Plan were implemented to examine for cross contamination, *in-situ* heterogeneity and repeatability of field estimates.

The RSD results calculated for triplicate samples are summarised in Table A5 and Table A6. Laboratory results indicate that RSD values for all analytes were within acceptable limits (<50%). Cu and Pb were detected at low concentrations in one rinsate sample, although does not appear to have influenced sampling results for these concentrations which remained low.

Table A5: RSD for toxicants in triplicate water samples

Site ID	Al	Sb	As (III)	Be	B	Cd	Cr (III)	Co	Cu	Fe	Pb	Mn	Mo	Ni	Se	Ag	Sn	Zn	Hg
LOR	5	0.5	0.5	0.1	100	0.2	0.5	0.2	1	5	0.2	0.5	0.1	0.5	2	0.1	5	5	0.005
Units	µg/L																		
W2	<5	<0.5	1.8	<0.1	3960	<0.2	<0.5	<0.2	<1	<5	<0.2	<0.5	7.5	<0.5	<2	<0.1	<5	<5	<0.005
Trip 1	<5	<0.5	1.6	<0.1	3570	<0.2	<0.5	<0.2	<1	<5	<0.2	0.5	8.2	<0.5	<2	<0.1	<5	<5	<0.005
Trip 2	<5	<0.5	1.7	<0.1	3480	<0.2	<0.5	<0.2	<1	<5	<0.2	<0.5	8.4	<0.5	<2	<0.1	<5	<5	<0.005
RSD	--	--	6%	--	7%	--	--	--	--	--	--	43%	6%	--	--	--	--	--	--

Note: Blue text indicates values below the LOR that have been halved for comparison

Table A6: RSD for Chlorophyll-α and nutrient concentrations in triplicate water samples

Sites	Total Nitrogen (TN)	Total Kjeldahl Nitrogen (TKN)	Nitrite (NO ₂ ⁻)	Nitrate (NO ₃ ⁻)	Oxides of Nitrogen (NO _x ⁻)	Total Phosphorus (TP)	Filterable Reactive Phosphorus (FRP)	Chlorophyll-α (Chl-α)
LOR	0.01	0.01	0.002	0.002	0.002	0.005	0.001	1
Unit	mg/L							
W2	0.19	0.17	<0.002	0.019	0.019	<0.005	<0.001	<1
Trip 1	0.17	0.16	<0.002	0.012	0.012	<0.005	<0.001	<1
Trip 2	0.19	0.17	<0.002	0.016	0.016	<0.005	<0.001	<1
RSD	6%	3%	--	22%	22%	--	--	--

3.3. Sediment Quality

3.3.1. Particle Size Distribution

PSD results are presented in Figure A2. The area showed slight variation in PSD, with sand content ranging from 64% to 94% (mean = 87%), gravel from 2% to 31% (mean = 9.6%), and clay from 1% to 4% (mean = 2.7%). Notable variability was observed among the S4 replicates, where sand content ranged from 64% to 90% and gravel content from 7% to 31%. The variation may reflect small-scale spatial heterogeneity within the site. While the spatial extent of sediment sites from the coast was relatively limited, sites closer to the outer lagoon (S4, S6 and S7) exhibited slightly lower sand content and higher gravel content compared to other sites.

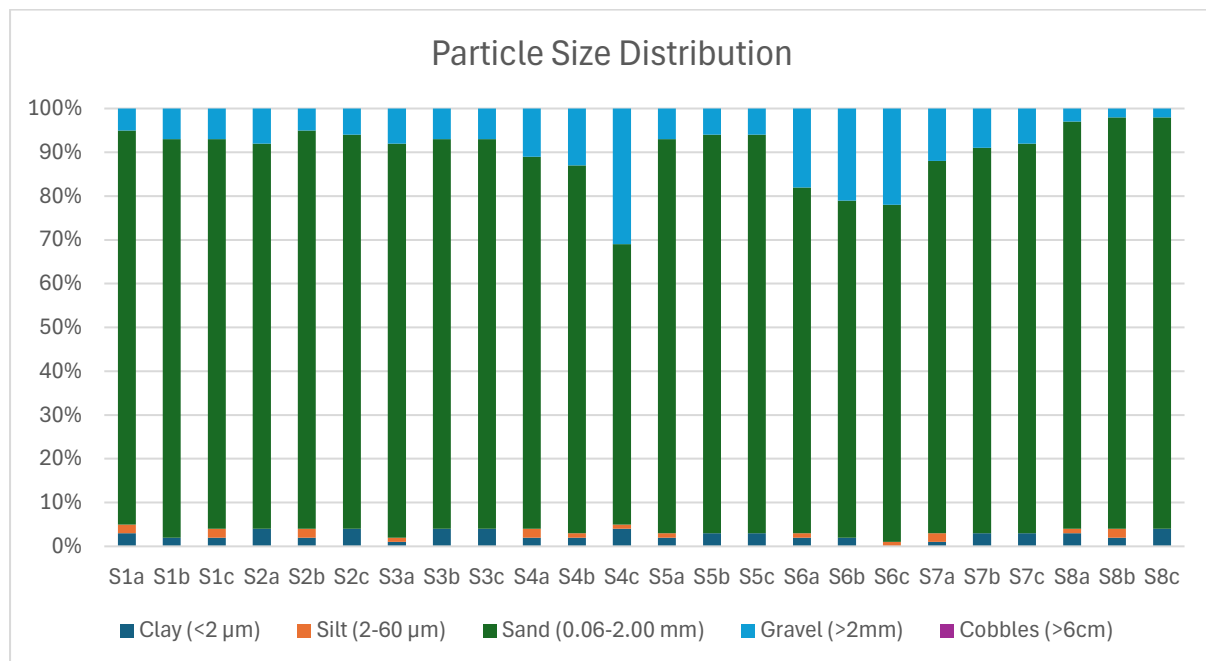


Figure A2: PSD of sediments collected at sampling locations.

3.3.2. Toxicants

Results for toxicants in sediments are presented in Table A7 and Table A8. Detailed results from the laboratory are provided in Appendix A.3.

Key findings are summarised below:

- Metal concentrations were typically low and below the ANGZ (2018) DGVs
- The results for Sb, Cd, Cu, Pb and Hg were recorded below the LOR
- Metals and metalloids without DGVs included Al, Fe, Co, Mn, Se and V. Results for these metal constituents across sites were typically low and homogenous.
- BTEXN compounds were all recorded below the LOR at all sites.
- Low-level detections were reported for TPH in the C15-C28 fraction at all sites and normalised TPH below the ANGZ (2018) DGVs. Similarly, low-level detections were reported for TRH in the C16-C34 fraction at all sites.
- TOC results range from 0.1 – 0.3%, while moisture content ranges from 31 – 34%
- PFAS were reported below LOR at all sample sites.

Table A7: Metals concentration results in sediment

Site ID	Al	Fe	Sb	As	Cd	Cr	Cu	Co	Pb	Mn	Ni	Se	Ag	V	Zn	Hg
Unit	mg/kg															
LOR	50	50	0.5	1	0.1	1	1	0.5	1	10	1	0.1	0.1	2	1	0.01
DGV	-	-	2	20	1.5	80	65	-	50	-	21	-	1	-	200	0.15
S1	330	1,330	<0.50	4.2	<0.1	13.1	<1.0	1.2	<1.0	26.0	9.6	0.1	0.1	4.4	3.3	<0.01
S2	240	1,160	<0.50	2.1	<0.1	12.2	<1.0	1.1	<1.0	24.0	8.8	0.1	<0.1	4.2	2.0	<0.01
S3	220	740	<0.50	2.8	<0.1	9.7	<1.0	<0.5	<1.0	15.0	3.2	0.1	<0.1	4.0	1.4	<0.01
S4	240	1,260	<0.50	2.0	<0.1	12.6	<1.0	1.3	<1.0	26.0	10.6	0.1	<0.1	3.6	2.0	<0.01
S5	300	1,090	<0.50	2.5	<0.1	12.5	<1.0	0.9	<1.0	25.0	7.4	0.1	<0.1	3.9	2.4	<0.01
Mean	266	1,116	<0.50	2.7	<0.1	12.0	<1.0	1.1	<1.0	23.2	7.9	0.1	<0.1	4.0	2.2	<0.01
Median	240	1,160	<0.50	2.5	<0.1	12.5	<1.0	1.2	<1.0	25.0	8.8	0.1	<0.1	4.0	2.0	<0.01
Maximum	330	1,330	<0.50	4.2	<0.1	13.1	<1.0	1.3	<1.0	26.0	10.6	0.1	0	4.4	3.3	<0.01
Minimum	220	740	<0.50	2.0	<0.1	9.7	<1.0	<0.5	<1.0	15.0	3.2	0.1	<0.1	3.6	1.4	<0.01
Mean	266	1,116	<0.50	2.7	<0.1	12.0	<1.0	1.1	<1.0	23.2	7.9	0.1	<0.1	4.0	2.2	<0.01

Table A8: Hydrocarbons and moisture content results in sediment

Units LOR	BTEXN		TRH	TPHs	Normalised TPH	TOC	Moisture
	Sum of BTEX	Naphthalene	mg/kg				
	0.2	0.2					
DGVs	--	--	--	--	280	-	-
S1	<0.2	<0.2	18	16	80	0.2	31.4
S2	<0.2	<0.2	14	13	59	0.22	33.8
S3	<0.2	<0.2	8	7	41	0.17	34.1
S4	<0.2	<0.2	14	12	36	0.33	34.1
S5	<0.2	<0.2	13	12	67	0.18	31.5
Median	<0.2	<0.2	14	12	59	0.2	34
Mean	<0.2	<0.2	13.4	12	57	0.2	33
Minimum	<0.2	<0.2	8	7	36	0.2	31
Maximum	<0.2	<0.2	18	16	80	0.3	34
Std Dev	--	--	3.6	3.2	18	0.1	1

3.3.3. QA/QC

The laboratory QA/QC results from the ALS are presented in Appendix A.4. A summary of the results is provided below:

- All laboratory blanks are below the LOR
- All laboratory control samples are within acceptable limits
- All laboratory duplicate samples are within acceptable limits
- All matrix spike samples are within acceptable limits.

Laboratory QA/QC results also indicate that the holding times for several analytes, including TOC and moisture content from all sites, were exceeded by 29 and 15 days, respectively.

Procedures for collection and analysis of duplicate samples set out in the approved BMT Sampling Plan were followed for all samples collected to examine for cross contamination, *in-situ* heterogeneity and repeatability of field estimates.

The QA/QC assessment results for the sediment samples are shown in Table A9 and Table A10. Returned RPD exceedances (>35%) were recorded for As, Se, Ag and Zn (Table A9). RPD exceedances were a result of comparison between low-level detections of toxicants and values reported below the LOR, which resulted in a proportionally larger RPD value.

Table A9: RPD for toxicants (metals) in duplicate sediment samples

Sites	Al	Fe	Sb	As	Cd	Cr	Cu	Co	Pb	Mn	Ni	Se	Ag	V	Zn	Hg
LOR	50	50	0.5	1	0.1	1	1	0.5	1	10	1	0.1	0.1	2	1	0.01
Units																
S1	330	1330	<0.50	4.21	<0.1	13.1	<1.0	1.2	<1.0	26	9.6	0.1	0.1	4.4	3.3	<0.01
Duplicate	320	1120	<0.50	1.74	<0.1	11	<1.0	0.9	<1.0	23		7.4	<0.1	<0.1	3.4	2
RPD (%)	3%	17%	--	83%	--	17%	--	29%	--	12%	26%	67%	67%	26%	49%	--

Note:

Blue text indicates values below the LOR that have been halved for comparison

RPD values highlighted in red > 35%

Table A10: RPD for remaining toxicants in duplicate sediment samples

Sites	Ammonia (NH ₃)	Sum of BTEX	Naphthalene	TPHs	TOC	Moisture
LOR	5	0.2	0.2	3	0.02	1
Units						
S1	<10	<0.2	<0.2	16	0.2	31.4
Duplicate	<0.01	<10	<0.2	<0.2	13	0.25
RPD (%)	--	--	--	21%	22%	9%

3.4. Benthic infauna results

The marine benthic survey collected 452 individuals from 39 taxa. The top three most abundant taxa across all sites were the *Metilidae* (n = 113), the *Cirratulus-sp1* (n = 100), and the *Nematonereis-unicornis* (n = 27).

Four indices are selected to analyse diversity among the macrobenthic infauna samples: Margalef's species richness, Shannon's-H species diversity, Evenness, and Dominance-D. The results of the indices are summarized in Figure A3. Analysis of variance (ANOVA) revealed no significant statistical difference in taxonomic richness among the different sites, with an $F_{(7,16)} = 0.788$; ($F_{0.05 (7,16)} = 2.657$), $p = 0.608$.

ANOVA revealed no significant statistical difference in taxonomic diversity among the different sites, with an $F_{(7,16)} = 1.062$; ($F_{0.05 (7,16)} = 2.657$), $p = 0.430$.

ANOVA revealed no significant statistical difference in evenness among the different sites, with an $F_{(7,16)} = 0.718$; ($F_{0.05 (7,16)} = 2.707$), $p = 0.659$.

ANOVA revealed no significant statistical difference in dominance among the different sites, with an $F_{(7,16)} = 0.858$; ($F_{0.05 (7,16)} = 2.657$), $p = 0.558$. The evenness index and the dominance index are somewhat correlated. Across the survey, sites presented with >0.7 evenness values and <0.63 dominance values. This indicates a relative even distribution of individual counts among different species, with no single species dominating the area.

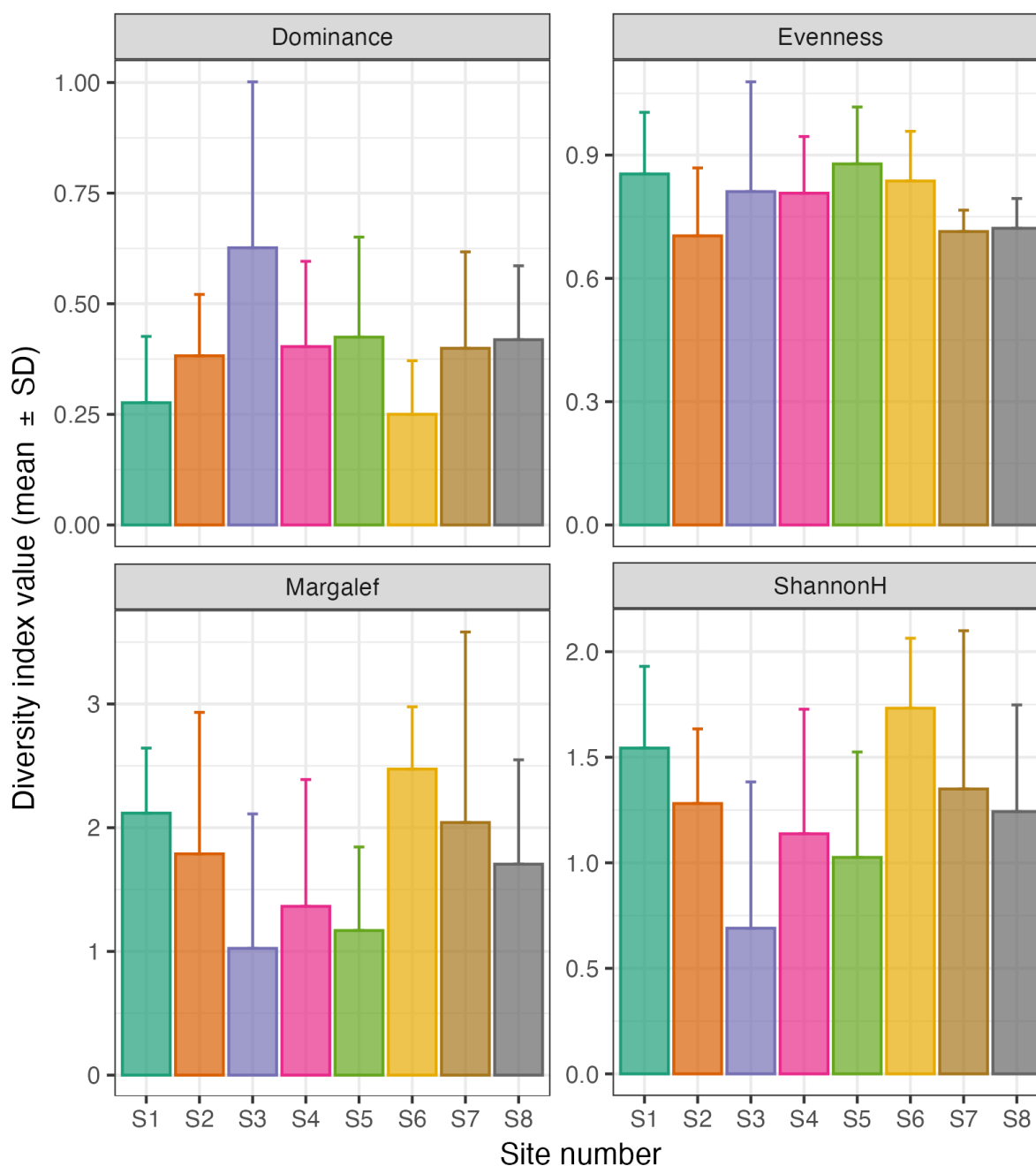


Figure A3: Diversity index value for Site S1 – S8

The MDS plot (Figure A4) presents a stress value of 0.22, indicating that the points are close to being arbitrary, and the placement of sites within the ordination may not accurately represent similarities. Notably, site S6 and S7 are closely clustered in the upper central region, suggesting these sites share similar faunal assemblages dominated by taxa such as *Metillidae*, and *Syllidae*. Both sites share similar PSD characteristics and are located near Dawsons Point further from the jetty. Meanwhile, Site S1 and S8 appear near the centre of the plot, suggesting a more uniform community composition found across all sites with taxa such as *Ophiodromus-sp1* and *Cirratulus-sp1* contributing to their structure.

Site S1 and S6 present tight clustering of their replicates, indicating good within-site similarity, while Site S4 and S5 are more dispersed, suggesting heterogeneity between replicates within those sampling sites.

The *Nematode*, *Polygordiidae*, *Solemyidae*, *Metilidae* and *Harpacticoida* contribute strongly to the dissimilarity between sample groups. Their prominent positioning suggests that these taxa are influential in shaping the community composition. Similarly, *Lumbrineris-sp1* and *Orbiniidae* are a strong influence on certain sites.

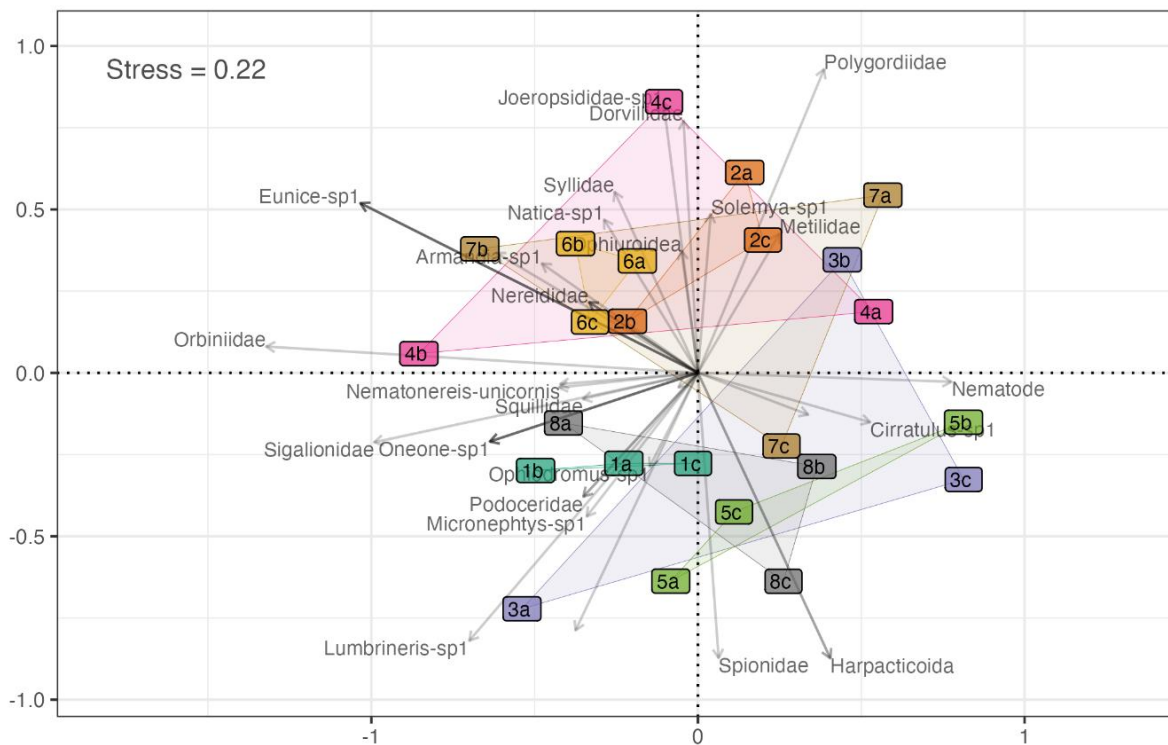


Figure A4: MDS ordination of infauna composition

4. Discussion

In this study, sea temperatures at the impact site ranged from 25.0°C to 26.2°C, with an average of 25.5°C. This closely aligns with previous records, including a summer monthly average of 24.5°C (CSIRO 2009), 25.4°C (Davis *et al.* 2020), and a peak daily average of 26.8°C at Sylph's Hole in February 2019 (Moriarty *et al.* 2023). The water is typically warmer than the Manning Shelf mesoscale bioregion closer to the mainland, possibly due to being a shallow lagoon with lower water exchange, or being situated within the East Australia Current. Despite these relatively stable conditions, coral bleaching has been recorded around Lord Howe Island in 1998, 2010, 2011, and 2019. Notably, during the 2010 summer, sea surface temperatures exceeded 28°C—approximately 2–3°C above the typical seasonal maximum—resulting in an accumulated thermal stress of over 19°C heating weeks (Dalton *et al.* 2020 and Harrison *et al.* 2011). This anomaly, combined with high light penetration, led to a severe bleaching event, with more than 95% of coral cover bleached at the most affected lagoon sites. These findings highlight the sensitivity of

Lord Howe Island's coral ecosystems to thermal stress during periods of elevated summer temperatures.

Salinity, EC, and DO concentrations recorded in this study were slightly higher, although still representative, when compared to that reported from previous studies (CSIRO, 2009 and Davis *et al.*, 2020). pH values ranged from 7.8 to 8.1, with two sites (WP1 and WP2) recording values slightly below the ANZG (2018) DGV lower limit. Nonetheless, the overall median pH remained within the acceptable DGV range. Turbidity measurements varied from 0.0 to 7.4 NTU, with most sites representative of low sediment resuspension and clear water quality. Only two impact sites and two reference sites recorded turbidity values above 3.0 NTU. This is supported by low levels of TSS recorded within water samples.

All toxicants assessed in this study, including metals, ammonia, hydrocarbons, and PFAS, were reported at low concentrations, remaining below their respective ANZG (2018) DGVs. Similarly, nutrient parameters such as TN, NO_3^- , NO_2^- , TP, FRP, TKN, NO_x^- and Chl-a were also recorded at low concentrations at or below their relevant DGVs. These findings are consistent with previous studies, including Moriarty *et al.* (2023), which reported low concentrations of nutrient nitrogen (NO_3^-) and phosphorus in surface waters surrounding Lord Howe Island. The Lord Howe Island Marine Park Draft Management Plan (DCCEE, 2023) also supports this, noting that seawater nutrient levels around the island are generally low, indicative of good water quality.

The waters of the Lord Howe Island are vulnerable to land-based pollution sources (Davis 2022a). While point source discharges (such as sewage outfalls and solid waste) can be managed more directly to maintain compliance with water quality guidelines, diffuse sources of pollution remain more challenging to control. The impact of such inputs on marine biodiversity depends on several factors, including pollutant type, catchment size and condition, and the extent of industrial, urban, or agricultural development.

A foundational study conducted by Haskoning (2014) determined that approximately 99 % of beach and lagoon sediments within the Lord Howe Island consist of carbonate material, primarily originating from the skeletal remains of marine organisms. PSD results are consistent with previous findings, indicating sand content ranged from 64 % to 94 % (mean = 87 %), gravel from 2 % to 31 % (mean = 9.6 %), and clay from 1 % to 4 % (mean = 2.7 %). In terms of sediment quality, concentrations of metals and metalloids were generally low and remained below the ANZG (2018) DGVs. Hydrocarbon levels were also reported to be low and within acceptable limits, while PFAS concentrations were below the limit of reporting LOR at all sampled sites.

Two potential sources of contamination affecting water and sediment quality have been identified: the rodent eradication project (Lord Howe Island Board, 2019) and the historical use of PFAS-containing AFFF on the island (NSW EPA, 2018). The rodent eradication program was assessed to have minimal marine impacts, owing to the implementation of strict controls that limited bait exposure to the marine environment. In contrast, PFAS contamination presents a greater concern, preliminary testing has detected PFAS in soil and groundwater near the airport, lagoon, and depot. The NSW EPA is planning to assess the extent of PFAS contamination through further investigations, which will include targeted soil, sediment, and water sampling at key locations such as residential bores. However, no PFAS was detected in any of the water or sediment samples collected during this survey.

The survey for marine benthic infauna recorded a total of 452 individuals representing 39 taxa. Four indices were used to assess diversity among the macrobenthic infauna samples: Margalef's species richness, Shannon's H diversity index, evenness, and dominance. ANOVA results indicated no statistical differences in taxonomic richness, diversity, evenness, or dominance across the surveyed sites. Overall, evenness values exceeded 0.7 and dominance values remained below 0.63, suggesting a relatively even distribution of individuals among species, with no single species dominating assemblages. Historical studies from Lord Howe Island have suggested heterogeneity from infauna results (Anderson *et al.*, 2013). Differences in the consistency in the community composition of infauna found in this study compared to previous studies are likely due to variation in sampling locations. The current survey focused on sheltered areas within the lagoon, while Anderson *et al.*, (2013) included more exposed, outer coastal sites. While the survey by Geoscience Australia (Anderson *et al.*, 2013) reported generally low infaunal species richness across the Lord Howe Island, it documented a high proportion of rare, previously undescribed, and potentially endemic species (Anderson *et al.*, 2013), highlighting the ecological uniqueness of the region.

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Appendix A.1. ALS Laboratory water quality results



CERTIFICATE OF ANALYSIS

Work Order : **ES2509079**
Client : **BMT COMMERCIAL AUSTRALIA PTY LTD**
Contact : **ANGUS WILLIAMS**
Address : **PO BOX 203 SPRING HILL**
BRISBANE QLD 4004
Telephone : **----**
Project : **3430 LHI Baseline Study**
Order number : **----**
C-O-C number : **----**
Sampler : **ANGUS WILLIAMS, Tobias Probst**
Site : **----**
Quote number : **EB25BMTWBM0003_V2**
No. of samples received : **7**
No. of samples analysed : **6**

Page : 1 of 13
Laboratory : Environmental Division Sydney
Contact : Customer Services ES
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61-2-8784 8555
Date Samples Received : 31-Mar-2025 13:45
Date Analysis Commenced : 31-Mar-2025
Issue Date : 04-Apr-2025 15:58



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Sanjeshni Jyoti	Senior Chemist Volatiles	Sydney Organics, Smithfield, NSW



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EK255A-CM: LOR raised for Ammonia on various samples due to sample matrix.
- EP231X - Per- and Polyfluoroalkyl Substances (PFAS): Samples received in 20mL or 125mL bottles have been tested in accordance with the QSM5.4 compliant, NATA accredited method. 60mL or 250mL bottles have been tested to the legacy QSM 5.1 aligned, NATA accredited method.
- EK271A-CM: Samples for Ultra-Trace Reactive Phosphorus by FIA should be frozen upon sampling. If not, low-level results (below 0.01 mg/L) may bias low.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EK259A-CM: Lab filtered light green bottle reported for NOx on samples 2, 3 & 4.
- EG020A: Positive results for sample ES2509079 # 006 have been confirmed by reanalysis.
- EP132: Where reported, Total PAH reported as the sum of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene and Benzo(g,h,i)perylene.
- EP231: Stable isotope enriched internal standards are added to samples prior to extraction. Target compounds have a direct analogous internal standard with the exception of PFPeS, PFHpA, PFDS, PFTrDA and 10:2 FTS. These compounds use an internal standard that is chemically related and has a retention time close to that of the target compound. The DQO for internal standard response is 50-150% of that established at initial calibration or as per tables in USEPA 1633 where listed. PFOS is quantified using a certified, traceable standard consisting of linear and branched PFOS isomers. These practices are in line with recommendations in the National Environmental Management Plan for PFAS and also conform to QSM 5.4 (US DoD) requirements.

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	W1	W2	Trip 1	Trip 2	Rinsate 1
Sampling date / time				27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	
Compound	CAS Number	LOR	Unit	ES2509079-001	ES2509079-002	ES2509079-003	ES2509079-004	ES2509079-005	
				Result	Result	Result	Result	Result	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	----	
EG020T: Total Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	----	----	----	----	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	----	----	----	----	<0.0001	
Chromium	7440-47-3	0.001	mg/L	----	----	----	----	<0.001	
Copper	7440-50-8	0.001	mg/L	----	----	----	----	<0.001	
Nickel	7440-02-0	0.001	mg/L	----	----	----	----	<0.001	
Lead	7439-92-1	0.001	mg/L	----	----	----	----	<0.001	
Zinc	7440-66-6	0.005	mg/L	----	----	----	----	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.005	µg/L	<0.005	<0.005	<0.005	<0.005	----	
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.005	µg/L	<0.005	<0.005	<0.005	<0.005	----	
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	----	----	----	----	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	----	----	----	----	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	----	----	----	----	<0.01	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	----	----	----	----	<0.1	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
Total Nitrogen as N	----	0.1	mg/L	----	----	----	----	<0.1	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L	----	----	----	----	<0.01	
EK255A: Ammonia									
Ammonia as N	7664-41-7	0.005	mg/L	<0.010	<0.010	<0.010	<0.010	----	
EK257A: Nitrite									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	W1	W2	Trip 1	Trip 2	Rinsate 1
Sampling date / time					27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		ES2509079-001	ES2509079-002	ES2509079-003	ES2509079-004	ES2509079-005
					Result	Result	Result	Result	Result
EK257A: Nitrite - Continued									
Nitrite as N	14797-65-0	0.002	mg/L		<0.002	<0.002	<0.002	<0.002	----
EK258A: Nitrate									
Nitrate as N	14797-55-8	0.002	mg/L		0.015	0.019	0.012	0.016	----
EK259A: Nitrite and Nitrate (NOx)									
Nitrite + Nitrate as N	----	0.002	mg/L		0.015	0.019	0.012	0.016	----
EK261A: Total Kjeldahl Nitrogen									
Total Kjeldahl Nitrogen as N	----	0.01	mg/L		0.14	0.17	0.16	0.17	----
EK262A: Total Nitrogen									
Total Nitrogen as N	----	0.01	mg/L		0.16	0.19	0.17	0.19	----
EK267A: Total Phosphorus (Persulfate Digestion)									
Total Phosphorus as P	----	0.005	mg/L		<0.005	<0.005	<0.005	<0.005	----
EK271A: Reactive Phosphorus									
Reactive Phosphorus as P	14265-44-2	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		<1	<1	<1	<1	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L		<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L		<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L		<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 201									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L		<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L		<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L		<100	<100	<100	<100	<100



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	W1	W2	Trip 1	Trip 2	Rinsate 1
Sampling date / time					27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		ES2509079-001	ES2509079-002	ES2509079-003	ES2509079-004	ES2509079-005
					Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	<100	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	<100	<100	<100	<100
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L		<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L		<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L		<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L		<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L		<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L		<5	<5	<5	<5	<5
EP132B: Polynuclear Aromatic Hydrocarbons									
3-Methylcholanthrene	56-49-5	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
2-Methylnaphthalene	91-57-6	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
7,12-Dimethylbenz(a)anthracene	57-97-6	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Acenaphthene	83-32-9	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Acenaphthylene	208-96-8	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Anthracene	120-12-7	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Benz(a)anthracene	56-55-3	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Benzo(a)pyrene	50-32-8	0.05	µg/L		<0.05	<0.05	<0.05	<0.05	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Benzo(e)pyrene	192-97-2	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Benzo(g,h,i)perylene	191-24-2	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Benzo(k)fluoranthene	207-08-9	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Chrysene	218-01-9	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Coronene	191-07-1	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Sample ID

				W1	W2	Trip 1	Trip 2	Rinsate 1
Sampling date / time				27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	ES2509079-001	ES2509079-002	ES2509079-003	ES2509079-004	ES2509079-005
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons - Continued								
Dibenz(a,h)anthracene	53-70-3	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Fluoranthene	206-44-0	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Fluorene	86-73-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Indeno(1.2.3.cd)pyrene	193-39-5	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Naphthalene	91-20-3	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Perylene	198-55-0	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Phenanthrene	85-01-8	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Pyrene	129-00-0	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
^ Sum of PAHs	----	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	----
^ Benzo(a)pyrene TEQ (zero)	----	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	----
EP231A: Perfluoroalkyl Sulfonic Acids								
Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.02	µg/L	----	----	----	----	<0.02
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	----	----	----	----	<0.02
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.02	µg/L	----	----	----	----	<0.02
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	----	----	----	----	<0.01
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.02	µg/L	----	----	----	----	<0.02
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	----	----	----	----	<0.01
Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.02	µg/L	----	----	----	----	<0.02
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.02	µg/L	----	----	----	----	<0.02
EP231B: Perfluoroalkyl Carboxylic Acids								
Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	----	----	----	----	<0.1
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	----	----	----	----	<0.02
Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	----	----	----	----	<0.02



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Sample ID

				W1	W2	Trip 1	Trip 2	Rinsate 1
Sampling date / time				27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	ES2509079-001	ES2509079-002	ES2509079-003	ES2509079-004	ES2509079-005
				Result	Result	Result	Result	Result
EP231B: Perfluoroalkyl Carboxylic Acids - Continued								
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	----	----	----	----	<0.02
Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	----	----	----	----	<0.01
Perfluorononanoic acid (PFNA)	375-95-1	0.02	µg/L	----	----	----	----	<0.02
Perfluorodecanoic acid (PFDA)	335-76-2	0.02	µg/L	----	----	----	----	<0.02
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.02	µg/L	----	----	----	----	<0.02
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.02	µg/L	----	----	----	----	<0.02
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	0.02	µg/L	----	----	----	----	<0.02
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.05	µg/L	----	----	----	----	<0.05
Perfluorohexadecanoic acid (PFHxDA)	67905-19-5	0.05	µg/L	----	----	----	----	<0.05
EP231C: Perfluoroalkyl Sulfonamides								
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.02	µg/L	----	----	----	----	<0.02
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.05	µg/L	----	----	----	----	<0.05
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.05	µg/L	----	----	----	----	<0.05
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.05	µg/L	----	----	----	----	<0.05
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.05	µg/L	----	----	----	----	<0.05
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.02	µg/L	----	----	----	----	<0.02
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.02	µg/L	----	----	----	----	<0.02
EP231D: (n:2) Fluorotelomer Sulfonic Acids								
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	----	----	----	----	<0.05



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	W1	W2	Trip 1	Trip 2	Rinsate 1
Sampling date / time					27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00	27-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		ES2509079-001	ES2509079-002	ES2509079-003	ES2509079-004	ES2509079-005
					Result	Result	Result	Result	Result
EP231D: (n:2) Fluorotelomer Sulfonic Acids - Continued									
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L		----	----	----	----	<0.05
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L		----	----	----	----	<0.05
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L		----	----	----	----	<0.05
EP231P: PFAS Sums									
Sum of PFAS	----	0.01	µg/L		----	----	----	----	<0.01
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.01	µg/L		----	----	----	----	<0.01
Sum of PFAS (WA DER List)	----	0.01	µg/L		----	----	----	----	<0.01
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		110	99.8	99.1	90.3	104
Toluene-D8	2037-26-5	2	%		117	108	105	89.8	108
4-Bromofluorobenzene	460-00-4	2	%		118	111	109	94.5	108
EP132T: Base/Neutral Extractable Surrogates									
2-Fluorobiphenyl	321-60-8	0.1	%		71.8	76.0	73.7	60.3	----
Anthracene-d10	1719-06-8	0.1	%		82.8	77.1	78.7	62.9	----
4-Terphenyl-d14	1718-51-0	0.1	%		85.3	79.5	82.3	65.2	----
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.02	%		----	----	----	----	101
13C8-PFOA	----	0.02	%		----	----	----	----	107



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	Rinsate 2	----	----	----	----
Sampling date / time					27-Mar-2025 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2509079-006	-----	-----	-----	-----
					Result	----	----	----	----
EG020T: Total Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L		0.004	----	----	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L		0.003	----	----	----	----
Zinc	7440-66-6	0.005	mg/L		<0.005	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<0.1	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	Rinsate 2	----	----	----	----
Sampling date / time					27-Mar-2025 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2509079-006	-----	-----	-----	-----
					Result	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons - Continued									
^ C10 - C36 Fraction (sum)				----	50	µg/L	<50	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 201									
C6 - C10 Fraction				C6_C10	20	µg/L	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)				C6_C10-BTEX	20	µg/L	<20	----	----
>C10 - C16 Fraction				----	100	µg/L	<100	----	----
>C16 - C34 Fraction				----	100	µg/L	<100	----	----
>C34 - C40 Fraction				----	100	µg/L	<100	----	----
^ >C10 - C40 Fraction (sum)				----	100	µg/L	<100	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)				----	100	µg/L	<100	----	----
EP080: BTEXN									
Benzene				71-43-2	1	µg/L	<1	----	----
Toluene				108-88-3	2	µg/L	<2	----	----
Ethylbenzene				100-41-4	2	µg/L	<2	----	----
meta- & para-Xylene				108-38-3 106-42-3	2	µg/L	<2	----	----
ortho-Xylene				95-47-6	2	µg/L	<2	----	----
^ Total Xylenes				----	2	µg/L	<2	----	----
^ Sum of BTEX				----	1	µg/L	<1	----	----
Naphthalene				91-20-3	5	µg/L	<5	----	----
EP231A: Perfluoroalkyl Sulfonic Acids									
Perfluoropropane sulfonic acid (PFPrS)				423-41-6	0.02	µg/L	<0.02	----	----
Perfluorobutane sulfonic acid (PFBS)				375-73-5	0.02	µg/L	<0.02	----	----
Perfluoropentane sulfonic acid (PFPeS)				2706-91-4	0.02	µg/L	<0.02	----	----
Perfluorohexane sulfonic acid (PFHxS)				355-46-4	0.01	µg/L	<0.01	----	----
Perfluoroheptane sulfonic acid (PFHpS)				375-92-8	0.02	µg/L	<0.02	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	Rinsate 2	----	----	----	----
Sampling date / time					27-Mar-2025 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2509079-006	-----	-----	-----	-----
					Result	----	----	----	----
EP231A: Perfluoroalkyl Sulfonic Acids - Continued									
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L		<0.01	----	----	----	----
Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.02	µg/L		<0.02	----	----	----	----
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.02	µg/L		<0.02	----	----	----	----
EP231B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L		<0.1	----	----	----	----
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L		<0.02	----	----	----	----
Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L		<0.02	----	----	----	----
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L		<0.02	----	----	----	----
Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L		<0.01	----	----	----	----
Perfluorononanoic acid (PFNA)	375-95-1	0.02	µg/L		<0.02	----	----	----	----
Perfluorodecanoic acid (PFDA)	335-76-2	0.02	µg/L		<0.02	----	----	----	----
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.02	µg/L		<0.02	----	----	----	----
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.02	µg/L		<0.02	----	----	----	----
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	0.02	µg/L		<0.02	----	----	----	----
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.05	µg/L		<0.05	----	----	----	----
Perfluorohexadecanoic acid (PFHxDA)	67905-19-5	0.05	µg/L		<0.05	----	----	----	----
EP231C: Perfluoroalkyl Sulfonamides									
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.02	µg/L		<0.02	----	----	----	----
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.05	µg/L		<0.05	----	----	----	----
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.05	µg/L		<0.05	----	----	----	----
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.05	µg/L		<0.05	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	Rinsate 2	----	----	----	----
Sampling date / time					27-Mar-2025 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2509079-006	-----	-----	-----	-----
					Result	----	----	----	----
EP231C: Perfluoroalkyl Sulfonamides - Continued									
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.05	µg/L		<0.05	----	----	----	----
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.02	µg/L		<0.02	----	----	----	----
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.02	µg/L		<0.02	----	----	----	----
EP231D: (n:2) Fluorotelomer Sulfonic Acids									
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L		<0.05	----	----	----	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L		<0.05	----	----	----	----
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L		<0.05	----	----	----	----
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L		<0.05	----	----	----	----
EP231P: PFAS Sums									
Sum of PFAS	----	0.01	µg/L		<0.01	----	----	----	----
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.01	µg/L		<0.01	----	----	----	----
Sum of PFAS (WA DER List)	----	0.01	µg/L		<0.01	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		98.4	----	----	----	----
Toluene-D8	2037-26-5	2	%		109	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		107	----	----	----	----
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.02	%		94.8	----	----	----	----
13C8-PFOA	----	0.02	%		110	----	----	----	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	72	143
Toluene-D8	2037-26-5	75	131
4-Bromofluorobenzene	460-00-4	73	137
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	43	135
Anthracene-d10	1719-06-8	48	138
4-Terphenyl-d14	1718-51-0	48	144
EP231S: PFAS Surrogate			
13C4-PFOS	-----	60	120
13C8-PFOA	-----	60	120



CERTIFICATE OF ANALYSIS

Work Order : **EB2514580**
Client : **BMT COMMERCIAL AUSTRALIA PTY LTD**
Contact : **ANGUS WILLIAMS**
Address : **PO BOX 203 SPRING HILL**
BRISBANE QLD 4004
Telephone : **07 3831 6744**
Project : **LHI Baseline Study**
Order number : **----**
C-O-C number : **----**
Sampler : **ANGUS WILLIAMS, Tobias Probst**
Site : **----**
Quote number : **EB25BMTWBM0003_V2**
No. of samples received : **4**
No. of samples analysed : **4**

Page : **1 of 7**
Laboratory : **Environmental Division Brisbane**
Contact : **Nathan King**
Address : **2 Byth Street Stafford QLD Australia 4053**
Telephone : **+61-7-3552-8685**
Date Samples Received : **30-Apr-2025 11:11**
Date Analysis Commenced : **02-May-2025**
Issue Date : **07-May-2025 18:10**



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Beatriz Llarinas	Senior Chemist - Inorganics	Brisbane Inorganics, Stafford, QLD
Timothy Creagh	Senior Chemist - Organics	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. are fully validated and are often at the client request.

In house developed procedures

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG093T (Total Metals in Saline Water by ORC-ICP-MS) is less than EG093F (Dissolved Metals in Saline Water by ORC-ICP-MS) for 'W1' (EB2514580-001). However, the difference is within experimental variation of the methods.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Sample ID

				W1	W2	Trip 1	Trip 2	----
Sampling date / time				26-Apr-2025 13:35	26-Apr-2025 14:05	26-Apr-2025 14:35	26-Apr-2025 14:48	----
Compound	CAS Number	LOR	Unit	EB2514580-001	EB2514580-002	EB2514580-003	EB2514580-004	-----
				Result	Result	Result	Result	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPM:								
Aluminium	7429-90-5	5	µg/L	<5	<5	<5	<5	----
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	1.7	1.8	1.6	1.7	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Boron	7440-42-8	100	µg/L	4860	3960	3570	3480	----
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	----
Iron	7439-89-6	5	µg/L	11	<5	<5	<5	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Manganese	7439-96-5	0.5	µg/L	<0.5	<0.5	0.5	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	7.7	7.5	8.2	8.4	----
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Selenium	7782-49-2	2	µg/L	<2	<2	<2	<2	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	----
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	15	6	16	17	----
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	2.0	2.0	2.1	2.1	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Boron	7440-42-8	100	µg/L	4330	4190	4170	4110	----
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.6	0.6	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	W1	W2	Trip 1	Trip 2	----
Sampling date / time					26-Apr-2025 13:35	26-Apr-2025 14:05	26-Apr-2025 14:35	26-Apr-2025 14:48	----
Compound	CAS Number	LOR	Unit		EB2514580-001	EB2514580-002	EB2514580-003	EB2514580-004	-----
					Result	Result	Result	Result	----
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued									
Copper	7440-50-8	1	µg/L		<1	<1	1	2	----
Iron	7439-89-6	5	µg/L		21	9	20	24	----
Lead	7439-92-1	0.2	µg/L		<0.2	<0.2	0.2	<0.2	----
Manganese	7439-96-5	0.5	µg/L		0.6	<0.5	0.7	0.7	----
Molybdenum	7439-98-7	0.1	µg/L		12.2	12.6	12.0	12.2	----
Nickel	7440-02-0	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	----
Selenium	7782-49-2	2	µg/L		<2	<2	<2	<2	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Tin	7440-31-5	5	µg/L		<5	<5	<5	<5	----
Zinc	7440-66-6	5	µg/L		<5	<5	<5	<5	----
EP231A: Perfluoroalkyl Sulfonic Acids									
Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0020	µg/L		<0.0020	<0.0020	<0.0020	<0.0020	----
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	µg/L		<0.0002	<0.0002	<0.0002	<0.0002	----
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
EP231B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.0020	µg/L		<0.0020	<0.0020	<0.0020	<0.0020	----
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorohexanoic acid (PFHxA)	307-24-4	0.0005	µg/L		<0.0005	<0.0005	<0.0005	<0.0005	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Sample ID

				W1	W2	Trip 1	Trip 2	----
Sampling date / time				26-Apr-2025 13:35	26-Apr-2025 14:05	26-Apr-2025 14:35	26-Apr-2025 14:48	----
Compound	CAS Number	LOR	Unit	EB2514580-001	EB2514580-002	EB2514580-003	EB2514580-004	-----
				Result	Result	Result	Result	----
EP231B: Perfluoroalkyl Carboxylic Acids - Continued								
Perfluorooctanoic acid (PFOA)	335-67-1	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorononanoic acid (PFNA)	375-95-1	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorodecanoic acid (PFDA)	335-76-2	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
EP231C: Perfluoroalkyl Sulfonamides								
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0005	µg/L	<0.0005	<0.0005	<0.0005	<0.0005	----
EP231D: (n:2) Fluorotelomer Sulfonic Acids								
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.001	µg/L	<0.001	<0.001	<0.001	<0.001	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	W1	W2	Trip 1	Trip 2	----
Sampling date / time					26-Apr-2025 13:35	26-Apr-2025 14:05	26-Apr-2025 14:35	26-Apr-2025 14:48	----
Compound	CAS Number	LOR	Unit		EB2514580-001	EB2514580-002	EB2514580-003	EB2514580-004	-----
					Result	Result	Result	Result	----
EP231D: (n:2) Fluorotelomer Sulfonic Acids - Continued									
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.001	µg/L		<0.001	<0.001	<0.001	<0.001	----
EP231P: PFAS Sums									
^ Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.0002	µg/L		<0.0002	<0.0002	<0.0002	<0.0002	----
^ Sum of PFAS (WA DER List)	----	0.0002	µg/L		<0.0002	<0.0002	<0.0002	<0.0002	----
^ Sum of PFAS	----	0.0002	µg/L		<0.0002	<0.0002	<0.0002	<0.0002	----
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.0005	%		105	102	74.3	76.7	----
13C8-PFOA	----	0.0005	%		129	127	126	122	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP231S: PFAS Surrogate			
13C4-PFOS	----	65	140
13C8-PFOA	----	71	133

Appendix A.2. ALS Laboratory water quality (quality control) report



QUALITY CONTROL REPORT

Work Order	: ES2509079	Page	: 1 of 14
Client	: BMT COMMERCIAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: ANGUS WILLIAMS	Contact	: Customer Services ES
Address	: PO BOX 203 SPRING HILL BRISBANE QLD 4004	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 3430 LHI Baseline Study	Date Samples Received	: 31-Mar-2025
Order number	: ----	Date Analysis Commenced	: 31-Mar-2025
C-O-C number	: ----	Issue Date	: 04-Apr-2025
Sampler	: ANGUS WILLIAMS, Tobias Probst		
Site	: ----		
Quote number	: EB25BMTWBM0003_V2		
No. of samples received	7		
No. of samples analysed	6		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Sanjeshni Jyoti	Senior Chemist Volatiles	Sydney Organics, Smithfield, NSW



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM.

In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot

CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

RPD = Relative Percentage Difference

= Indicates failed QC

* = The final LOR has been raised due to dilution or other sample specific cause; adjusted LOR is shown in brackets. The duplicate ranges for Acceptable RPD% are applied to the final LOR where applicable.

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 6481209)									
ES2508710-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.0	No Limit
ES2508879-005	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	155	157	1.3	0% - 20%
ES2509079-003	Trip 1	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	6	26.1	No Limit
EW2501121-004	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 6480380)									
ES2508991-003	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.425	0.418	1.8	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.012	0.012	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 6483523)									
ES2509079-001	W1	EG035F-UT: Mercury	7439-97-6	0.005	µg/L	<0.005	<0.005	0.0	No Limit
EG035T: Total Mercury by FIMS (QC Lot: 6480551)									
ES2509079-001	W1	EG035T-UT: Mercury	7439-97-6	0.005	µg/L	<0.005	<0.005	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 6480543)									
ES2508902-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 6480204)									
ES2509079-006	Rinsate 2	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	0.0	No Limit

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 Work Order : ES2509079
 Client : BMT COMMERCIAL AUSTRALIA PTY LTD
 Project : 3430 LHI Baseline Study



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 6477150)									
ES2508800-004	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.01	0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 6480203)									
ES2508824-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.07	0.07	0.0	No Limit
ES2508892-006	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.59	0.61	3.9	0% - 20%
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 6480205)									
ES2509079-006	Rinsate 2	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 6480200)									
ES2508910-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1 (2.0)*	mg/L	113	108	4.8	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 6480201)									
ES2509079-005	Rinsate 1	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
ES2508910-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01 (0.20)*	mg/L	21.7	22.3	2.6	0% - 20%
EK255A: Ammonia (QC Lot: 6476953)									
ES2509079-001	W1	EK255A-CM: Ammonia as N	7664-41-7	0.005 (0.010) *	mg/L	<0.010	<0.010	0.0	No Limit
EK257A: Nitrite (QC Lot: 6476951)									
ES2509079-001	W1	EK257A-CM: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	<0.002	0.0	No Limit
EK259A: Nitrite and Nitrate (NOx) (QC Lot: 6476950)									
ES2509079-001	W1	EK259A-CM: Nitrite + Nitrate as N	----	0.002	mg/L	0.015	0.013	8.6	No Limit
EK262A: Total Nitrogen (QC Lot: 6477169)									
EN2505268-001	Anonymous	EK262PA-CM: Total Nitrogen as N	----	0.01 (0.10)*	mg/L	6.60	6.52	1.3	0% - 20%
EK267A: Total Phosphorus (Persulfate Digestion) (QC Lot: 6477168)									
EN2505268-001	Anonymous	EK267PA-CM: Total Phosphorus as P	----	0.005 (0.050) *	mg/L	1.20	1.18	1.7	0% - 20%
EK271A: Reactive Phosphorus (QC Lot: 6476952)									
ES2509079-001	W1	EK271A-CM: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 6478636)									
EN2505287-001	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
ES2509079-004	Trip 2	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 6478636)									
EN2505287-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.0	No Limit
ES2509079-004	Trip 2	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.0	No Limit
EP080: BTEXN (QC Lot: 6478636)									
EN2505287-001	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP080: BTEXN (QC Lot: 6478636) - continued									
EN2505287-001	Anonymous	EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.0	No Limit
ES2509079-004	Trip 2	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.0	No Limit
EP132B: Polynuclear Aromatic Hydrocarbons (QC Lot: 6477952)									
ES2509079-001	W1	EP132: Benzo(a)pyrene	50-32-8	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP132: 3-Methylcholanthrene	56-49-5	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: 2-Methylnaphthalene	91-57-6	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: 7,12-Dimethylbenz(a)anthracene	57-97-6	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Acenaphthene	83-32-9	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Acenaphthylene	208-96-8	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Anthracene	120-12-7	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Benz(a)anthracene	56-55-3	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Benzo(b+j)fluoranthene	205-99-2 205-82-3	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Benzo(e)pyrene	192-97-2	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Benzo(g,h,i)perylene	191-24-2	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Benzo(k)fluoranthene	207-08-9	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Chrysene	218-01-9	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Coronene	191-07-1	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Dibenz(a,h)anthracene	53-70-3	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Fluoranthene	206-44-0	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Fluorene	86-73-7	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Indeno(1,2,3.cd)pyrene	193-39-5	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Naphthalene	91-20-3	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Perylene	198-55-0	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Phenanthrene	85-01-8	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP132: Pyrene	129-00-0	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EP231A: Perfluoroalkyl Sulfonic Acids (QC Lot: 6480054)							
ES2508982-001	Anonymous	EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	0.04	0.04	0.0	No Limit
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	0.13	0.14	0.0	0% - 50%



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP231A: Perfluoroalkyl Sulfonic Acids (QC Lot: 6480054) - continued									
ES2508982-001	Anonymous	EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.02	µg/L	<0.02	<0.02	0.0	No Limit
EP231B: Perfluoroalkyl Carboxylic Acids (QC Lot: 6480054)									
ES2508982-001	Anonymous	EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: Perfluorohexadecanoic acid (PFHxDA)	67905-19-5	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	<0.1	0.0	No Limit
EP231C: Perfluoroalkyl Sulfonamides (QC Lot: 6480054)									
ES2508982-001	Anonymous	EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.05	µg/L	<0.05	<0.05	0.0	No Limit
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QC Lot: 6480054)									
ES2508982-001	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	<0.05	0.0	No Limit



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QC Lot: 6480054) - continued									
ES2508982-001	Anonymous	EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	<0.05	0.0	No Limit
EP231P: PFAS Sums (QC Lot: 6480054)									
ES2508982-001	Anonymous	EP231X: Sum of PFAS	----	0.01	µg/L	0.17	0.18	5.7	0% - 50%

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Method Blank (MB) Report	Laboratory Control Spike (LCS) Report				
	Spike Concentration	Spike Recovery (%)	Acceptable Limits (%)		
		LCS	Low	High	
Result					
<5	150 mg/L	103	83.0	129	
<5	1000 mg/L	98.6	82.0	110	
<5	842 mg/L	110	83.0	118	
<0.001	0.1 mg/L	95.4	82.0	114	
<0.0001	0.1 mg/L	89.4	84.0	112	
<0.001	0.1 mg/L	98.1	86.0	116	
<0.001	0.1 mg/L	90.8	83.0	118	
<0.001	0.1 mg/L	95.1	85.0	115	
<0.001	0.1 mg/L	92.2	84.0	116	
<0.005	0.1 mg/L	92.0	79.0	117	
<0.005	0.1 µg/L	88.0	85.0	115	
<0.005	0.1 µg/L	89.0	85.0	115	
<0.0001	0.01 mg/L	103	77.0	111	
<0.01	0.5 mg/L	99.7	90.0	114	
<0.01	0.5 mg/L	102	82.0	114	
<0.01	0.5 mg/L	96.4	91.0	113	
<0.01	0.5 mg/L	92.3	91.0	113	
<0.1	5 mg/L	91.8	69.0	123	
<0.1	2.5 mg/L	94.0	70.0	123	



Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result			Low	High
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 6480201) - continued								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	2.21 mg/L	91.0	71.3	126
				<0.01	0.5 mg/L	94.1	71.3	126
EK255A: Ammonia (QCLot: 6476953)								
EK255A-CM: Ammonia as N	7664-41-7	0.005	mg/L	<0.005	0.1 mg/L	108	80.0	122
EK257A: Nitrite (QCLot: 6476951)								
EK257A-CM: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	0.1 mg/L	106	87.0	129
EK259A: Nitrite and Nitrate (NOx) (QCLot: 6476950)								
EK259A-CM: Nitrite + Nitrate as N	----	0.002	mg/L	<0.002	0.1 mg/L	104	89.0	123
EK262A: Total Nitrogen (QCLot: 6477169)								
EK262PA-CM: Total Nitrogen as N	----	0.01	mg/L	<0.01	1 mg/L	97.9	78.0	112
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 6477168)								
EK267PA-CM: Total Phosphorus as P	----	0.005	mg/L	<0.005	0.44 mg/L	98.7	88.0	114
EK271A: Reactive Phosphorus (QCLot: 6476952)								
EK271A-CM: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	0.1 mg/L	79.2	78.0	120
EP008: Chlorophyll (QCLot: 6479027)								
EP008: Chlorophyll a	----	1	mg/m³	<1	20 mg/m³	104	70.0	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 6478079)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	400 µg/L	72.8	53.7	97.0
EP071: C15 - C28 Fraction	----	100	µg/L	<100	600 µg/L	88.8	63.3	107
EP071: C29 - C36 Fraction	----	50	µg/L	<50	400 µg/L	107	58.3	120
EP080/071: Total Petroleum Hydrocarbons (QCLot: 6478636)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	260 µg/L	83.2	75.0	127
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 6478079)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	500 µg/L	65.0	53.9	95.5
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	700 µg/L	108	57.8	110
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	300 µg/L	67.2	50.5	115
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 6478636)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	310 µg/L	87.2	75.0	127
EP080: BTEXN (QCLot: 6478636)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	89.8	68.3	119
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	102	73.5	120
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	107	73.8	122
EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	10 µg/L	112	73.0	122
	106-42-3							



Sub-Matrix: **WATER**

Method: Compound				Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%)	
CAS Number	LOR	Unit					Low	High
EP080: BTEXN (QCLot: 6478636) - continued								
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	108	76.4	123
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	119	75.5	124
EP132B: Polynuclear Aromatic Hydrocarbons (QCLot: 6477952)								
EP132: 3-Methylcholanthrene	56-49-5	0.1	µg/L	<0.1	2 µg/L	83.5	60.0	120
EP132: 2-Methylnaphthalene	91-57-6	0.1	µg/L	<0.1	2 µg/L	70.8	59.0	123
EP132: 7,12-Dimethylbenz(a)anthracene	57-97-6	0.1	µg/L	<0.1	2 µg/L	72.4	36.0	144
EP132: Acenaphthene	83-32-9	0.1	µg/L	<0.1	2 µg/L	73.0	64.0	122
EP132: Acenaphthylene	208-96-8	0.1	µg/L	<0.1	2 µg/L	75.8	64.0	126
EP132: Anthracene	120-12-7	0.1	µg/L	<0.1	2 µg/L	76.8	65.0	127
EP132: Benz(a)anthracene	56-55-3	0.1	µg/L	<0.1	2 µg/L	86.9	64.0	130
EP132: Benzo(a)pyrene	50-32-8	0.05	µg/L	<0.05	2 µg/L	78.3	64.0	126
EP132: Benzo(b+j)fluoranthene	205-99-2 205-82-3	0.1	µg/L	<0.1	2 µg/L	79.0	62.0	126
EP132: Benzo(e)pyrene	192-97-2	0.1	µg/L	<0.1	2 µg/L	77.4	62.0	126
EP132: Benzo(g,h,i)perylene	191-24-2	0.1	µg/L	<0.1	2 µg/L	75.6	56.0	126
EP132: Benzo(k)fluoranthene	207-08-9	0.1	µg/L	<0.1	2 µg/L	77.2	68.0	130
EP132: Chrysene	218-01-9	0.1	µg/L	<0.1	2 µg/L	81.8	66.0	130
EP132: Coronene	191-07-1	0.1	µg/L	<0.1	2 µg/L	74.6	35.0	133
EP132: Dibenzo(a,h)anthracene	53-70-3	0.1	µg/L	<0.1	2 µg/L	77.9	58.0	128
EP132: Fluoranthene	206-44-0	0.1	µg/L	<0.1	2 µg/L	79.5	65.0	127
EP132: Fluorene	86-73-7	0.1	µg/L	<0.1	2 µg/L	75.1	64.0	124
EP132: Indeno(1,2,3-cd)pyrene	193-39-5	0.1	µg/L	<0.1	2 µg/L	77.8	57.0	127
EP132: Naphthalene	91-20-3	0.1	µg/L	<0.1	2 µg/L	68.3	54.0	128
EP132: Perylene	198-55-0	0.1	µg/L	<0.1	2 µg/L	77.0	66.0	130
EP132: Phenanthrene	85-01-8	0.1	µg/L	<0.1	2 µg/L	76.7	65.0	129
EP132: Pyrene	129-00-0	0.1	µg/L	<0.1	2 µg/L	78.8	66.0	128
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6480054)								
EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.02	µg/L	<0.02	0.25 µg/L	94.1	70.0	130
EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	0.25 µg/L	79.8	72.0	130
EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.02	µg/L	<0.02	0.25 µg/L	99.5	71.0	127
EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	<0.01	0.25 µg/L	88.1	68.0	131
EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.02	µg/L	<0.02	0.25 µg/L	96.6	69.0	134
EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	<0.01	0.25 µg/L	90.2	65.0	140
EP231X: Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.02	µg/L	<0.02	0.25 µg/L	83.8	70.0	130



Sub-Matrix: **WATER**

Method: Compound				Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%)	
CAS Number	LOR	Unit					Low	High
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6480054) - continued								
EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.02	µg/L	<0.02	0.25 µg/L	79.3	53.0	142
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 6480054)								
EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	1.25 µg/L	87.5	73.0	129
EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	<0.02	0.25 µg/L	105	72.0	129
EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	<0.02	0.25 µg/L	88.2	72.0	129
EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	0.25 µg/L	107	72.0	130
EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	0.25 µg/L	99.7	71.0	133
EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.02	µg/L	<0.02	0.25 µg/L	102	69.0	130
EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.02	µg/L	<0.02	0.25 µg/L	96.0	71.0	129
EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.02	µg/L	<0.02	0.25 µg/L	85.4	69.0	133
EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.02	µg/L	<0.02	0.25 µg/L	90.1	72.0	134
EP231X: Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.02	µg/L	<0.02	0.25 µg/L	84.2	65.0	144
EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.05	µg/L	<0.05	0.625 µg/L	98.0	71.0	132
EP231X: Perfluorohexadecanoic acid (PFHxDA)	67905-19-5	0.05	µg/L	<0.05	0.25 µg/L	93.3	62.9	136
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6480054)								
EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.02	µg/L	<0.02	0.25 µg/L	96.9	67.0	137
EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.05	µg/L	<0.05	0.625 µg/L	119	68.0	141
EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.05	µg/L	<0.05	0.625 µg/L	101	62.6	147
EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.05	µg/L	<0.05	0.625 µg/L	95.7	66.0	145
EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.05	µg/L	<0.05	0.625 µg/L	96.2	57.6	145
EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.02	µg/L	<0.02	0.25 µg/L	89.2	65.0	136
EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.02	µg/L	<0.02	0.25 µg/L	78.1	61.0	135
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 6480054)								
EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	0.25 µg/L	116	63.0	143
EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	0.25 µg/L	97.5	64.0	140
EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	0.25 µg/L	87.5	67.0	138
EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	0.25 µg/L	82.9	71.4	144

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 6480380)							
ES2508991-004	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	89.3	70.0	130
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	90.2	70.0	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	97.6	70.0	130
		EG020A-T: Copper	7440-50-8	1 mg/L	90.1	70.0	130
		EG020A-T: Lead	7439-92-1	1 mg/L	95.6	70.0	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	92.9	70.0	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	90.3	70.0	130
EG035F: Dissolved Mercury by FIMS (QCLot: 6483523)							
ES2509079-001	W1	EG035F-UT: Mercury	7439-97-6	0.1 µg/L	89.0	70.0	130
EG035T: Total Mercury by FIMS (QCLot: 6480551)							
ES2509079-002	W2	EG035T-UT: Mercury	7439-97-6	0.1 µg/L	86.0	70.0	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 6480543)							
ES2508909-001	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	103	70.0	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 6480204)							
ES2509079-006	Rinsate 2	EK055G: Ammonia as N	7664-41-7	0.5 mg/L	110	70.0	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 6477150)							
ES2508800-004	Anonymous	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	107	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 6480203)							
ES2508824-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	86.0	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 6480205)							
ES2509079-006	Rinsate 2	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	98.3	70.0	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 6480200)							
ES2508912-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	50 mg/L	89.4	70.0	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 6480201)							
ES2508912-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	# Not Determined	70.0	130
EK255A: Ammonia (QCLot: 6476953)							
ES2509079-001	W1	EK255A-CM: Ammonia as N	7664-41-7	0.2 mg/L	106	70.0	130
EK257A: Nitrite (QCLot: 6476951)							
ES2509079-002	W2	EK257A-CM: Nitrite as N	14797-65-0	0.1 mg/L	114	70.0	130
EK259A: Nitrite and Nitrate (NOx) (QCLot: 6476950)							
ES2509079-001	W1	EK259A-CM: Nitrite + Nitrate as N	----	0.1 mg/L	113	70.0	130
EK262A: Total Nitrogen (QCLot: 6477169)							
EN2505268-001	Anonymous						



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK262A: Total Nitrogen (QCLot: 6477169) - continued							
EN2505268-001	Anonymous	EK262PA-CM: Total Nitrogen as N	----	0.5 mg/L	# Not Determined	70.0	130
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 6477168)							
EN2505268-001	Anonymous	EK267PA-CM: Total Phosphorus as P	----	5 mg/L	101	70.0	130
EK271A: Reactive Phosphorus (QCLot: 6476952)							
ES2509079-001	W1	EK271A-CM: Reactive Phosphorus as P	14265-44-2	0.1 mg/L	93.2	70.0	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 6478636)							
EN2505287-001	Anonymous	EP080: C6 - C9 Fraction	----	325 µg/L	81.6	70.0	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 6478636)							
EN2505287-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	375 µg/L	80.9	70.0	130
EP080: BTEXN (QCLot: 6478636)							
EN2505287-001	Anonymous	EP080: Benzene	71-43-2	25 µg/L	84.6	70.0	130
		EP080: Toluene	108-88-3	25 µg/L	94.2	70.0	130
		EP080: Ethylbenzene	100-41-4	25 µg/L	97.6	70.0	130
		EP080: meta- & para-Xylene	108-38-3	25 µg/L	98.6	70.0	130
			106-42-3				
		EP080: ortho-Xylene	95-47-6	25 µg/L	96.8	70.0	130
		EP080: Naphthalene	91-20-3	25 µg/L	97.9	70.0	130
EP132B: Polynuclear Aromatic Hydrocarbons (QCLot: 6477952)							
ES2509079-002	W2	EP132: 3-Methylcholanthrene	56-49-5	2 µg/L	82.1	59.0	115
		EP132: 2-Methylnaphthalene	91-57-6	2 µg/L	73.2	46.0	120
		EP132: 7,12-Dimethylbenz(a)anthracene	57-97-6	2 µg/L	74.4	21.0	135
		EP132: Acenaphthene	83-32-9	2 µg/L	74.0	62.0	114
		EP132: Acenaphthylene	208-96-8	2 µg/L	76.3	61.0	119
		EP132: Anthracene	120-12-7	2 µg/L	76.3	68.0	116
		EP132: Benz(a)anthracene	56-55-3	2 µg/L	84.4	67.0	122
		EP132: Benzo(a)pyrene	50-32-8	2 µg/L	76.0	72.0	114
		EP132: Benzo(b+j)fluoranthene	205-99-2	2 µg/L	77.4	69.0	119
			205-82-3				
		EP132: Benzo(e)pyrene	192-97-2	2 µg/L	75.5	71.0	119
		EP132: Benzo(g,h,i)perylene	191-24-2	2 µg/L	73.4	49.0	133
		EP132: Benzo(k)fluoranthene	207-08-9	2 µg/L	75.1	71.0	124
		EP132: Chrysene	218-01-9	2 µg/L	79.6	70.0	118
		EP132: Coronene	191-07-1	2 µg/L	70.7	29.0	138
		EP132: Dibenz(a,h)anthracene	53-70-3	2 µg/L	75.6	60.0	122
		EP132: Fluoranthene	206-44-0	2 µg/L	77.8	65.0	121
		EP132: Fluorene	86-73-7	2 µg/L	75.2	63.0	118



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP132B: Polynuclear Aromatic Hydrocarbons (QCLot: 6477952) - continued							
ES2509079-002	W2	EP132: Indeno(1.2.3.cd)pyrene	193-39-5	2 µg/L	75.4	57.0	123
		EP132: Naphthalene	91-20-3	2 µg/L	70.7	53.0	115
		EP132: Perylene	198-55-0	2 µg/L	75.0	71.0	118
		EP132: Phenanthrene	85-01-8	2 µg/L	76.1	67.0	120
		EP132: Pyrene	129-00-0	2 µg/L	77.0	70.0	117
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6480054)							
ES2508982-001	Anonymous	EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.25 µg/L	118	70.0	130
		EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.25 µg/L	80.0	72.0	130
		EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.25 µg/L	84.2	71.0	127
		EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.25 µg/L	105	68.0	131
		EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.25 µg/L	112	69.0	134
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.25 µg/L	111	65.0	140
		EP231X: Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.25 µg/L	104	70.0	130
		EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.25 µg/L	105	53.0	142
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 6480054)							
ES2508982-001	Anonymous	EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	1.25 µg/L	91.4	73.0	129
		EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.25 µg/L	123	72.0	129
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.25 µg/L	104	72.0	129
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.25 µg/L	107	72.0	130
		EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.25 µg/L	114	71.0	133
		EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.25 µg/L	90.7	69.0	130
		EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.25 µg/L	82.4	71.0	129
		EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.25 µg/L	96.6	69.0	133
		EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.25 µg/L	82.0	72.0	134
		EP231X: Perfluorotridecanoic acid (PFTriDA)	72629-94-8	0.25 µg/L	118	65.0	144
		EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.625 µg/L	109	71.0	132
		EP231X: Perfluorohexadecanoic acid (PFHxDA)	67905-19-5	0.25 µg/L	104	62.9	136
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6480054)							
ES2508982-001	Anonymous	EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.25 µg/L	95.7	67.0	137
		EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.625 µg/L	111	68.0	141
		EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.625 µg/L	97.7	62.6	147
		EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.625 µg/L	91.1	66.0	145
		EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.625 µg/L	94.0	57.6	145
		EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.25 µg/L	80.5	65.0	136



Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6480054) - continued							
ES2508982-001	Anonymous	EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.25 µg/L	87.4	61.0	135
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 6480054)							
ES2508982-001	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.25 µg/L	75.3	63.0	143
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.25 µg/L	124	64.0	140
		EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.25 µg/L	81.2	67.0	138
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.25 µg/L	117	71.4	144



QUALITY CONTROL REPORT

Work Order	: EB2514580	Page	: 1 of 7
Client	: BMT COMMERCIAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ANGUS WILLIAMS	Contact	: Nathan King
Address	: PO BOX 203 SPRING HILL BRISBANE QLD 4004	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 3831 6744	Telephone	: +61-7-3552-8685
Project	: LHI Baseline Study	Date Samples Received	: 30-Apr-2025
Order number	: ----	Date Analysis Commenced	: 02-May-2025
C-O-C number	: ----	Issue Date	: 07-May-2025
Sampler	: ANGUS WILLIAMS, Tobias Probst		
Site	: ----		
Quote number	: EB25BMTWBM0003_V2		
No. of samples received	4		
No. of samples analysed	4		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Beatriz Llarinas	Senior Chemist - Inorganics	Brisbane Inorganics, Stafford, QLD
Timothy Creagh	Senior Chemist - Organics	Brisbane Organics, Stafford, QLD

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot

CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

RPD = Relative Percentage Difference

= Indicates failed QC

* = The final LOR has been raised due to dilution or other sample specific cause; adjusted LOR is shown in brackets. The duplicate ranges for Acceptable RPD% are applied to the final LOR where applicable.

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Laboratory Duplicate (DUP) Report

[illegible]



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 6547468) - continued									
EB2514392-001	Anonymous	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	1.3	1.3	0.0	0% - 50%
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.0	No Limit
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	2.2	2.1	5.4	0% - 50%
		EG093A-T: Lead	7439-92-1	0.2	µg/L	3.0	3.0	0.0	0% - 50%
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	0.8	0.7	0.0	No Limit
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	0.7	0.6	0.0	No Limit
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	5.9	6.0	0.0	0% - 50%
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	109	108	0.8	0% - 20%
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	8.8	8.9	0.0	0% - 50%
		EG093A-T: Copper	7440-50-8	1	µg/L	10	11	0.0	0% - 50%
		EG093A-T: Boron	7440-42-8	100 (105)*	µg/L	264	270	2.4	No Limit
		EG093A-T: Aluminium	7429-90-5	5	µg/L	2370	2340	1.4	0% - 20%
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.0	No Limit
		EG093A-T: Zinc	7440-66-6	5	µg/L	35	33	5.0	No Limit
EB2514392-010	Anonymous	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	0.4	0.4	0.0	No Limit
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.0	No Limit
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	0.5	0.5	0.0	No Limit
		EG093A-T: Lead	7439-92-1	0.2	µg/L	1.1	1.0	0.0	No Limit
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	1.1	1.0	0.0	No Limit
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	<0.5	<0.5	0.0	No Limit
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	1.3	1.3	0.0	No Limit
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	229	215	6.4	0% - 20%
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	2.4	2.2	7.9	No Limit
		EG093A-T: Copper	7440-50-8	1	µg/L	8	7	0.0	No Limit
		EG093A-T: Boron	7440-42-8	100 (105)*	µg/L	485	468	3.5	No Limit
		EG093A-T: Aluminium	7429-90-5	5	µg/L	239	232	3.3	0% - 20%
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.0	No Limit
		EG093A-T: Zinc	7440-66-6	5	µg/L	26	25	0.0	No Limit
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 6547469)									
EB2514392-001	Anonymous	EG093B-T: Selenium	7782-49-2	2	µg/L	<2	<2	0.0	No Limit
		EG093B-T: Iron	7439-89-6	5	µg/L	2550	2560	0.2	0% - 20%
EB2514392-010	Anonymous	EG093B-T: Selenium	7782-49-2	2	µg/L	<2	<2	0.0	No Limit
		EG093B-T: Iron	7439-89-6	5	µg/L	2400	2280	5.3	0% - 20%



Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result			Low	High
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 6547470)								
EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	50 µg/L	103	85.0	118
EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	2 µg/L	96.6	87.0	115
EG093A-F: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	98.3	87.0	116
EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	115	80.0	120
EG093A-F: Boron	7440-42-8	100	µg/L	<100	----	----	----	----
EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	96.1	88.0	114
EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	95.6	83.0	115
EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	94.3	86.0	116
EG093A-F: Copper	7440-50-8	1	µg/L	<1	10 µg/L	114	81.0	117
EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	93.2	80.0	117
EG093A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	98.0	80.0	119
EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	96.8	80.0	118
EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	95.9	87.0	117
EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	1 µg/L	104	80.0	127
EG093A-F: Tin	7440-31-5	5	µg/L	<5	10 µg/L	92.5	82.0	118
EG093A-F: Zinc	7440-66-6	5	µg/L	<5	10 µg/L	98.4	81.0	120
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 6547471)								
EG093B-F: Iron	7439-89-6	5	µg/L	<5	50 µg/L	95.9	78.0	123
EG093B-F: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	92.2	87.0	121
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 6547468)								
EG093A-T: Aluminium	7429-90-5	5	µg/L	<5	50 µg/L	105	85.0	120
EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	2 µg/L	101	83.0	116
EG093A-T: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	108	86.0	117
EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	99.6	87.0	120
EG093A-T: Boron	7440-42-8	100	µg/L	<105	----	----	----	----
EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	108	84.0	115
EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	102	84.0	120
EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	105	85.0	116
EG093A-T: Copper	7440-50-8	1	µg/L	<1	10 µg/L	107	84.0	119
EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	99.1	84.0	120



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit			LCS	Low	High
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 6547468) - continued								
EG093A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	105	86.0	124
EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	104	84.0	118
EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	105	80.0	120
EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	2 µg/L	87.9	80.0	120
EG093A-T: Tin	7440-31-5	5	µg/L	<5	10 µg/L	104	83.0	114
EG093A-T: Zinc	7440-66-6	5	µg/L	<5	10 µg/L	97.2	81.0	124
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 6547469)								
EG093B-T: Iron	7439-89-6	5	µg/L	<5	50 µg/L	109	80.0	128
EG093B-T: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	100	89.0	119
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6544117)								
EP231X-SUT: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	----	µg/L	----	0.00366 µg/L	104	60.0	140
EP231X-SUT: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0005	µg/L	<0.0005	0.00355 µg/L	96.4	72.0	130
EP231X-SUT: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0005	µg/L	<0.0005	0.00376 µg/L	86.4	71.0	127
EP231X-SUT: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0005	µg/L	<0.0005	0.00379 µg/L	96.7	68.0	131
EP231X-SUT: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0005	µg/L	<0.0005	0.00381 µg/L	108	69.0	134
EP231X-SUT: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	µg/L	<0.0002	0.00371 µg/L	119	65.0	140
EP231X-SUT: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0005	µg/L	<0.0005	0.00385 µg/L	88.1	53.0	142
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 6544117)								
EP231X-SUT: Perfluorobutanoic acid (PFBA)	375-22-4	0.002	µg/L	<0.0020	0.02 µg/L	88.0	73.0	129
EP231X-SUT: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0005	µg/L	<0.0005	0.004 µg/L	92.0	72.0	129
EP231X-SUT: Perfluorohexanoic acid (PFHxA)	307-24-4	0.0005	µg/L	<0.0005	0.004 µg/L	93.2	72.0	129
EP231X-SUT: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0005	µg/L	<0.0005	0.004 µg/L	91.2	72.0	130
EP231X-SUT: Perfluorooctanoic acid (PFOA)	335-67-1	0.0005	µg/L	<0.0005	0.004 µg/L	99.6	71.0	133
EP231X-SUT: Perfluorononanoic acid (PFNA)	375-95-1	0.0005	µg/L	<0.0005	0.004 µg/L	90.8	69.0	130
EP231X-SUT: Perfluorodecanoic acid (PFDA)	335-76-2	0.0005	µg/L	<0.0005	0.004 µg/L	89.6	71.0	129
EP231X-SUT: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0005	µg/L	<0.0005	0.004 µg/L	92.0	69.0	133
EP231X-SUT: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0005	µg/L	<0.0005	0.004 µg/L	93.2	72.0	134
EP231X-SUT: Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0005	µg/L	<0.0005	0.004 µg/L	110	65.0	144
EP231X-SUT: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	µg/L	<0.0005	0.01 µg/L	96.0	71.0	132
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6544117)								
EP231X-SUT: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0005	µg/L	<0.0005	0.004 µg/L	85.6	67.0	137
EP231X-SUT: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.001	µg/L	<0.001	0.01 µg/L	82.2	68.0	141
EP231X-SUT: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.001	µg/L	<0.001	0.01 µg/L	86.6	57.9	141

Matrix Spike (MS) Report

Sub-Matrix: WATER

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 6547470)							
EB2514580-001	W1	EG093A-F: Arsenic	7440-38-2	500 µg/L	122	70.0	130
		EG093A-F: Beryllium	7440-41-7	500 µg/L	109	70.0	130
		EG093A-F: Cadmium	7440-43-9	125 µg/L	115	70.0	130
		EG093A-F: Chromium	7440-47-3	500 µg/L	119	70.0	130
		EG093A-F: Cobalt	7440-48-4	500 µg/L	124	70.0	130
		EG093A-F: Copper	7440-50-8	500 µg/L	108	70.0	130
		EG093A-F: Lead	7439-92-1	500 µg/L	123	70.0	130
		EG093A-F: Manganese	7439-96-5	500 µg/L	120	70.0	130
		EG093A-F: Nickel	7440-02-0	500 µg/L	122	70.0	130
		EG093A-F: Zinc	7440-66-6	500 µg/L	116	70.0	130
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 6547468)							



Sub-Matrix: WATER

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 6547468) - continued							
EB2514392-002	Anonymous	EG093A-T: Arsenic	7440-38-2	500 µg/L	105	70.0	130
		EG093A-T: Beryllium	7440-41-7	500 µg/L	105	70.0	130
		EG093A-T: Cadmium	7440-43-9	125 µg/L	108	70.0	130
		EG093A-T: Chromium	7440-47-3	500 µg/L	109	70.0	130
		EG093A-T: Cobalt	7440-48-4	500 µg/L	105	70.0	130
		EG093A-T: Copper	7440-50-8	500 µg/L	107	70.0	130
		EG093A-T: Lead	7439-92-1	500 µg/L	105	70.0	130
		EG093A-T: Manganese	7439-96-5	500 µg/L	105	70.0	130
		EG093A-T: Nickel	7440-02-0	500 µg/L	106	70.0	130
		EG093A-T: Zinc	7440-66-6	500 µg/L	111	70.0	130

Appendix A.3. ALS Laboratory sediment quality results



CERTIFICATE OF ANALYSIS

Work Order : **ES2509116**
Client : **BMT COMMERCIAL AUSTRALIA PTY LTD**
Contact : **ANGUS WILLIAMS**
Address : **PO BOX 203 SPRING HILL**
BRISBANE QLD 4004
Telephone : **07 3831 6744**
Project : **3430 LHI Baseline Study**
Order number : **-**
C-O-C number : **----**
Sampler : **ANGUS WILLIAMS, Tobias Probst**
Site : **----**
Quote number : **EB25BMTWBM0003_V2**
No. of samples received : **6**
No. of samples analysed : **6**

Page : 1 of 9
Laboratory : Environmental Division Sydney
Contact : Customer Services ES
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61-2-8784 8555
Date Samples Received : 31-Mar-2025 13:45
Date Analysis Commenced : 31-Mar-2025
Issue Date : 09-Apr-2025 15:52



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Edwandy Fadjjar	Organic Coordinator	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Sanjeshni Jyoti	Senior Chemist Volatiles	Sydney Organics, Smithfield, NSW



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EP080-SD: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- ASS: EA033 (CRS Suite): Analysis is performed as per the Acid Sulfate Soils Laboratory Methods Guidelines (2004) and the updated National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT (2018)
- ASS: EA033 (CRS Suite): Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): Laboratory determinations of ANC needs to be corroborated by effectiveness of the measured ANC in relation to incubation ANC. Unless corroborated, the results of ANC testing should be discounted when determining Net Acidity for comparison with action criteria, or for the determination of the acidity hazard and required liming amounts.
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO₃) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m³ in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m³'.
- ASS: EA003 (NATA Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Sample ID				S1a	S2a	S3a	S4a	S5a
Sampling date / time				26-Mar-2025 10:45	26-Mar-2025 11:05	26-Mar-2025 11:27	26-Mar-2025 11:44	26-Mar-2025 12:05
Compound	CAS Number	LOR	Unit	ES2509116-001	ES2509116-002	ES2509116-003	ES2509116-004	ES2509116-005
				Result	Result	Result	Result	Result
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	8.8	9.0	9.0	9.0	9.0
pH (Fox)	----	0.1	pH Unit	6.5	6.5	6.5	6.5	6.5
Reaction Rate	----	1	Reaction Unit	2	2	2	2	2
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	9.7	9.8	9.8	9.8	9.8
Titrateable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titrateable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.041	0.038	0.029	0.026	0.032
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	26	24	18	16	20
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	80.6	81.1	81.3	80.8	80.1
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	16100	16200	16200	16100	16000
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	25.8	26.0	26.0	25.9	25.7
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.04	0.04	0.03	0.02	0.03
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	26	24	18	16	20
Liming Rate excluding ANC	----	1	kg CaCO3/t	2	2	1	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	31.4	33.8	34.1	34.1	31.5
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Sample ID	S1a	S2a	S3a	S4a	S5a
Sampling date / time					26-Mar-2025 10:45	26-Mar-2025 11:05	26-Mar-2025 11:27	26-Mar-2025 11:44	26-Mar-2025 12:05
Compound	CAS Number	LOR	Unit		ES2509116-001	ES2509116-002	ES2509116-003	ES2509116-004	ES2509116-005
					Result	Result	Result	Result	Result
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		0.3	0.2	0.3	0.3	0.3
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		0.3	0.2	0.3	0.3	0.3
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		230	220	240	260	270
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		230	220	240	260	270
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		423	439	419	355	394
EK255A SD: Ammonium in Sediment									
Ammonium as N	14798-03-9_N	0.2	mg/kg		4.0	2.6	2.4	3.2	2.3
Ammonium as NH4	----	0.2	mg/kg		5.2	3.4	3.1	4.1	3.0
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
C10 - C14 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
C15 - C28 Fraction	----	3	mg/kg		16	13	7	12	12
C29 - C36 Fraction	----	5	mg/kg		<5	<5	<5	<5	<5
^ C10 - C36 Fraction (sum)	----	3	mg/kg		16	13	7	12	12
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons									
C6 - C10 Fraction	C6_C10	3	mg/kg		<3	<3	<3	<3	<3
>C10 - C16 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg		<3.0	<3.0	<3.0	<3.0	<3.0
>C16 - C34 Fraction	----	3	mg/kg		18	14	8	14	13
>C34 - C40 Fraction	----	5	mg/kg		<5	<5	<5	<5	<5
^ >C10 - C40 Fraction (sum)	----	3	mg/kg		18	14	8	14	13
EP080-SD: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Sample ID

				S1a	S2a	S3a	S4a	S5a
Sampling date / time				26-Mar-2025 10:45	26-Mar-2025 11:05	26-Mar-2025 11:27	26-Mar-2025 11:44	26-Mar-2025 12:05
Compound	CAS Number	LOR	Unit	ES2509116-001	ES2509116-002	ES2509116-003	ES2509116-004	ES2509116-005
				Result	Result	Result	Result	Result
EP080-SD: BTEXN - Continued								
Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	77.0	84.4	82.4	79.6	76.0
Toluene-D8	2037-26-5	0.2	%	75.5	79.2	74.7	74.9	75.0
4-Bromofluorobenzene	460-00-4	0.2	%	78.2	79.2	75.6	75.4	75.1



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Sample ID	Dup	----	----	----	----
Sampling date / time					26-Mar-2025 10:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2509116-006	-----	-----	-----	-----
				Result	----	----	----	----	----
EA003 :pH (field/fox)									
pH (F)	----	0.1	pH Unit		8.9	----	----	----	----
pH (Fox)	----	0.1	pH Unit		6.5	----	----	----	----
Reaction Rate	----	1	Reaction Unit		2	----	----	----	----
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		9.8	----	----	----	----
Titrateable Actual Acidity (23F)	----	2	mole H+ / t		<2	----	----	----	----
sulfidic - Titrateable Actual Acidity (s-23F)	----	0.02	% pyrite S		<0.02	----	----	----	----
EA033-B: Potential Acidity									
Chromium Reducible Sulfur (22B)	----	0.005	% S		0.050	----	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		31	----	----	----	----
EA033-C: Acid Neutralising Capacity									
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3		78.2	----	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t		15600	----	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S		25.0	----	----	----	----
EA033-E: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		1.5	----	----	----	----
Net Acidity (sulfur units)	----	0.02	% S		<0.02	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t		<10	----	----	----	----
Liming Rate	----	1	kg CaCO3/t		<1	----	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		0.05	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		31	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t		2	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		34.2	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	----	----	----	----



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Sample ID	Dup	----	----	----	----
Sampling date / time					26-Mar-2025 10:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2509116-006	-----	-----	-----	-----
				Result	----	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		0.2	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		0.2	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		250	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		250	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		413	----	----	----	----
EK255A SD: Ammonium in Sediment									
Ammonium as N	14798-03-9_N	0.2	mg/kg		4.0	----	----	----	----
Ammonium as NH4	----	0.2	mg/kg		5.1	----	----	----	----
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	----	----	----	----
C10 - C14 Fraction	----	3	mg/kg		<3	----	----	----	----
C15 - C28 Fraction	----	3	mg/kg		13	----	----	----	----
C29 - C36 Fraction	----	5	mg/kg		<5	----	----	----	----
^ C10 - C36 Fraction (sum)	----	3	mg/kg		13	----	----	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons									
C6 - C10 Fraction	C6_C10	3	mg/kg		<3	----	----	----	----
>C10 - C16 Fraction	----	3	mg/kg		<3	----	----	----	----
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg		<3.0	----	----	----	----
>C16 - C34 Fraction	----	3	mg/kg		15	----	----	----	----
>C34 - C40 Fraction	----	5	mg/kg		<5	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	3	mg/kg		15	----	----	----	----
EP080-SD: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	----	----	----	----



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Sample ID

				Dup	----	----	----	----
Sampling date / time				26-Mar-2025 10:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES2509116-006	-----	-----	-----	-----
				Result	----	----	----	----
EP080-SD: BTEXN - Continued								
Toluene	108-88-3	0.2	mg/kg	<0.2	----	----	----	----
Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	----	----	----	----
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	----	----	----	----
^ Total Xylenes	----	0.5	mg/kg	<0.5	----	----	----	----
^ Sum of BTEX	----	0.2	mg/kg	<0.2	----	----	----	----
Naphthalene	91-20-3	0.2	mg/kg	<0.2	----	----	----	----
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	102	----	----	----	----
Toluene-D8	2037-26-5	0.2	%	93.4	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.2	%	96.9	----	----	----	----



Surrogate Control Limits

Sub-Matrix: SEDIMENT		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080-SD: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	67	137
Toluene-D8	2037-26-5	74	134
4-Bromofluorobenzene	460-00-4	73	137

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry / Biology).

(SOIL) EA003 :pH (field/fox)

(SOIL) EA033-B: Potential Acidity

(SOIL) EA033-C: Acid Neutralising Capacity

(SOIL) EA033-D: Retained Acidity

(SOIL) EA033-A: Actual Acidity

(SOIL) EA033-E: Acid Base Accounting



CERTIFICATE OF ANALYSIS

Work Order : **EB2514707**
Client : **BMT COMMERCIAL AUSTRALIA PTY LTD**
Contact : Tobias Probst
Address : PO BOX 203 SPRING HILL
BRISBANE QLD 4004
Telephone : ----
Project : LHI Baseline Study
Order number : No PO Provided
C-O-C number : ----
Sampler : TP/AW
Site : ----
Quote number : EB25BMTWBM0003_V2
No. of samples received : 26
No. of samples analysed : 25

Page : 1 of 20
Laboratory : Environmental Division Brisbane
Contact : Nathan King
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3552-8685
Date Samples Received : 30-Apr-2025 11:11
Date Analysis Commenced : 07-May-2025
Issue Date : 16-May-2025 15:54



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kirsty Watson	Senior Chemist - Organics	Brisbane Organics, Stafford, QLD
Kirsty Watson	Senior Chemist - Organics	Brisbane Soil Preparation, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. are fully validated and are often at the client request.

In house developed procedures

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005SD (Total Fe and Al in Sediments by ICP-AES): S1a (EB2514707-001) shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.
- EP231: Stable isotope enriched internal standards are added to samples prior to extraction. Target compounds have a direct analogous internal standard with the exception of PFPeS, PFHpA, PFDS, PFTrDA and 10:2 FTS. These compounds use an internal standard that is chemically related and has a retention time close to that of the target compound. The DQO for internal standard response is 50-150% of that established at initial calibration or as per USEPA 1633 limits where listed. PFOS is quantified using a certified, traceable standard consisting of linear and branched PFOS isomers. These practices are in line with recommendations in the National Environmental Management Plan for PFAS and also conform to QSM 5.4 (US DoD) requirements.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S1a	S1b	S1c	S2a	S2b
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-001	EB2514707-002	EB2514707-003	EB2514707-004	EB2514707-005
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		29.0	----	----	35.0	----
EA150: Particle Sizing									
+75µm	----	1	%		95	97	96	96	96
+150µm	----	1	%		72	85	84	88	81
+300µm	----	1	%		48	55	51	70	55
+425µm	----	1	%		42	45	41	61	45
+600µm	----	1	%		34	37	33	51	35
+1180µm	----	1	%		14	17	16	23	15
+2.36mm	----	1	%		1	3	3	2	1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		3	2	2	4	2
Silt (2-60 µm)	----	1	%		2	<1	2	<1	2
Sand (0.06-2.00 mm)	----	1	%		90	91	89	88	91
Gravel (>2mm)	----	1	%		5	7	7	8	5
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.52	2.62	2.67	2.64	2.63
EG005(ED093)-SD: Total Metals in Sediments by ICP-AE									
Aluminium	7429-90-5	50	mg/kg		330	----	----	240	----
Iron	7439-89-6	50	mg/kg		1330	----	----	1160	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	----	----	<0.50	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				S1a	S1b	S1c	S2a	S2b
Sampling date / time				26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	EB2514707-001	EB2514707-002	EB2514707-003	EB2514707-004	EB2514707-005
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Arsenic	7440-38-2	1.00	mg/kg	4.21	----	----	2.11	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	----	----	<0.1	----
Chromium	7440-47-3	1.0	mg/kg	13.1	----	----	12.2	----
Copper	7440-50-8	1.0	mg/kg	<1.0	----	----	<1.0	----
Cobalt	7440-48-4	0.5	mg/kg	1.2	----	----	1.1	----
Lead	7439-92-1	1.0	mg/kg	<1.0	----	----	<1.0	----
Manganese	7439-96-5	10	mg/kg	26	----	----	24	----
Nickel	7440-02-0	1.0	mg/kg	9.6	----	----	8.8	----
Selenium	7782-49-2	0.1	mg/kg	0.1	----	----	0.1	----
Silver	7440-22-4	0.1	mg/kg	0.1	----	----	<0.1	----
Vanadium	7440-62-2	2.0	mg/kg	4.4	----	----	4.2	----
Zinc	7440-66-6	1.0	mg/kg	3.3	----	----	2.0	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	----	----	<0.01	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.20	0.31	0.19	0.22	0.33
EP231A: Perfluoroalkyl Sulfonic Acids								
Ø Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	<0.0005	----	----	<0.0005	----
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	<0.0002	----	----	<0.0002	----
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	<0.0002	----	----	<0.0002	----
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	<0.0002	----	----	<0.0002	----
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	<0.0002	----	----	<0.0002	----
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	<0.0002	----	----	<0.0002	----
Ø Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.0002	mg/kg	<0.0002	----	----	<0.0002	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S1a	S1b	S1c	S2a	S2b
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-001	EB2514707-002	EB2514707-003	EB2514707-004	EB2514707-005
					Result	Result	Result	Result	Result
EP231A: Perfluoroalkyl Sulfonic Acids - Continued									
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
EP231B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg		<0.001	----	----	<0.001	----
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
EP231C: Perfluoroalkyl Sulfonamides									
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg		<0.0002	----	----	<0.0002	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S1a	S1b	S1c	S2a	S2b
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-001	EB2514707-002	EB2514707-003	EB2514707-004	EB2514707-005
					Result	Result	Result	Result	Result
EP231C: Perfluoroalkyl Sulfonamides - Continued									
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
EP231D: (n:2) Fluorotelomer Sulfonic Acids									
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg		<0.0005	----	----	<0.0005	----
EP231P: PFAS Sums									
Sum of PFAS	----	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
Sum of PFAS (WA DER List)	----	0.0002	mg/kg		<0.0002	----	----	<0.0002	----
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.0002	%		116	----	----	105	----
13C8-PFOA	----	0.0002	%		108	----	----	103	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S2c	S3a	S3b	S3c	S4a
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-006	EB2514707-007	EB2514707-008	EB2514707-009	EB2514707-010
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		----	28.6	----	----	33.2
EA150: Particle Sizing									
+75µm	----	1	%		96	98	96	96	96
+150µm	----	1	%		83	92	82	81	88
+300µm	----	1	%		60	68	58	58	72
+425µm	----	1	%		51	52	50	50	64
+600µm	----	1	%		42	41	43	42	54
+1180µm	----	1	%		18	17	18	18	27
+2.36mm	----	1	%		1	3	2	3	4
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		4	1	4	4	2
Silt (2-60 µm)	----	1	%		<1	1	<1	<1	2
Sand (0.06-2.00 mm)	----	1	%		90	90	89	89	85
Gravel (>2mm)	----	1	%		6	8	7	7	11
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.54	2.45	2.49	2.48	2.50
EG005(ED093)-SD: Total Metals in Sediments by ICP-AE									
Aluminium	7429-90-5	50	mg/kg		----	220	----	----	240
Iron	7439-89-6	50	mg/kg		----	740	----	----	1260
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		----	<0.50	----	----	<0.50



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				S2c	S3a	S3b	S3c	S4a
Sampling date / time				26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	EB2514707-006	EB2514707-007	EB2514707-008	EB2514707-009	EB2514707-010
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Arsenic	7440-38-2	1.00	mg/kg	----	2.75	----	----	1.99
Cadmium	7440-43-9	0.1	mg/kg	----	<0.1	----	----	<0.1
Chromium	7440-47-3	1.0	mg/kg	----	9.7	----	----	12.6
Copper	7440-50-8	1.0	mg/kg	----	<1.0	----	----	<1.0
Cobalt	7440-48-4	0.5	mg/kg	----	<0.5	----	----	1.3
Lead	7439-92-1	1.0	mg/kg	----	<1.0	----	----	<1.0
Manganese	7439-96-5	10	mg/kg	----	15	----	----	26
Nickel	7440-02-0	1.0	mg/kg	----	3.2	----	----	10.6
Selenium	7782-49-2	0.1	mg/kg	----	0.1	----	----	0.1
Silver	7440-22-4	0.1	mg/kg	----	<0.1	----	----	<0.1
Vanadium	7440-62-2	2.0	mg/kg	----	4.0	----	----	3.6
Zinc	7440-66-6	1.0	mg/kg	----	1.4	----	----	2.0
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	----	<0.01	----	----	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.32	0.17	0.18	0.22	0.33
EP231A: Perfluoroalkyl Sulfonic Acids								
Ø Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	----	<0.0005	----	----	<0.0005
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	----	<0.0002	----	----	<0.0002
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	----	<0.0002	----	----	<0.0002
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	----	<0.0002	----	----	<0.0002
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	----	<0.0002	----	----	<0.0002
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	----	<0.0002	----	----	<0.0002
Ø Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.0002	mg/kg	----	<0.0002	----	----	<0.0002



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S2c	S3a	S3b	S3c	S4a
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-006	EB2514707-007	EB2514707-008	EB2514707-009	EB2514707-010
					Result	Result	Result	Result	Result
EP231A: Perfluoroalkyl Sulfonic Acids - Continued									
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
EP231B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg		----	<0.001	----	----	<0.001
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
EP231C: Perfluoroalkyl Sulfonamides									
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg		----	<0.0002	----	----	<0.0002



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S2c	S3a	S3b	S3c	S4a
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-006	EB2514707-007	EB2514707-008	EB2514707-009	EB2514707-010
					Result	Result	Result	Result	Result
EP231C: Perfluoroalkyl Sulfonamides - Continued									
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
EP231D: (n:2) Fluorotelomer Sulfonic Acids									
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg		----	<0.0005	----	----	<0.0005
EP231P: PFAS Sums									
Sum of PFAS	----	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
Sum of PFAS (WA DER List)	----	0.0002	mg/kg		----	<0.0002	----	----	<0.0002
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.0002	%		----	104	----	----	110
13C8-PFOA	----	0.0002	%		----	101	----	----	106



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S4b	S4c	S5a(a)	S5b	S5c
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-011	EB2514707-012	EB2514707-013	EB2514707-014	EB2514707-015
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		----	----	27.7	----	----
EA150: Particle Sizing									
+75µm	----	1	%		95	93	97	97	97
+150µm	----	1	%		90	92	86	82	81
+300µm	----	1	%		81	90	54	48	47
+425µm	----	1	%		74	88	42	39	38
+600µm	----	1	%		63	84	34	32	31
+1180µm	----	1	%		29	64	16	15	15
+2.36mm	----	1	%		6	17	2	3	2
+4.75mm	----	1	%		5	2	<1	<1	<1
+9.5mm	----	1	%		2	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		2	4	2	3	3
Silt (2-60 µm)	----	1	%		1	1	1	<1	<1
Sand (0.06-2.00 mm)	----	1	%		84	64	90	91	91
Gravel (>2mm)	----	1	%		13	31	7	6	6
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.52	2.47	2.55	2.53	2.50
EG005(ED093)-SD: Total Metals in Sediments by ICP-AE									
Aluminium	7429-90-5	50	mg/kg		----	----	300	----	----
Iron	7439-89-6	50	mg/kg		----	----	1090	----	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		----	----	<0.50	----	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				S4b	S4c	S5a(a)	S5b	S5c
Sampling date / time				26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	EB2514707-011	EB2514707-012	EB2514707-013	EB2514707-014	EB2514707-015
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Arsenic	7440-38-2	1.00	mg/kg	----	----	2.54	----	----
Cadmium	7440-43-9	0.1	mg/kg	----	----	<0.1	----	----
Chromium	7440-47-3	1.0	mg/kg	----	----	12.5	----	----
Copper	7440-50-8	1.0	mg/kg	----	----	<1.0	----	----
Cobalt	7440-48-4	0.5	mg/kg	----	----	0.9	----	----
Lead	7439-92-1	1.0	mg/kg	----	----	<1.0	----	----
Manganese	7439-96-5	10	mg/kg	----	----	25	----	----
Nickel	7440-02-0	1.0	mg/kg	----	----	7.4	----	----
Selenium	7782-49-2	0.1	mg/kg	----	----	0.1	----	----
Silver	7440-22-4	0.1	mg/kg	----	----	<0.1	----	----
Vanadium	7440-62-2	2.0	mg/kg	----	----	3.9	----	----
Zinc	7440-66-6	1.0	mg/kg	----	----	2.4	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	----	----	<0.01	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.28	0.19	0.18	0.19	0.18
EP231A: Perfluoroalkyl Sulfonic Acids								
Ø Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	----	----	<0.0005	----	----
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	----	----	<0.0002	----	----
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	----	----	<0.0002	----	----
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	----	----	<0.0002	----	----
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	----	----	<0.0002	----	----
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	----	----	<0.0002	----	----
Ø Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.0002	mg/kg	----	----	<0.0002	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S4b	S4c	S5a(a)	S5b	S5c
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-011	EB2514707-012	EB2514707-013	EB2514707-014	EB2514707-015
					Result	Result	Result	Result	Result
EP231A: Perfluoroalkyl Sulfonic Acids - Continued									
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg		----	----	<0.0002	----	----
EP231B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg		----	----	<0.001	----	----
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0002	mg/kg		----	----	<0.0002	----	----
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg		----	----	<0.0005	----	----
EP231C: Perfluoroalkyl Sulfonamides									
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg		----	----	<0.0002	----	----
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg		----	----	<0.0005	----	----
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg		----	----	<0.0005	----	----
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg		----	----	<0.0005	----	----
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg		----	----	<0.0005	----	----
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg		----	----	<0.0002	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S4b	S4c	S5a(a)	S5b	S5c
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-011	EB2514707-012	EB2514707-013	EB2514707-014	EB2514707-015
					Result	Result	Result	Result	Result
EP231C: Perfluoroalkyl Sulfonamides - Continued									
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg		----	----	<0.0002	----	----
EP231D: (n:2) Fluorotelomer Sulfonic Acids									
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg		----	----	<0.0005	----	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg		----	----	<0.0005	----	----
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg		----	----	<0.0005	----	----
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg		----	----	<0.0005	----	----
EP231P: PFAS Sums									
Sum of PFAS	----	0.0002	mg/kg		----	----	<0.0002	----	----
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.0002	mg/kg		----	----	<0.0002	----	----
Sum of PFAS (WA DER List)	----	0.0002	mg/kg		----	----	<0.0002	----	----
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.0002	%		----	----	106	----	----
13C8-PFOA	----	0.0002	%		----	----	109	----	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				S6a	S6b	S6c	S7a	S7b
Sampling date / time				26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	EB2514707-016	EB2514707-017	EB2514707-018	EB2514707-019	EB2514707-020
				Result	Result	Result	Result	Result
EA150: Particle Sizing								
+75µm	----	1	%	97	98	98	97	97
+150µm	----	1	%	93	94	94	96	96
+300µm	----	1	%	63	66	67	82	81
+425µm	----	1	%	49	51	54	67	66
+600µm	----	1	%	41	43	46	52	52
+1180µm	----	1	%	27	30	31	23	20
+2.36mm	----	1	%	15	18	18	7	4
+4.75mm	----	1	%	4	7	8	3	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	2	2	<1	1	3
Silt (2-60 µm)	----	1	%	1	<1	1	2	<1
Sand (0.06-2.00 mm)	----	1	%	79	77	77	85	88
Gravel (>2mm)	----	1	%	18	21	22	12	9
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.50	2.58	2.55	2.50	2.55
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.18	0.23	0.22	0.17	0.18



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S7c	S8a	S8b	S8c	DUP
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-021	EB2514707-022	EB2514707-023	EB2514707-024	EB2514707-025
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		----	----	----	----	27.3
EA150: Particle Sizing									
+75µm	----	1	%		97	96	96	96	95
+150µm	----	1	%		95	87	85	86	77
+300µm	----	1	%		80	48	49	45	49
+425µm	----	1	%		64	32	34	30	41
+600µm	----	1	%		49	21	22	19	33
+1180µm	----	1	%		19	6	7	5	14
+2.36mm	----	1	%		3	<1	<1	<1	2
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		3	3	2	4	5
Silt (2-60 µm)	----	1	%		<1	1	2	<1	<1
Sand (0.06-2.00 mm)	----	1	%		89	93	94	94	89
Gravel (>2mm)	----	1	%		8	3	2	2	6
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.49	2.55	2.62	2.62	2.52
EG005(ED093)-SD: Total Metals in Sediments by ICP-AE									
Aluminium	7429-90-5	50	mg/kg		----	----	----	----	320
Iron	7439-89-6	50	mg/kg		----	----	----	----	1120
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		----	----	----	----	<0.50



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				S7c	S8a	S8b	S8c	DUP
Sampling date / time				26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit	EB2514707-021	EB2514707-022	EB2514707-023	EB2514707-024	EB2514707-025
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Arsenic	7440-38-2	1.00	mg/kg	----	----	----	----	1.74
Cadmium	7440-43-9	0.1	mg/kg	----	----	----	----	<0.1
Chromium	7440-47-3	1.0	mg/kg	----	----	----	----	11.0
Copper	7440-50-8	1.0	mg/kg	----	----	----	----	<1.0
Cobalt	7440-48-4	0.5	mg/kg	----	----	----	----	0.9
Lead	7439-92-1	1.0	mg/kg	----	----	----	----	<1.0
Manganese	7439-96-5	10	mg/kg	----	----	----	----	23
Nickel	7440-02-0	1.0	mg/kg	----	----	----	----	7.4
Selenium	7782-49-2	0.1	mg/kg	----	----	----	----	<0.1
Silver	7440-22-4	0.1	mg/kg	----	----	----	----	<0.1
Vanadium	7440-62-2	2.0	mg/kg	----	----	----	----	3.4
Zinc	7440-66-6	1.0	mg/kg	----	----	----	----	2.0
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	----	----	----	----	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.20	0.27	0.25	0.23	0.25
EP231A: Perfluoroalkyl Sulfonic Acids								
Ø Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	----	----	----	----	<0.0005
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	----	----	----	----	<0.0002
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	----	----	----	----	<0.0002
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	----	----	----	----	<0.0002
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	----	----	----	----	<0.0002
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	----	----	----	----	<0.0002
Ø Perfluorononane sulfonic acid (PFNS)	68259-12-1	0.0002	mg/kg	----	----	----	----	<0.0002



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S7c	S8a	S8b	S8c	DUP
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-021	EB2514707-022	EB2514707-023	EB2514707-024	EB2514707-025
					Result	Result	Result	Result	Result
EP231A: Perfluoroalkyl Sulfonic Acids - Continued									
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg		----	----	----	----	<0.0002
EP231B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg		----	----	----	----	<0.001
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0002	mg/kg		----	----	----	----	<0.0002
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg		----	----	----	----	<0.0005
EP231C: Perfluoroalkyl Sulfonamides									
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg		----	----	----	----	<0.0002
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg		----	----	----	----	<0.0005
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg		----	----	----	----	<0.0005
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg		----	----	----	----	<0.0005
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg		----	----	----	----	<0.0005
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg		----	----	----	----	<0.0002



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	S7c	S8a	S8b	S8c	DUP
Sampling date / time					26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00	26-Mar-2025 00:00
Compound	CAS Number	LOR	Unit		EB2514707-021	EB2514707-022	EB2514707-023	EB2514707-024	EB2514707-025
					Result	Result	Result	Result	Result
EP231C: Perfluoroalkyl Sulfonamides - Continued									
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg		----	----	----	----	<0.0002
EP231D: (n:2) Fluorotelomer Sulfonic Acids									
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg		----	----	----	----	<0.0005
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg		----	----	----	----	<0.0005
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg		----	----	----	----	<0.0005
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg		----	----	----	----	<0.0005
EP231P: PFAS Sums									
Sum of PFAS	----	0.0002	mg/kg		----	----	----	----	<0.0002
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.0002	mg/kg		----	----	----	----	<0.0002
Sum of PFAS (WA DER List)	----	0.0002	mg/kg		----	----	----	----	<0.0002
EP231S: PFAS Surrogate									
13C4-PFOS	----	0.0002	%		----	----	----	----	111
13C8-PFOA	----	0.0002	%		----	----	----	----	104



Surrogate Control Limits

Sub-Matrix: SOIL		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP231S: PFAS Surrogate			
13C4-PFOS	----	76	136
13C8-PFOA	----	78	131

Appendix A.4. ALS Laboratory sediment quality (quality control) report



QUALITY CONTROL REPORT

Work Order	: ES2509116	Page	: 1 of 7
Client	: BMT COMMERCIAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: ANGUS WILLIAMS	Contact	: Customer Services ES
Address	: PO BOX 203 SPRING HILL BRISBANE QLD 4004	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3831 6744	Telephone	: +61-2-8784 8555
Project	: 3430 LHI Baseline Study	Date Samples Received	: 31-Mar-2025
Order number	: -	Date Analysis Commenced	: 31-Mar-2025
C-O-C number	: ----	Issue Date	: 09-Apr-2025
Sampler	: ANGUS WILLIAMS, Tobias Probst		
Site	: ----		
Quote number	: EB25BMTWBM0003_V2		
No. of samples received	6		
No. of samples analysed	6		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Edwandy Fadjar	Organic Coordinator	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Sanjeshni Jyoti	Senior Chemist Volatiles	Sydney Organics, Smithfield, NSW



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot

CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

RPD = Relative Percentage Difference

= Indicates failed QC

* = The final LOR has been raised due to dilution or other sample specific cause; adjusted LOR is shown in brackets. The duplicate ranges for Acceptable RPD% are applied to the final LOR where applicable.

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EK255A SD: Ammonium in Sediment (QC Lot: 6477032)									
ES2509116-001	S1a	EK255A: Ammonium as N	14798-03-9_N	0.2	mg/kg	4.0	4.1	0.0	0% - 20%
		EK255A: Ammonium as NH4	----	0.2	mg/kg	5.2	5.3	0.0	0% - 20%
EA003 :pH (field/fox) (QC Lot: 6487828)									
EM2505311-031	Anonymous	EA003: pH (F)	----	0.1	pH Unit	6.5	6.3	3.1	0% - 20%
		EA003: pH (Fox)	----	0.1	pH Unit	2.0	1.9	6.5	0% - 20%
ES2509116-006	Dup	EA003: pH (F)	----	0.1	pH Unit	8.9	8.9	0.0	0% - 20%
		EA003: pH (Fox)	----	0.1	pH Unit	6.5	6.5	0.0	0% - 20%
EA033-A: Actual Acidity (QC Lot: 6487808)									
EB2511122-006	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	8	7	21.8	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.1	5.3	2.7	0% - 20%
ES2509116-004	S4a	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	9.8	9.7	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 6487808)									
EB2511122-006	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.020	0.020	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	12	12	0.0	No Limit
ES2509116-004	S4a	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.026	0.029	12.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	16	18	12.0	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EA033-C: Acid Neutralising Capacity (QC Lot: 6487808)									
ES2509116-004	S4a	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	80.8	80.7	0.1	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	25.9	25.8	0.1	0% - 20%
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	16100	16100	0.1	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 6478179)									
ES2508620-027	Anonymous	EA055: Moisture Content	----	0.1	%	23.8	20.4	15.2	0% - 20%
ES2509014-005	Anonymous	EA055: Moisture Content	----	0.1 (1.0)*	%	<1.0	<1.0	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 6478171)									
ES2508862-006	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.1	<0.1	0.0	No Limit
ES2509116-002	S2a	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 6478172)									
ES2508862-006	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.5	0.4	0.0	No Limit
ES2509116-002	S2a	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.2	0.2	0.0	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 6495105)									
EM2505289-013	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	200	180	8.4	No Limit
ES2508862-008	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	2550	2470	3.0	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 6495106)									
EM2505289-013	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	121	110	9.5	0% - 20%
ES2508862-008	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	348	355	1.9	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 6495107)									
ES2509116-006	Dup	EK067G: Total Phosphorus as P	----	2	mg/kg	413	457	10.1	0% - 20%
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QC Lot: 6477726)									
ES2509116-001	S1a	EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	<3	0.0	No Limit
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QC Lot: 6478085)									
ES2509116-001	S1a	EP071-SD-SV: C10 - C14 Fraction	----	3	mg/kg	<3	<3	0.0	No Limit
		EP071-SD-SV: C15 - C28 Fraction	----	3	mg/kg	16	12	24.4	No Limit
		EP071-SD-SV: C10 - C36 Fraction (sum)	----	3	mg/kg	16	12	28.6	No Limit
		EP071-SD-SV: C29 - C36 Fraction	----	5	mg/kg	<5	<5	0.0	No Limit
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QC Lot: 6478085)									
ES2509116-001	S1a	EP071-SD-SV: >C10 - C16 Fraction	----	3	mg/kg	<3	<3	0.0	No Limit
		EP071-SD-SV: >C16 - C34 Fraction	----	3	mg/kg	18	14	23.7	No Limit
		EP071-SD-SV: >C10 - C40 Fraction (sum)	----	3	mg/kg	18	14	25.0	No Limit
		EP071-SD-SV: >C34 - C40 Fraction	----	5	mg/kg	<5	<5	0.0	No Limit
EP080-SD: BTEXN (QC Lot: 6477726)									
ES2509116-001	S1a	EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.0	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP080-SD: BTEXN (QC Lot: 6477726) - continued									
ES2509116-001	S1a	EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	0.0	No Limit
		EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	0.0	No Limit
		EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	0.0	No Limit
		EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	0.0	No Limit



Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%)	
							Low	High
EK255A SD: Ammonium in Sediment (QCLot: 6477032)								
EK255A: Ammonium as N	14798-03-9_N	0.2	mg/kg	<0.2	1 mg/kg	112	80.0	120
EK255A: Ammonium as NH4	----	0.2	mg/kg	<0.2	1.288 mg/kg	112	80.0	120
EA033-A: Actual Acidity (QCLot: 6487808)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.7 pH Unit	98.9	80.0	120
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	23.5 mole H+ / t	102	80.0	120
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 6487808)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.283 % S	89.1	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 6487808)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	96.8	91.0	112
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser (QCLot: 6478171)								
EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	2.5 mg/kg	93.4	85.0	111
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 6478172)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	94.1	88.0	118
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 6495105)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	500 mg/kg	86.7	72.0	116
				<20	250 mg/kg	91.9	70.0	122
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 6495106)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2	221 mg/kg	94.8	76.0	108
				<2	55.2 mg/kg	89.8	70.0	118
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 6495107)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2	221 mg/kg	90.6	76.0	108
				<2	55.2 mg/kg	89.2	70.0	118
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 6477726)								
EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	6.2 mg/kg	83.2	61.0	133
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 6478085)								
EP071-SD-SV: C10 - C14 Fraction	----	3	mg/kg	<3	5 mg/kg	99.7	73.0	119



Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result			Low	High
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 6478085) - continued								
EP071-SD-SV: C15 - C28 Fraction	----	3	mg/kg	<3	7.5 mg/kg	98.8	70.0	130
EP071-SD-SV: C29 - C36 Fraction	----	5	mg/kg	<5	5 mg/kg	99.9	84.0	118
EP071-SD-SV: C10 - C36 Fraction (sum)	----	3	mg/kg	<3	----	----	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 6478085)								
EP071-SD-SV: >C10 - C16 Fraction	----	3	mg/kg	<3	6.25 mg/kg	101	78.0	118
EP071-SD-SV: >C16 - C34 Fraction	----	3	mg/kg	<3	8.75 mg/kg	98.2	74.0	138
EP071-SD-SV: >C34 - C40 Fraction	----	5	mg/kg	<5	3.75 mg/kg	101	63.0	131
EP071-SD-SV: >C10 - C40 Fraction (sum)	----	3	mg/kg	<3	----	----	----	----
EP080-SD: BTEXN (QCLot: 6477726)								
EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	0.2 mg/kg	97.7	66.0	122
EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	0.2 mg/kg	104	70.0	130
EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	0.2 mg/kg	101	66.0	126
EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	0.4 mg/kg	106	59.0	129
EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	0.2 mg/kg	106	66.0	126

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike Concentration	SpikeRecovery(%) MS	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number			Low	High
EK255A SD: Ammonium in Sediment (QCLot: 6477032)							
ES2509116-002	S2a	EK255A: Ammonium as N	14798-03-9_ N	0.5 mg/kg	113	70.0	130
		EK255A: Ammonium as NH4	----	0.6439 mg/kg	# Not Determined	70.0	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 6478171)							
ES2508862-006	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	2.5 mg/kg	103	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 6478172)							
ES2508862-006	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	2.5 mg/kg	96.8	70.0	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 6495105)							
EM2505289-013	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	200 mg/kg	87.8	70.0	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 6495106)							
EM2505289-013	Anonymous	EK067G: Total Phosphorus as P	----	40 mg/kg	77.0	70.0	130



Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 6495107)							
ES2509116-006	Dup	EK067G: Total Phosphorus as P	----	40 mg/kg	102	70.0	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 6477726)							
ES2509116-001	S1a	EP080-SD: C6 - C9 Fraction	----	6.5 mg/kg	76.4	70.0	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 6478085)							
ES2509116-001	S1a	EP071-SD-SV: C10 - C14 Fraction	----	14 mg/kg	80.0	70.0	130
		EP071-SD-SV: C15 - C28 Fraction	----	59 mg/kg	74.6	70.0	130
		EP071-SD-SV: C29 - C36 Fraction	----	42 mg/kg	75.4	70.0	130
EP080-SD: BTEXN (QCLot: 6477726)							
ES2509116-001	S1a	EP080-SD: Benzene	71-43-2	0.5 mg/kg	75.8	70.0	130
		EP080-SD: Toluene	108-88-3	0.5 mg/kg	80.7	70.0	130
		EP080-SD: Ethylbenzene	100-41-4	0.5 mg/kg	85.5	70.0	130
		EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.5 mg/kg	83.1	70.0	130
		EP080-SD: ortho-Xylene	95-47-6	0.5 mg/kg	87.1	70.0	130



QUALITY CONTROL REPORT

Work Order	: EB2514707	Page	: 1 of 9
Client	: BMT COMMERCIAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: Tobias Probst	Contact	: Nathan King
Address	: PO BOX 203 SPRING HILL BRISBANE QLD 4004	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3552-8685
Project	: LHI Baseline Study	Date Samples Received	: 30-Apr-2025
Order number	: No PO Provided	Date Analysis Commenced	: 07-May-2025
C-O-C number	: ----	Issue Date	: 16-May-2025
Sampler	: TP/AW		
Site	: ----		
Quote number	: EB25BMTWBM0003_V2		
No. of samples received	: 26		
No. of samples analysed	: 25		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kirsty Watson	Senior Chemist - Organics	Brisbane Organics, Stafford, QLD
Kirsty Watson	Senior Chemist - Organics	Brisbane Soil Preparation, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot

CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

RPD = Relative Percentage Difference

= Indicates failed QC

* = The final LOR has been raised due to dilution or other sample specific cause; adjusted LOR is shown in brackets. The duplicate ranges for Acceptable RPD% are applied to the final LOR where applicable.

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 6562361)									
EB2514707-001	S1a	EG005-SD: Aluminium	7429-90-5	50	mg/kg	330	400	18.2	No Limit
		EG005-SD: Iron	7439-89-6	50	mg/kg	1330	1570	16.4	0% - 20%
EB2515351-014	Anonymous	EG005-SD: Aluminium	7429-90-5	50	mg/kg	520	540	3.1	0% - 50%
		EG005-SD: Iron	7439-89-6	50	mg/kg	790	790	0.0	0% - 50%
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 6562363)									
EB2514707-001	S1a	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.0	No Limit
EB2515351-014	Anonymous	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.0	No Limit
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 6559166)									
EB2513540-001	Anonymous	EA055: Moisture Content	----	0.1 (1.0)*	%	12.2	12.9	5.9	0% - 50%
EB2514707-013	S5a(a)	EA055: Moisture Content	----	0.1 (1.0)*	%	27.7	27.7	0.0	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 6562362)									
EB2514707-001	S1a	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Selenium	7782-49-2	0.1	mg/kg	0.1	0.1	0.0	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	0.1	<0.1	0.0	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.0	No Limit
		EG020-SD: Cobalt	7440-48-4	0.5	mg/kg	1.2	1.6	27.3	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	4.21	2.80	40.2	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	13.1	14.3	8.9	0% - 50%
		EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	<1.0	0.0	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 6562362) - continued									
EB2514707-001	S1a	EG020-SD: Nickel	7440-02-0	1	mg/kg	9.6	12.6	27.2	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	3.3	3.1	4.4	No Limit
		EG020-SD: Manganese	7439-96-5	10	mg/kg	26	33	25.0	No Limit
		EG020-SD: Vanadium	7440-62-2	2	mg/kg	4.4	5.0	13.5	No Limit
EB2515351-014	Anonymous	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Selenium	7782-49-2	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.0	No Limit
		EG020-SD: Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	0.0	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	1.22	1.19	2.2	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	5.5	4.9	10.8	No Limit
		EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	2.5	2.1	20.2	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	2.0	1.7	12.9	No Limit
		EG020-SD: Manganese	7439-96-5	10	mg/kg	<10	<10	0.0	No Limit
		EG020-SD: Vanadium	7440-62-2	2	mg/kg	<2.0	<2.0	0.0	No Limit
		EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 6559082)							
EB2514707-001	S1a	EP003: Total Organic Carbon	----	0.02	%	0.20	0.23	11.7	0% - 50%
EB2514707-011	S4b	EP003: Total Organic Carbon	----	0.02	%	0.28	0.29	4.1	0% - 50%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 6559083)									
EB2514707-021	S7c	EP003: Total Organic Carbon	----	0.02	%	0.20	0.23	15.0	0% - 50%
EP231A: Perfluoroalkyl Sulfonic Acids (QC Lot: 6554462)									
EB2514491-002	Anonymous	EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
EB2514491-039	Anonymous	EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	<0.0002	0.0002	0.0	No Limit
		EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	0.0004	0.0004	0.0	No Limit
		EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP231B: Perfluoroalkyl Carboxylic Acids (QC Lot: 6554462)									
EB2514491-002	Anonymous	EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg	<0.001	<0.001	0.0	No Limit
EB2514491-039	Anonymous	EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg	<0.001	<0.001	0.0	No Limit
EP231C: Perfluoroalkyl Sulfonamides (QC Lot: 6554462)									
EB2514491-002	Anonymous	EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
EB2514491-039	Anonymous	EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP231C: Perfluoroalkyl Sulfonamides (QC Lot: 6554462) - continued									
EB2514491-039	Anonymous	EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg	<0.0002	<0.0002	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QC Lot: 6554462)									
EB2514491-002	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
EB2514491-039	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg	<0.0005	<0.0005	0.0	No Limit



Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result		LCS	Low	High
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 6562361)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	7232 mg/kg	101	70.0	130
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	24060 mg/kg	105	70.0	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 6562363)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	0.087 mg/kg	113	70.0	130
EA152: Soil Particle Density (QCLot: 6546564)								
EA152: Soil Particle Density (Clay/Silt/Sand)	----	----	g/cm3	----	2.68 g/cm3	98.9	80.0	120
EA152: Soil Particle Density (QCLot: 6546566)								
EA152: Soil Particle Density (Clay/Silt/Sand)	----	----	g/cm3	----	2.68 g/cm3	98.9	80.0	120
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 6562362)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	-----	-----	-----	-----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	33.25 mg/kg	110	80.0	124
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.95 mg/kg	104	87.0	122
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	25.5 mg/kg	128	79.0	129
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	103.55 mg/kg	117	85.0	118
EG020-SD: Cobalt	7440-48-4	0.5	mg/kg	<0.5	10.1 mg/kg	128	70.0	130
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	121 mg/kg	112	86.0	119
EG020-SD: Manganese	7439-96-5	10	mg/kg	<10	461.5 mg/kg	124	70.0	130
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	30.05 mg/kg	122	77.0	123
EG020-SD: Selenium	7782-49-2	0.1	mg/kg	<0.1	-----	-----	-----	-----
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	0.55 mg/kg	86.1	70.0	130
EG020-SD: Vanadium	7440-62-2	2	mg/kg	<2.0	23.5 mg/kg	127	70.0	130
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	209 mg/kg	124	71.0	127
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 6559082)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.55 %	104	80.0	120
				<0.02	32.3 %	98.2	80.0	120
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 6559083)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.55 %	102	80.0	120
				<0.02	32.3 %	100	80.0	120
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6554462)								
EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.0005	mg/kg	<0.0005	0.00125 mg/kg	100	60.0	140



Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6554462) - continued								
EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0002	mg/kg	<0.0002	0.0011 mg/kg	95.0	72.0	128
EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.0002	mg/kg	<0.0002	0.00117 mg/kg	102	73.0	123
EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.0002	mg/kg	<0.0002	0.00118 mg/kg	83.9	67.0	130
EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.0002	mg/kg	<0.0002	0.00119 mg/kg	118	70.0	132
EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.0002	mg/kg	<0.0002	0.00116 mg/kg	101	68.0	136
EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0002	mg/kg	<0.0002	0.0012 mg/kg	108	59.0	134
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 6554462)								
EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.001	mg/kg	<0.001	0.00625 mg/kg	100	71.0	135
EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.0002	mg/kg	<0.0002	0.00125 mg/kg	92.0	69.0	132
EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.0002	mg/kg	<0.0002	0.00125 mg/kg	92.4	70.0	132
EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0002	mg/kg	<0.0002	0.00125 mg/kg	93.2	71.0	131
EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.0002	mg/kg	<0.0002	0.00125 mg/kg	97.2	69.0	133
EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.0002	mg/kg	<0.0002	0.00125 mg/kg	96.8	72.0	129
EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.0002	mg/kg	<0.0002	0.00125 mg/kg	104	69.0	133
EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.0002	mg/kg	<0.0002	0.00125 mg/kg	97.6	64.0	136
EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.0002	mg/kg	<0.0002	0.00125 mg/kg	103	69.0	135
EP231X: Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0002	mg/kg	<0.0002	0.00125 mg/kg	98.0	66.0	139
EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.0005	mg/kg	<0.0005	0.00312 mg/kg	108	69.0	133
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6554462)								
EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.0002	mg/kg	<0.0002	0.00125 mg/kg	90.8	67.0	137
EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.0005	mg/kg	<0.0005	0.00312 mg/kg	103	59.6	143
EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.0005	mg/kg	<0.0005	0.00312 mg/kg	98.7	62.8	140
EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.0005	mg/kg	<0.0005	0.00312 mg/kg	100	61.5	139
EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.0005	mg/kg	<0.0005	0.00312 mg/kg	99.8	61.9	137
EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.0002	mg/kg	<0.0002	0.00125 mg/kg	92.0	63.0	144
EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.0002	mg/kg	<0.0002	0.00125 mg/kg	85.6	61.0	139
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 6554462)								
EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.0005	mg/kg	<0.0005	0.00117 mg/kg	111	62.0	145
EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.0005	mg/kg	<0.0005	0.00118 mg/kg	99.6	64.0	140
EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0005	mg/kg	<0.0005	0.0012 mg/kg	99.6	65.0	137
EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0005	mg/kg	<0.0005	0.0012 mg/kg	85.4	54.8	124



Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 6562363)							
EB2514707-004	S2a	EG035T-LL: Mercury	7439-97-6	0.5 mg/kg	97.4	70.0	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 6562362)							
EB2514707-004	S2a	EG020-SD: Arsenic	7440-38-2	50 mg/kg	118	70.0	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	95.8	70.0	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	129	70.0	130
		EG020-SD: Copper	7440-50-8	250 mg/kg	106	70.0	130
		EG020-SD: Lead	7439-92-1	250 mg/kg	97.7	70.0	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	109	70.0	130
		EG020-SD: Selenium	7782-49-2	50 mg/kg	104	70.0	130
		EG020-SD: Zinc	7440-66-6	250 mg/kg	112	70.0	130
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 6554462)							
EB2514491-006	Anonymous	EP231X: Perfluoropropane sulfonic acid (PFPrS)	423-41-6	0.00125 mg/kg	104	60.0	140
		EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.0011 mg/kg	95.4	72.0	128
		EP231X: Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.00117 mg/kg	105	73.0	123
		EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.00118 mg/kg	98.7	67.0	130
		EP231X: Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.00119 mg/kg	126	70.0	132
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.00116 mg/kg	105	68.0	136
		EP231X: Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.0012 mg/kg	115	59.0	134
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 6554462)							
EB2514491-006	Anonymous	EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.00625 mg/kg	106	71.0	135
		EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.00125 mg/kg	100	69.0	132
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.00125 mg/kg	102	70.0	132
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.00125 mg/kg	104	71.0	131
		EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.00125 mg/kg	101	69.0	133
		EP231X: Perfluorononanoic acid (PFNA)	375-95-1	0.00125 mg/kg	105	72.0	129
		EP231X: Perfluorodecanoic acid (PFDA)	335-76-2	0.00125 mg/kg	111	69.0	133
		EP231X: Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.00125 mg/kg	102	64.0	136
		EP231X: Perfluorododecanoic acid (PFDoDA)	307-55-1	0.00125 mg/kg	119	69.0	135
		EP231X: Perfluorotridecanoic acid (PFTriDA)	72629-94-8	0.00125 mg/kg	113	66.0	139
		EP231X: Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.00312 mg/kg	108	69.0	133
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6554462)							
EB2514491-006	Anonymous	EP231X: Perfluorooctane sulfonamide (FOSA)	754-91-6	0.00125 mg/kg	99.6	48.0	128
		EP231X: N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.00312 mg/kg	119	70.0	130



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP231C: Perfluoroalkyl Sulfonamides (QCLot: 6554462) - continued							
EB2514491-006	Anonymous	EP231X: N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.00312 mg/kg	98.1	70.0	130
		EP231X: N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.00312 mg/kg	108	70.0	130
		EP231X: N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.00312 mg/kg	105	70.0	130
		EP231X: N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.00125 mg/kg	86.4	63.0	144
		EP231X: N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.00125 mg/kg	84.8	61.0	139
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 6554462)							
EB2514491-006	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.00117 mg/kg	115	62.0	145
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.00118 mg/kg	111	64.0	140
		EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.0012 mg/kg	103	65.0	137
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.0012 mg/kg	105	54.8	124

Appendix A.5. Chain of Custody form



COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

If I!

W/ter Container Codes: P[™] Unpreserved Plastic; N[™]. Nitric Pm: orved Plastic; ORC = Nitric Prasef/ed ORC; SH[™] Sodium Hydroxide/Cd Preserved; S= Sodium Hydroxide Preser, ed Plastic; AG= Amber Glass Unpreserved; AP[™] Airfreight Uni[™]:<reserved Pl5t1c
V[™] VOA Vial HCl Preserved; VB[™]: VOA Vial Sodium Bisulphate Preserved; VS= VOA Vial Sulfuric Preserved; AV= Airfreight Unpreserved Vial SG = Sulfuric Preserved Plastic; H[™]. HCl preserved Plastic: HS= PreStlrvcd Plastic SpecHon bottle; SP= Sulfuric Preserved Pnstic; F = Fomul/dehyde Pmsr.ed Glass;
Z = Zinc Acetate Prese1vud Bottle; E[™] EDTA Preserved Bomes; ST= Sterile Bottle; ASS[™] Plastic Beas for Ac,d1 Sulnate Soils -8 = Unoresel/ed Bao; L1: Ltaols to<:line Preserved Bomes; STT = sterile Sodium Thiosulfate Preserved Bottons

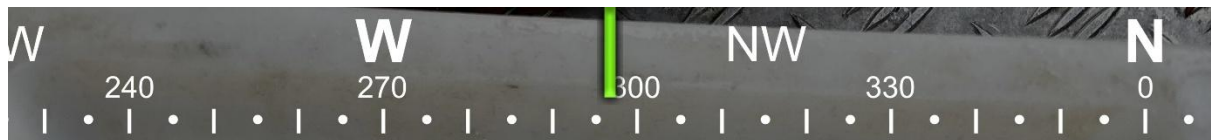
Mandatory Fields				CHAIN OF CUSTODY												Page 1 of 1			
CLIENT CODE:				PROJECT MANAGER: Tobias Probst				SAMPLER: TP/AW										CoC #: (if applicable)	
CLIENT:				PM MOBILE: 07 3831 6744				SMAPLER MOBILE:											
OFFICE: (Invoiced Office)				ALS QUOTE: EB25BMT WBM 0003 V2				PURCHASE ORDER NO.:											
PROJECT NO./PROJECT: LH Baseline Study								Site,											
INVOICE TO: (client default if nil) tobias.probst@anac.hmt.org								CC Invoice to PM ☐										BIOSECURITY	
EMAIL REPORTS TO: (default to PM, if blank)								ANALYSIS REQUIRED										Country of Origin: (if not Australia)	
STORAGE REQUIREMENTS				TURNAROUND				ANALYSIS REQUIRED										Environmental Division	
Er Standard Storage				IS 3 5+ days (no surcharge)				NS: ALS C-JCU Ne), m/for An: 1/2 is Swr1 Cedet mu r / o / i / od re ; fr: r-1 ct s, m, loc. otod pr...										Brisbane	
Please check box.				Please check box.				Wh...re M:ais are r...quod, sp...cityTotal (nfilter, d bottle roc;uire...;) or D...1>0IY(d fmlld filtered bottle re,quod).										Work Order Reference	
Sta 11dDrd Storage lime from rccce,pt of amp/ct				0 3 day (-15%)				Mark 11.n X in tht bc.)es belc.w analy,U to indic...te \ht> paramet,l u- limd a.hove to be t,i-std on that sample.										EB2514707	
Wlrrs - 3 weeks				0 2 day (-30%)														Barcode	
Comments:																		Telepl 10rm - 61-7-3552-8681,	
ALS Uia, Only				Sample ID				Depth				Date/Time-				Additional Information			
Lab ID																Dup MS			
S1a				26/3/25															
S1b																			
S1c																			
2																			
52.b																			
S3																			
S3h																			
S3c																			
S4a																			
Receipt Detail (id: U)				Chill/ing Method: Frozen / Melted				Ice Bricks: Frozen / Thawed				Sample Temp at Receipt				Security Seal Intact (circle)			
Relinquished by: AW				Sgn: nunc:				Date/Time: 30/4/25				Received by: 30/4/25				Signature			

Mandatory Fields				CHAIN OF CUSTODY												Page 2 of 2					
CLIENT CODE:				*PROJECT MANAGER, PM				*CLIENT:				SAMPLED				Coe# : (rapo, c dte)					
5,V" T				MOBILE, D=J SI'31 C.rL..t+				MOBILE,													
OFFICE: (Invoiced Office)				ALS QUOTE# (Clien: PL if blanki)				PURCHASE ORDER NO.,													
PROJECT NO./PROJECT				SITE,																	
*INVOICE TO:				CC Invoice to PM				BIOSECURITY													
"EMAIL REPORTS TO:				*ANALYSIS REQUIRED				Country of Origin:													
/defa **t to P.V i bi-mk/d				(Nf: ALS Cueto No. ndlor AM, yoi: Sw, to Ccdo 7Wll bo /mod U, mr: c w telquo 1, d pm: o) Wh: m M, 11; 11 iIM requir d, p, icify Tcd 1; 11 (urfr: 11ed bottle requu, d) or Di; Sdved (f, e'd f, it> red botle rec, moCJ. Mark an X in the boxu below analysIS to indicate the pl 1 ram l lter listed .: l bove to be tested or, that nmp l c.				WO Sticker to go here. (ALS use only)													
* STORAGE REQUIREMENTS				Standard Storage				* TURNAROUND				LnbQC Additional Information									
Please c . e dbox				E: < tnded Storage				5+ dnys (no surch; irge)													
StandMd Storage time from rece, pt of sampos-				Spedfy Disposal Dnte:				3day(+15%)				Dup									
W/lcrs + 3 wech Soils - 2 months				Notoi EKtondod storgo incur, a h: a and Nl/quire _ : " sigm, d a9raemant.				2 day(+30%)													
Comments:				1				2				Di									
ALS Use				Only				Sample ID													
S4b				S4-c..				S o..				S				S					
12				13				1\$				If,				11					
111				I'l				20				Re, ceipt				Ice;					
Rdii19uU1eci Uy				SignCturCt:				D,ile, Time:				Rc>ceind by:				Packaging:					
/4'.r-/				yf(				1,0, b. lzt;				SO(C-I{::J-..t: 11I l				Co. int					
Sig-atvtn:				Date/ Trnu				Rnc<lw, c br				I Si9natme				D0m/ une.					

Appendix A.6. Sediment sampling photographs







☼ 297°NW (T) ● 31°31'34"S, 159°3'25"E ±42ft ▲ 22ft







☼ 201°S (T) ● 31°31'33"S, 159°3'49"E ±259ft ▲ 37ft



Appendix B. Benthic Communities and Habitat Survey Summary

Appendix B. Benthic Communities and Habitat Survey Summary

A benthic habitat field survey was undertaken to support the Coastal Marine Ecology Assessment for the Lord Howe Island Critical Infrastructure Project. The survey was undertaken by BMT between February – April 2025 in accordance with a sampling plan designed by BMT and approved by DCCEEW. The data collected during the survey was provided to O2 Marine for analysis and interpretation. This report provides a summary of the baseline benthic habitat data collected to support approvals for the Lord Howe Island Critical Infrastructure Project.

1. Methods

The benthic habitat assessment was informed initially by a desktop review of existing environmental data and reports. Field-based mapping was subsequently undertaken and divided into two distinct survey zones: intertidal and subtidal (Figure 1), with each area assessed using the most appropriate technique for environmental conditions and visibility.

Intertidal area

- Drone imagery was used to acquire high-resolution images of reef flats and emergent reef structures. These images facilitated the identification of substrate types, geomorphic features, and conspicuous biological cover such as macroalgae or sessile invertebrates.
- Ground-truthing was conducted through on-foot survey during low tide, using georeferenced photographs and handheld video to validate image interpretations and to identify dominant physical substrate classes and floral and faunal communities.

Subtidal area

- Drone imagery was captured over shallow lagoon and nearshore reef zones during periods of optimal water clarity. These images provided an overview of broad habitat distribution and were used to identify boundaries between substrate types.
- Towed video camera (TVC) transects were conducted using a high-definition underwater camera system. The TVC was towed at a height of approximately 0.5 m above the seabed, and video was collected at multiple locations to support habitat classification and species identification.
- Spot transect dive surveys were undertaken during fieldwork primarily to focus on fish assemblages but also to supplement the benthic community survey using methods based on the Lord Howe Island Reef Life Surveys by Stuart-Smith et al. (2019). Images were taken facing straight down, ~ 0.8 m above the habitat, and a 3 m high-definition video was taken whilst a diver swam the length of the transect.

For interpretation and reporting, results have been framed under two headline ecosystems consistent with the environmental values of the Lord Howe Island Marine Park: the Lagoon ecosystem, covering the western lagoon and modern fringing reef, plus carbonate sand plains that support seagrass and nursery functions; and the Intertidal and shallow subtidal ecosystems, comprising open coastal reefs from the intertidal to the inner shelf and rocky shores where wave exposure drives assemblage structure.

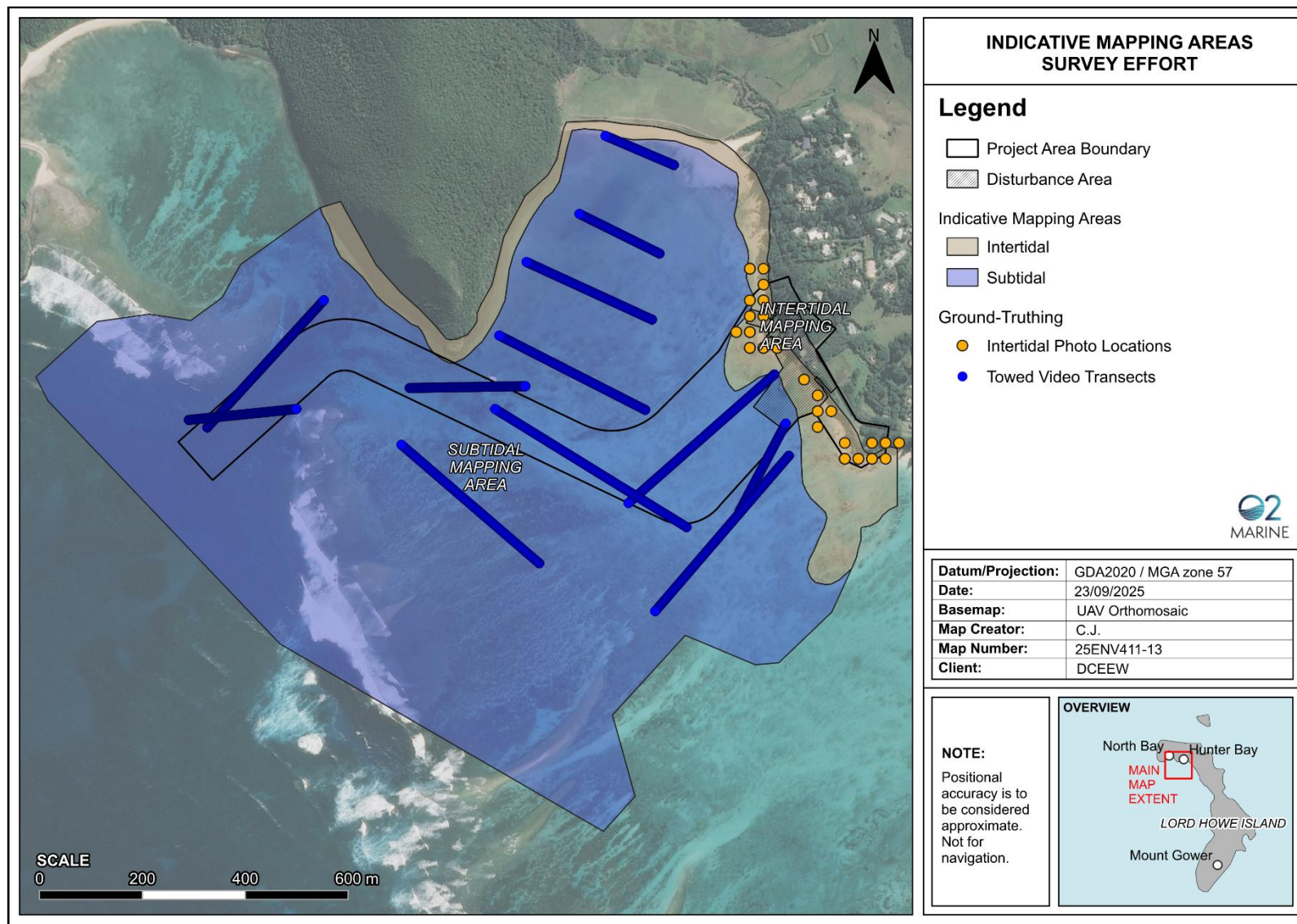


Figure 1: Location of Subtidal and Intertidal mapping areas used to focus field survey efforts

Within these ecosystems, two primary BCH value categories are retained for synthesis: Corals and Macrophytes. In lagoonal settings, scleractinian corals are the dominant benthic cover, with macroalgae next most abundant, while seagrass stabilises sediments and supports nursery and foraging. On intertidal and shallow subtidal reefs, wave climate shapes assemblages in which corals, macroalgae and habitat-forming invertebrates are prominent. This approach links ecological importance to values of the Lord Howe Island Marine Park and supports clear reporting of sensitivities to project impact pathways for environmental approvals.

1.1. Acquisition of field data

1.1.1. Drone Imagery

A drone was used to acquire high-resolution imagery across intertidal and shallow subtidal environments during periods of optimal water clarity and low wind conditions. These conditions were selected to maximise water column transparency and minimise surface distortion, thereby improving image quality for benthic interpretation.

Drone flights were conducted using a pre-programmed grid flight path, with lateral overlap and forward overlap settings optimised to ensure complete and continuous image coverage. Flights captured imagery at a resolution of approximately 2 cm, suitable for detecting fine-scale features such as reef crest textures, algal assemblages, and transitions in substrate composition.

1.1.2. Towed Video Camera

The towed video survey was conducted on 1 March 2025 aboard a locally operated charter vessel. The primary equipment consisted of a high-definition subsea video camera capable of transmitting live imagery to a topside control unit. A dedicated marine scientist monitored the live feed during deployment, adjusting lighting and camera angles to ensure continuous data quality.

Prior to fieldwork, satellite imagery was reviewed to inform the survey design and to highlight potential areas of reef and exposed sediment. TVC transects were aligned parallel to anticipated depth contours to minimise equipment adjustment during deployment and to reduce the risk of seabed collision.

During each transect, the camera was maintained at a consistent altitude of approximately 0.5 m above the seafloor. Between one and seven minutes of benthic video footage was recorded per transect. Vessel speed was kept between 1 and 2 knots to optimise video clarity and coverage. The total summary of TVC survey effort is shown in Table 1.

The following information was recorded on field sheets at each targeted location:

- Date and time
- GPS coordinates
- Water depth (m)
- Dominant BCH type
- Comments to aid post-processing.

Table 1: Daily survey effort for TVC

Survey Date	Survey duration	TVC Transects	Total distance covered (km)
1 March 25	76.3 min	12	3.43 km

1.1.3. Spot Transect Surveys

A georeferenced transect was positioned by the first diver (BMT) and used as a visual reference to take 10 images equally spaced, looking straight down ~0.8 m above the habitat. The first diver also recorded a 3 min high resolution video whilst slowly swimming the full 50 m length of the transect following a consistent depth contour and heading. The same transect was then surveyed by the second diver (O2 Marine) for fish and invertebrates as per the Reef Life Survey methodology (see Appendix D).

1.2. Data processing and analysis

1.2.1. Processing of drone imagery

Drone photo imagery was stitched into a georeferenced orthomosaic using photogrammetry software.

1.2.2. Classification of towed video

Ground truthing videos were classified by analysing footage using TransectMeasure. Recordings were visually analysed by a suitably qualified marine scientist and classified into habitat classes following the Collaborative and Automated Tools for Analysis of Marine Imagery (CATAMI) standard classification scheme for scoring marine biota and physical characteristics from underwater imagery, which defines benthic habitats based on the physical and biological characteristics (Table 2).

A quality assurance and quality control (QA/QC) check was conducted by an experienced marine scientist specialising in taxonomy and habitat classifications of benthic video, including verification of percent cover estimates and species identification.

The TransectMeasure data output was synced with the GPS track log, as well as the corresponding auxiliary information (time, depth), to attribute the appropriate BCH category (Table 2) at each point location. Still images were also extracted from each transect at the point which identified a change or transition of BCH type.

1.2.3. Classification of spot transect imagery

The georeferenced video and still imagery from the transects were classified and collated to provide additional ground truthing and produce a reference map which was subsequently used to integrate ecological observations into the BCH mapping framework.

Table 2: Classifications scheme used for towed video

Substrate	Major Class	Detailed Class	Total biota cover (%)
Unconsolidated (Soft): Mud / Silt (<64 um) Sand / Mud - Flat Sand / Mud - 2D Sand / Mud - 3D Sand / Mud - Bioturbation Infrastructure Pebble / Gravel Coarse Sand (with shell fragments) Biogenic Veneer: Flat Low (<1 m) Consolidated (Hard): Cobbles Boulders Rock - Flat Rock - Low (<1 m) Rock - Moderate (1-3 m) Rock - High (>3 m) Rock - Wall Infrastructure	Seagrass	Halophila spp.	Bare (0%) Low (<15%) Moderate (15% - 45%) High (45% - 75%) Dense (>75%)
		Zostera spp.	
		Unconfirmed (ephemeral)	
		Unconfirmed (perennial)	
		Mixed	
	Macroalgae	Red	
		Brown	
		Green	
		Mixed	
		Other	
	Hard Coral	Massive	
		Submassive	
		Plating	
		Encrusting	
		Branching	
		Free Living	
		Mixed	
		Other	
	Filter Feeders	Sponges	
		Bivalves	
		Ascidians	
		Soft Coral	
		Mixed	
Other			
Microphytobenthos	Microphytobenthos		
Bare	Bare		

1.3. Benthic habitat mapping

Spatial dataset layers (Table 3) were compiled in QGIS for integration and analysis to assess and map BCH types across the survey area.

Table 3: Datasets used in mapping

Dataset	Description	Spatial Data Type	Resolution	Source
Classified towed video transects	Points with attributes including substrate, relief, dominant taxa, cover, subdominant taxa. Transects distributed evenly across mapping area.	Vector (point)	N/A	BMT
Drone orthomosaic	Continuous high resolution imagery across the intertidal mapping area.	Raster	2 cm	BMT
Bathymetry	Provides information on depth and terrain.	Raster	5 m	Linklater et al., (2018)
Slope	Derived from bathymetry. Provides information on reef relief and terrain.	Raster	5 m	Derived from bathymetry dataset from Linklater et al., (2018)
Spot transect imagery	Photoquadrats and video taken along fish and invertebrate survey transects.	N/A	N/A	BMT

Habitat classification was undertaken using a manual object-based approach within an Object-Based Image Analysis (OBIA) framework, leveraging segmented units generated by the *LargeScaleMeanShift* algorithm in OTB.

The object-based segmentation method groups spectrally and spatially similar pixels into discrete polygon features, producing a vector shapefile that delineates homogeneous regions across the image. Compared to pixel-based approaches, object-based segmentation provides units that more closely align with natural ecological boundaries. Due to the limited spatial extent of the mapping area and the high visibility of benthic features in the drone orthomosaic, a manual classification approach was considered the best approach for optimal accuracy. Each segmented polygon was assessed individually with reference to both the visual characteristics observed in the orthomosaic and the classified towed video transects. Habitat types were manually assigned to each polygon based on this combined interpretation. Where adjacent segments shared the same classification, they were merged to form continuous habitat units. This approach was considered the most accurate method for delineating benthic habitats under the given conditions.

Traditional accuracy assessments, such as error matrices and Kappa statistics, could not be applied, as these are specific to supervised classification methods. However, a visual validation indicated strong alignment between habitat classifications, aerial imagery, and ground-truth data. The high coverage of ground-truthing points across the mapping area and clear visibility of benthic features in the drone orthomosaic supports a high level of confidence in the mapped distribution of benthic habitats.

1.4. Desktop Assessment

A desktop assessment was undertaken to complement field survey data by incorporating existing scientific literature, monitoring programs and geospatial datasets relevant to the benthic ecology and geomorphology of Lord Howe Island's northern lagoon. This component aimed to refine habitat characterisation, confirm species distributions, and identify conservation values and potential sensitivities within key habitat zones.

The assessment focused on seven geomorphic and ecological zones: Outer Reef, Reef Crest, Reef Flat, Patch Reefs and Coral Bommies, Seagrass Beds, Lagoon Floor, and Fringing Reef. For each zone, benthic biodiversity, dominant communities, key ecological functions, and the potential presence of threatened or conservation-significant species were reviewed.

The desktop review drew on the following sources:

- **Reef Life Survey (2025):** Source of long-term quantitative data on benthic cover, reef condition, and fish/invertebrate communities.
- **Woods, C. (2022). Intertidal Biodiversity of the LHIMP:** Baseline for macroinvertebrate assemblages, REPI scores, and spatial biodiversity patterns.
- **Harasti et al. (2022). Environmental Values of the LHIMP:** Key document for identifying high-value habitats, endemism, and conservation priorities.
- **NSW DPI and Parks Australia – Marine Park Zoning and Management Plans:** Defines current protection levels, permissible activities, and zoning boundaries across habitats.
- **NSW DPI (2023). Diesel Spill Incident Monitoring Report:** Documents impacts of disturbance on carbonate reef platforms, macroalgal blooms, and sediment health.
- **Kennedy (1999). Reef Growth and Lagoonal Sedimentation:** Primary geomorphic reference for lagoon stratigraphy, reef accretion, and sediment dynamics.
- **Tecchiato et al. (n.d.). Systematic Literature Review of Lord Howe Marine Systems:** Synthesises key ecological themes, threats, and knowledge gaps relevant to benthic communities.
- **Nearmap Satellite Imagery (2023):** Provides high-resolution spatial context for interpreting drone gaps and verifying geomorphic zones.
- **Temperate East Marine Parks Network Management Plan (Director of National Parks, 2018):** Relevant to outer reef and marine biodiversity management beyond the state marine park.
- **Biodiversity Management Plan for Lord Howe Island (DECC, 2007):** Identifies species of conservation concern and ecological communities under stress.
- **CATAMI Classification Framework:** Defines the habitat categories used in both drone and TVC classifications.

Species-specific and habitat-based biodiversity indicators were drawn from classified field datasets and relevant literature. Zonation and ecological interpretation were cross-referenced with established typologies used in Lord Howe Island Marine Park planning documents.

2. Results

2.1. Ground truthing

2.1.1. Towed Video Camera

The ground-truthing dataset comprised 4,086 classified points (Table 4, Table 5), representing a detailed cross-section of benthic habitat types and associated biota within the survey area. The classification captured both dominant biota type (Figure 2) and percent cover (Figure 3), providing insight into the structure and composition of the benthic community. Consistent with the LHIMP environmental values, these data are interpreted for two primary BCH value categories, Corals and Macrophytes (macroalgae and seagrass), synthesised across the Lagoon and Intertidal and shallow subtidal ecosystems in later sections.

Coral-dominated transects were primarily located along the western edge of the lagoon and near North Passage (Figure 2) (e.g., GX010282, GX010283), where branching and massive hard coral assemblages were prevalent. Hard corals (predominantly classified as “Mixed”) represented the most abundant biotic group, making up 37.6% of all classified points. Hard coral cover ranged across all classes, with the majority falling within the moderate (18.6%) and high (9.6%) categories, indicating well-established coral assemblages in several areas. Most hard coral records were grouped as “Mixed,” but smaller proportions were also identified as Massive (1.6%) and Branching (0.2%) forms. The dominance of mixed hard corals and their distribution across varying cover classes is indicative of the mosaic of reef conditions in the survey area, ranging from patch reefs or bommies to more consolidated reef platforms. Macroalgae comprised 23.9% of the total classified points (as “Mixed”) and were most found in the low cover class (19.8%). Moderate and high cover classes were relatively underrepresented (1.3% and 2.9%, respectively). The dominance of low cover macroalgae indicates its widespread but sparse occurrence, occupying inter-reef areas and sand/rubble substrates. Macroalgae was mainly recorded on mid-lagoon transects, particularly across areas of coral rubble (Figure 2).

Seagrass was identified as *Zostera* spp. (18.2%), *Halophila* spp. (12.3%), and a minor amount of unidentified ephemeral species (0.2%). Combined, seagrass represented a significant portion (30.7%) of all classified points. Seagrass occurred across all cover categories, with a considerable share in moderate (12.5%), high (11.9%), and dense (4.6%) classes indicative of extensive and often high-biomass meadows. These were predominantly located in the northern corner of Hunter Bay.

Taken together, the coral and macrophyte signals represent the principal BCH values for the Marine Park, and they structure the reporting of patterns and sensitivities that follows.

Bare substrate was recorded at 13.6% of points, mainly found in patch locations between broader areas of biota.

Table 4: Major biota and associated percent cover classifications across the ground-truth towed video transects

Biota Class	Cover	Points classified	Percentage of classified points with biota
Hard Coral	Low	208	5.1
	Moderate	761	18.6
	High	392	9.6
	Dense	174	4.3
Macroalgae	Low	808	19.8
	Moderate	52	1.3
	High	118	2.9
Seagrass	Low	70	1.7
	Moderate	510	12.5
	High	487	11.9
	Dense	188	4.6
Bare	Bare	318	7.8
Total		4086	100

Table 5: Dominant biota classifications recorded across the ground-truth towed video transects

Biota Class	Number of points classified	Percentage (%)
Hard Coral - Mixed	1462	35.8
MA - Mixed	978	23.9
Seagrass - <i>Zostera</i> spp.	745	18.2
Seagrass - <i>Halophila</i> spp.	503	12.3
Bare	318	7.8
Hard Coral - Massive	67	1.6
Seagrass - Other (Ephemeral)	7	0.2
Hard Coral - Branching	6	0.2
Total	4086	100

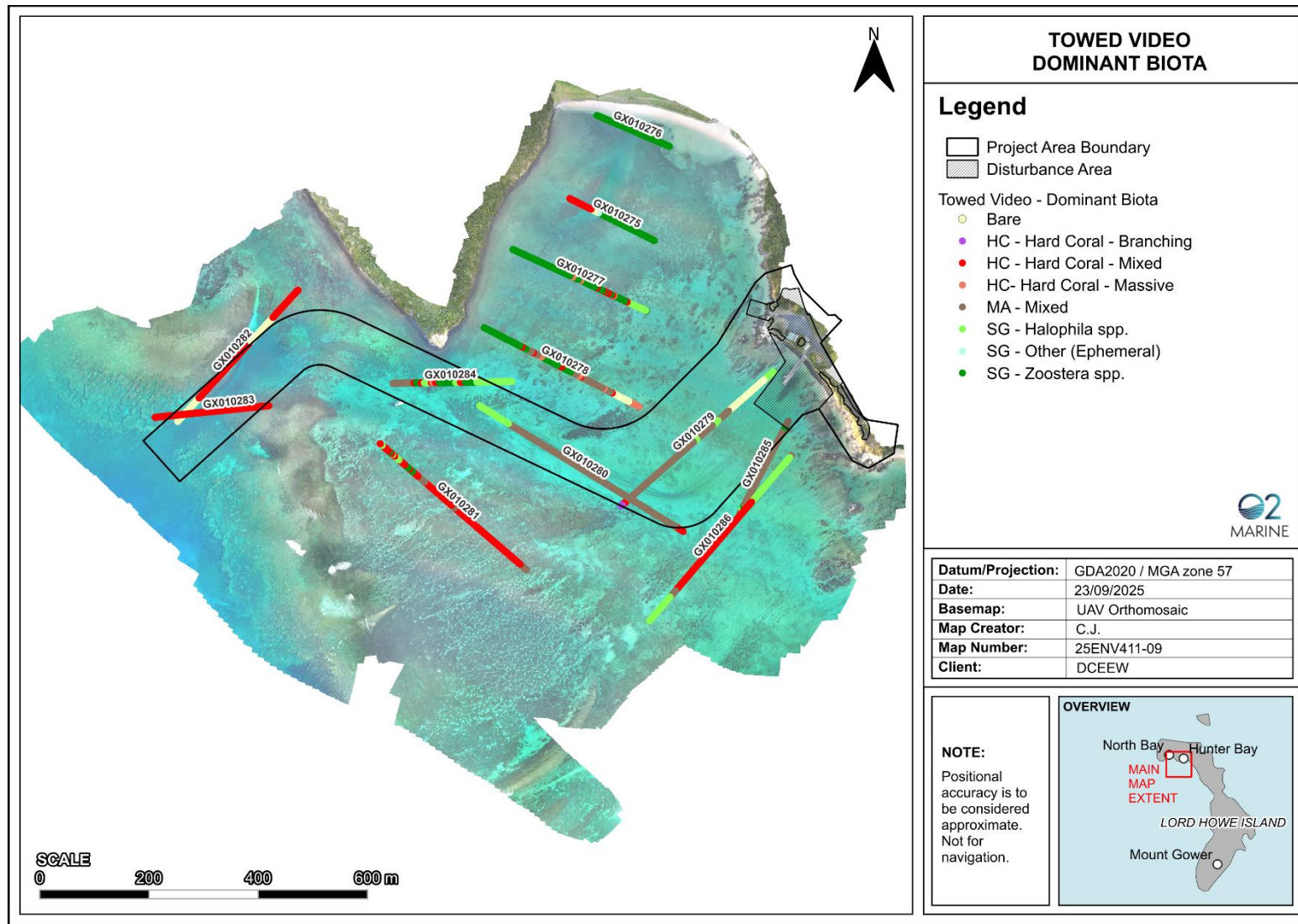


Figure 2: Drone orthomosaic overlaid with classified video transects (Dominant biota)

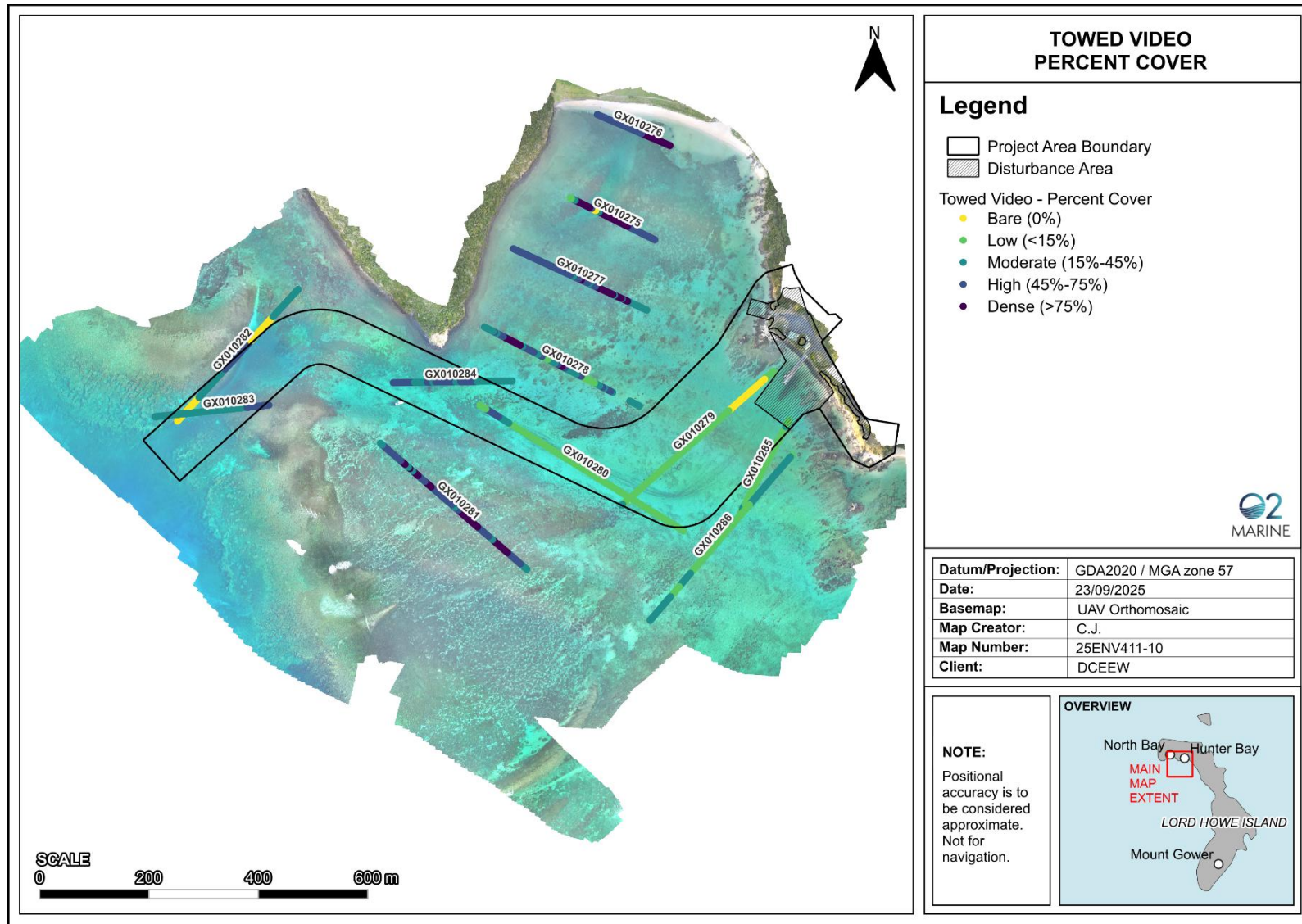


Figure 3: Drone orthomosaic overlaid with classified video transects (Percent cover)

2.1.2. Spot Transect Dive Surveys

Fifteen spot dive transects were completed within the project area (Figure 4). These provided direct diver-based observations of fish assemblages and benthic habitat structure. While fish data are presented in Appendix D, the benthic imagery and notes were used here to validate substrate classifications and ensure consistency across survey methods.

Observations from the dive transects confirmed the presence of key habitat features recorded in the towed video, including mixed hard coral assemblages (branching and massive), macroalgal patches, and seagrass meadows. This provided additional confidence that the BCH map accurately reflects the distribution of benthic communities, while also enhancing the ecological context by linking habitat types with associated reef fish assemblages along the same transect.

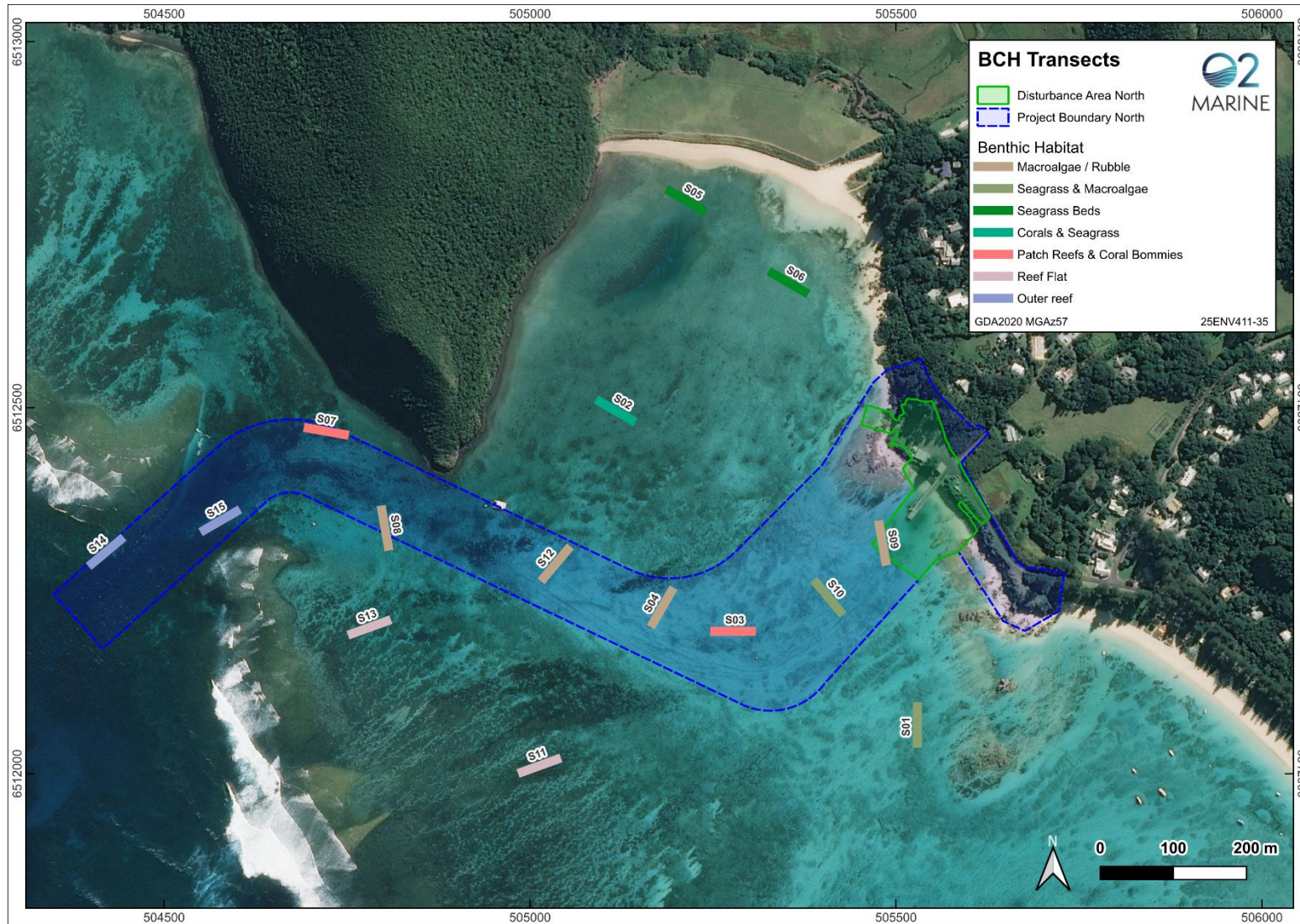


Figure 4: Transect Dive Survey locations and BCH observations used to supplement benthic habitat mapping.

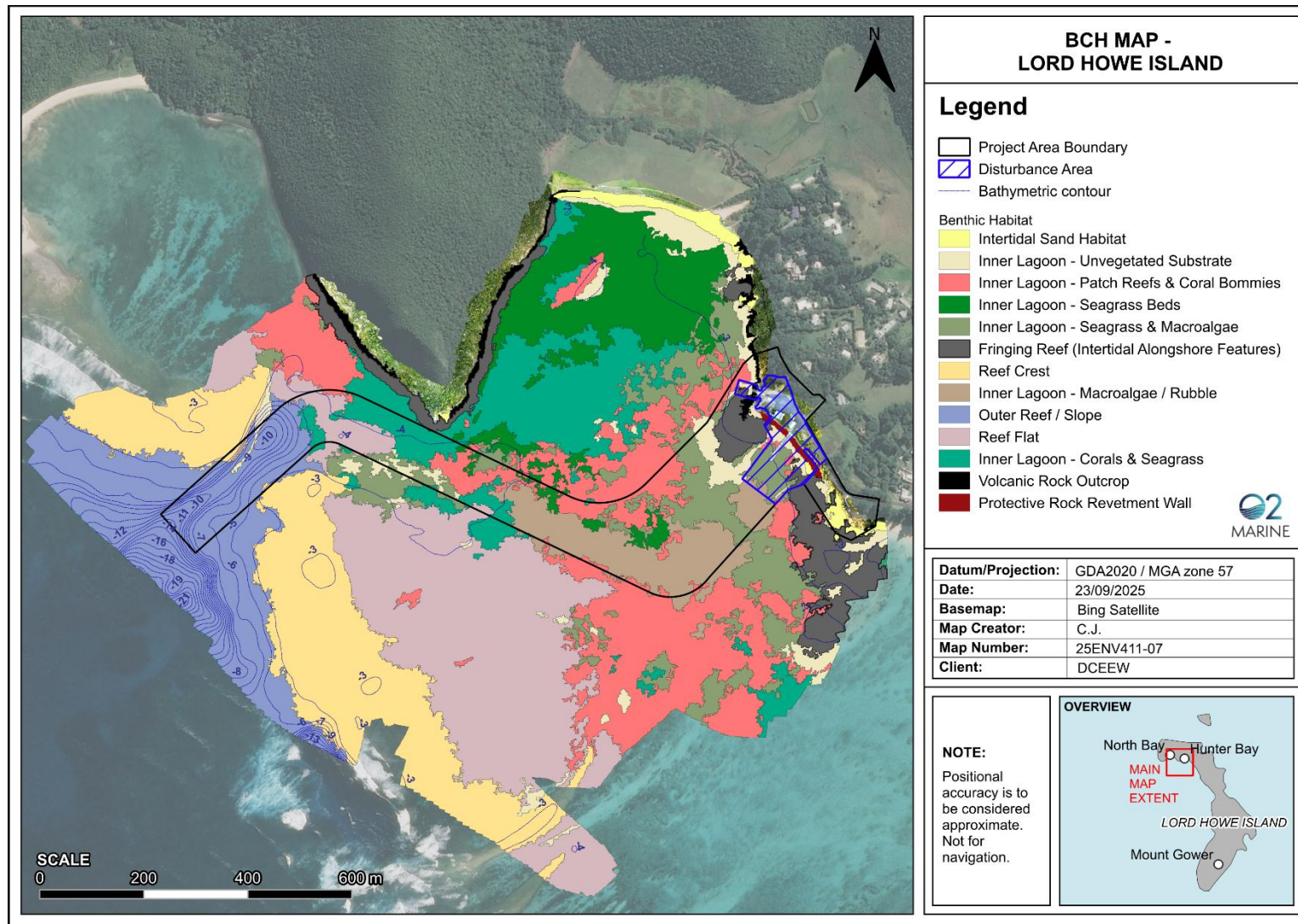


Figure 5: Benthic habitat map.

2.2. Distribution of Benthic Habitat

The benthic habitat map (**Error! Reference source not found.**), developed from the integration of drone imagery, towed video transects, spot dive transects and bathymetric modelling, identifies twelve (12) discrete BCH types across the mapped area. The total mapped area encompassed approximately 117.37 ha, with habitat types distributed unevenly according to geomorphic setting, water depth, exposure regime, and substrate type (Table 6).

BCH types are categorised under subtidal and intertidal zones, with varying substrate complexity, biological cover, and ecological function (Table 7). Geomorphology-based classes were used because they could be mapped at the available resolution and aligned with natural ecological boundaries, allowing later polygons to be delineated with an object-based image analysis workflow and manual interpretation of the orthomosaic and ground-truthing data. These geomorphology-based classes follow the Lord Howe Island Marine Park ecosystem schema, which is organised by horizontal and depth zonation and incorporates recent geomorphological classifications. In this framework, lagoon reefs, seagrasses and ocean or lagoon beaches fall under the Lagoon ecosystem, while intertidal reef and open-coast fringing reefs fall under the Intertidal and shallow subtidal ecosystems. The lagoon's carbonate-dominated sands with seagrass bands, and the wave-exposed open-coast reefs, further support using reef flat, reef crest, outer slope, patch reefs, seagrass beds and related units as discrete mapping classes. At Lord Howe Island, these classes reflect established geomorphic units of the fringing reef, crest and outer slope described for the lagoon system (Kennedy, 1999) and align with the Marine Park's geomorphic classification derived from bathymetric and geological data.

Following the environmental values of the Lord Howe Island Marine Park, those geomorphology categories were grouped under the Lagoon ecosystem and the Intertidal and shallow subtidal ecosystems.

2.2.1. The Lagoon ecosystem

The most extensive habitat class was the Reef Flat, which accounted for 22.03 ha (19%). This habitat forms a broad horizontal zone across the mid-lagoon region and is characterised by encrusting coralline algae, turf algae, and occasional low-growing coral colonies.

Inner Lagoon Patch Reefs and Coral Bommies were the second most dominant habitat, covering 17.81 ha (15%). These bommies are distributed across the southern and western portions of the lagoon floor, typically embedded within sandy substrates and supporting diverse coral assemblages dominated by *Acropora* and *Porites* spp.

The Reef Crest, a shallow and narrow ridge at the transition between the lagoon and outer reef, accounted for 17.09 ha (15%) and acts as a physical barrier subjected to high wave energy. It supports low-relief corals and dense turf algae.

The Outer Reef / Slope occupied 14.09 ha (12%) and forms the deeper, wave-exposed perimeter of the mapping area. This zone is defined by consolidated volcanic substrate with moderate coral cover and encrusting biota. It provides ecological connectivity between inner lagoon habitats and offshore reef environments.

Several inner lagoon habitats with varying combinations of seagrass, macroalgae, and coral were also prominent. Corals & Seagrass covered 10.71 ha (9%), typically occurring in low-energy zones with patchy benthic structure. Seagrass & Macroalgae spanned 9.33 ha (8%), reflecting transitional assemblages, while Seagrass Beds alone comprised 9.15 ha (8%), mostly dominated by *Zostera muelleri* and *Halophila ovalis* meadows.

Macroalgae / Rubble habitats covered 4.99 ha (4%), generally forming low-relief substrates within the western inner lagoon. These areas featured patchy macroalgal cover interspersed with coral rubble and soft sediment pockets.

Unvegetated Substrates, typically composed of bare sand or silt, accounted for 4.2 ha (4%) and were located primarily in the deeper inner lagoon basins and between reef structures.

2.2.2. Intertidal and shallow subtidal ecosystems

Intertidal soft and hard substrates were limited in areal extent. Intertidal Sand Habitats, including tidally influenced sandy beaches, made up 1.25 ha (1%), while Volcanic Rock Outcrops, comprising irregular boulder fields and rounded rock platforms derived from weathered cliff deposits, accounted for 1.11 ha (1%). Both categories were spatially restricted but remain ecologically relevant due to their role in shoreline buffering and provision of niche intertidal habitats.

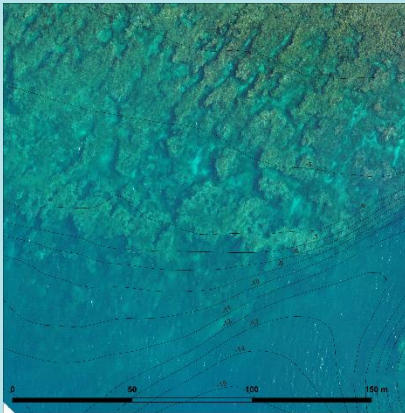
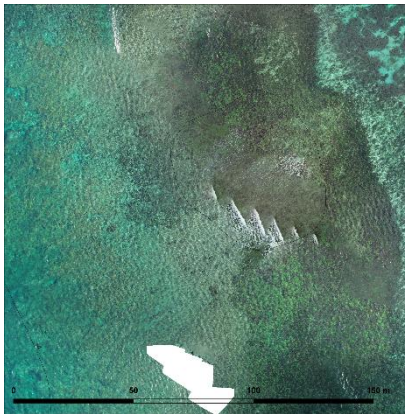
Fringing Reef (Intertidal Alongshore Features) was mapped along the western and northeastern shoreline margins, occupying 5.61 ha (5%). These narrow, emergent reefs are dominated by turf algae, gastropods, and encrusting organisms, and are regularly exposed during low tide.

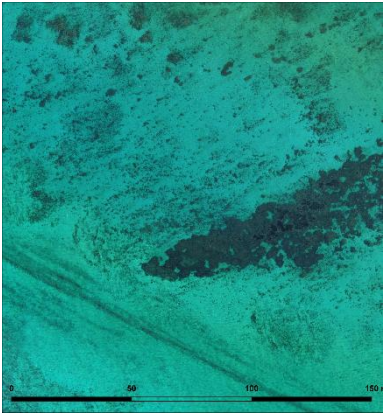
Overall, the mapped benthic habitats are spatially heterogeneous, with high biotic complexity concentrated in the mid- to inner lagoon and outer reef zones, while structurally simpler habitats such as unvegetated substrates and rocky intertidal zones are more fragmented and peripheral. This spatial mosaic supports diverse ecological functions, from juvenile fish foraging grounds to coral-algal competition zones and sediment-trapping platforms.

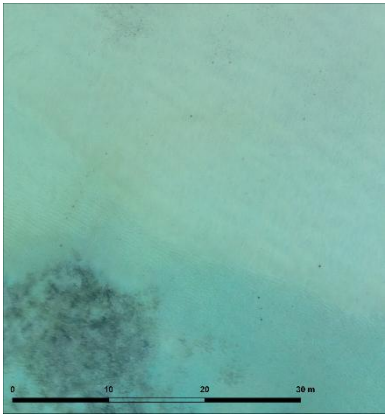
Table 6: Area (hectares) and proportion (%) of mapped benthic communities and habitats in the mapping area

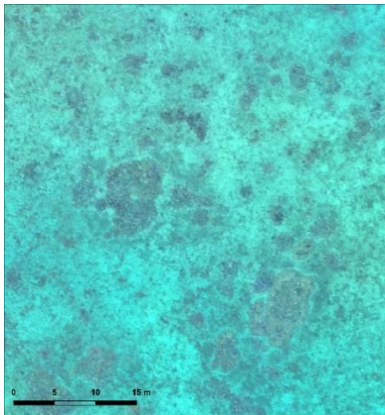
Benthic habitat classification	Area (ha)	Proportion (% of area)
Reef Flat	22.03	19%
Inner Lagoon - Patch Reefs & Coral Bommies	17.81	15%
Reef Crest	17.09	15%
Outer Reef / Slope	14.09	12%
Inner Lagoon - Corals & Seagrass	10.71	9%
Inner Lagoon - Seagrass & Macroalgae	9.33	8%
Inner Lagoon - Seagrass Beds	9.15	8%
Fringing reef (intertidal alongshore features)	5.61	5%
Inner Lagoon - Macroalgae / Rubble	4.99	4%
Inner Lagoon - Unvegetated Substrate	4.2	4%
Intertidal Sand Habitat	1.25	1%
Volcanic Rock Outcrop	1.11	1%
Total	117.37	100

Table 7: Classifications used in BCH mapping

BCH Class	Description	Example Image (left: drone imagery; right: towed video stills)	
SUBTIDAL AREA			
Outer Reef / Slope	Steeply sloping outer reef zone beyond the reef crest, composed of consolidated volcanic or carbonate substrate. Characterised by moderate coral cover, encrusting sponges, and turf algae. High exposure to wave energy.		
Reef Crest	Narrow, shallow ridge at the seaward edge of the reef flat. Subject to intense wave action, typically dominated by encrusting coralline algae, low-profile corals, and turf algae. Functions as a physical barrier between lagoon and outer reef environments.		

BCH Class	Description	Example Image (left: drone imagery; right: towed video stills)	
Reef Flat	Horizontal or gently sloping reef flat at or near the low tide mark. Typically supports encrusting coralline algae, turf algae, macroalgae, and low-growing hard coral species.		
Patch Reefs & Coral Bommies (Inner Lagoon);	Discrete coral outcrops or bommies occurring within sandy lagoon substrate. Vary in size and elevation, often dominated by <i>Acropora</i> and <i>Porites</i> spp. with associated reef fauna.		

BCH Class	Description	Example Image (left: drone imagery; right: towed video stills)	
Inner Lagoon - Seagrass Beds	Shallow, soft-sediment areas colonised by seagrasses. <i>Zostera muelleri</i> and <i>Halophila ovalis</i> form sparse to moderate beds providing nursery habitat for fish and invertebrates.		
Inner Lagoon - Unvegetated Substrates	Flat, featureless sandy or silty substrates with no visible benthic cover. Typically located in deeper lagoon basins or between patch reefs.		

BCH Class	Description	Example Image (left: drone imagery; right: towed video stills)	
Inner Lagoon - Seagrass & Macroalgae	Mixed habitat where seagrass beds are interspersed or co-located with erect brown macroalgae. Reflects transitional zones or seasonal shifts in dominance.		
Inner Lagoon – Corals & Seagrass	Patchy habitat where seagrass meadows co-occur with isolated coral colonies or rubble bases. Found in low-energy zones, supporting benthic diversity and ecological connectivity.		

BCH Class		Description	Example Image (left: drone imagery; right: towed video stills)	
Inner Lagoon - Macroalgae / Rubble (Inner Lagoon)		Low-relief lagoon floor with scattered coral rubble and patchy macroalgal cover. Often supports turfing algae, invertebrates, and juvenile fish.		
INTERTIDAL AREA				
Fringing reef (intertidal alongshore features)		Narrow reef structures aligned parallel to the shoreline. Exposed at low tide, often dominated by encrusting algae, gastropods, barnacles, and turf algae.		

BCH Class	Description	Example Image (left: drone imagery; right: towed video stills)	
Volcanic Rock Outcrop	Irregular volcanic rock outcrops, talus slopes, coral rubble, and rounded rock platforms. These intertidal features form from geological outcrops or weathered cliff material, structurally complex but spatially discontinuous.		
Intertidal Sand Habitat	Unconsolidated sandy shorelines subject to tidal inundation.		

3. Discussion

This section provides a habitat-by-habitat desktop assessment of BCH types present in the northern lagoon of Lord Howe Island, with a focus on the western side where marine infrastructure development is proposed. The aim is to synthesise available ecological information, both spatial and biological, to inform the understanding of current habitat condition, biodiversity values, and potential vulnerabilities to development.

The desktop assessment integrates multiple lines of evidence, including:

- A description of geomorphic and environmental features,
- Identification of dominant and subdominant benthic communities,
- Cross-referencing with relevant scientific reports and survey data,
- Notation of species or assemblages of conservation significance,
- Assessment of ecological sensitivity and pressures.

The zones assessed include:

The Lagoon ecosystem

- Outer Reef / Slope
- Reef Crest
- Reef Flat (Coral / Macroalgae reef)
- Patch Reefs and Coral Bommies (Inner Lagoon)
- Seagrass Beds (Inner Lagoon)
- Unvegetated Substrates (Inner Lagoon)
- Seagrass and Macroalgae (Inner Lagoon)
- Seagrass and Corals (Inner Lagoon)
- Lagoon Floor, Macroalgae / Rubble (Inner Lagoon)

Intertidal and shallow subtidal ecosystems

- Intertidal Sand Habitat
- Volcanic Rock Outcrop
- Fringing Reef (intertidal alongshore features)

3.1. The Lagoon ecosystem

3.1.1. Outer Reef / Slope

The Outer Reef or barrier slope along the northern lagoon of Lord Howe Island, particularly on the western flank adjacent to the planned marine infrastructure footprint, forms the seaward boundary of the lagoon system. This zone comprises sloping volcanic and carbonate reef structures exposed to dominant swell energy from the northeast and east. It provides a critical buffer protecting the interior lagoon from wave action while supporting distinct benthic assemblages shaped by high-energy hydrodynamics.

Geomorphic data and historical studies indicate that this section of the Outer Reef exhibits a consolidated volcanic substrate with coralline algae and low-relief coral development (Kennedy, 1999). Drone footage and towed video imagery collected adjacent to the Project area confirm the presence of moderate coral cover interspersed with turf algae, sponges, and encrusting invertebrates. Coral communities include encrusting and branching forms of *Acropora*, *Pocillopora*, and *Porites*, mostly in zones of moderate relief and reduced wave scouring.

Benthic invertebrate data collected from adjacent northern platform plots revealed several ecologically significant taxa. The vermetid gastropod *Thylacodes siphon* was recorded in very high abundance (>6,000 individuals across plots), suggesting stable substrate availability and extended reef development. This sessile suspension feeder forms calcareous tubes and can influence sediment dynamics and water flow across reef surfaces.

Predatory gastropods were also present in moderate densities, including *Oppomorus noduliferus* (East Australasian distribution) with >150 individuals and *Dicathais orbita* (Australasian), a muricid whelk commonly associated with coral rubble and macroalgal substrate. Less common taxa included *Euplyca scripta* and *Ergalatax contracta*, representing Indo-Pacific detritivore and predatory niches respectively. These records suggest the outer slope and its proximal platform areas host a functionally diverse benthic invertebrate community, including reef-associated predators, filter feeders, and detritivores. Their distribution correlates with structural reef features documented in video transects and supports the classification of this zone as ecologically productive.

The ecological significance of the Outer Reef zone is further supported by Harasti et al. (2022), who identified this habitat as critical for sustaining endemism and biodiversity hotspots within the Lord Howe Island Marine Park.

This section of reef is located within a designated Sanctuary Zone under the NSW Lord Howe Island Marine Park Zoning Plan and lies adjacent to the Habitat Protection Zone of the Temperate East Marine Parks Network (Director of National Parks, 2018). These designations restrict extractive activities and vessel anchoring, recognising the area's ecological importance and sensitivity.

Given its location adjacent to the planned works area and its function as a biophysical barrier, this zone is considered ecologically sensitive, with vulnerability to mechanical disturbance, sediment plumes, and chronic stressors such as climate-driven bleaching and water quality degradation. Targeted mitigation and exclusion measures are recommended for any marine construction activity with potential to influence this habitat.

3.1.2. Reef Crest

The reef crest along the northern lagoon of Lord Howe Island, particularly adjacent to the proposed development footprint, constitutes a shallow, wave-exposed geomorphic zone immediately landward of the outer reef slope. It plays a critical role in dissipating wave energy and marks a transitional zone between deeper coral assemblages and the more sheltered reef flat and lagoon environments.

Geomorphologically, the reef crest is characterised by low-relief algal ridges and consolidated carbonate substrate. Based on historical assessments (Kennedy, 1999) and satellite-derived geomorphic mapping, the crest is emergent or near-surface at low tide and demonstrates variable width

and complexity. Reef crest features documented in the vicinity of the works area include encrusting coralline algae, macroalgae (notably *Sargassum* and *Turbinaria*), and shallow coral colonies such as *Pocillopora damicornis* and *Porites cylindrica*.

Benthic imagery and towed video data confirm that the reef crest exhibits a patchy mosaic of coral rubble, low-growing hard corals, and turf algae. This assemblage is consistent with other high-energy reef crests at subtropical latitudes and reflects seasonal shifts in temperature, turbidity, and macroalgal competition.

While the reef crest supports relatively low coral cover compared to deeper slope zones, it provides critical habitat for sessile invertebrates, turfing macroalgae, and juvenile stages of reef-dwelling organisms. Stewart Smith (2025) benthic invertebrate surveys identified vermetid gastropods (*Thylacodes* spp.), small echinoids (e.g., *Echinometra mathaei*), and crustaceans such as *Cyclograpsus* spp. in adjacent platform areas that likely extend into the reef crest during tidal inundation.

This habitat zone also exhibits high physical variability due to constant wave exposure and episodic storm surges. As such, benthic community composition may be highly dynamic and spatially heterogeneous.

The reef crest adjacent to the proposed works lies within a Habitat Protection Zone under the NSW Lord Howe Island Marine Park Zoning Plan, providing a degree of regulatory oversight for extractive activities. The broader area is also within the multiple-use boundary of the Temperate East Marine Parks Network (Director of National Parks, 2018), which recognises the role of reef crest habitats in maintaining ecosystem connectivity.

Given the reef crest's ecological role in energy dissipation, early-stage habitat provision, and reef accretion processes, this zone is considered sensitive to hydrodynamic alterations, sediment deposition, and potential shading or scour effects from anthropogenic disturbances.

3.1.3. Reef Flat (Coral / Macroalgal reef)

The reef flat in the northern lagoon of Lord Howe Island, directly landward of the reef crest and adjacent to the proposed development footprint, forms a shallow, semi-exposed habitat that transitions between high-energy outer reef zones and the sheltered inner lagoon. Typically ranging from 0.5 to 2 m in depth, this zone features flat to gently undulating carbonate substrates and serves as a biologically diverse and geomorphically stable platform for benthic assemblages.

Geomorphic observations and drone-based mapping (March 2025) confirm the reef flat comprises consolidated reef platform with patchy coral rubble and carbonate sand veneers. Distinct benthic structures observed include microatolls, encrusting coral colonies, and scattered macroalgae, with higher structural complexity noted along shallow depressions and reef pool features. These structural features are associated with seasonal hydrodynamic variation and reef-building processes.

Benthic towed video transects across this zone documented moderate cover of macroalgae, turf algae, and encrusting coral species. Taxa included *Lobophora* and *Sargassum* spp. as dominant macroalgal forms, and hard coral taxa such as *Porites cylindrica* and *Acropora* spp. as scattered colonies or crusts. Substrate relief was generally low to moderate, with areas of intact coral pavement interspersed with rubble and biogenic sediment.

Fish and Invertebrate transects (Appendix B) recorded ecologically relevant species within reef flat environments, particularly at Sites S06 and S09, including herbivorous sea urchins (*Tripneustes gratilla*), detritivorous gastropods (e.g. *Euplica* spp.), and mobile crustaceans such as *Grapsus* spp. Although coral cover was lower than on the reef slope, the reef flat supports early successional stages of coral growth and acts as a recruitment area for benthic invertebrates and juvenile fish.

The reef flat also plays an important functional role in primary productivity and nutrient cycling, with dense patches of macroalgae contributing to seasonal trophic inputs and supporting grazers and epifaunal invertebrates. Its position within the tidal frame makes it highly responsive to environmental shifts, including temperature extremes, freshwater inputs, and light availability.

The reef flat lies within the Habitat Protection Zone of the Lord Howe Island Marine Park, providing limited protection against anchoring, trampling, and extraction. While some sections are directly adjacent to the proposed infrastructure development area, they remain outside the immediate disturbance footprint. However, potential indirect pressures from sediment transport, shading, and altered flow dynamics warrant careful consideration in project planning and mitigation.

This habitat is considered moderately sensitive, especially to smothering and macroalgal proliferation, which could follow sedimentation or nutrient enrichment. It is ecologically significant due to its transitional nature and its role in reef regeneration and community connectivity.

3.1.4. Patch Reefs & Coral Bommies (Inner Lagoon)

Within the northern lagoon of Lord Howe Island—particularly west of North Passage and near the proposed infrastructure footprint—numerous isolated patch reefs and coral bommies rise from the lagoon floor, punctuating areas of soft sediment with complex three-dimensional structure. These features provide critical habitat for sessile benthic taxa, invertebrates, and reef-associated fish, contributing substantially to localised biodiversity within the lagoon system.

Towed video transects and drone imagery captured during the March 2025 surveys indicate that patch reefs and bommies vary in height, diameter, and rugosity. Substrates range from consolidated carbonate platforms with coral pavement to coral rubble and coarse sand matrices. Coral cover across these bommies is highly variable but can exceed 40% in areas of moderate relief. *Acropora* spp. and *Montipora* spp. dominate on the bommie crests, while massive *Porites* colonies are often observed at the base. The presence of turf algae, *Lobophora* spp., and encrusting macroalgae suggests an active balance between coral growth and algal colonisation, potentially influenced by seasonal variation and water quality gradients.

Benthic invertebrate data from the Fish and Invertebrate survey (Appendix D) support the ecological significance of these structures. At bommie-associated transects (e.g., S11, S13, S14), mean invertebrate richness reached up to seven species per 100 m²—among the highest recorded across all surveyed habitats. Noteworthy taxa included:

- *Tridacna maxima* (Small Giant Clam), observed embedded within coral heads at S13 and S14;
- *Centrostephanus rodgersii* (Long-spined Sea Urchin), recorded at high densities at S14 (72 individuals/100 m²), indicative of herbivory function on algal surfaces;
- *Tripneustes gratilla*, an echinoid grazer was observed in lower abundance on elevated bommie crests;

- Encrusting sponges and ascidians, noted in shaded overhangs and vertical faces on drone imagery and confirmed via stills extracted from towed footage.

Patch reefs and bommies serve as connectivity nodes within the lagoonal mosaic, functioning as stepping-stone habitats between more expansive reef flats, seagrass beds, and the outer slope. Their role in larval retention, predator refuge, and benthic recruitment enhances the ecological integrity of the lagoon.

This habitat lies within a designated Habitat Protection Zone under the NSW Lord Howe Island Marine Park Zoning Plan, with parts bordering a Sanctuary Zone. Harasti et al. (2022) highlight the conservation significance of patch reefs due to their structural complexity, coral health, and role in supporting endemic species and broader biodiversity values.

Given their physical prominence, coral assemblages, and faunal diversity, patch reefs and bommies are considered highly sensitive to mechanical disturbance, sediment smothering, and hydrodynamic alteration. Any adjacent anchoring, or construction-related activity must implement robust spatial buffers and water quality controls to avoid degradation of these ecologically valuable microhabitats.

3.1.5. Seagrass Beds (*Zostera muelleri* and/or *Halophila ovalis*)

Seagrass beds within the northern lagoon of Lord Howe Island occur predominantly in shallow, sheltered zones of the inner lagoon, west of North Passage and adjacent to the planned development area. These habitats are typically located between the shoreline and patch reef fields, in areas characterised by low wave energy, fine sediment substrates, and moderate tidal influence. Their ecological function is vital, providing sediment stabilisation, organic matter production, and nursery grounds for benthic invertebrates and juvenile fish species.

Drone imagery and TVC transects conducted in March 2025 confirmed the presence of two dominant seagrass species: *Zostera muelleri* subsp. *capricorni* and *Halophila ovalis*. These species form sparse to moderately dense meadows interspersed with bare sediment and patches of macroalgae. Orthomosaic imagery showed seagrass coverage to be fragmented, with small patches concentrated near Transects S05 and S06. *Halophila* occurred more frequently in deeper, sheltered areas, while *Zostera* was observed in slightly elevated, shallower flats.

Field observations and Fish and Invertebrate survey (Appendix D) data indicate that these seagrass beds support a relatively depauperate assemblage of macroinvertebrates compared to reef habitats. Key results include:

- Low species richness at seagrass transects (S05 and S06), with only 1–2 invertebrate taxa per 100 m².
- Very low invertebrate abundance (<10 individuals/100 m²), suggesting limited macrofaunal utilisation.
- Minimal presence of key echinoids, gastropods, or decapods commonly observed on adjacent reef habitats.

These findings are consistent with literature on high-latitude seagrass ecosystems, where benthic productivity is often driven by epifauna and microbial processes rather than dense macroinvertebrate assemblages. The primary ecological value of these meadows lies in their role as foraging habitat for juvenile fish and as sediment traps contributing to water clarity and biogeochemical cycling.

Mapped seagrass areas west of the existing jetty fall within a Habitat Protection Zone of the NSW Lord Howe Island Marine Park. While seagrass-specific designations do not exist in current zoning overlays, these habitats are recognised in strategic planning as critical contributors to lagoon ecosystem integrity. Seagrass meadows in this area are highly sensitive to anthropogenic pressures. Mechanical disturbance from vessel traffic and anchoring may uproot rhizomes or fragment meadow continuity. Additionally, shading from suspended sediments or marine infrastructure (e.g., piling) can reduce photosynthetic capacity. Management strategies should include exclusion zones, and turbidity control measures to maintain light penetration and prevent degradation of these vulnerable habitats.

3.1.6. Unvegetated Substrates (Inner Lagoon)

Unvegetated substrates dominate the deeper interior of the northern lagoon at Lord Howe Island and occupy transitional spaces between reef features, including areas adjacent to Fish and Invertebrate transects S05, S09, and S10 (see Appendix D). However, benthic habitat observations or data were not provided for this assessment. These habitats are typically characterised by flat, low-relief expanses of unconsolidated carbonate sands and silts, interspersed with occasional coral rubble and shell fragments. TVC footage and drone orthomosaics show a largely homogeneous benthos with minimal visible macrobiota or structural complexity.

The ecological function of these habitats is primarily associated with sediment retention, organic matter cycling, and as habitat for infaunal assemblages. Analysis of adjacent invertebrate field data, including sediment core samples, indicates the presence of small-bodied deposit feeders and burrowing organisms such as polychaetes, bivalves, and amphipods. However, overall diversity and abundance were low relative to reef and seagrass habitats.

The Fish and Invertebrate data in Appendix D corroborate this pattern:

- S05, located outside the channel and approximately 525 m from the jetty, recorded only one epibenthic macroinvertebrate species per 500 m².
- S09 and S10, both within the historical dredge footprint, showed no visible mobile invertebrates and consisted of coarse sand and rubble. Visual observations noted signs of compaction and possible seabed scouring, potentially linked to past vessel traffic or hydrodynamic exposure.

Although not considered biodiversity hotspots, these unvegetated substrates are important for maintaining lagoon sediment dynamics and may serve as recovery zones for benthic colonisation following disturbances. Their ecological contribution includes bioturbation, detritus processing, and stabilisation of fine sediments.

These areas fall within the Habitat Protection Zone of the NSW Lord Howe Island Marine Park. While not formally zoned for benthic infauna conservation, a precautionary approach to managing potential indirect effects from nearby development is warranted. Given the proximity of proposed marine infrastructure, it is recommended that activities such as anchoring, and propeller wash be managed using good-practice environmental controls. These could include real-time turbidity monitoring, scheduling works during calm weather conditions, and avoiding plume dispersion into sensitive neighbouring habitats.

3.1.7. Seagrass & Macroalgae (Inner Lagoon)

This habitat class represents a mosaic of mixed vegetation zones within the inner northern lagoon of Lord Howe Island, where seagrass meadows (predominantly *Zostera muelleri* and *Halophila ovalis*) overlap with macroalgal communities such as *Sargassum*, *Caulerpa*, and turf-forming red algae. These habitats are typically located in sheltered sandy basins between patch reefs and fringing reef structures, including areas around the northwestern infrastructure footprint.

Drone orthomosaics and towed video footage reveal that this composite habitat exhibits spatial heterogeneity, with alternating bands of seagrass, erect macroalgae, and unvegetated sediment. Vegetation density is variable, with denser cover observed in low-energy pockets adjacent to bommies and reef flats. These areas likely benefit from nutrient inputs and sediment stability created by surrounding structural habitats.

The macroinvertebrate assemblage associated with this habitat class was assessed through field sampling in the northern platform plots. Invertebrate taxa included detritivores, filter feeders, and grazers, indicating a functionally diverse assemblage supported by mixed vegetation. Notable records from the invert data included:

- *Batillaria australis* (detritivorous gastropod) – consistently abundant in vegetated plots across sampling periods.
- *Thylacodes sipho* (sessile vermetid gastropod) – present in moderate numbers, contributing to microhabitat complexity.
- *Pseudopolydora spp.* and *Capitella spp.* (deposit-feeding polychaetes) – indicative of fine sediment and organic input.
- Several taxa of macroalgae-associated amphipods and small decapods – primarily found in plots with dense algal fronds.

Although total species richness was moderate, the functional diversity suggests the habitat supports nutrient cycling, sediment retention, and a degree of nursery function for both invertebrates and juvenile fishes. Compared to unvegetated or purely seagrass zones, these mixed beds show higher trophic complexity and spatial resilience to physical disturbance.

While no listed threatened invertebrates were recorded in these zones, their ecological role in enhancing habitat connectivity and productivity is evident. These vegetated mosaics fall within the Habitat Protection Zone of the Lord Howe Island Marine Park and are located near mapped EPBC-listed marine vegetation areas. Their patchy structure may buffer adjacent reef habitats by slowing flow velocities and trapping sediment.

The sensitivity of this habitat is low. It is potentially impacted by nutrient shifts from surface/groundwater runoff or sediment resuspension from vessel movement.

3.1.8. Seagrass / Coral (Inner Lagoon)

In the inner lagoon west of North Passage, a patchy mosaic of coral and seagrass habitat occurs in shallow, low-energy areas. These mosaics form in zones where small coral heads (mainly *Acropora spp.* and *Porites cylindrica*) emerge from coarse sediment interspersed with *Zostera muelleri* or *Halophila ovalis*. Drone and TVC imagery confirm that this mixed habitat is structurally heterogeneous, with

variable coral cover and intermittent seagrass meadows concentrated around elevated microtopography or near bommie bases.

Benthic community complexity in this zone is relatively high, with a combination of sessile and motile taxa supported by the dual habitat structure. Field observations and benthic video transects show a visible overlap of turf algae, encrusting sponges, macroalgae, and coral rubble, often accompanied by isolated clumps of seagrass growing in sandy interstitial spaces. This fine-scale heterogeneity increases microhabitat availability, promoting invertebrate diversity and providing foraging and refuge opportunities for reef-associated fauna.

Macroinvertebrate data from adjacent Lagoon North platform plots indicate that several species consistently occur in these coral–seagrass interface zones. These include:

- *Thylacodes sipho*: a sessile vermetid gastropod recorded in extremely high abundance (up to 1,000 individuals/500 m²), suggesting stable carbonate substrate and strong filtering capacity.
- *Oppomorus noduliferus*: a predatory muricid found in increasing densities over time (up to 39 individuals per plot), typically associated with rubble and mixed substrates.
- *Dicathais orbita*: another muricid whelk present in lower but consistent numbers, indicating long-term substrate suitability.
- Occasional records of detritivores like *Euplica scripta* and *Ergalatax contracta* suggest the presence of organic matter accumulation zones.

The structural and trophic diversity observed in this zone underscores its ecological role in supporting reef resilience and lagoonal productivity. The habitat acts as a transitional interface between patch reefs, seagrass beds, and bare sediment areas, enhancing benthic connectivity and recovery potential.

Mapped coral–seagrass mosaics within the proposed development area fall inside the Habitat Protection Zone of the Lord Howe Island Marine Park. These habitats are not formally designated for specific protection but are nonetheless recognised for their contribution to lagoon health and biodiversity maintenance (Harasti et al., 2022).

Given the shallow depth, low flushing, and the ecological significance of these mixed habitats, they are considered moderately sensitive to impacts such as shading, sediment resuspension, or alterations to water movement.

3.1.9. Macroalgae / Rubble (Inner Lagoon)

The lagoon floor of the northern lagoon west of Lord Howe Island, particularly in the region extending from the jetty toward North Passage, supports a low relief benthic habitat typified by patchy macroalgal mats interspersed with coral rubble and coarse carbonate sand. These areas generally occur at depths of 3 to 5 m, in zones with moderate light penetration and reduced hydrodynamic energy.

Drone and towed video footage collected across the development footprint and adjacent zones show the substrate to consist of consolidated sand, embedded coral fragments, and scattered rubble. Macroalgal coverage is discontinuous and includes genera such as *Sargassum*, *Lobophora*, and *Dictyota*, often colonising rubble crevices and depressions. Filamentous turf algae were also common, particularly where hard substratum was exposed.

Fish and Invertebrate transects (appendix D), including S03, S04, S06, and S10, recorded macroalgal dominance in several inner lagoon patches. S03 consisted primarily of rubble and sand with sparse

macroalgae and minimal macroinvertebrate activity. S04, closer to the fringing reef, showed elevated structural complexity and higher benthic species richness (20 taxa/500 m²), including cryptic gastropods and amphipods. S10, located near the dredged channel, displayed low macroalgal density and signs of recent scouring or sediment redistribution.

Mobile macroinvertebrate diversity across these sites was generally low. S10 recorded no visible invertebrates, and adjacent rubble dominated areas supported one to 2 taxa/100 m². Notably, echinoids such as *Centrostephanus rodgersii* were absent from this zone, likely due to discontinuous hard substrate and limited foraging potential. Some small polychaetes and cryptic molluscs were noted within turf covered microhabitats. The macroalgae and rubble habitat plays an important ecological role by:

- Stabilising substrate and limiting sediment resuspension
- Acting as a transitional zone between coral rich and unvegetated seafloor
- Providing refuge and foraging opportunities for early life stage reef fauna

This zone falls within the Habitat Protection Zone of the Temperate East Marine Parks Network, a designation that limits extractive activities and supports benthic conservation objectives (Director of National Parks, 2018). Its ecological function, despite patchy biological cover, warrants consideration in impact planning.

This habitat is considered moderately sensitive to seabed contact, sediment plumes, and hydrodynamic shifts. The unconsolidated rubble and low profile macroalgal mats are vulnerable to chronic disturbance, and recovery may be slow given the sparse biological structure and limited refugia.

3.2. Intertidal and shallow subtidal ecosystems

3.2.1. Intertidal sand habitat

The intertidal sand habitats of Lord Howe Island's northern lagoon occur as narrow, unconsolidated sandy shorelines exposed to tidal inundation. These habitats are dynamic, shaped by tidal currents, wave action, and episodic storm events. Substrates are composed predominantly of fine to coarse carbonate sands with scattered shell fragments and occasional organic detritus.

Biological cover is generally sparse, limited to microphytobenthos, diatom films, and scattered macroalgae. Opportunistic seagrass shoots of *Halophila ovalis* may establish seasonally in lower intertidal zones but are not persistent. Invertebrate assemblages are dominated by burrowing taxa such as polychaetes, bivalves (notably *Donax* spp.), and small amphipods. These assemblages provide critical ecological functions, including sediment stabilisation, organic matter turnover, and trophic support for shorebirds and juvenile fishes.

Although limited in spatial extent (1.25 ha, approximately 1% of mapped BCH), intertidal sand habitats are ecologically relevant as transitional zones linking terrestrial runoff with lagoonal processes. They contribute to nutrient cycling, serve as feeding areas for wading birds, and act as buffer zones that dissipate energy from wave and tidal action. Given their unconsolidated nature, these habitats are highly sensitive to trampling, sediment compaction, and chronic disturbance from coastal modification or vessel activity.

3.2.2. Fringing reef (intertidal alongshore features)

The fringing reef system along the western shoreline of the northern lagoon of Lord Howe Island, particularly adjacent to Old Settlement Beach, Ned's Beach, and southward towards the proposed development zone, marks the landward boundary of the lagoon and comprises emergent intertidal platforms of high ecological and geomorphic significance. These reef flats are subject to diurnal exposure and are shaped by both marine and terrestrial processes.

Geomorphologically, the fringing reefs consist of consolidated volcanic rock with a superficial carbonate veneer. Structural features include micro runnels, ledges, and tide pools that support habitat heterogeneity. Drone surveys and field observations reveal that benthic cover is generally patchy but includes key intertidal assemblages such as encrusting coralline algae, filamentous turf algae (such as *Gelidiella* spp. and *Centroceras* spp.), and diatom films in depressions and protected microhabitats.

Biological data from intertidal invertebrate plots confirm the presence of diverse sessile and mobile macroinvertebrates. Common taxa include serpulid polychaetes, barnacles (*Tetraclita* spp.), and small oysters (*Saccostrea scyphophilla*), as well as motile gastropods such as *Nerita atramentosa* and *Cellana tramoserica*. Survey records also indicate the presence of limpets, chitons (*Acanthochitona* spp.), juvenile urchins, and amphipods, with higher species richness in sites influenced by freshwater outflow or detrital accumulation. Functional groups include grazers, filter feeders, and detritivores.

These habitats function as ecotonal interfaces linking terrestrial runoff and marine nutrient cycling. Their ecological role includes:

- Providing foraging habitat and refuge for mobile intertidal species
- Supporting nutrient transformation via algal and detrital processing
- Stabilising sediment and buffering shoreline erosion

These fringing reef systems are zoned as Sanctuary Zones under the NSW Lord Howe Island Marine Park and are further buffered by adjacent Habitat Protection Zones of the Temperate East Marine Parks Network (Director of National Parks, 2018). These designations reflect their ecological value and vulnerability.

Fringing reef habitats are considered highly sensitive to physical disturbance, including trampling, shoreline construction and smothering from changes to coastal processes. Their limited spatial extent and exposure to fluctuating conditions make them particularly susceptible to degradation. In the context of nearby development, proactive mitigation strategies such as exclusion zones, sediment controls, and restricted shoreline access during sensitive periods are recommended to preserve the integrity of intertidal assemblages.

3.2.3. Volcanic rock outcrop

Volcanic rock outcrops are small, irregular features within the intertidal zone, comprising weathered basaltic material and talus derived from cliff erosion. These outcrops (1.11 ha, 1% of mapped BCH) are structurally complex but spatially patchy, typically occurring along shoreline margins adjacent to consolidated fringing reef systems.

Surface relief varies from flat pavements to blocky boulder fields and rounded platforms. This heterogeneity supports microhabitats such as tide pools, crevices, and overhangs. Biological cover includes encrusting coralline algae, turf algae, and sessile invertebrates such as barnacles, serpulid polychaetes, and small oysters (*Saccostrea* spp.). Mobile macroinvertebrates recorded in adjacent intertidal plots (Woods, 2022) include chitons (*Acanthochitona* spp.), limpets (*Cellana* spp.), and neritid gastropods, which exploit algal films and detrital accumulations.

Volcanic outcrops provide critical ecological functions, including stabilisation of adjacent sediments, provision of foraging surfaces, and refuge for mobile invertebrates and juvenile fishes during tidal inundation. Their structural integrity contributes to shoreline buffering against wave action. These habitats are considered ecologically valuable despite their small areal extent and are sensitive to physical disturbance, trampling, and changes in sediment supply. Conservation designations within the Lord Howe Island Marine Park (Sanctuary and Habitat Protection Zones) afford a degree of protection, recognising their role in maintaining intertidal biodiversity.

3.3. Alignment with Conservation Values

The benthic communities within the northern lagoon of Lord Howe Island, particularly along the western margin where development is proposed, intersect with multiple high-value conservation attributes recognised under both NSW Marine Park legislation and the island's designation as a UNESCO World Heritage Site. These values emerge from the diversity and endemism of invertebrate assemblages, the geomorphic rarity of lagoonal coral systems at high latitudes, and the critical functional roles of habitats such as seagrass beds and fringing reefs.

3.3.1. Alignment with NSW Marine Park Conservation Values

Within the Lord Howe Island Marine Park, several zones identified in BCH mapping are formally protected as Sanctuary Zones or Habitat Protection Zones, with management objectives to preserve:

- High species richness and endemism
- Structurally complex habitat features
- Breeding, nursery, and foraging grounds for marine invertebrates
- Threatened and conservation-listed taxa

Field and desktop data confirm that several BCH units in the project area support these values:

- **Patch Reefs and Coral Bommies (Inner Lagoon):** Sites such as S14 and S15 recorded the presence of *Centrostephanus rodgersii* (Long-spined sea urchin), with densities up to 72 individuals/100 m² and support high microhabitat complexity important for cryptic taxa.
- **Lagoon Floor – Macroalgae/Rubble Assemblages:** These areas provide refuge for infaunal communities and include individuals of *Tridacna maxima* (Small Giant Clam), recorded at transect S13. While not listed as threatened under NSW legislation, *T. maxima* is considered 'Least Concern' by the IUCN and is protected under marine park harvest restrictions.
- **Seagrass Beds:** Observed at S05 and S06, these habitats support dense benthic infauna, including polychaetes and bivalves, and represent designated seasonal protection zones under the zoning plan due to their nursery function for fish and invertebrates.
- **Fringing Reef and Intertidal Platforms:** As documented by Woods (2022), intertidal sites exhibit significant macroinvertebrate biodiversity and scored high REPI (Reef Environmental Performance Index) values, highlighting their importance as biodiversity reservoirs.

These documented values justify the inclusion of avoidance zones, construction setbacks, and habitat-specific management strategies for BCH types intersecting with protected marine zones.

2.3.1 Alignment with World Heritage Outstanding Universal Value (OUV)

Lord Howe Island was inscribed on the World Heritage List under criteria (vii)–(x), which recognise the island's:

- Natural beauty and scenic geomorphology (vii)
- Ongoing ecological and geological processes (viii, ix)
- Exceptional biodiversity and endemism (x)

In the northern lagoon, several features contribute directly to these OUV criteria:

- **Coral Bommies and Reef Crest microatolls** (OUV viii–ix): Represent lagoonal reef growth and carbonate accretion under marginal climatic conditions (Kennedy, 1999).
- **Macroinvertebrate communities on intertidal and subtidal substrates** (OUV x): Include endemic or range-restricted taxa, such as *Stichopus herrmanni* and localised sea urchin populations.
- **High-latitude seagrass beds** (OUV ix): Provide evidence of ecological processes linked to tropical–temperate transition zones, particularly *Zostera muelleri* and *Halophila ovalis* distributions.

These habitats illustrate the integrity and representativeness of the island's marine ecosystems and underscore the need for BCH-integrated spatial planning to uphold the island's OUV and marine conservation objectives.

Appendix C. Conservation Significant Marine Fauna Desktop Assessment

Lord Howe Island Critical Infrastructure Program

Conservation Significant Marine Fauna Desktop



ENVIRONMENT
An O2Marine company



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Acknowledgement Of Country

O2 Marine acknowledges Aboriginal and Torres Strait Islander people as this land's first storytellers and holders of scientific knowledge through their ongoing and continued connection to land, sea and community. We pay our respect to Elders past and present for their custodianship of the land and sea over millennia, which inspires us daily in our collective responsibility to sustain the land and sea country which we live by, work in and dream about.

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Acronyms and Abbreviations

Term	Description
AIMS	Australian Institute of Marine Science
AMSIS	Australian Marine Spatial Information System
ALA	Atlas of Living Australia
APMPL	Australian Priority Marine Pest List
BIA	Biologically Important Area
BC Act	<i>Biodiversity Act No. 63 (NSW)</i>
BioNet	DCCEEW (NSW) Biodiversity Web Atlas
BMT	BMT Commercial Australia Pty Ltd
CIP	Critical Infrastructure Project
CSIRO	Commonwealth Scientific and Industrial Research Organisation
cm	Centimetres
Cth	Commonwealth of Australia
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Cth)
DCCEEW (NSW)	Department of Climate Change, Energy, the Environment and Water (State)
DEH	Department of Environment and Heritage (NSW)
DEWHA	Department of the Environment, Water, Heritage and the Arts (now DCCEEW)
DSEWPac	Department of Sustainability, Environment, Water, Population and Communities (now DCCEEW)
DNA	Deoxyribonucleic Acid
DoEE	Department of Environment and Energy (now DCCEEW)
DPI	Department of Primary Industries NSW
DPIRD	Department of Primary Industries and Regional Development WA
DSEWPac	Department of Sustainability, Environment, Water, Population and Communities (now DCCEEW)
EAC	East Australian Current
EEPL	Exotic Environmental Pests List
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Authority
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999 (Cth)</i>
FM Act	<i>Fisheries Act No. 38 (NSW)</i>
GA	Geoscience Australia

Term	Description
GBRMPA	Great Barrier Reef Marine Park Authority
ha	hectares
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMMA	Important Marine Mammal Area
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
KEF	Key Ecological Feature
Km	Kilometres
LHI	Lord Howe Island
LHIMP	Lord Howe Island Marine Park
LHIB	Lord Howe Island Board
m	Metres
MEMA Act	<i>Marine Estate Management Act 2014</i>
MPSC	Marine Pest Sectoral Committee
MMPATF	Marine Mammal Protected Area Taskforce
N/A	Not Applicable
NSW	New South Wales
NT	Northern Territory
NIMPIS	National Introduced Marine Pest Information System
NPWS	National Parks and Wildlife Service (NSW)
NSW	New South Wales
PMST	Protected Matters Search Tool
QA/QC	Quality Assurance/Quality Control
QLD	Queensland
RLS	Reef Life Survey
SA	South Australia
SEARS	Secretary's Environmental Assessment Requirements
SPRAT	Species Profile and Threats database
TEMB Plan	Marine Bioregional plan for the Temperate East Marine Region
TSSC	Threatened Species Scientific Committee
Vic	Victoria
VMS	Vessel Monitoring System
WA	Western Australia
WCPA	World Commission on Protected Areas

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1. Introduction

The Lord Howe Island Board (LHIB) and New South Wales (NSW) National Parks & Wildlife Service (NPWS), which is part of the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) has obtained NSW Government funding to renew critical infrastructure on Lord Howe Island (LHI) (Table 1). The Critical Infrastructure Project (CIP), that includes five interdependent projects, has been designed to support the LHIB to ensure the ongoing care, control, and management of LHI affairs and trade. This includes the care and welfare of LHI residents and the long-term future of the tourism industry and visitor economy, which is critical to the sustainability of the island community. The current marine freight vessel is at the end-of-life, and the service is critical to supporting LHI residents and the Island's economy.

The five components of the LHI CIP are:

- Master Plans and Authority Approvals
- Marine Infrastructure
- Replacement Marine Vessel and Operations; and
- Biosecurity infrastructure
- Waste Management Facility

To ensure the effective operation of the replacement marine vessel, a core component of the LHI CIP is the upgrade to the associated marine infrastructure and freight services. The existing jetty infrastructure will remain to support lift-on lift-off cargo handling operations, whilst the replacement marine vessel will have roll-on roll-off cargo handling capacity. For this method, a fixed-piled vessel ramp is required to allow forklifts and vehicles to access the new vessel's deck via its stern door to facilitate loading and unloading operations. A series of mooring dolphins will be constructed, in line with the end of the existing jetty.

All works will be taken on the western side of LHI, with most works taking place in the Northern Project area and the Waste Management Facility works taking place in the Southern Project area (Figure 1).

Table 1: Short Summary of Project Description.

Proposal Title	Lord Howe Island Critical Infrastructure Program
Proponent Name	NSW DCCEEW (representing NSW National Parks and Wildlife Service and the Lord Howe Island Board).
Short Description	Under the LHI CIP, the LHIB and NPWS are proposing to upgrade the marine infrastructure and freight services which support the community residing at LHI. In addition to upgrading the service vessel, which is at its operational end of life, the Project is proposing to upgrade the associated infrastructure by the construction of a piled vessel ramp and additional piled mooring dolphins.

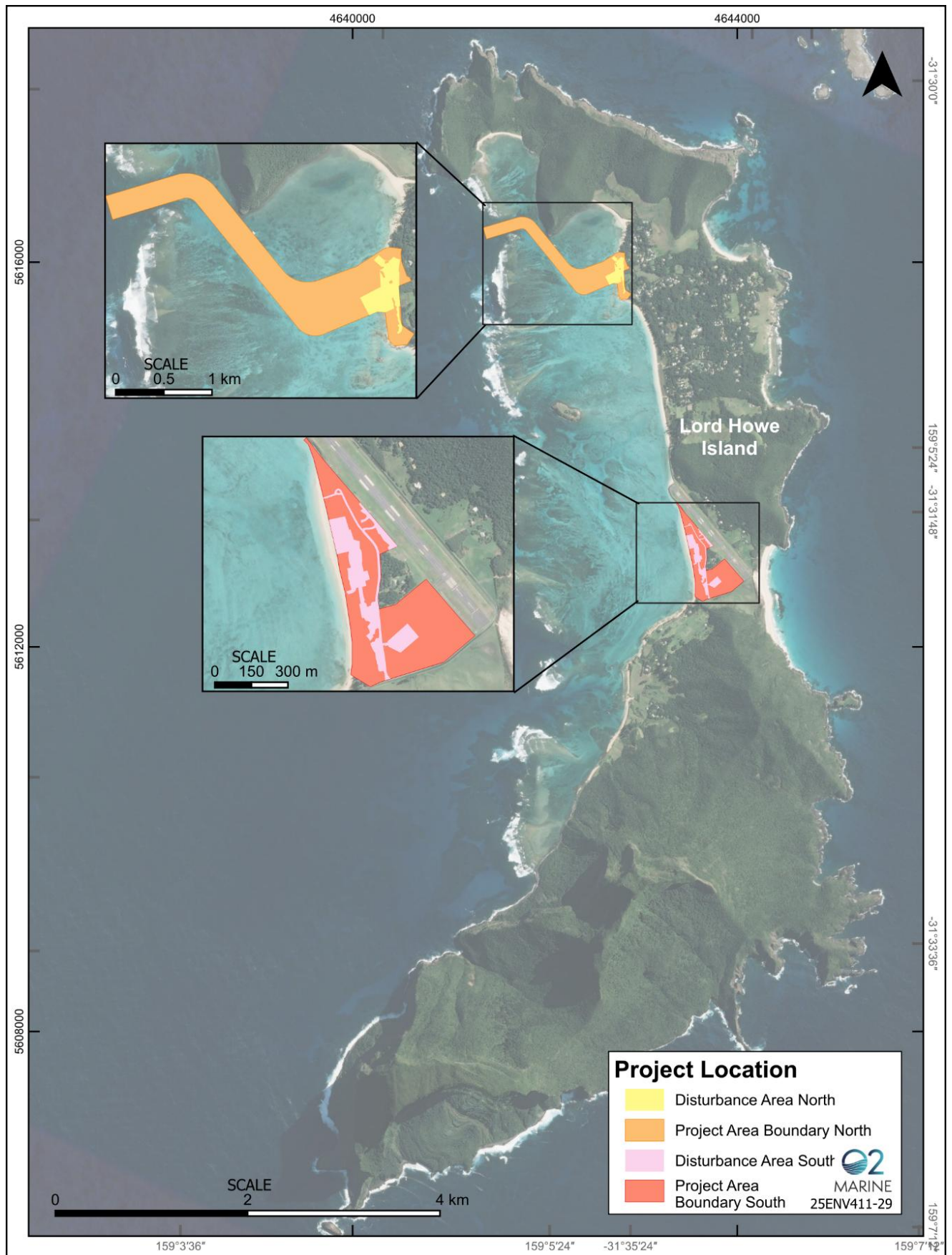


Figure 1: General Project location, showing Northern and Southern Project Boundaries.

1.1. Purpose

DCCEEW (NSW) has engaged O2 Marine to undertake a series of baseline studies, including this Conservation Significant Marine Fauna Desktop. This report describes conservation-significant marine fauna species and their habitats within the local, regional, and national context, in line with regulatory expectations (Table 3) and identifies key species to inform the impact assessment and development of suitable management measures.

For this report's purpose, conservation-significant marine fauna species are defined as those that Are:

- Threatened or Migratory under the EPBC Act,
- 'Iconic' or locally important, and / or
- Threatened or Protected under the BC or FM Acts

Additionally, this report provides information required to address the requirements of the Project's Secretary's Environmental Assessment Requirements (SEARs). The relevant SEARs Key Issue and Requirements are shown in Table 2..

Outcomes of this report are presented within the Marine Ecology Assessment document, which will be incorporated into the overarching EIS being prepared by Environmental Resources Management (ERM) for the LHI CIP.

Table 2: SEAR's Key Issues and Requirements addressed in this desktop report

Key Issue and Desired Protection Outcome	Requirements
2. Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity, compensation / or supplementary measures are assured to mitigate residual impacts of construction and operation	4. Prepare a threatened aquatic species assessment (under Part 7A of Fisheries Management Act 1994 (FM Act)) to address whether there are likely to be any significant impacts on listed threatened species, populations or ecological communities listed under the FM Act.
	6. Assess impacts to the ecological and biological values of the Lord Howe Island Marine Park during construction and operation, including impacts to threatened species such as (but not limited to) the Black rockcod, Ballina angelfish, Elegant wrasse, Bluefish, Syngnathids, marine mammals, marine reptiles and seabirds

1.2. Objectives

The objectives of this report are as follows.

- Identify and describe the key characteristics of the regional and local environment likely to drive species distribution, including the presence of recognised important areas (e.g., Biologically Important Areas) and key habitat types.
- Identify and describe marine fauna (i.e., mammals, reptiles and fish) known or likely to be present, including species and communities listed under Commonwealth and State legislation.
- Identify key species (i.e., inherently vulnerable species potentially impacted by the Project and likely to be present), their ecological characteristics (including habitat preferences and key ecological windows) and existing pressures and threats. As well as the existing policies relevant to their conservation and management, and their relevance to the Proposal (i.e. potential impact pathways), as would be a required input to the environmental approvals process.

1.3. Key Species'

Key species in this study are defined as those marine fauna species most

- likely to be present, AND
- inherently vulnerable to potential impacts due to their biology and ecology and exposure to existing pressures which is usually reflected by their conservation status.

This report includes marine mammals, marine reptiles and marine fishes (including sharks and rays), with birds being out of scope

Key species were identified so that the correct proportionality of information is considered when assessing the nature and risk of potential project related impacts. This means that species with the greatest potential of being impacted by the Proposal will be given the greatest attention during EIA and management planning, aligning with the NSW EPA's emphasis on a structured approach to environmental impact assessments, management plans and offset strategies.

Key species will act as 'umbrella species' in management planning, whereby measures implemented for their conservation and protection will benefit other species within their ecosystem. As such, care was taken to select representative species from each taxonomic group. The precautionary principle was upheld through this process, and key documents under the EPBC Act were consulted.

2. Relevant Marine Fauna Legislation

Key legislation governing the protection of conservation-significant marine fauna and their habitats in NSW are:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cth)
- *Environmental Planning and Approvals Act 1979* (EP&A Act) (NSW)
- *Protection of the Environment Operations Act 1997* (NSW)
- *Marine Estate Management Act 2014* (MEMA Act) (NSW)
- *Biodiversity Conservation Act 2016* (BC Act) (NSW)
- *Fish Resources Management Act 1994* (FM Act) (NSW)
- *Biosecurity Act 2015* (Biosecurity Act) (Cth).

The EPBC Act and EP&A Act govern the environmental approval processes, depending on whether a Project is referred at the National or State level. They aim to support environmentally sustainable development while protecting environmental values, including biodiversity. Proposals referred under the EPBC Act are assessed by the DCCEEW (Cth). Proposals referred under the EP&A Act are assessed by the NSW Department of Planning, Housing and Infrastructure (DPHI). Should a Project be referred only at State level, the EPBC Act is still considered for species either listed as or contributing to Matters of National Environmental Significance (MNES), including World Heritage status. A bilateral agreement is in place between the Commonwealth and State of NSW, enabling streamlined assessment for projects requiring both Commonwealth and State level approvals assessments. The bilateral agreement allows the State of NSW to conduct environmental assessments on behalf of the Commonwealth reducing duplication while ensuring matters of national environmental significance are properly considered. A summary of the legislation is presented in Table 3.

Table 3 Summary of relevant marine fauna legislation

Legislation	Relevance
<i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act)	The Australian Government has responsibilities for biodiversity conservation through the EPBC Act. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined as Matters of National Environmental Significance (MNES). It aims to ensure that potential negative impacts are carefully considered before changes in land use or new developments are approved. In relation to marine fauna, protection and impact assessments are focused on listed Threatened and Migratory species. The Act also recognises recovery plans for threatened species, guiding research and management for their survival. It helps Australia meet international conservation commitments, including those under the International Union's Conservation of Nature (IUCN) Red List, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and conventions for migratory species. The Act protects species listed as Marine and/or Cetaceans, with the Australian Whale Sanctuary protecting cetaceans from harm within Commonwealth waters (out to 200 nautical miles (nm)). Marine species are addressed under Part 13 of the EPBC Act, and it is an offence to kill, injure, take or trade marine species, in or <u>from a Commonwealth area</u> .

Legislation	Relevance
	The Act requires that World Heritage values be identified, protected, and managed, and that management plans are developed in consultation with relevant stakeholders, including Indigenous communities. The listing of a site as a World Heritage property under the EPBC Act means that its protection becomes a matter of national environmental significance (NES), triggering a robust environmental assessment process. The Commonwealth may enter into bilateral agreements with states and territories to streamline the assessment process, provided that World Heritage protections are maintained or enhanced. Further, these agreements provide the exchange of information and building cooperative relationships between countries. Classification are as follows: Threatened species: EX: extinct; EW: extinct in the wild; CE: critically endangered; EN: endangered; VU: vulnerable; CD: conservation dependent. Other protected species: MI: Migratory; CT: Cetacean; MA: Marine.
Environmental Protection & Approvals Act 1979 (EP&A Act)	The EP&A Act is the key piece of legislation governing land use planning and development in NSW. Its purpose is to ensure sustainable development of land while balancing environmental, social, and economic considerations. The Act provides a framework for the environmental approvals process, identifying State Environmental Planning Policies (SEPP's) and Local Environment Plans (LEP's), planning authorities. Recent reforms have placed a greater focus on community engagement with the introduction of Community Participation Plans (CPP's) to ensure public involvement in plan-making and development decisions. The SEPP Biodiversity and Conservation (2021) is relevant to marine fauna as one of its focuses is the management of NSW's coastal and aquatic resources of the States Marine Estate, which is guided by the Marine Estate Management Strategy to reduce impacts on threatened and protected species. The EPA pays special attention in EIA to marine fauna species that are of social, cultural, economic or ecological significance. Importantly, the precautionary principle, also embedded in the EP&A Act, requires that where there is a threat of serious or irreversible environmental harm, a lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation. In practice, this principle underlines the need for careful consideration of risks to marine fauna during EIA, even where data may be limited. Actions and assessments should err on the side of caution, particularly where vulnerable or migratory species are concerned. In conjunction with the precautionary principle, the principle of proportionality ensures that the scale and intensity of environmental assessment and management measures are appropriate to the level of potential risk. This means that projects likely to cause greater disturbance to marine fauna (e.g. through underwater noise, habitat alteration or vessel traffic) are expected to demonstrate more robust avoidance, mitigation, and monitoring strategies. Together, these principles support a risk-based, scientifically informed approach that safeguards marine biodiversity and aligns with both state legislation and international conservation standards.
Protection of the Environment Operations Act 1997 (POEO Act)	The NSW POEO Act is the primary piece of environmental legislation in New South Wales for regulating pollution and promoting sustainable environmental management. Administered by the NSW Environment Protection Authority (EPA), the Act provides a comprehensive framework for the prevention, control, and monitoring of pollution across air, water, land, and noise. It establishes a licensing regime for certain industrial and scheduled activities, sets enforceable limits on emissions, and requires licensees to report and respond to pollution incidents. The Act also supports the waste management hierarchy, promoting the reduction, reuse, and recycling of waste before disposal. Enforcement mechanisms include clean-up and prevention notices, fines, and court prosecutions, all underpinned by the "polluter pays" principle. Through these provisions, the POEO Act aims to protect human health and the environment while promoting accountability and transparency in pollution management.

Legislation	Relevance
<i>Marine Estate Management Act 2014 (MEMA Act)</i>	The <i>Marine Estate Management Act 2014</i> (NSW) establishes a strategic legal framework for the integrated and sustainable management of NSW marine estate—comprising coastal waters, estuaries, lagoons, coastal wetlands, and adjacent lands shaped by marine processes. The Act's primary objectives are to uphold ecological sustainability by fostering a marine estate that is biologically diverse, healthy, and productive while supporting economic, cultural, social, and recreational uses, as well as scientific research and education. It also mandates coordinated governance across public authorities and the creation and administration of marine parks and aquatic reserves—including zoning, management planning, and enforcement mechanisms.
<i>Biodiversity Conservation Act 2016 (BC Act)</i>	The aim is to conserve and protect NSW's biodiversity and support sustainable use of species, habitats, ecosystems, and ecological processes. It also includes measures to prevent the harassment or disturbance of fauna. Native species are classified as Threatened species: CR: critically endangered; EN: endangered; VU: vulnerable.
<i>Fish Resources Management Act 1994 (FM Act)</i>	The principal Act that regulates the management, utilisation, and conservation of fish (i.e. all aquatic organisms except reptiles, birds, mammals, amphibians) and their habitats in NSW, including addressing biosecurity risks from invasive marine species (IMS). Administered by the Department of Primary Industries (DPI), the Act provides advice to the EPA and DCCEEW (Cth) on potential impacts of proposed actions on fish or fish habitats. Proposals with significant impacts on fish or fish habitats in NSW State waters must be assessed by the EPA, and by the DCCEEW for those in Commonwealth waters. The Act defines 'fish' as (a) oysters and other aquatic molluscs, (b) crustaceans, (c) echinoderms, and (d) beachworms and other aquatic polychaetes. It does not include whales, mammals, reptiles, birds, amphibians or other things excluded from the definition by the regulations.
<i>Biosecurity Act 2015 (Biosecurity Act)</i>	The Department of Agriculture, Forestry and Fisheries are responsible for managing biosecurity risks of IMS from ballast water and biofouling from vessels operating in Australian seas. The Biosecurity Act (NSW) provide for the prevention, elimination, minimisation and management of biosecurity risks aims to prevent new pests from entering NSW and restrict the spread of those that are present, including in marine waters. It is designed to facilitate cooperation between government agencies, as well as with interested groups ranging from primary producers to the public and aquaculture interests.

3. Receiving Environment

This section of the report describes the receiving environment that contributes to the habitat characteristics of LHI relevant to the Project. CIP construction will occur on the western side of LHI, in the shallow lagoon and along the shore. This desktop focuses on conservation-significant marine fauna and habitats in the lagoon, while also considering offshore species that may be affected by underwater noise, artificial light, and vessel movements.

3.1. International and National Conservation Significance

The Lord Howe Island Group consists of LHI and nearby islands and sea stacks, including Balls Pyramid. The group is a recognised World Heritage Property, and a National Heritage Place. Adjacent and connecting to the State-managed Lord Howe Island Marine Park (LHIMP) are two Commonwealth Marine Park areas; a National Park Zone located on the east of the island and a Habitat Protection zone (Figure 3) LHI is situated in the LHIMP and covers an area of approximately 480 km², located 600 km from the coast of NSW (Harasti et al. 2022). The LHIMP includes numerous ecosystems spanning a wide range of habitats and biological communities. These include estuarine ecosystems, lagoons, fringing reef, intertidal, shallow subtidal, pelagic and shelf ecosystems including coral communities. There are also slope ecosystems though these are mainly outside of the LHIMP. It supports high biodiversity with tropical, subtropical, and temperate species co-occurring, including many endemic and conservation-significant species.

3.2. Regional setting

3.2.1. Oceanography

LHI has a humid and sub-tropical climate. LHI's oceanography creates a dynamic mixing zone of warm and cool waters, varied habitats, and high connectivity, underpinning its marine biodiversity and conservation significance. The waters around LHI are primarily influenced by the East Australian Current (EAC), which brings subtropical waters south before meeting the Tasman Front carrying subantarctic waters north. Wave heights average 1.9–2.7 m, peaking in winter, with swell generally from the south-southwest to southeast. Tides are mixed semi-diurnal, with a mean spring range of 1.51 m and neap range of 0.81 m, though anomalies can occur due to EAC influence. Wind direction does alter through the seasons, with wind coming from the northeast and east in summer and autumn, and from the southwest in winter and spring. The region also experiences major storms and cyclone activity with storms occurring throughout the year (Harasti et al 2022).

3.2.2. Geology and geomorphology

The geology and geomorphology of LHI has formed the development of marine fauna habitats that are present in coastal lagoons, and offshore. LHI and Balls Pyramid to the south were formed as shield volcanoes approximately 6 to 7 million years ago as part of a chain of islands and seamounts along the Lord Howe Rise (McDougall et al 1981). Over time, the islands move northwards into warmer waters, where corals were able to form approximately 120,000 years Before Present (BP).

On the LHI shelf, a large fossil barrier reef (155 km²) comprises approximately one-third of the 504 km² shelf. This barrier reef encircles the mid-shelf in 25 – 50 m water depth, and drill cores indicated that the upper portion is Holocene, likely forming a capping over older reef (Harasti et al 2022). On the mid and upper shelf in 30 to 60 m depth, sedimentary basins occur, infilled with up to 25 m of carbonate sediment (Brooke et al 2010).

LHI originated as a larger volcano compared to Balls Pyramid and remains larger following the erosion over time. There is also a greater area of inner shelf bedrock and reef outcrops in shallow waters, providing more habitat for corals now and into the future with rising sea levels, and Balls Pyramid seems to have decreased in rate of growth. However, it is estimated that the modern rates of calcification at both LHI and Balls Pyramid are lower than those at higher latitude coral reefs.

3.2.3. Key ecological features

Key ecological features (KEFs) are elements of the Commonwealth marine environment that are of regional importance for either a regions' biodiversity or its ecosystem function and integrity. Two KEFs within the Project area: Lord Howe Seamount chain and Tasman Front and eddy field (DSEWPC 2012).

The seamounts create productive pelagic environments that support foraging, migration, and aggregation of offshore conservation-significant species. They generate nutrient-rich upwelling, varied depth and current zones, and migration corridors. These features support small pelagic fish, large predators such as sharks and tuna, and provide aggregation and foraging areas for threatened and migratory species including seabirds, marine turtles, and cetaceans.

The Tasman Front and associated eddy field enhances the dynamic oceanographic conditions, mixing subtropical and subantarctic waters. This further increases nutrient availability, plankton production, and foraging and opportunities

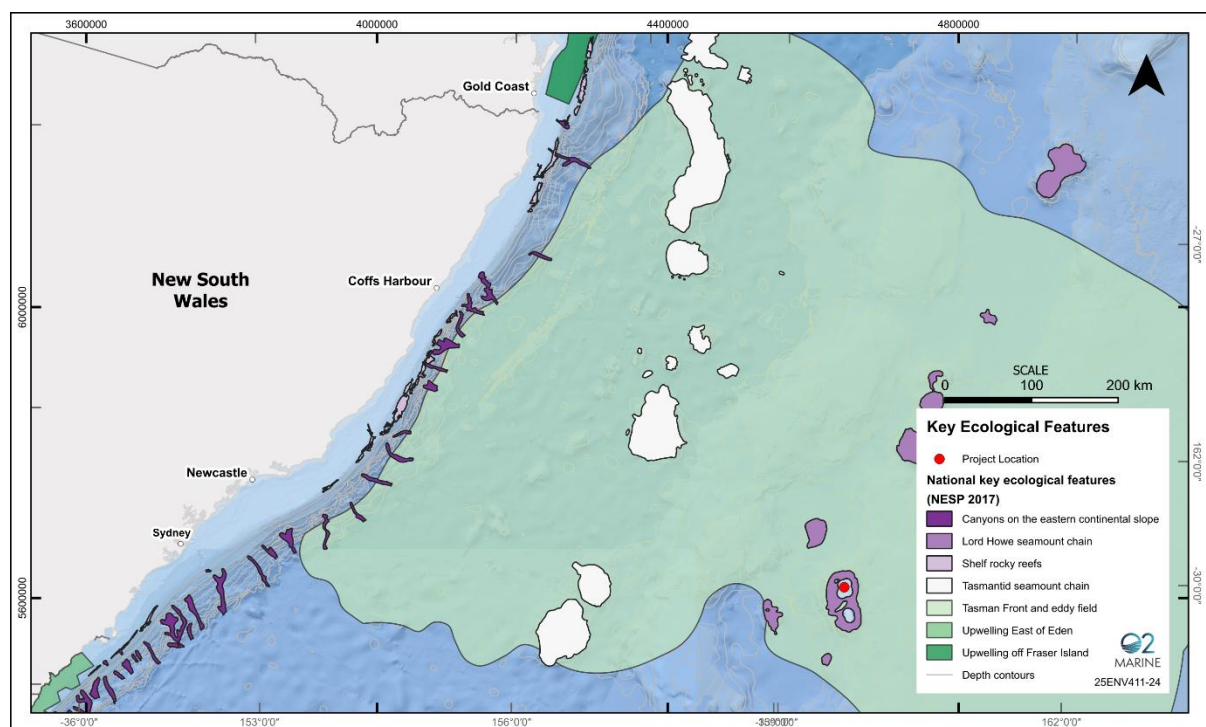


Figure 2: Key Ecological Features of surrounding LHI.

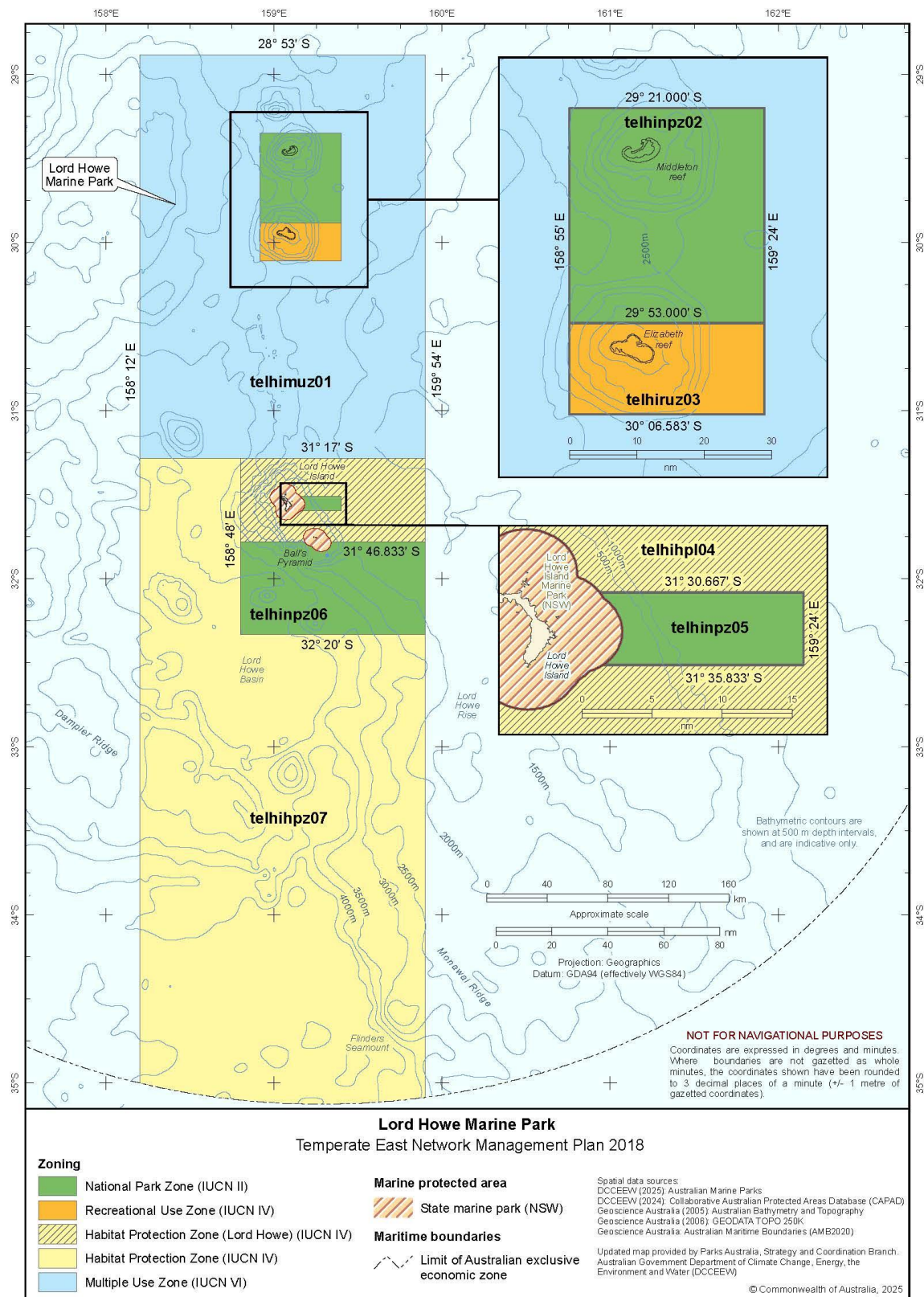


Figure 3: Protected zones within and surrounding Lord Howe Island.

3.2.4. Local habitats

The LHI local coastal habits represent geologically and ecologically significant habitats, characterized by a sheltered coral reef lagoon, fringing and intertidal reefs, sandy beaches, seagrass meadows, and rocky littoral zones. The western side of the island is bordered by the southernmost coral reef in the world. This reef feature forms a fringing reef system that encloses a shallow lagoon which is approximately 1.5km wide. The lagoon ecosystem provides a diverse range of benthic habitats including corals, seagrass, anemones, sand- and rubble-based habitats. These habitats support the diverse fish assemblage of LHI and serve as critical nursery for reef-associated, cryptic, and endemic species.

LHI's fringing reefs, are both coral- and macroalgal-dominated and line much of the shoreline providing shelter to the beaches from wave action. These intertidal and subtidal zones extending across the lagoon beaches are dynamic and seasonally influenced by the unique convergence of the warm tropical EAC and cooler temperate flows offshore from the island. The resulting marine fauna ecology represents a diverse range both tropical and temperate species, producing outstanding value in biodiversity.

4. Methods

This desktop review was informed by a comprehensive database search and literature review. The methods employed are consistent with the background information requirements of the National Light Pollution Guidelines for Wildlife (DCCEEW 2023b) and the National Guidelines for the Survey of Cetaceans, Marine Turtles, and the Dugong (DCCEEW 2024a). This requires the Proponent to identify species that may occur in the proposed area of interest and obtain as much historical and contemporary information (<5 years) as possible about the presence, distribution, abundance, and functional importance of the area (i.e. functional use of habitat and biological importance of the area) for each species. Additionally, environmental values, including features of LHI biodiversity that contribute to outstanding value as a World Heritage site are detailed in the report Environmental Values of the Lord Howe Island Marine Park (Harasti et al 2022) and this represents a key piece of relevant contemporary information for the Project's remote location. Table 4 outlines the databases reviewed for each step in identifying species, important habitats and conducting the likelihood of occurrence assessment.

Table 4: Process of database searches completed to identify species, important habitats, and inform the likelihood of occurrence assessment and key species identification. A description of the databases are provided in Databases.

Purpose	Database	Type	Citation/s
Step 1: Identify species that could be present under the EPBC Act			
Identify known and likely conservation significant species* in the search areas	Commonwealth Protected Matters Search Tool (PMST)	Government (Commonwealth)	DCCEEW (2025)
Identify Biologically Important Areas (BIAs) and Critical Habitats that overlap with the search areas	PMST Australian Marine Spatial Information System (AMSIS)	Government (Commonwealth)	DCCEEW (2025) Geoscience Australia (n.d.)
Step 2: Species occurrence and additional species protected at the State BC and FM Acts, or that are iconic			
Review species sighting records for search areas	Atlas of living Australia (ALA) NSW BioNet Threatened Species Database ReefLife Survey (RLS)	Combined Government, industry and research community including citizen science.	ALA (2025) BioNet (2025) RLS (2025)
Apply NSW BC Act Threatened Species Listing and FM Act Species Listing for recorded species	DCCEEW Threatened Species List (BC Act 2016 No. 63) DPI Threatened and Protected Species List (FM Act 1994 No. 38 and Fisheries Management (General) Regulation 2019)	Government (State)	BC Act 2016 FM Act 1994 No. 38 Fisheries Management (General) Regulation 2019
Step 3: Consider the Regional and Global Conservation Context			
Consider regional and global context	IUCN Red List LHI Environmental Values	Research community at an international level.	IUCN (2025) Haraast et al (2022)

Purpose	Database	Type	Citation/s
	World Heritage	Government (Commonwealth)	DCCEEW (2025)
Identify Important Marine Mammal Areas (IMMAs) that overlap with the search areas	IMMA E-atlas	Research community at an international level.	IUCN MMPATF (2022a, n.d.)
Step 4: Available scientific knowledge, considering the Significant Impact Guidelines and the National Survey Guidelines, and obtain species information			
Obtain species biology, ecology, abundance, distribution, habitat use, and population status	Species Profile and Threats Database (SPRAT) IUCN Literature review EPBC Act documents LHI Environmental Values	Combined Government, industry and research community including citizen science.	DCCEEW (2025c) IUCN (2025) Harasti et al (2022) See Appendix D
Obtain information for MNES – life history traits, area of occupancy	SPRAT IUCN Literature review EPBC Act documents	Combined Government, industry and research community including citizen science.	DCCEEW (2025c) IUCN (2025) See Appendix D
Step 5: Existing Pressures and Threats			
EPBC Legal Status and Documents (e.g., Recovery Plans, Threat Abatement plans, Conservation advices)	SPRAT	Government (Commonwealth)	DCCEEW (2025c)
Bioregional Plan	Temperate East Marine Bioregional Plan Temperate East Species report cards	Government (Commonwealth)	DSEWPac (2012) DSEWPac (2012b)
Range wide threats	IUCN Red List SPRAT	Combined Government and research community.	IUCN (2025) DCCEEW (2025c)

4.1. Search Areas

Two search areas were generated in QGIS software to gather and interpret data for this desktop. A 20 km buffer to determine species presence and/or critical habitat usage was generated in line with the National Light Pollution Guidelines for Wildlife (DCCEEW 2023b). This area was used to extract data from the PMST search tool and ALA, NSW BioNet and RLS sightings databases. Additional species listed as threatened or protected in NSW were identified from the BC Act No 63, FM Act No 38 and Fisheries Management (General) Regulation 2019.

A narrower 10 km buffer was also used to focus on species and habitats more likely to be affected by Project activities. This remains a precautionarily large area, extending well beyond the lagoon, reflecting the Project's isolated location, limited data availability, and World Heritage status.

Project boundaries for the North and South construction areas of the new marine facilities at LHI are shown in Figure 1. Therefore, for the purpose of this report, the term broader search area is considered as the 20 km search area used to identify conservation significant species and which is also in line with the National Light Pollution Guidelines for Wildlife (DCCEEW 2023). Reference to the Project boundaries (either North Zone or South Zone) refer to the areas shown in Figure 1. Further detail on search areas is provided in Section 4.1 Furthermore, the identification of key conservation significant marine fauna in this report can inform later stages in the approvals process including environmental impact assessment (EIA) and facilitate the development of effective mitigation and management measures, to comply with regulatory requirements

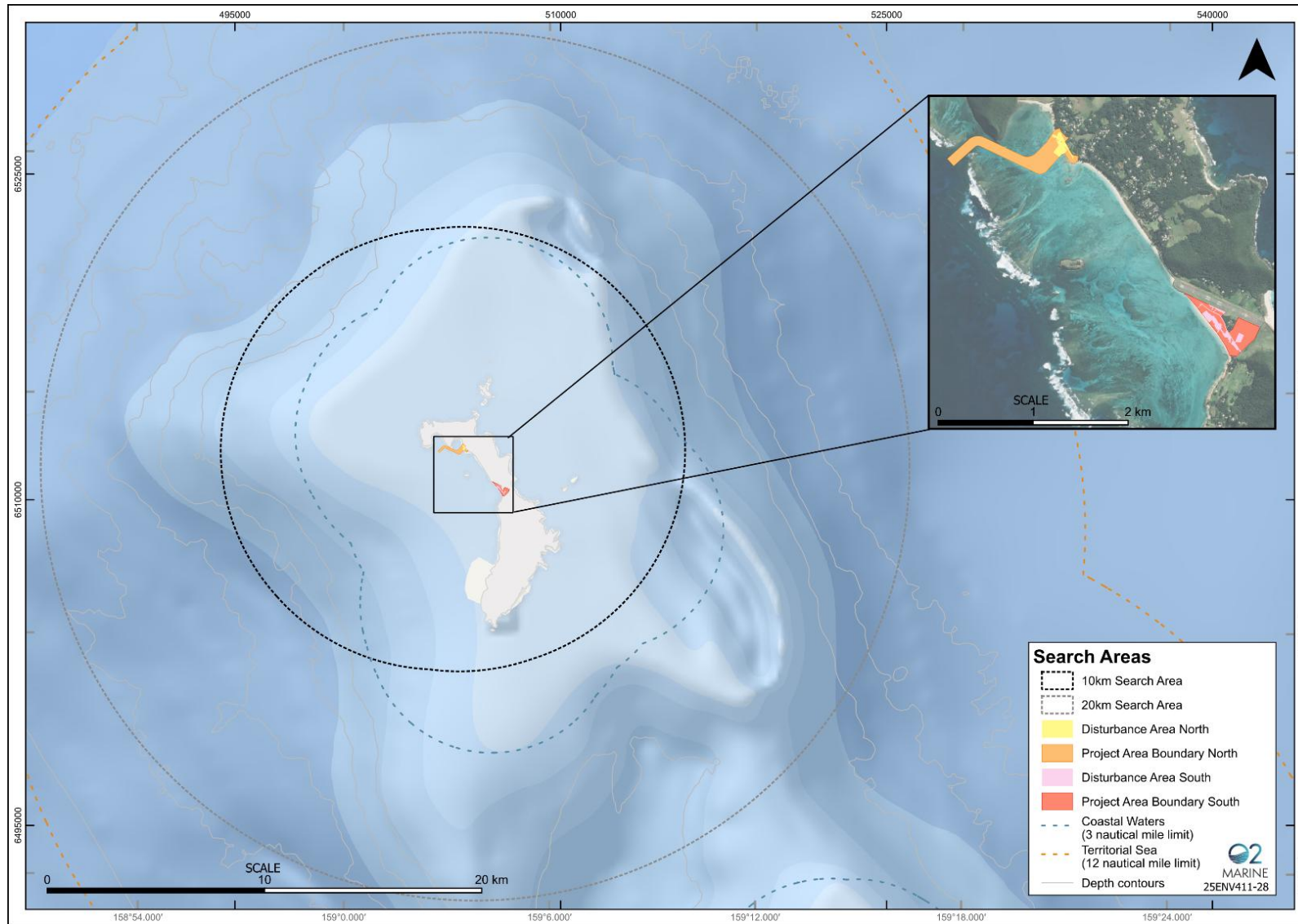


Figure 4: Search areas used to identify conservation significant marine fauna.

4.2. Sighting Records

Sighting records have been interpreted with caution, based on the following dataset limitations.

- Presence-only data: the records represent only confirmed sightings and do not account for areas where species may occur but have not been observed. A lack of recorded sightings does not imply absence.
- Data sources: the BioNet and ALA databases compile information from various sources, including formal surveys, monitoring programs, translocations, opportunistic sightings, evidence such as tracks or scats, museum specimens, and historical records. This diversity of sources contributes to variability in data quality.
- Locational accuracy: the spatial accuracy of records varies considerably, with some observations lacking precise geographic coordinates.
- Strandings: stranding data reflects the presence of injured or deceased individuals found onshore and may not accurately represent the species' distribution or typical habitat use.
- Data verification: not all records are verified and may include multiple sightings of the same individual (re-sights), particularly in areas of limited population size.
- Data completeness: record completeness varies by species and is influenced by factors such as the remoteness of the species' range and the level of survey effort in that area.
- Data currency: contemporary data are considered as less than five years old. Older records may not reflect current distributions or population trends.

4.3. Literature Review

Literature was sought from peer-reviewed papers, government reports, field studies and baseline assessments, relevant to the Project area and surrounding environment. The purpose of the literature review was to compile relevant, contemporary information for conservation-significant species using the topics and parameters outlined below. Obtaining this information is required to satisfy the background information requirement for the Matters of National Environmental Significance: Significant Impact Guidelines 1.1 (DEWHA 2013) and to meet the State and Commonwealth requirements for the Proposal.

Table 5: Literature review parameters for key conservation-significant species.

Topics	Parameters
Population	• Abundance • Population estimates (global, regional, and local if available) • Trends
Distribution	• Range and area of occupancy (State, regional and local) • Local patterns • Animal movement • Temporal occurrence
Habitat use and life history	• Longevity and fecundity • Breeding

Topics	Parameters
	• Foraging (habitat and prey) • Ecological windows • Critical habitat • Biologically important areas • Habitat availability
Relevant guidance and policies (including threats and pressures)	• Recovery plans and conservation actions • Threat abatement plans • Relevant pressures and threats (direct and indirect) as outlined in the South-west Marine Bioregional Plan (DSEWPac 2012a) • Conservation status (State, Federal, and International).

4.4. Likelihood of Occurrence Assessment

The likelihood of occurrence assessment was completed by combining the individual records of database searches and literature review for species likely to be in vicinity of the Proposal area. Using the definitions below, the resulting species were ranked by their likelihood of occurring near the Proposal area. If a species' presence was uncertain, it was ranked as more likely to occur, following the precautionary principle.

Table 6: Species likelihood of occurrence definitions

Likelihood	Definition
High	Individuals of the species have been frequently recorded in the Proposal area or the potential vessel movement area and/or surrounding habitat. The Project location is within the species' known range and the surrounding habitat is expected to support populations of the species. The species contributes to the ecological values of the Proposal location.
Moderate	Individuals of the species have been infrequently recorded in the Proposal area and/or surrounding habitat. Suitable (not necessarily preferred) habitat may occur within the DE or the surrounding area. The surrounding habitat may support individuals or populations of the species.
Low	Individuals of the species have been identified in the searches, but the Proposal area and surrounding habitat are not likely to be within the species' range, or the species has not been confirmed to be sighted there. Suitable habitat may be present.

4.4.1. Key Species Identification

Key species were identified based on likelihood of occurrence, sightings data, conservation status (i.e., Threatened or Migratory under the EPBC Act, Endangered, Vulnerable or otherwise protected under BC or FM Acts), known nearby BIAs, and/or critical habitat overlapping the Proposal area. Iconic and locally important species have also been included, even if not formally listed as Threatened or Protected under relevant biodiversity legislation

4.5. Identification of Existing Threats and Pressures

The identification of existing pressures was informed by datasets of existing human activity, the Marine Bioregional plan for the Temperate East Marine Region (TEMB Plan) (DSEWPac 2012), species' recovery plans, conservation guidance and threat abatement plans. The threats and pressures for conservation values (i.e., marine fauna) within the TEMB Plan have been assessed in terms of their relative importance/concern, which allows for the pressures to inform conservation priorities and the development of regional advice (DSEWPac 2012).

4.6. Knowledge Gaps

Where limited information is available, a precautionary principle can be applied in its place; however, completing a gap analysis for missing information is beyond the scope of this report. This report identifies only where current knowledge gaps may exist for key species of marine fauna, with these gaps being identified through the database searches and review of relevant literature.

5. Results

5.1. Database Search results

The following sections present the results of the database searches undertaken for this desktop review.

5.1.1. Protected Matters Search Tool

A summary of all conservation-significant marine fauna species derived from database searches is presented in Table 7. Detailed results for individual species are provided in Appendix C.

Table 7: Summary of conservation significant marine fauna species listed by database searches.

Fauna Group	BC Act	FM Act	EPBC Act			
	Threatened, or Other	Threatened, or Other	Threatened	Migratory	Marine	Cetacean
Mammals	6	N/A	5	9	4	32
Reptiles	3	N/A	5	5	5	N/A
Marine fishes	N/A	21	6	7	5	N/A

*Note: N/A = Not Applicable, due to fauna group being not relevant to legislation or listing type i.e. Mammals and Reptiles not listed under FM Act.

5.1.2. Biologically Important Areas (BIAs)

Five BIAs were identified for conservation significant marine fauna in the NSW region adjacent to the mainland. The details of these BIA's are presented in Table 8 below and shown in Figure 5 and Figure 6.

Table 8: BIAs of the NSW region, within the temperate east marine bioregion

Marine Fauna Group	Common Name	Scientific Name	Type	Relevance to Proposal
Mammal	Southern right whale	<i>Eubalaena australis</i>	Reproduction	No overlap (568 km to migration; 571 km to reproduction BIA)
	Humpback whale	<i>Megaptera novaengliae</i>	Foraging and Migration	Migration BIA overlap (502 km to foraging BIA)
	Indo-Pacific bottlenose dolphin	<i>Tursiops aduncus</i>	Breeding	No overlap (566 km to breeding BIA)
Fish	Grey Nurse shark	<i>Carcharodon taurus</i>	Migrations	No overlap (559 km to migration; 566 km to foraging BIA)
	White shark	<i>Carcharodon carcharias</i>	Aggregation and Distribution	No overlap (541 km to distribution; 629 km to aggregation BIA)

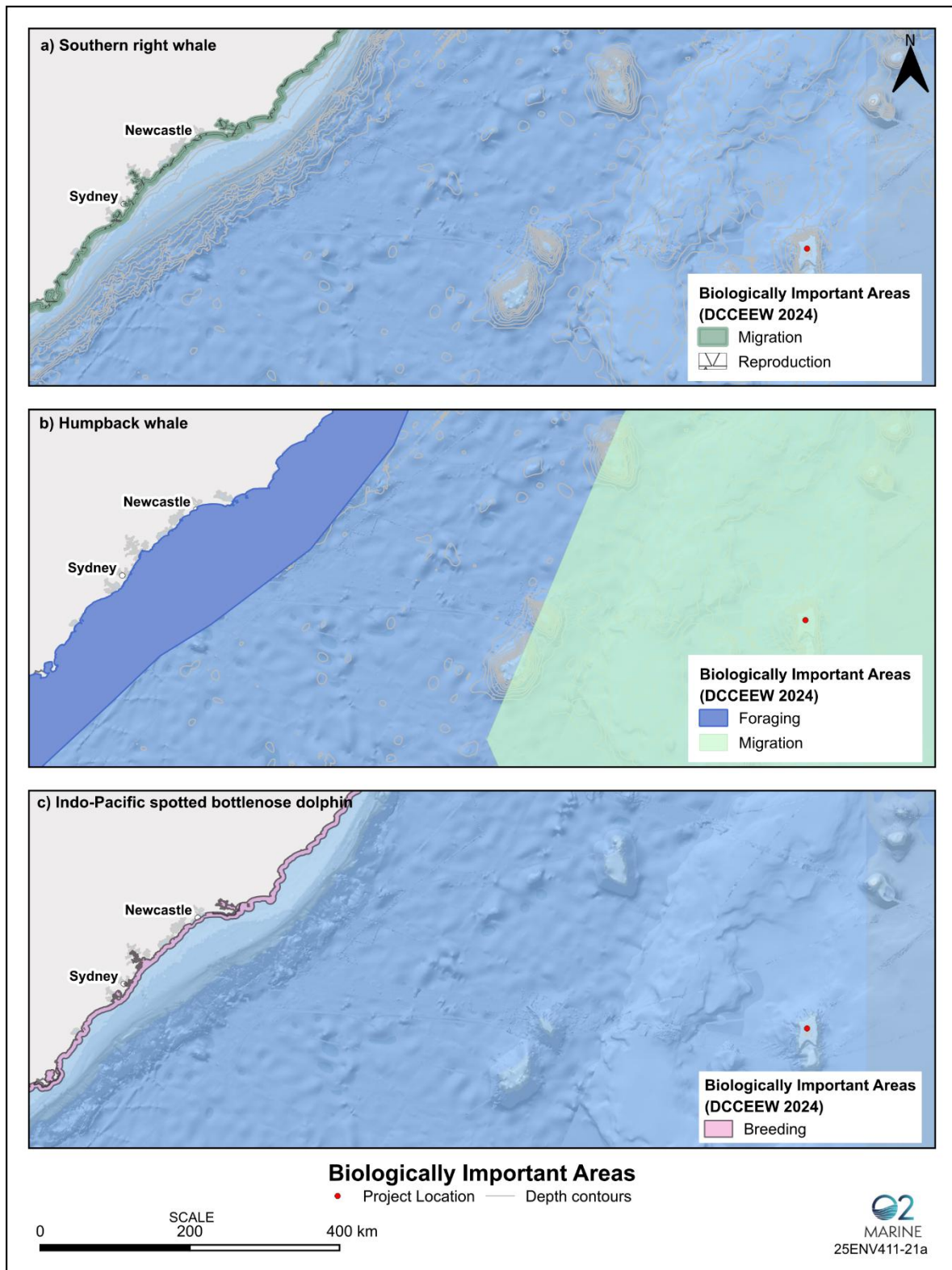


Figure 5: Biologically Important Areas for marine mammals.

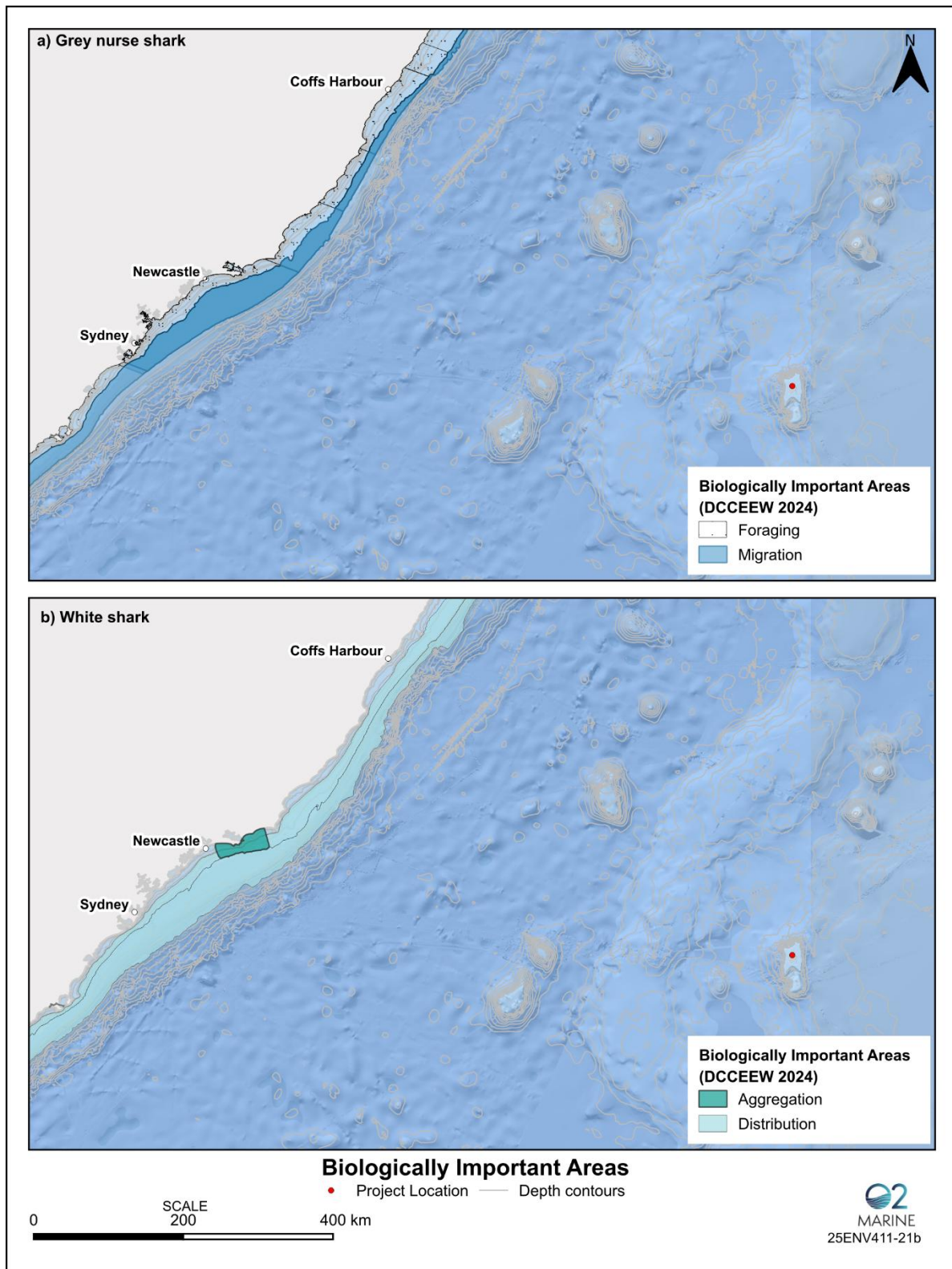


Figure 6: Biologically Important Areas for sharks.

5.1.3. BioNet, ALA and RLS Database Searches

Marine fauna species sightings data provided by the NSW DCCEE BioNet Atlas (BioNet 2025), ALA (ALA 2025) and RLS (RLS 2025) represent historical sightings spanning multiple years and collected by various sources, methods and effort throughout the LHI region. Sightings within the broader search area are presented in Figure 7 through to Figure 13.

Marine fauna species, especially marine mammals, are highly mobile, and the figures presented below represent only a point in time for these species. These maps were considered for known occurrence of a species in the region and the number of sightings within a certain area often reflects the survey effort and/or survey area, although no recorded sightings do not necessarily indicate a species absence from an area. These datasets provide sightings across the broader 20 km search area in relation to the Project area. However, exact locational accuracy varies across records as some are unverified and may include repeated sightings of the same individual.

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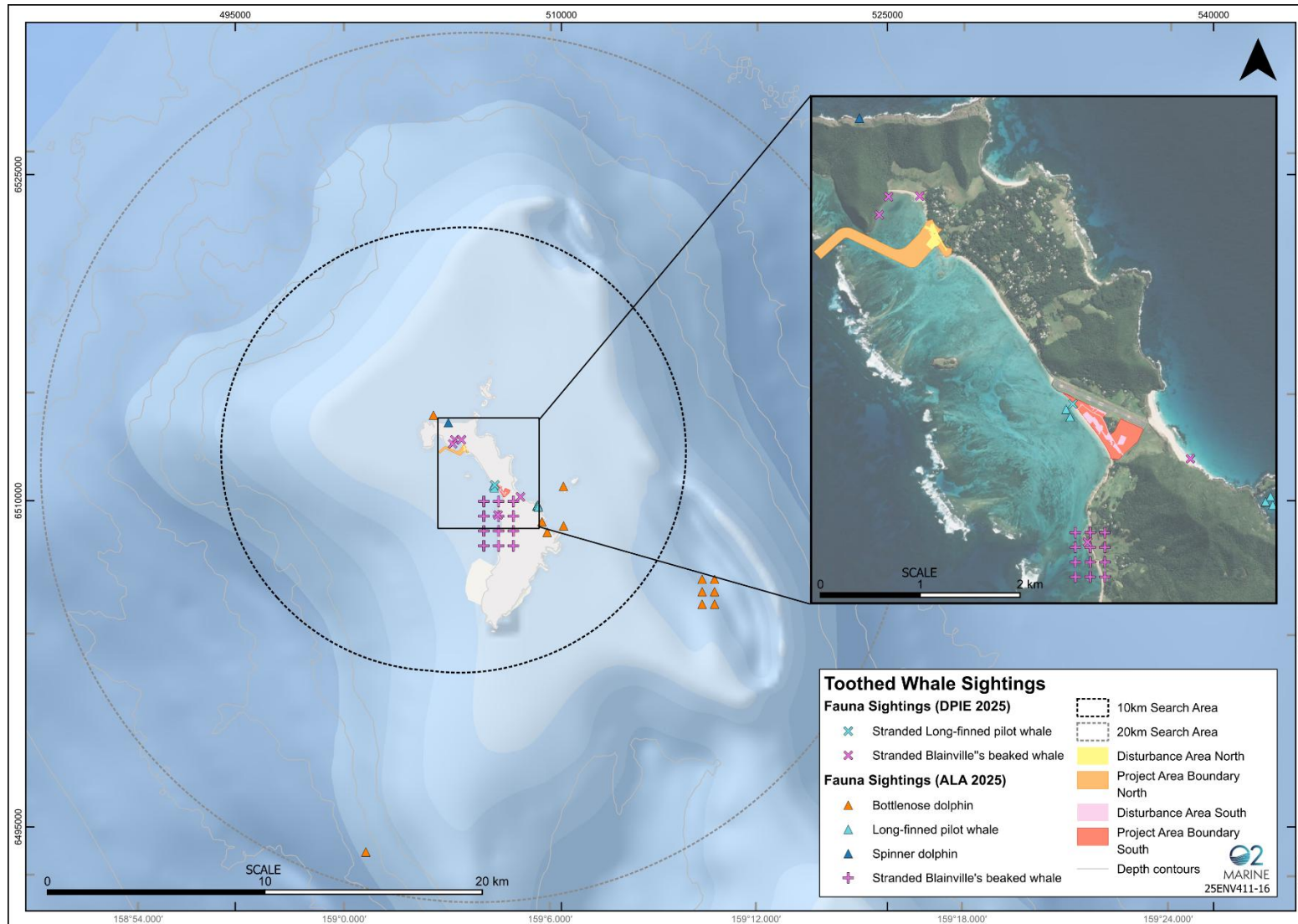


Figure 8: Toothed whale and dolphin sightings within the Proposal area.

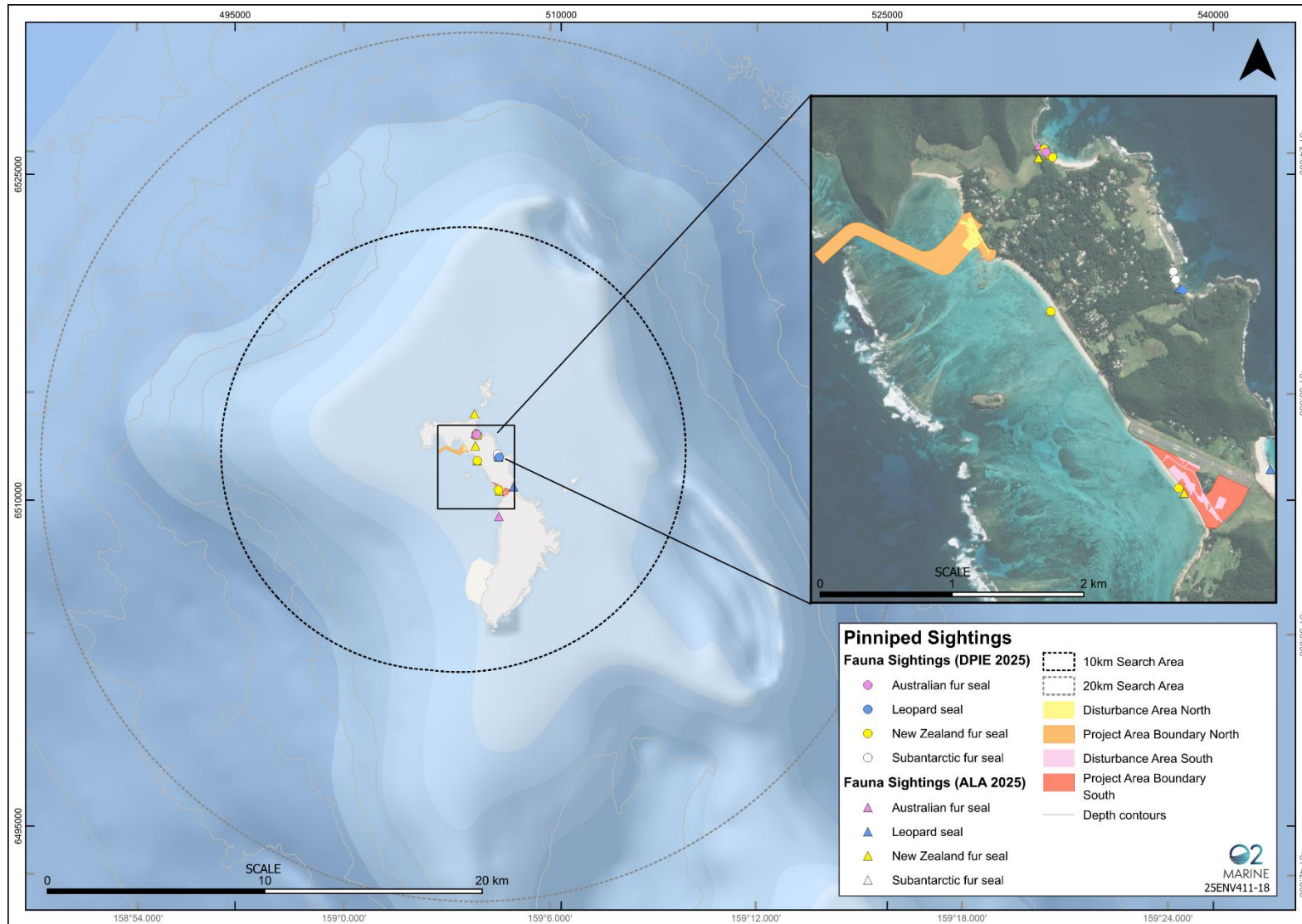


Figure 9: Pinniped sightings within the Proposal area.

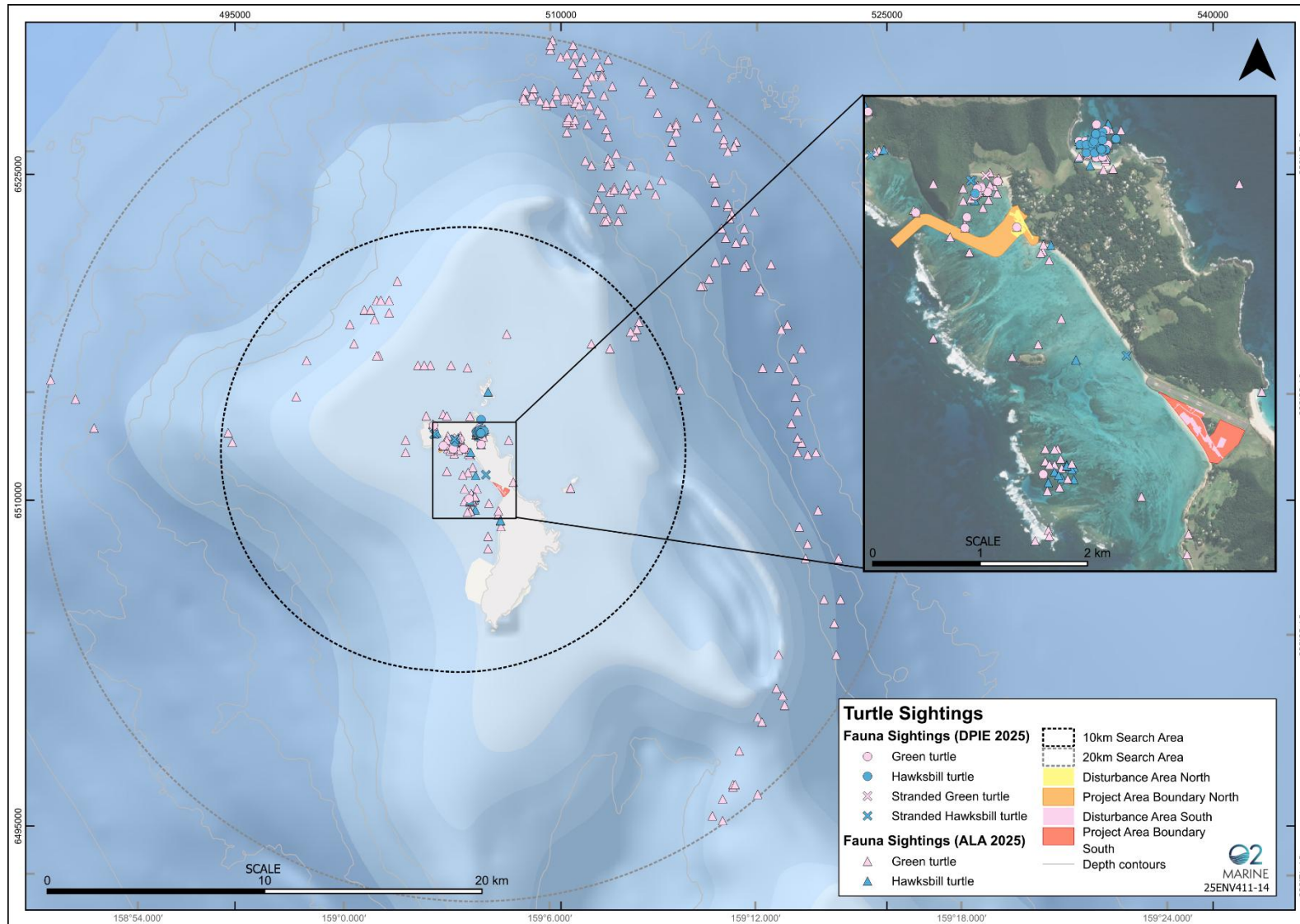


Figure 10: Turtle sightings within the Proposal area.

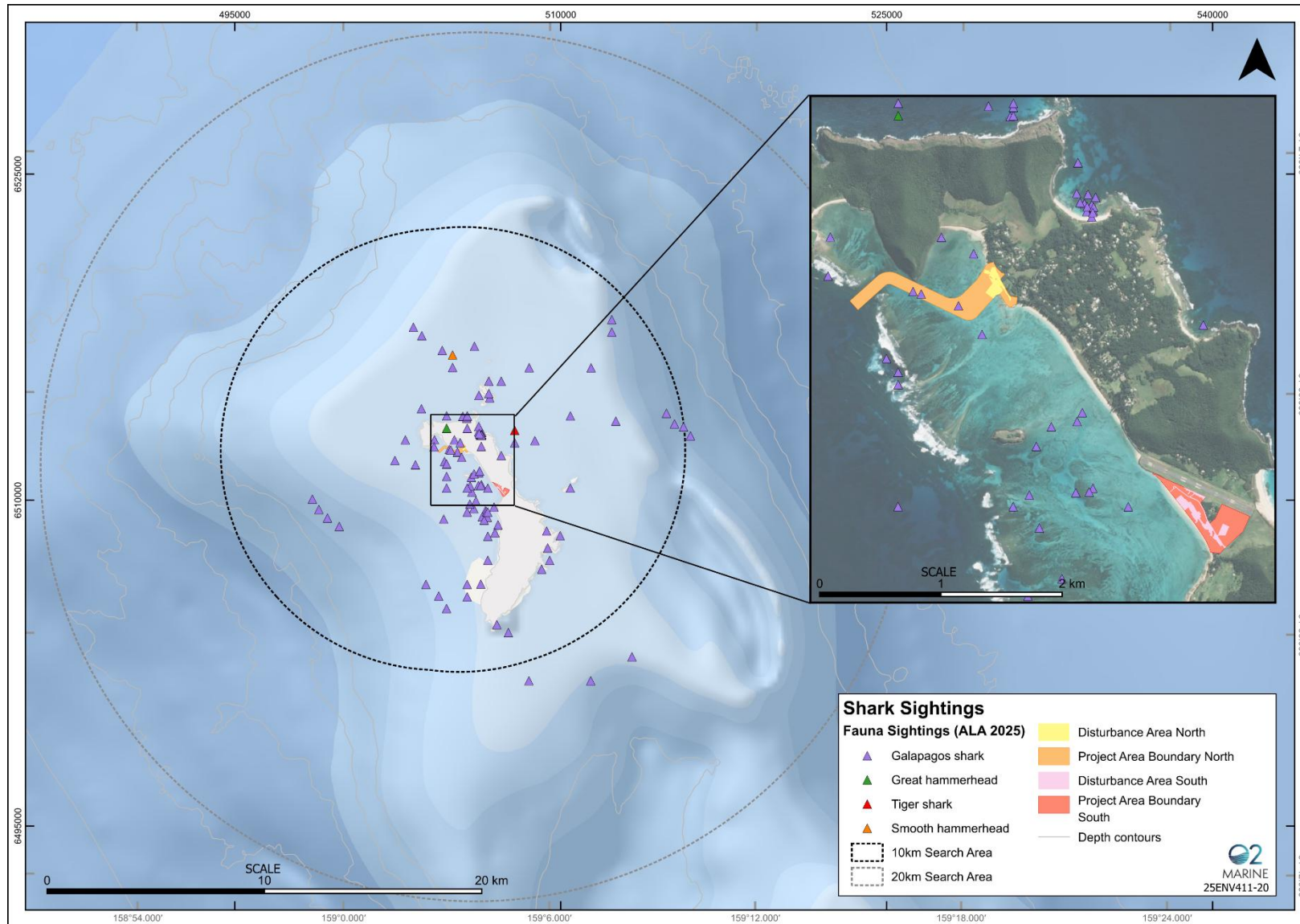


Figure 11: Shark sightings within the Proposal area.

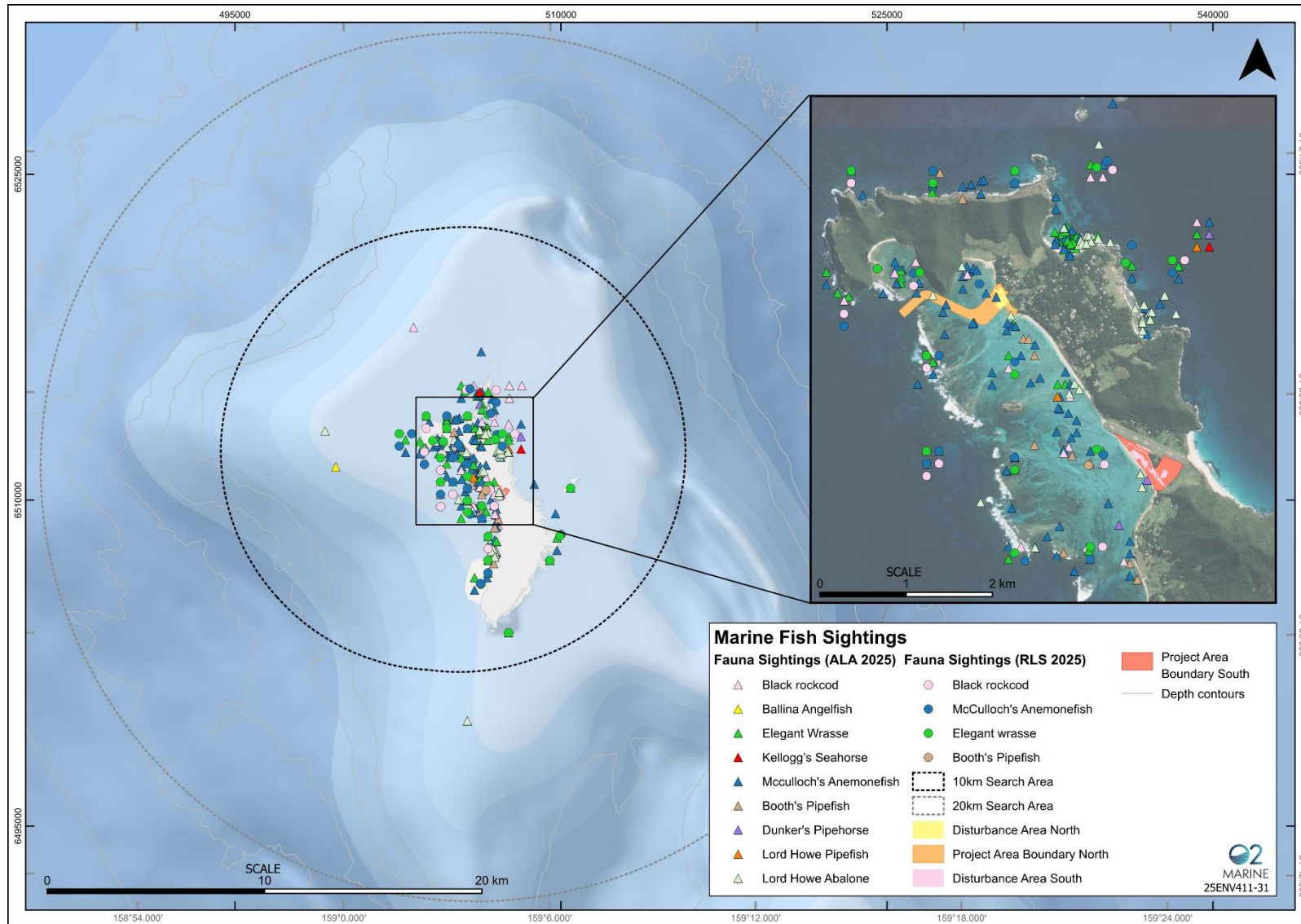


Figure 12: Bony fish sightings within the Proposal areas.

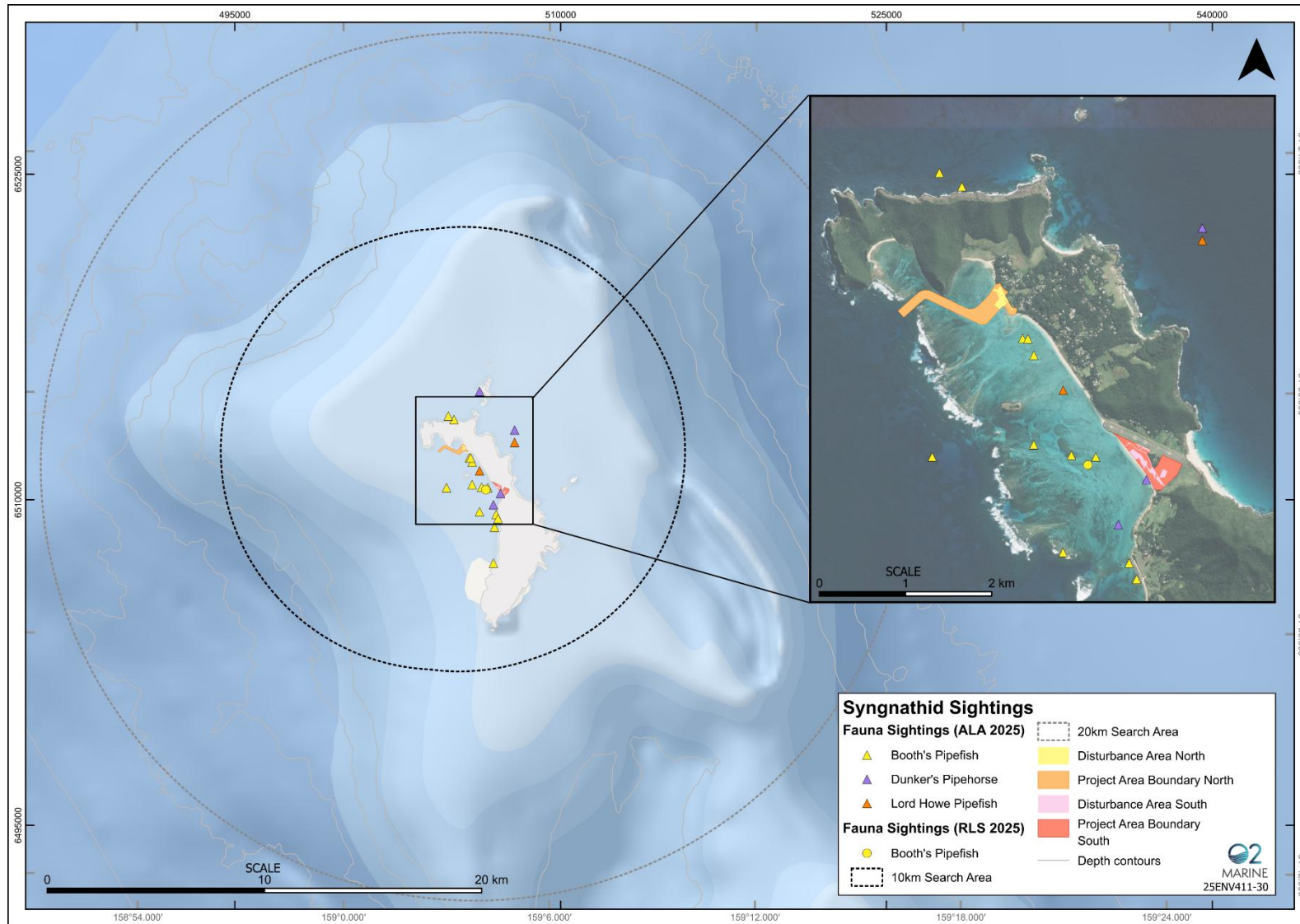


Figure 13: Seahorse and pipefish sightings within the Proposal areas.

5.1.4. Important Marine Mammal Areas (IMMAs)

Important Marine Mammal Areas (IMMAs) are non-statutory areas identified to inform area-based conservation priorities and support national and international conservation efforts. They have been identified by the Marine Mammal Protected Areas Task Force (established by the IUCN Marine Mammal Protected Areas Task Force and its partners) through in-country consultation with marine mammal scientists.

IMMAs are based on qualifying species that meet certain criteria and include a list other species that “utilise the area or have habitat present but do not specifically utilise the area the same way as the qualifying species” (IUCN MMPATF n.d.).

LHI is far offshore from the East Coast Migration Corridor IMMA (Table 9; Figure 14).

Table 9: IMMAs relevant to the Proposal area

Name	Qualifying Species and Criteria	Marine Mammal Diversity
East Coast Migration Corridor	• Dwarf minke whale <i>Balaenoptera acutorostrata</i> Criterion C3 (important areas for aggregation). • Humpback whale <i>Megaptera novaeangliae</i>: Criteria C3 (important areas for aggregation) and D1 (important for migration).	• Australian fur seal <i>Arctocephalus pusillus doriferus</i> • Australian humpback dolphin <i>Sousa sahalensis</i> • Bryde’s whale <i>Balaenoptera edeni</i> • Common bottlenose dolphin <i>Tursiops truncatus</i> • Dugong <i>Dugong dugon</i> • False killer whale <i>Pseudorca crassidens</i> • Indian Ocean bottlenose dolphin <i>Tursiops aduncus</i> • Long snouted spinner dolphin <i>Stenella longirostris</i> • Orca <i>Orcinus orca</i> • New Zealand fur seal <i>Arctocephalus forsteri</i> • Short beaked common dolphin <i>Delphinus delphis</i> • Snubfin dolphin <i>Orcaella heinsohni</i>, • Southern right whale (<i>Eubalaena australis</i>)

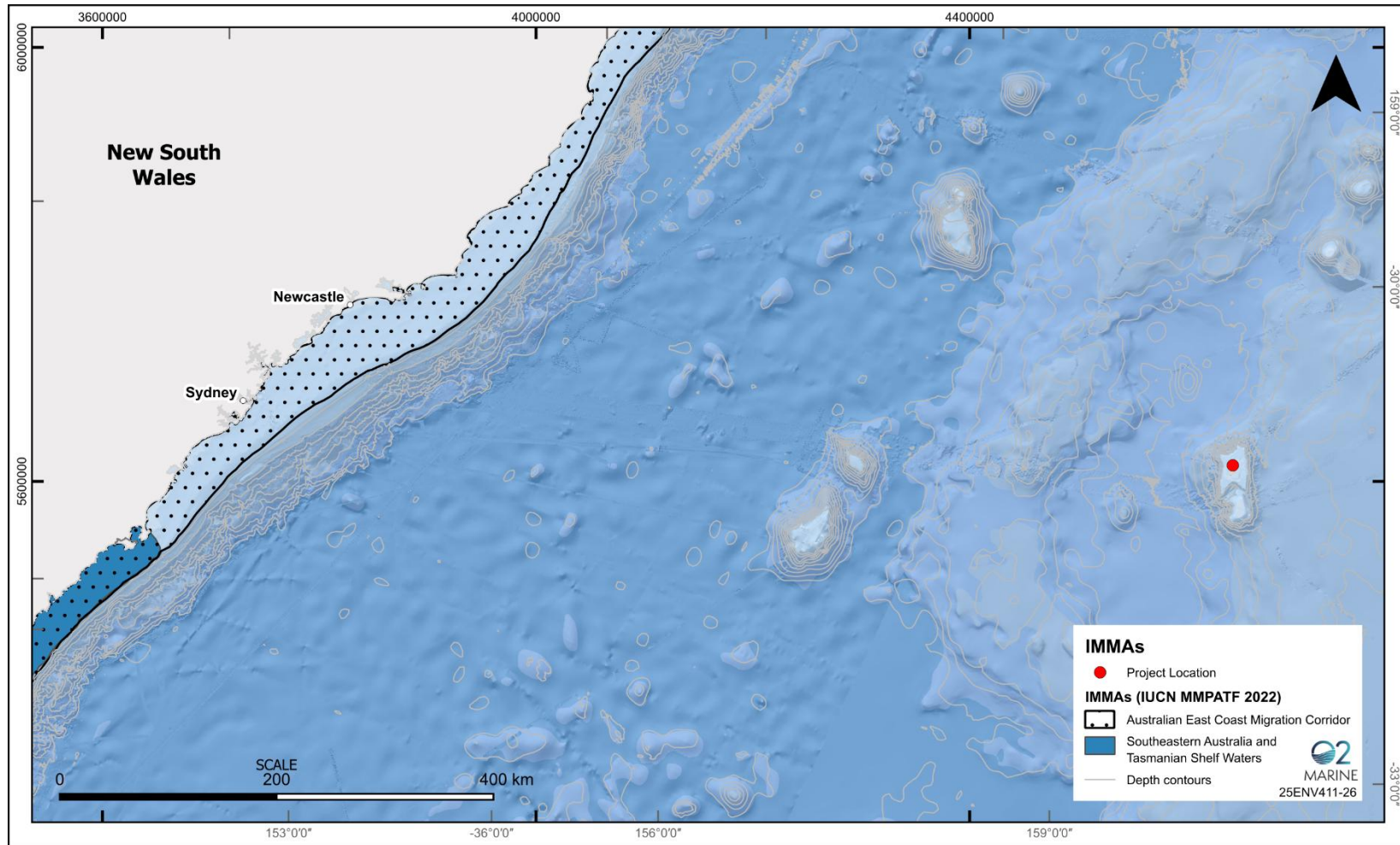


Figure 14: Important Marine Mammal Areas in the region of the Project.

5.2. Key Publications and Studies

O2 Marine reviewed relevant publications and studies in the Project region to assist in assessing the likelihood of occurrence of what marine fauna is in the area. LHI is much more remote than other locations around Australia; thus, some species may have more limited data and publications available than others. Contemporary reports and studies (<5 years old) have been utilised where this information is available to support species assessments. Additionally, environmental values, including features of LHI biodiversity that contribute to outstanding value as a World Heritage site are detailed in the report Environmental Values of the Lord Howe Island Marine Park (Harasti et al 2022) and this represents a key piece of relevant contemporary information for the Project's remote location.

5.3. Likelihood of Occurrence

The likelihood of occurrence results for species within the broad search area (20 km PMST search area) with a 'Known' or 'Likely' PMST rank are presented in Table 10 to Table 12. Additionally, these tables also present the likelihood of occurrence results for aquatic species with a threatened status listing under NSW legislation, which may not be listed as threatened under the EPBC Act. All species identified within the broad search area, including those with a PMST rank of 'May', are presented in Appendix C with their likelihood of occurrence assessment result. As a precautionary measure, some species with a 'May' PMST ranking, or species which are not listed, but are represented in literature as being locally important, are also presented in the following tables. Therefore, this likelihood of occurrence assessment provides a holistic representation of the key species likely to be present during the implementation of the LHI CIP and ensures that all relevant marine fauna groups are considered during the impact assessment process.

5.3.1. Marine Mammals

Table 10: Summary of marine mammals' likelihood of occurrence, PMST Rank, listing status (EPBC, Biodiversity, Fisheries, IUCN). NA = PMST Rank Not Available at LHI

Common Name	Scientific Name	Listing status			PMST Rank	Likelihood of occurrence in broad search area
		EPBC Act	BC Act	IUCN (non-statutory)		
Antarctic minke whale	<i>Balaenoptera bonaerensis</i>	Migratory, Cetacean	-	Near Threatened	Likely	Low
Australian fur seal *	<i>Arctocephalus pusillus</i>	Marine	Vulnerable	Least Concern	NA	Moderate
Blainville's Beaked whale	<i>Mesoplodon densirostris</i>	Cetacean	-	Least Concern	May	Moderate
Common bottlenose dolphin *	<i>Tursiops truncatus</i>	Cetacean	-	Least Concern	May	High
Bryde's whale	<i>Balaenoptera edeni</i>	Migratory Cetacean	-	Least Concern	Likely	Moderate
False killer whale	<i>Pseudorca crassidens</i>	Cetacean	-	Data Deficient	Likely	Low
Fin whale	<i>Balaenoptera physalus</i>	Vulnerable Migratory Cetacean	-	Vulnerable	Likely	Low
Humpback whale *	<i>Megaptera novaengliae</i>	Migratory Cetacean	-	Least Concern	May	High
New Zealand fur seal *	<i>Arctocephalus forsteri</i>	Marine	Vulnerable	Least Concern	NA	Moderate
Sei whale	<i>Balaenoptera borealis</i>	Vulnerable Migratory Cetacean	-	Endangered	Likely	Low
Sub-Antarctic fur seal *	<i>Arctocephalus tropicalis</i>	Endangered Marine	Vulnerable	Least Concern	NA	Low

Species represented with an asterix () are identified from State legislation and/or literature reviews and are included as a precautionary measure. Ecological information and justifications for species with Moderate and Low likelihood of occurrence results are presented in Appendix D.*

5.3.2. Marine Reptiles

Table 11: Summary of marine reptiles likelihood of occurrence and corresponding PMST Rank, listing status (EPBC, Biodiversity, Fisheries, and IUCN).

Common Name	Scientific Name	Listing status			PMST Rank	Likelihood of occurrence in broad search area
		EPBC Act	BC Act	IUCN (non-statutory)		
Flatback turtle	<i>Natator depressus</i>	Vulnerable Migratory Marine	-	Data deficient	Likely	Low
Green turtle	<i>Chelonia mydas</i>	Vulnerable Migratory Marine	Vulnerable	Endangered	Likely	High
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Vulnerable Migratory Marine	-	Critically Endangered	Likely	High
Leatherback turtle	<i>Dermochelys coriacea</i>	Endangered Migratory Marine	Endangered	Vulnerable	Likely	Low
Loggerhead turtle	<i>Caretta caretta</i>	Endangered Migratory Marine	Endangered	Vulnerable	Likely	Low

5.3.3. Marine Fishes

Table 12: Summary of elasmobranchs and marine fishes likelihood of occurrence and corresponding PMST Rank, listing status (EPBC, Biodiversity, Fisheries, and IUCN). N/A = Not Assessed

Common Name	Scientific Name	Listing status			PMST Rank	Likelihood of occurrence in broad search area
		EPBC Act	FM Act	IUCN (non-statutory)		
Ballina angelfish *	<i>Chaetodontoplus ballinae</i>	-	Protected	Least Concern	NA	Low
Black rockcod	<i>Epinephelus daemeli</i>	Vulnerable	Vulnerable	Near Threatened	Likely	High
Bluefish *	<i>Girella cyanea</i>	-	Protected	Not Evaluated	NA	Moderate
Booth's pipefish	<i>Halicampus boothae</i>	Marine	Protected	Least Concern	May	Moderate
Duncker's pipefish	<i>Solegnathus dunckeri</i>	Marine	Protected	Data Deficient	May	Moderate
Doubleheader wrasse *	<i>Coris bulbifrons</i>	-	-	Vulnerable	NA	High
Eastern blue devil *	<i>Paraplesiops bleekeri</i>	-	Protected	Not Evaluated	NA	Moderate
Elegant wrasse *	<i>Anampses elegans</i>	-	Protected	Least Concern	NA	High
Galapagos shark *	<i>Carcharhinus galapagensis</i>	-	-	Near Threatened	N/A	High
Giant manta ray	<i>Mobula birostris</i>	Migratory	-	Endangered	Likely	Low
Gold spot rock cod *	<i>Epinephelus coioides</i>	-	Protected	Near Threatened	NA	Low
Great hammerhead *	<i>Sphyrna mokarran</i>	-	Vulnerable	Endangered	NA	Low
Grey nurse shark	<i>Carcharhinus taurus</i>	Critically Endangered	Critically Endangered	Critically Endangered	NA	Low
Kellogg's seahorse	<i>Hippocampus kelloggi</i>	Marine	Protected	Vulnerable	May	Moderate
Lord Howe abalone *	<i>Haliotis rubiginosa</i>		Critically Endangered	Critically Endangered	NA	High
Lord Howe pipefish	<i>Cosmocampus howensis</i>	Marine	Protected	Least Concern	May	Moderate

Common Name	Scientific Name	EPBC Act	Listing status		PMST Rank	Likelihood of occurrence in broad search area
			FM Act	IUCN (non-statutory)		
Longfin mako	<i>Isurus paucus</i>	Migratory		Vulnerable	Likely	Low
McCulloch's anemonefish (Whitesnout)	<i>Amphiprion mccullochi</i>	Critically Endangered	Critically Endangered	Vulnerable	Known	High
Orange roughy	<i>Hoplostethus atlanticus</i>	Conservation Dependent		Vulnerable	Likely	Low
Queensland groper *	<i>Epinephelus lanceolatus</i>		Protected	Data deficient	NA	Moderate
Reef manta ray	<i>Mobula alfredi</i>	Migratory		Vulnerable	Likely	Low
Sand tiger shark	<i>Odontaspis ferox</i>		Protected	Endangered	NA	Low
Scalloped hammerhead	<i>Sphyrna lewini</i>	Conservation Dependent	Endangered	Critically Endangered	Likely	Low
Shortfin mako	<i>Isurus oxyrinchus</i>	Migratory		Endangered	Likely	Low
Southern bluefin tuna	<i>Thunnus maccoyii</i>		Endangered	Endangered	NA	Low
White shark	<i>Carcharodon carcharias</i>	Vulnerable, Migratory, Marine	Vulnerable	Vulnerable	Likely	Moderate
White's seahorse	<i>Hippocampus whitei</i>	Endangered	Endangered	Endangered	May	Moderate
Species represented with an asterix (*) are identified from State legislation and/or literature reviews OR have a 'May' PMST' Rank and are included as a precautionary measure. Ecological information and justifications for species with Moderate and Low likelihood of occurrence results are presented in Appendix D.						

5.4. Key Species

A total of 12 species were identified as key species for consideration in the impact assessment: four marine mammals, two marine reptiles, and six fish (Table 13). These species are both likely to occur within the region and are inherently vulnerable to potential impacts due to their biology, ecology, and existing pressures. Their conservation significance is based on either their formal legal protection status or recognition as iconic or locally important species. Likelihood of occurrence varies according to species ecology, with marine mammals more likely to occur offshore in areas of potential underwater noise exposure, and lagoonal fish occurring in closer proximity to construction activities. Given the high level of uncertainty in the available data, a precautionary approach has been applied. Focusing management and mitigation measures on these key species is expected to provide broader protection for other non-key species within the same taxonomic groups.

Table 13: Key Species and Rationale

Species	Conservation significance	Occurrence	Precautionary approach
Mammals			
Bottlenose dolphin	Not threatened but an iconic species contributing to LHI's biodiversity values (Harasti et al 2022).	High likelihood of occurrence in 20 km & 10 km search area. May enter the lagoon. Present year round, with main area of occupancy in channels located to the south of the island and between LHI and Balls Pyramid.	Species considered for potential impacts from underwater noise. They are a representative dolphin species for the medium-frequency cetacean hearing group.
Humpback whale	Humpback whales are listed as Migratory and Cetacean under EPBC Act	High likelihood of occurrence in 20 km & 10 km search area. May enter the lagoon. Migration BIA surrounds LHI, humpback whales present at LHI only during periods of migration	Species considered for potential impacts from underwater noise, and in particular the sensitivity of mother/calf pairs present during the southern migration. They are a representative species for the low-frequency cetacean hearing group.
Reptiles			
Green turtle	Green turtles are listed as Vulnerable under both the BC Act and EPBC Act.	High likelihood of occurrence in 20 km & 10 km search area. This species utilises the lagoon for foraging in seagrass and algae habitats.	Species considered for important foraging habitat during juvenile and sub-adult life history phases. Considered also for potential impacts from underwater noise. They are a representative species for the sea turtle hearing group.
Hawksbill turtle	Hawksbill turtles are listed as Vulnerable under the EPBC Act.	High likelihood of occurrence in 20 km & 10 km search area. This species utilises the lagoon for foraging in coral reef habitat.	Species considered for important foraging habitat during sub-adult and adult life history phases. Considered also for potential impacts from underwater noise.

Species	Conservation significance	Occurrence	Precautionary approach
			They are a representative species for the sea turtle hearing group.
Fish			
Black rockcod*	Black rockcod are listed as Vulnerable under The EPBC Act and FM Act and Near Threatened by the IUCN	Black rockcod have been sighted at numerous locations around LHI, including within the lagoon. These are likely to be female juveniles and sub-adults with mature males becoming site attached in overhangs in deeper waters	Black rockcod are considered as key due to this species experiencing population pressures for most of the last century. Juvenile and sub-adults present in the lagoon represent potential egg producers which are a significant factor for breeding success, Considered also for potential impacts from underwater noise. They are a representative species for the Fish with swim bladder hearing group.
Doubleheader wrasse	Doubleheader wrasse are not listed as threatened under State or Commonwealth legislation, but listed as Vulnerable by the IUCN. They may be fished recreationally with restriction at LHI.	Both juveniles and adult Doubleheader wrasse are highly likely to be present within the LHI lagoon and Northern Zone boundary.	Doubleheader wrasse are considered an iconic species at LHI contributing to LHI's diverse fish assemblage. Considered also for potential impacts from underwater noise. They are a representative species for the Fish with swim bladder hearing group.
Elegant wrasse*	Elegant wrasse are not a listed threatened species, but are a Protected species under the FM Act. This species has not been evaluated by the IUCN.	This species is identified with a high number of sightings near the North Project boundary and within the LHI lagoon. These locations represent very suitable habitat, and it is highly likely to be present in these locations year-round.	Elegant wrasse are considered an iconic species at LHI contributing to LHI's diverse fish assemblage. Considered also for potential impacts from underwater noise. They are a representative species for the Fish with swim bladder hearing group.
Galapagos shark	Galapagos sharks are not listed under State or Commonwealth legislation, but listed as Near Threatened by the IUCN	High likelihood of occurrence in 20 km & 10 km search area. Australia's largest population for this species occurs regionally around LHI.	Considered also for potential impacts from underwater noise. They are a representative species for the Fish with no swim bladder hearing group.
Lord Howe abalone	Lord Howe abalone are listed as Critically Endangered under the FM Act, and are	The Lord Howe abalone is a threatened endemic species under State legislation with sightings near the North Project boundary and within	Lord Howe abalone are endemic to the LHI and an iconic threatened species contributing to LHI's diverse fish assemblage.

Species	Conservation significance	Occurrence	Precautionary approach
	on the 2025 Priority Assessment list for Critically Endangered status under the EPBC Act	the lagoon. It is also present at other shallow intertidal areas around LHI	Considered for potential impacts due to habitat modification and disturbance due to this species highly localised shallow water range.
McCulloch's anemonefish	McCulloch's anemonefish are listed as Critically Endangered under the EPBC and FM Acts. It is listed as Vulnerable by the IUCN	This species is endemic to the LHI region, including at Elizabeth and Middleton Reefs. The LHI lagoon supports 75% of this species population.	McCulloch's anemonefish are endemic to the LHI region and an iconic threatened species contributing to LHI's diverse fish assemblage. Considered also for potential impacts from underwater noise. They are a representative species for the Fish with swim bladder hearing group.

5.4.1. Ecological Windows

Ecological windows reflect sensitive periods of time when marine species are most likely to use a habitat for an important life phase, such as for breeding, feeding, or migration. Understanding these seasonal patterns helps to determine when species are most vulnerable and avoid disturbances. While several conservation-significant species are likely present year-round, sightings may be occasional due to population size or life-history patterns. Key species' ecological windows are presented in Table 14.

Table 14: Key Species' Ecological Windows (Dark blue represent- full duration of presence. Light blue – represents timing of specific behaviours.

Species presence	J	F	M	A	M	J	J	A	S	O	N	D	Data Source
Humpback whale													Andrews-Goff (2023), Seyboth (2023)
<i>Northern migration</i>													Andrews-Goff (2023), Seyboth (2023)
<i>Southern Migration</i>													Andrews-Goff (2023), Seyboth (2023)
Common bottlenose dolphin													Harasti et al (2022)
Green turtle													DOEE (2017b)
<i>-Foraging</i>													DOEE (2017b)
Hawksbill turtle													DoEE (2017b)
<i>-Foraging</i>													DoEE (2017b)
Black rockcod													DPI (2006d, 2012)
Doubleheader wrasse													Spawning unknown, Bray (2023)
Elegant wrasse													DPI (2006e)
Galapagos shark													DEWHA (2008)
<i>-Pupping*</i>													DEWHA (2008)
Lord Howe abalone													Harasti et al (2022)
McCulloch;s Anemonefish (Whitesnout)													TSSC 2024

6. Discussion

Key species which were deemed to have a High likelihood of occurrence within the Proposal area and are of conservation significance are described in further detail in the following sections below. Other species with a lower likelihood of occurrence within the Proposal area are discussed in Appendix D.

6.1. Marine Mammals

6.1.1. Bottlenose dolphin

6.1.1.1. Population

The common bottlenose dolphin (*Tursiops truncatus*) is found throughout both hemispheres, across both tropical and temperate waters. There are many regionally important populations that are fragmented from each other, as such there is no global population estimate available, and population studies are regionally focussed (Allen 2021). In NSW, this species is widely distributed along the coastline, with populations exhibiting strong site fidelity and localized social structures, particularly within estuarine and coastal embayments. In regions such as the Port Stephens–Great Lakes Marine Park and Jervis Bay, resident communities have been identified through photo-identification and genetic studies, suggesting stable, long-term associations and limited dispersal between subpopulations (Wiszniewski et al., 2009). It is estimated that the Byron Bay population consists of 865 individuals, with subgroups utilising discrete core habitats for foraging, socialising, and resting (Hawkins et al., 2014). There are no population studies available for the LHI population, although a local population of Bottlenose dolphins are present year-round (Harasti et al 2022).

6.1.1.2. Distribution

The bottlenose dolphin is globally cosmopolitan, inhabiting temperate and tropical coastal and offshore waters across all major oceans, except within polar regions. In Australia, they occur around the entire mainland, inhabiting a variety of marine and estuarine environments, preferring continental shelf waters, including in pelagic waters, near oceanic islands, and over the continental shelf, (Ross, 2006, Wells and Scott 2009). At LHI, it is the most common cetacean species sighted and occurs year-round the island seamount (Harasti et al 2022). The Bottlenose dolphins which inhabit LHI are most commonly sighted in the offshore trench between LHI and Ball's Pyramid; and near the lagoon (Figure 8, Harasti et al 2022). These sightings typically involve small, mobile pods, consistent with the species' known behavioural flexibility and capacity to exploit both coastal and pelagic habitats (Hale et al., 2000). While their occurrence in this remote marine environment suggests that LHI forms part of their wider oceanic range, the absence of formal population studies means their residency patterns and habitat use remain largely undocumented.

6.1.1.3. Habitat use and life history

Bottlenose dolphins exhibit flexible habitat use and life history traits that enable them to thrive in a wide range of marine environments, from shallow estuaries and coastal bays to deep offshore waters. In NSW, their habitat use is strongly influenced by local environmental conditions, prey availability, and social structure. Coastal populations often show site fidelity to sheltered embayments and estuaries,

using these areas for foraging, resting, and socializing (Fury & Harrison, 2011). Around offshore islands like Lord Howe Island, they are typically observed in deeper pelagic habitats, including steep drop-offs and oceanic trenches, where they likely exploit aggregations of schooling fish or squid (Harasti et al 2022).

This species forms part of complex, often semi-resident communities with well-documented site fidelity and social structures, particularly in embayments like Port Stephens, Jervis Bay, and Byron Bay (Wiszniewski et al., 2009). Bottlenose dolphins exhibit slow reproductive rates and long lifespans, making them particularly vulnerable to environmental and anthropogenic pressures. Females typically give birth to a single calf every 3 to 6 years after a gestation period of about 12 months, and calves remain dependent on their mothers for up to three years (Wells & Scott, 2009). Sexual maturity occurs around 10–12 years for females and slightly later for males, while individuals may live for more than 40 years in the wild. These traits result in low intrinsic population growth rates, meaning that population recovery following disturbance may be slow.

Common bottlenose dolphins employ a suite of sophisticated foraging behaviours that vary by habitat and prey type. Documented strategies include sponging, barrier feeding, plume feeding and strand feeding. Offshore animals feed primarily on mesopelagic fish and oceanic squids (DCCEEW 2025c).

6.1.1.4. Relevant Policy and Guidance

- Australian National Guidelines for Whale and Dolphin Watching (DoEE 2017a)
- National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a)
- EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DEWHA 2008a)
- Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012).

6.1.1.5. Threats and Pressures

Based on the TEMB Plan (DSEWPaC 2012), habitat modification is listed as a threat of concern for Bottlenose dolphins. Additionally, the following threats of potential concern have been identified that may be relevant to consider for the LHI CIP include:

- Chemical, nutrient and light pollution
- Marine debris
- Underwater noise
- Human presence
- Collision with vessels

6.1.1.6. Relevance to the Project area

Likelihood of Occurrence: **High**

This species is not listed as threatened, however it is listed as ‘Cetacean’ under the EPBC Act and ‘Least Concern’ by the IUCN. The Bottlenose dolphin is an iconic species contributing to LHI’s biodiversity values and is present at the island year-round (Harasti et al 2022). It is highly likely that Bottlenose dolphins will be present during the Project and potentially impacted by Project activities.

6.1.2. Humpback whale

6.1.2.1. Population

Humpback whales (*Megaptera novaengliae*) are a cosmopolitan baleen whale species and one of the most studied of all the cetacean species in the world and the most common whale sighted within the LHIMP (Harasti et al 2022). In Australia, there are two distinct populations, a west coast population and an east coast population. The east-coast population of Humpback whales are part of Breeding Stock E (Group V), which is one of seven geographically distinct populations of humpback whales (IWC 2016, Seyboth et al 2023). Further, Breeding Stock E can be further divided into Stock E1, migrating from Antarctic feeding grounds to Queensland, and Stock E2, migrating from Antarctic feeding grounds to New Caledonia and Stock E3 migrating from Antarctic feeding grounds to Tonga. This iconic whale species has undergone a remarkable recovery following near-extinction due to intense commercial whaling, which reduced its numbers to a mere 3.5–5% of pre-whaling abundance by the early 1960s after approximately 216,000 whales were killed (Alison 2020). Since the end of whaling for this species in 1986 (IWC 2016), its population has continued to increase, with current estimates for both the east and west coast populations exceeding 40,000 individuals. The sum of the median abundance projected for each southern hemisphere stock for 2015 was 96,675, indicating a recovery of ~70% (IWC 2016). In recognition of this species population recovery, it is no longer listed as a threatened species under the EPBC Act, it remains listed as ‘Cetacean’ and ‘Migratory’ and ‘Least Concern’ by the IUCN.

6.1.2.2. Distribution

Arguably one of the most iconic whale species, the Humpback whale has a cosmopolitan distribution and is found in both the northern and southern hemispheres. However, due to temporal influences on their migration patterns, the Northern and Southern Hemisphere populations never meet (DCCEEW 2025c). Like many baleen whales, southern hemisphere Humpback whales undergo an annual migration between their feeding grounds in Antarctica (south of 56° S) during the austral summer to lower tropical latitudes (15° S to 20° S) for calving during the austral autumn and winter. Humpback whales occurring at LHI may be migrating to or from either Queensland (Stock E1) or to or from New Caledonia (Stock E2 (Seyboth et al 2023). The east Australian population tends to remain close to the coastal mainland, while the E2 stock is reportedly more oceanic, with calving near lagoons on coral reefs and congregations on seamounts and other oceanic features (Figure 15, Garrigue et al 2015, Garrigue et al 2020), Humpback whales from both breeding stocks may pass LHI, during their migration to two different calving locations in tropical waters (Seyboth et al 2023) and the migration BIA for humpback whales encompasses LHI, within the broader search area(Figure 5).

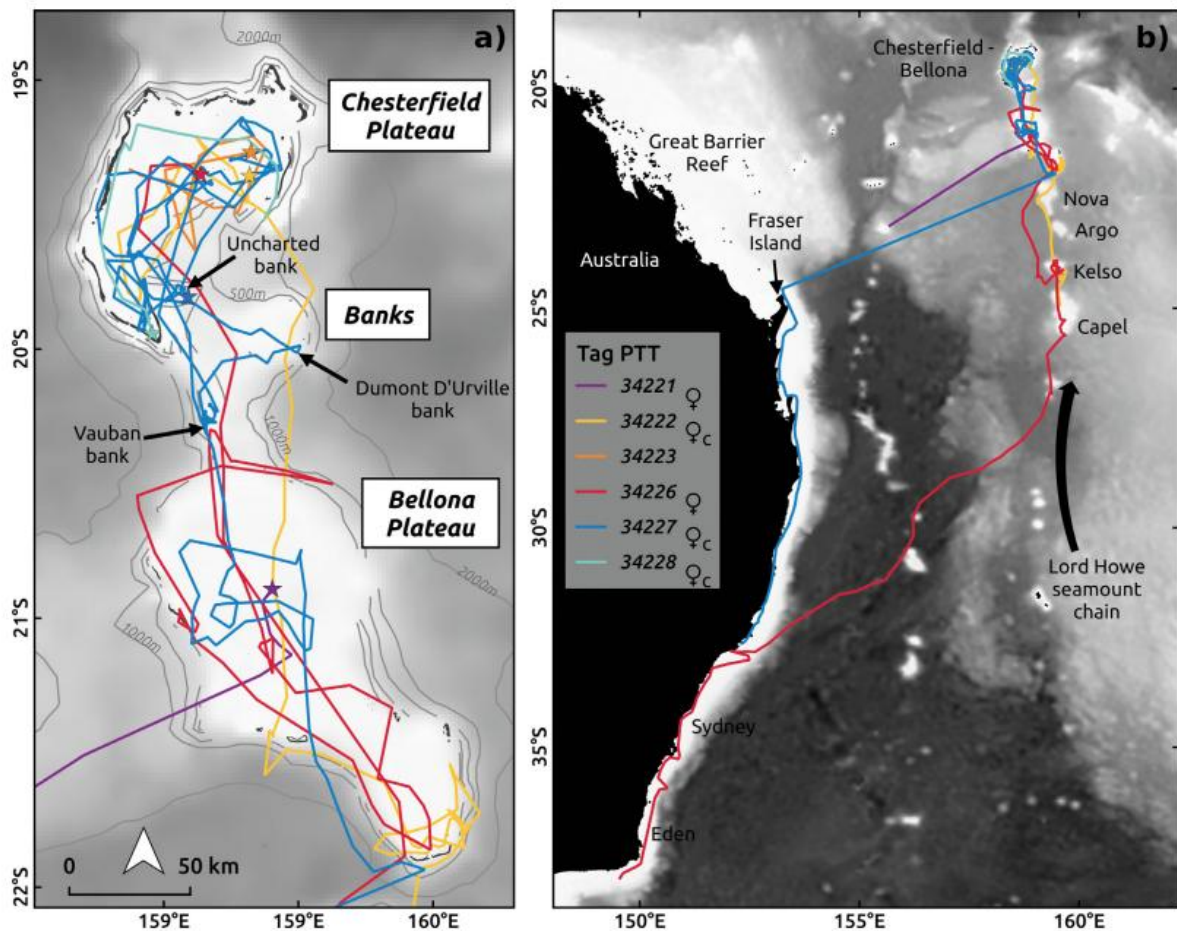


Figure 15: Satellite tracking of 6 humpback whales *Megaptera novaeangliae* tagged in Chesterfield ($n = 4$), Bellona ($n = 1$), and the offshore banks ($n = 1$) in 2017. (a) Zoom on the Chesterfield-Bellona archipelago, and (b) whole tracks from start to end of transmission. Tracks are modelled with a correlated random walk and interpolated with 1 location every 6 h. Deployment positions shown with stars. Sex and presence of a calf ('c') indicated in the tag colour key, except tag 34223 of unknown sex. (Source: Garrigue et al 2020).

6.1.2.3. Habitat use and life history

They undergo seasonal migrations between summer foraging grounds in cold productive waters to winter breeding grounds in warm waters at lower latitudes. The exact timing of the annual Humpback whale migration can vary from year to year depending on water temperature, Antarctic sea ice, predation risk, prey abundance, and the location of the feeding ground. Breeding Stock E whales migrate annually from the southern Antarctic feeding grounds to the north, entering waters of Queensland, New Caledonia and Tonga around June, to breed and give birth to their calves, until later returning to the southern waters of the Antarctic around October (DSEWPaC 2012, Andrews-Goff 2023; Seyboth 2023). Although warmer tropical waters have traditionally provided comfortable conditions for calving, observations of humpback whale neonates as far south as southern NSW have been recently observed and indicate changes of preferred habitat use (Jolliffe et al. 2024). Additionally, while productive Antarctic waters have thought to be the traditional feeding grounds, recent observations of bubble feeding in the Tasman Sea indicates a need to supplement their energy intake during migration (Pirodda et al 2021).

Humpback whales live to around 48 years old, with a mean sexual maturity age of five years. Female humpback whales calve every 2 to 3 years. Humpback whale calves remain with their mothers for the first year of their lives, with mothers providing food, protection, and helping their development (Seeary et al. 2022). This mother-calf association is thought to increase the calves' reproductive success due to the mother teaching essential skills. Occasionally mother-calf pairs will be escorted along their migratory route by male humpback whales (Seeary et al. 2022). Lactating female humpback whales spend a significant amount of time resting, remaining stationary at shallow depths which increases the potential for ship strike collisions (Bejder et al. 2019). Although recorded occasionally, we still have limited information on the species diversity, migratory patterns, near-shore behaviour and beaching of whales that visit and/or reside in the LHIMP.

6.1.2.4. Relevant Policy and Guidance

Humpback whales are listed as 'Migratory' and 'Cetacean' under the EPBC Act. They were previously listed as Vulnerable and were removed from their Vulnerable status under the EPBC Act as of the 26 February 2022 due to increasing numbers. Their global (non-statutory) listing by the IUCN is Least Concern. Relevant EPBC Act documents are:

- Listing Advice *Megaptera novaeangliae* Humpback Whale (TSSC 2022)
- Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans (DoEE 2018)
- Australian National Guidelines for Whale and Dolphin Watching (DoEE 2017a)
- National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEE 2024a)
- EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DEWHA2008a)
- Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012).

6.1.2.5. Threats and Pressures

The greatest threats to humpback whales are from human-made underwater noise (resulting in hearing impairment, organ damage, communication interference, elevated stress levels and/or avoidance of important habitat), vessel strike, entanglement in lobster pot lines and marine debris (TSSC 2022). At LHI, humpback whales present during Project construction may be impacted by underwater noise or vessel strike. Neonate calves are particularly vulnerable to vessel strikes as they have limited swimming and diving abilities and low breath-hold capacity (Irvine and Salgado 2018). Lactating humpback whales are susceptible to even moderate noise levels that can decrease their communication range (Bejder et al. 2019).

Based on the TEMB Plan, underwater noise and vessel strike have been identified as existing threats that may be relevant to consider when assessing impacts of the Proposal (DSEWPac 2012, Appendix A).

6.1.2.6. Relevance to the Project area

Likelihood of Occurrence: **High**

There is limited data on humpback whale presence at LHI. However, they are likely to occur in the waters surrounding the island during both the north and south annual migrations between the periods of June-November. On the southern migration, mothers with calves are present which are particularly

vulnerable to impacts during this sensitive period. It is noted this species of whale is the most commonly sighted within the LHIMP and contributes to the biodiversity values of the area (Harasti et al 2022).

6.2. Marine Reptiles

6.2.1. Green turtle

6.2.1.1. Population

There are no global population estimates for the Green turtle (*Chelonia mydas*); however, the global population appears to be decreasing. In Australia, up to 17 genetically distinct stocks have been described which are spread across seven populations. The total Australian population of Green turtles is estimated to be more than 70 000 individuals, with about 8000 of these occurring in the southern Great Barrier Reef region (DCCEW 2025c). The genetic stock composition of green turtles found around LHI, has been investigated via mixed-stock analysis that covers an extensive foraging range—spanning roughly 870 km of NSW coastline as well as Lord Howe Island, using mitochondrial DNA data. This analysis sampled turtles of various life stages (from post-hatchlings to adults) that had stranded between 1997 and 2021. Although only two individuals from LHI were included, the overall findings for green turtles of the NSW region, including LHI was that the region supports multiple stocks, however they are dominated by those of the southern Great Barrier Reef and New Caledonia genetic stock (Day et al 2024).

6.2.1.2. Distribution

Green turtles exhibit a broad global distribution, inhabiting tropical and subtropical waters across the Atlantic, Pacific, and Indian Oceans. In Australian waters, they are commonly found along the northern and eastern coastlines, with key foraging and nesting sites located in the Great Barrier Reef, Torres Strait, and Coral Sea. In NSW, green turtles primarily use coastal and estuarine habitats as developmental foraging grounds, with juveniles and sub-adults commonly recorded around areas such as Moreton Bay, Port Stephens, the Solitary Islands, and LHI (DCCEW 2025c). In NSW, at the southern limit of their typical range. Green turtles are increasingly observed as rising ocean temperatures, driven by a strengthening EAC, enable them to occupy southern, temperate waters more frequently (Day et al 2024). Most individuals found in NSW originate from major nesting rookeries in the southern Great Barrier Reef and New Caledonia (Day et al 2024). Their wide distribution reflects complex migratory patterns influenced by ocean currents, natal homing behaviour, and the availability of food sources. At LHI, Green turtles are frequently seen during at least the summer months, especially within the lagoon area which they access for foraging and resting (Figure 10).

6.2.1.3. Habitat use and life history

Similar to other marine turtles, Green turtles exhibit a complex life history characterised by extensive ontogenetic shifts in habitat use that span both oceanic and coastal environments. After hatching on tropical or subtropical beaches, young turtles embark on a pelagic “lost years” phase in offshore oceanic zones, feeding opportunistically on prey such as jellyfish, crustaceans, and floating algae (Arthur et al 2008). As they grow into juveniles, they undergo a developmental migration to nearshore coastal environments, including estuaries, seagrass meadows, and coral or rocky reefs (Arthur et al

2008, DCCEEW 2025c). In Australia, key foraging habitats include the Great Barrier Reef, Moreton Bay, and temperate areas such as the Solitary Islands and LHI in NSW. In these regions, juveniles and sub-adults feed primarily on seagrass and algae. During these periods of foraging, Green turtles exhibit varying home-range sizes and movement patterns depending on size and location, these foraging ranges may be very small, <2km² (Pillans et al 2021).

Green turtles can spend up to 5 hours underwater when resting, and up to 5 minutes during active movement, with 89-100% of diving time being spent at shallow water depths <5 m (Hazel et al 2009). Diel and seasonal variations investigated in this study also found that resting dives were 3 to 4 times longer in median duration, and 6 times longer in maximum duration, at cool temperatures than they were at warm temperatures, but there was no evidence of winter diapause or location shift to avoid cold water. There was a large decrease in dive duration with higher water temperatures, however dive depth did not appear to be affected (Hazel et al 2009, Figure 16).

Sexual maturity is reached between 20 and 40 years of age, at which point adults migrate long distances—often over 1,000 km—to return to their natal beaches to breed, demonstrating strong natal homing fidelity. Nesting typically occurs every 2–8 years, with females laying multiple clutches per season. Although most green turtles nesting in Australian waters originate from rookeries in the northern and central Great Barrier Reef, individuals from these stocks are widely dispersed across eastern and southeastern foraging grounds (Day et al 2024). Throughout their life cycle, green turtles face a variety of natural and anthropogenic threats, including predation, marine debris ingestion, boat strikes, and climate change impacts on both nesting and feeding habitats.

Understanding the dynamic habitat use and life stage transitions of Green turtles is essential for targeted conservation strategies, particularly in regions like NSW where juveniles and sub-adults dominate the population structure. Nesting is not a behaviour which has been observed at LHI and this location has not been identified as important habitat for Green turtle nesting, with the nearest nesting site being located in the southern Great Barrier Reef area of mainland Queensland (DCCEEW 2025c).

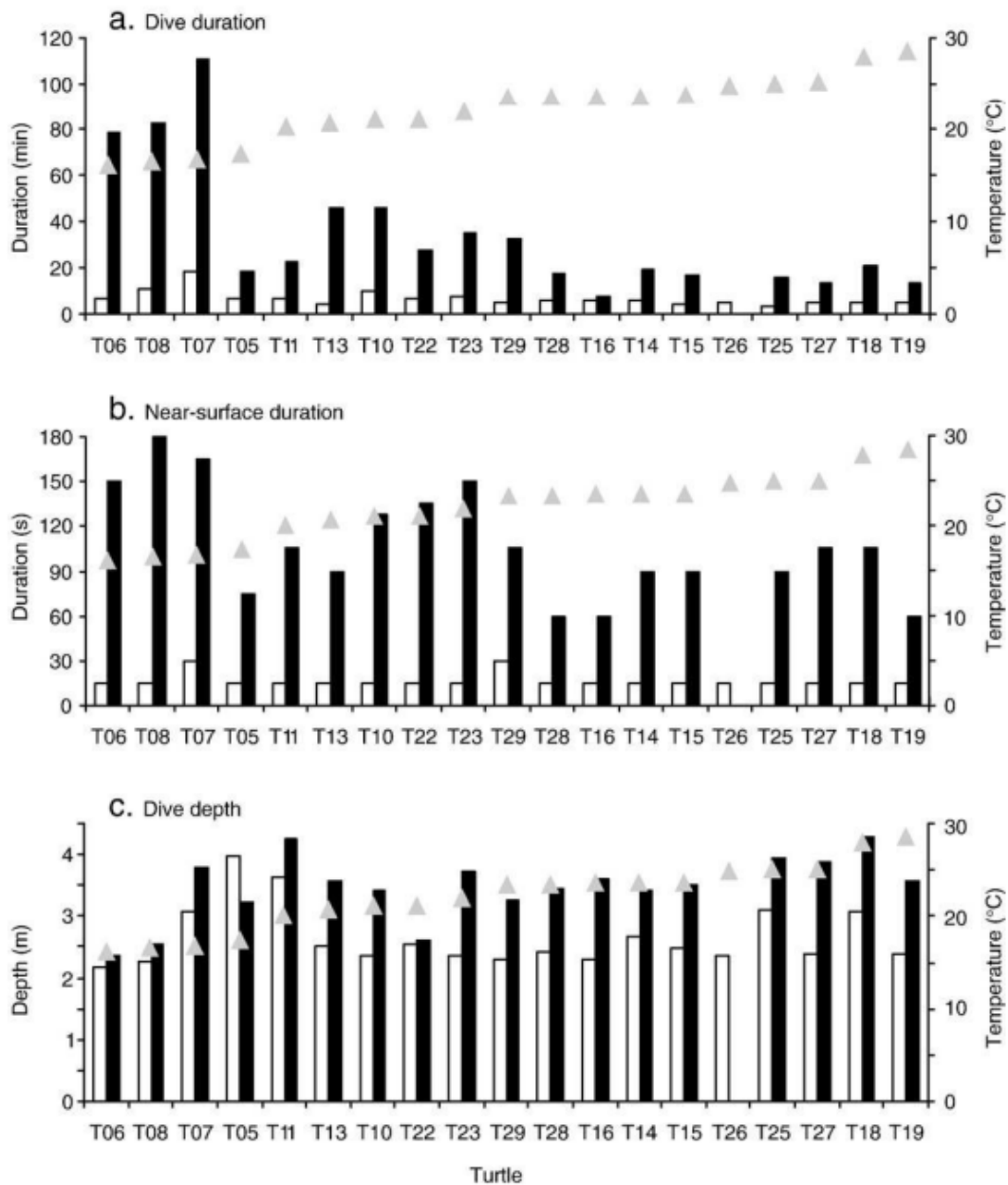


Figure 16: *Chelonia mydas*. Median duration of dives (panel a) and near-surface events between dives (panel b) was shorter by day (white bars) and longer by night (black bars) for all turtles except T26. The latter made no qualifying dives at night as it remained at depths ≤ 2 m. With increasing sea temperature (grey triangles) durations tended to decrease, with the exception of diurnal near-surface events. Note left-hand y-axes of panels a and b use different units. Dive depth (panel c) was greater by night, and night depth tended to increase with temperature. (Source: Hazel et al 2009)

6.2.1.4. Relevant Policy and Guidance

Green turtles are listed as Vulnerable, Migratory and Marine under the EPBC Act and Vulnerable under the BC Act. The global (non-statutory) listing by the IUCN is 'Endangered'. Other relevant EPBC Act documents are:

- Recovery Plan for Marine Turtles in Australia (DoEE 2017b)
- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018)
- National Light Pollution Guidelines for Wildlife (DCCEEW 2023)
- National Guidelines for the Survey of Cetaceans, Marine turtles and the Dugong (DCCEEW 2024a)

6.2.1.5. Threats and Pressures

Based on the TEMB Plan (DSEWPac 2012), the threat of bycatch and vessel strike are identified as threats of concern for Green turtles. Additionally, the following threats have been identified as threats of potential concern that may be relevant to consider for the LHI CIP include:

- Changes in sea temperature
- Ocean acidification
- Chemical, nutrient and light pollution
- Marine debris
- Human presence
- Collision/entanglement with infrastructure.

6.2.1.6. Relevance to the Project area

Likelihood of Occurrence: **High**

Green turtles are listed under Cth and State legislation as a Vulnerable threatened species. This species is commonly sighted in the LHI lagoon with sightings being recorded both in the Disturbance Footprint and Northern Zone boundary. The LHI lagoon area likely represents important foraging habitat for Green turtles, particularly during the summer months.

6.2.2. Hawksbill turtle

6.2.2.1. Population

Hawksbill turtle (*Eretmochelys imbricata*) populations in eastern Australia represent a significant global stronghold for this threatened species. Historical data estimate that between 8,000 and 9,000 nesting females nest annually across Australia, including this region—one of the few remaining robust aggregations (Hoenner et al. 2016). However, long-term monitoring at a key nesting site on the Great Barrier Reef (Limpus et al 2000), revealed a severe nesting decline of approximately 57–58% over 28 years, although the decline has slowed to ~3-4% annually in the last 10 years (DCCEEW 2025c). In Australia, there are two genetically separate subpopulations; one in the northern Great Barrier Reef, Torres Strait and Arnhem Land; and the other on the North West Shelf of Western Australia. This genetic distinctiveness means that individuals from these two subpopulations interbreed very rarely. Additionally, Australian stocks of Hawksbill turtles are genetically different from the stocks that breed

in neighbouring countries such as the Solomon Islands and Malaysia (DCCEEW 2025c). While Australia still supports some of the largest remaining nesting populations globally, the ongoing population declines demonstrate the need for enhanced conservation measures and management action.

6.2.2.2. Distribution

Hawksbill turtles are primarily distributed throughout tropical and subtropical coastal waters, with their Australian range concentrated along the northern and eastern coastline, encompassing the Great Barrier Reef, Torres Strait, and northern Cape York Peninsula (GBRMPA 2022, DCCEEW 2025c). While most individuals remain near tropical reefs, occasional sightings of Hawksbill turtles have been reported in more temperate waters off southern Queensland and northern New South Wales, suggesting low frequency but wide-ranging movements (DCCEEW 2025c).

This southernmost area of Hawksbill turtle habitat range in the Tasman Sea represents one of the least studied locations in terms of Hawksbill turtle studies (Robinson et al 2023) and many knowledge gaps still exist regarding in-water habitats where turtles spend most of their lives (Madden et al 2025). Although Hawksbill turtles are concentrated across Papua New Guinea, north Queensland, Northern Territory, frequent sightings of Hawksbill turtles have occurred at LHI (Figure 10) and there is evidence of satellite tagged individual turtles roaming in a southwards direction (Figure 17, Madden Hof et al 2023).

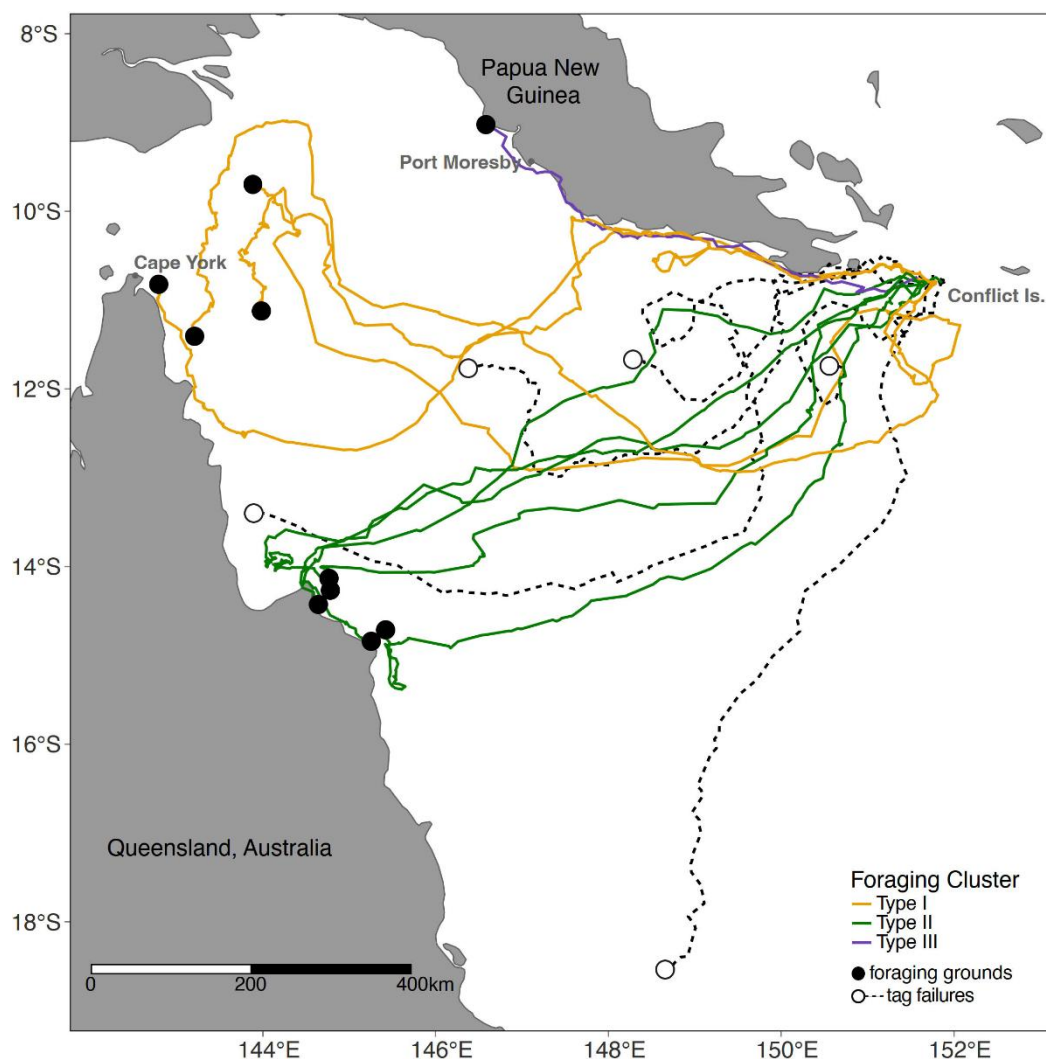


Figure 17: Satellite tagging location of hawksbill turtles. Migratory routes and foraging ground end points (shown as circle). Foraging ground clusters (Type I,II,III) shown in colour as per legend. (Source: Madden-Hof et al 2023).

6.2.2.3. Habitat use and life history

Habitat preference varies with age, with hatchlings and juveniles utilising the open ocean before recruiting to coastal coral reefs at around 30–40 cm carapace length (GBRMPA 2022). Nesting occurs primarily in the northern Great Barrier Reef, especially at sites like Milman Island, although low-density nesting has been recorded as far south as Fraser Island (Limpus et al 2008). Milman Island is the only location within Australia where sufficient scientific studies have been conducted on Hawksbill turtle biology and habitat usage, and significant knowledge gaps still exist for this turtle species (GBRMPA 2022, Madden et al 2025). While they show highly site-fidelity to nesting and foraging areas, satellite tracking has shown hawksbills can undertake long-distance migrations across the Coral Sea and Indo-Pacific, indicating a complex spatial ecology linkage across marine ecosystems (Madden Hof et al 2023). Hawksbill turtles are long lived and slow growing, reaching sexual maturity at 31 years of age (DCCEEW 2025c). Adult Hawksbill turtles have a varied diet of mainly sponges although they also feed on seagrasses, algae, sea cucumbers, soft corals and shellfish. The pointed jaws are well adapted to prising food from crevices in and around coral, while juveniles eat plankton during their oceanic ‘lost years’ (GBRMPA 2022, DCCEEW 2025c).

6.2.2.4. Relevant Policy and Guidance

Hawsbill turtles are listed as Vulnerable, Migratory and Marine under the EPBC Act. The global (non-statutory) listing by the IUCN is 'Critically Endangered'. Other relevant EPBC Act documents are:

- Recovery Plan for Marine Turtles in Australia (DoEE 2017b)
- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018)
- National Light Pollution Guidelines for Wildlife (DCCEEW 2023)
- National Guidelines for the Survey of Cetaceans, Marine turtles and the Dugong (DCCEEW 2024a)

6.2.2.5. Threats and Pressures

Based on the TEMB Plan (DSEWPac 2012), the threat of vessel strike is identified as a threat of concern for Hawksbill turtles. Additionally, the following threats have been identified as threats of potential concern that may be relevant to consider for the LHI CIP include:

- Changes in sea temperature
- Changes in oceanography
- Ocean acidification
- Chemical, nutrient and light pollution
- Marine debris
- Human presence
- Collision/entanglement with infrastructure.

6.2.2.6. Relevance to the Project area

Likelihood of Occurrence: **High**

Hawsbill turtles are listed as Vulnerable under Cth legislation as a threatened species. This species is commonly sighted in the lagoon, sightings being recorded in close proximity to the Nort Zone boundary. The LHI lagoon area likely represents important foraging habitat for Hawksbill turtles, particularly during the summer months.

6.3. Marine fishes

6.3.1. Black Rockcod

6.3.1.1. Population

Black rockcod (*Epinephelus daemeli*) is one of several marine fish species that have undergone major declines in distribution and abundance and have been listed as threatened under the schedules of the FM Act. Black rockcod populations along the southeastern Australian coast remain under threat despite decades of protection in NSW and years of conservation management. Once common throughout NSW and LHI, the species suffered dramatic declines from as early as 1916 due to intense fishing pressure, particularly from recreational spear and line fishers (DPI 2012). This species inherent vulnerability is due to its slow growth, long lifespan (up to 60–70 years), territorial behaviour, and late sexual maturation. NSW prohibited its capture in 1983, later listing it as Vulnerable under both state and Commonwealth

legislation (DCCCEEW 2025c) Analysis of long-term underwater visual census surveys comparing baseline data (2009–2011) with results from 2023 surveys revealed a ~40 % decline in relative abundance and reduced site occupancy, indicating that species recovery has not occurred. During the 2023 surveys at LHI, a total of 8 Black rockcod were observed at 6 survey sites. Three of these Black rockcod were found within lagoon sanctuary zones (Harasti and Malcolm 2025). Although population recovery was not observed, the surveys detected a shift in the population's structure, with a higher proportion of mature, larger females which may enhance reproductive potential.

6.3.1.2. Distribution

Black rockcod are known to occur in warm temperate and subtropical waters of the southwestern Pacific Ocean. In Australia, the species has been recorded from southern Queensland to Kangaroo Island off South Australia and around LHI and Norfolk Islands. Sightings of Black rockcod have also been reported from the northern Bass Strait waters however there are no records from the coast of Tasmania (DPI 2012). Within the NSW jurisdiction, Black rockcod are distributed along the entire mainland coast, and all waters surround LHI (Figure 18). The presence of this species at LHI is likely due to presence of seamounts, with the isolation of these features creating refuges for rare species such as the Black rockcod (DSEWPac 2012a).

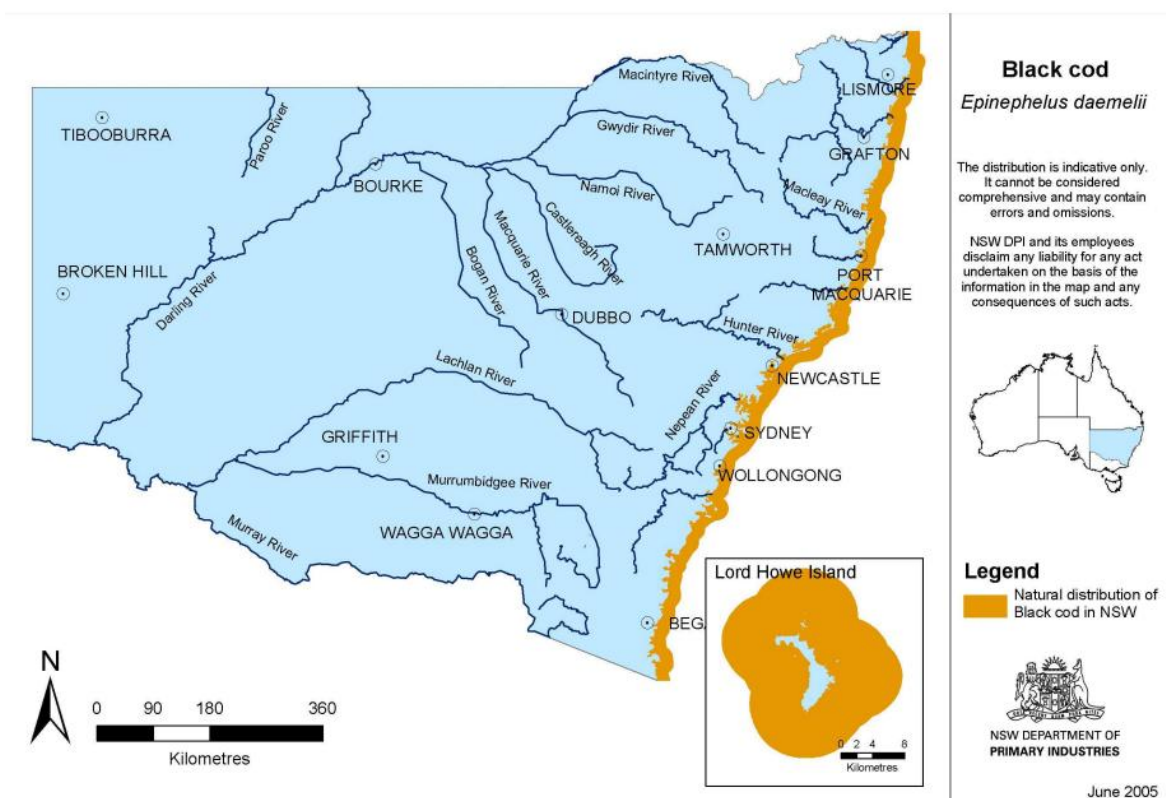


Figure 18: Distribution of Black Rockcod *Epinephelus daemeli* in NSW. Source DPI 2012).

6.3.1.3. Habitat use and life history

Black rockcod are known to occur in caves, gutters and on rocky reefs from near shore environments to depths of at least 50 m (Heemstra and Randall 1993). Recently settled small juveniles are occasionally found in intertidal rock pools along the NSW coastline and larger juveniles are generally captured by anglers on rocky reefs in estuary systems. These observations indicate that, like other serranids, estuarine habitats may play a critical role during certain life history stages for this species. Black rockcod also occur in deeper water and commercial fishers have reported catching the species at depths of greater than 100 m. Black rockcod are a territorial and site attached species, with individuals often encountered persisting in the same location or cave over time. Individual adult fish may occupy a particular cave for most of their adult life (DPI 2012, Harasti 2025).

Like other species within this genus, Black rockcod are protogynous hermaphrodites, exhibiting female characteristics early in life, and then changing sex to become males as they mature. This change in sex happens when individual fish have grown to around 100 cm in length (DPI 2012). Otoliths from a 127 cm Black rockcod from LHI were aged at 42 years (Harasti et al. 2011). There is little other information known about aspects of their biology including diet, formation and of spawning aggregations, range extent, sex ratios, recruitment and settlement and the seasonality of reproduction.

6.3.1.4. Relevant Policy and Guidance

The following policy and guidance documents are useful for the conservation management of the Black rockcod:

- Black Rockcod (*Epinephelus daemeli*) recovery plan (DPI 2012)
- Review of the Black Rockcod Recovery Plan. Published by the NSW Department of Primary Industries (DPI 2023)
- Approved Conservation Advice for *Epinephelus daemeli* (black cod) (DSEWPac 2012a)
- Marine Bioregional Plan for the Temperate East Marine Region (DSEWPac 2012).
- Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPac 2011)

6.3.1.5. Threats and Pressures

Based on the TEMB Plan (DSEWPac 2012), no threats of concern are identified. However, the following threats have been identified as threats of potential concern that may be relevant to consider for the LHI CIP include:

- Changes in sea temperature
- Changes in oceanography
- Chemical, nutrient and light pollution
- Habitat modification

6.3.1.6. Relevance to the Project area

Likelihood of Occurrence: **High**

The Black rockcod is a threatened species listed as Vulnerable under both State and Commonwealth legislation. It is present in close proximity to the Northern Zone Boundary, with high number of sightings within the lagoon (Figure 12). The shallow waters of the LHI lagoon, including the North Zone boundary represent important habitat for this species, in particular for juveniles and sub-adults, which are female with the potential for egg production.

6.3.2. Doubleheader wrasse

6.3.2.1. Population

The Doubleheader wrasse (*Coris bulbifrons*) is a regionally endemic fish species with populations across southeastern Australia, including LHI, Elizabeth and Middleton Reefs, Norfolk Island, and the northern New South Wales coast. Although there is limited information regarding the species' populations, they appear stable and locally abundant in their reef habitats. Recent ecological surveys at Elizabeth and Middleton Reefs reported a mean density of approximately 1.17 individuals per 300 m² (about 3.9 per 1,000 m²), with the highest numbers found in the Middleton Reef lagoon and back reef zones (Carroll et al 2021). The geographically isolated population at LHI has shown rare recessive genetic traits of a pied coloration in the local population, which is distinct from this species' usual steely blue colouration. This trait has likely resulted from the limited genetic mixing in this remote reef habitat. This species is fished recreationally at LHI, with regulation, however there is no current indication of population decline. Doubleheader wrasses are totally protected at Middleton Reef. Within the LHI lagoon, Doubleheader wrasse makes up 10% of the fish biomass by weight (Harasti et al 2022).

6.3.2.2. Distribution

The Doubleheader wrasse is found in eastern Australia from about Byron Bay to Sydney in NSW, with juveniles also recorded in Shellharbour. The species is more common in the northern Tasman Sea at

islands and reefs LHI, Elizabeth and Middleton Reefs. It is considered rare at Norfolk Island (Bray 2023). The species also occurs in northern New Zealand. Doubleheader wrasse inhabit coral, rubble and sandy areas on coral and rocky reefs, usually above 20 m depth and is commonly by snorkellers and divers in the lagoon and offshore dive locations at LHI (Figure 12: Bony fish sightings within the Proposal areas.). Juvenile Doubleheader wrasse utilise very shallow water reef habitats and have been collected from tide pools.

6.3.2.3. Habitat use and life history

Doubleheaders is the largest species in the *Coris* genus, growing to 90 cm in length. This distinctive looking wrasse has steely blue colouration with a large bulbous hump on the head above the front of the eye that is very pronounced in large males. Juveniles appear visually distinct to the adult colouration and are black with two rows of large white spots and scattered smaller spots along the side (Randall et al 1999). Like other wrasse species, the Doubleheader wrasse is a protogynous hermaphrodite, changing sex from female to male during its life cycle. Doubleheaders usually occur on as harems in small to large family groups dominated by a single large male (Bray 2023). Doubleheader wrasse at LHI show a moderate longevity, with otoliths from LHI samples showing a maximum age of 21 years (Ferrell 2005). Diet for this species consists of gastropod and bivalve molluscs, also consuming crabs (Bray 2023).

6.3.2.4. Relevant Policy and Guidance

While the Doubleheader wrasse is not a listed threatened or fully protected species under State or Commonwealth legislation, it is listed as Vulnerable by the IUCN due to its limited distribution range as a regionally endemic fish species of the north Tasman Sea. It is noted as an 'other significant species' acting as a keystone species to provide important ecological function.

- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022)

6.3.2.5. Threats and Pressures

As the Doubleheader wrasse is not a listed as a threatened species, no threats of concern are identified. However, the following threats are identified by O2 Marine as threats that may be relevant to consider for the LHI CIP.

- Chemical, nutrient and light pollution
- Habitat modification

6.3.2.6. Relevance to the Project area

Likelihood of Occurrence: **High**

This species is not threatened, however is an iconic species which contributes significantly to LHI's biodiversity. It is present at LHI year-round. Fish surveys identified this species within the lagoon (Figure 12). Both juveniles and adult Doubleheader wrasse are highly likely to be present within the LHI lagoon and North Zone boundary.

6.3.3. Elegant wrasse

6.3.3.1. Population

The Elegant wrasse (*Anampses elegans*) is a protected species in NSW under FM Act. It is listed as Least Concern by the IUCN. There is limited information available about the broader population dynamics for this species which has been previously identified as a knowledge gap for LHI (Harasti et al 2022). However, at LHI, RLS data indicated that biomass of Elegant wrasse increased in 2014-2018, following a slight decline during 2012 surveys. The recent increase in Elegant wrasse biomass at LHI aligns with the biomass observed during the 2006 surveys (Stuart-Smith *et al.*, 2019). Elegant wrasses are protected due to their natural rarity and low abundance (DPI 2006e)

6.3.3.2. Distribution

This wrasse species is naturally uncommon but geographically widespread along the eastern coast of Australia, with populations concentrated around offshore islands. Its distribution extends from Broughton Island to southern NSW, throughout the Lord Howe Province and Norfolk Island in the Tasman Sea. The species is relatively widespread in sub-tropical to warm temperate waters of the Tasman Sea including northern New Zealand (Bray 2022). Elegant wrasse can be found inhabiting rocky and coral reefs, commonly around offshore reefs and islands. Juveniles may form small schools amongst algae in coastal bays and harbours. Elegant wrasses occur within the LHI lagoon (Figure 12) and on coral and rocky reefs to 35 m depth with adults tending to occupy deeper water (Harasti et al 2022). Diet is carnivorous and consist of small crustaceans and molluscs, which are captured by scraping the surface of small seaweeds with their comb-like teeth (DPI 2006e).

6.3.3.3. Habitat use and life history

Morphologically, males of this species are distinctly colourful, with brown upper bodies, a yellow/orange-lateral stripe, blue lower sides, and a yellow tail. Females display a more subdued coloration of light brown with faint blue and gold accent (Bray 2022). Juveniles will often form large aggregations in shallow waters and are generally found around coral and algae habitats. Elegant wrasse are protogynous hermaphrodite, changing sex from female to male during its life cycle

Like many of the wrasses, adult Elegant wrasses are likely to be found in harems, with a single dominant male controlling a group of females. In the absence of a dominant male wrasse, the largest female wrasse will change sex to become the dominant male of the harem group (DPI 2006e).

6.3.3.4. Relevant Policy and Guidance

While the Elegant wrasse is not a listed threatened species under Commonwealth legislation, it is protected under State legislation. It is noted as a 'protected species of importance for LHI.

- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022)
- NSW DPI Primefact 166: Elegant wrasse (*Anampses elegans*)(DPI 2006e)

6.3.3.5. Threats and Pressures

Not reported as bycatch by fishers and there are not considered to be any significant threats to the species within the LHIMP. (Harasti et al 2022).

6.3.3.6. Relevance to the Project area

Likelihood of Occurrence: **High**

Elegant wrasses are a protected species under State legislation. It has been identified with a high number of sightings near the North Project boundary and within the LHI lagoon. These locations represent very suitable habitat for this species, and it is highly likely to be present in these locations year-round.

6.3.4. Galapagos shark

6.3.4.1. Population

The Galapagos shark (*Carcharhinus galapagensis*) is a large requiem shark that inhabits offshore and pelagic waters of the Indo–West Pacific, including Australia’s largest population of this species at Elizabeth and Middleton Reefs and the LHIMP.

A genetic study based on non-coding mitochondrial DNA revealed strong population structuring between Elizabeth and Middleton Reefs which constitute a single genetic stock, distinct from the LHI population (AMOVA F_{ST} = 0.5416, $P < 0.0001$), with notably lower genetic diversity ($h = 0.186$; $\pi = 0.29\%$) compared to the more genetically resilient Lord Howe population ($h = 0.933$; $\pi = 1.18\%$) (DEWHA 2008). Analysis of the coalescence age and mismatched distribution between the Elizabeth and Middleton Reef population and the LHI population suggest that the Lord Howe population appears to be older (~30,000 years) than the Middleton and Elizabeth Reefs population (~7000 years) when minimum, mean and maximum ages are considered (DEWHA 2008).

Densities of Galapagos sharks at Elizabeth and Middleton Reefs and at LHI were almost an order of magnitude higher than in other tropical areas surveyed (Great Barrier Reef Marine Park QLD and Rowley Shoals Marine Park WA). indicating healthy populations at that time (Oxley et al, 2004, Choat et al 2006, Speare et al 2004).

6.3.4.2. Distribution

The Galapagos shark has a worldwide patchy distribution throughout the Indo-Pacific across tropical and temperate waters. It’s largest population within Australia is located at Elizabeth and Middleton Reefs and the LHIMP in the north Tasman Sea, with other known aggregations being found at the Great Barrier Reef, Rowley Shoals and the Great Australian Bight (DEWHA 2008). The global distribution of the Galapagos shark suggests that it has the ability for trans-oceanic. Tagging studies, however, show that movements spanned small distances, at least during times of aggregation. It has been suggested that these sharks are localised around islands but can travel distances of at least 50 km between islands and range an average of 36 km at LHI Compagno (1984, Mitchell et al 2021). This species occupies deeper reef environments with recorded depths up to approximately 180 m, while juveniles remain in shallower regions, typically less than 25 m, with these shallower waters functioning as nursery areas. The Galapagos shark is a key indicator species for the management of the marine parks surrounding LHI (Edgar et al., 2010, Mitchell et al 2021, Harasti et al 2022)

6.3.4.3. Habitat use and life history

Galapagos sharks are observed to have site fidelity, especially in islands, however, Galapagos sharks are capable of substantial movements—reported over distances exceeding 600 km from tagging locations—highlighting at least occasional long-distance dispersal behaviours (Compagno 1984).

This species is characterized by a slow maturation of ~10 years, a long gestation period of 12 months and the production of few offspring with each litter consisting of 6-16 pups. Pupping tends to occur every 2-3 years. (Wetherbee et al 1996). Mating usually occurs from January to March (in some regions), followed by a gestation period of around one year; parturition often takes place in spring, and juveniles inhabit shallow nurseries until they are less vulnerable to predation. Males reach sexual maturity between 6 to 8 years of age at lengths of 2.1–2.5 m, while females mature slightly later at 7 to 9 years and similar sizes, with reproduction likely commencing around 10 years of age. Estimated lifespan exceeds 24 years (DEWHA 2008). At LHI, depredation and consumption of bait and hooked fish has been an increasingly observed behaviour by fishers (Mitchell et al 2021). This increase may be attributed to a change in shark behaviour, where this species has become accustomed to boat engine noise and associating this noise with the availability of food in the form of hooked fish, bait, or released and discarded fish. (Mitchell et al 2021). In order to reduce negative human-wildlife interactions, fishing pressure and Galapagos shark presence has been spatially mapped, highlighting locations within LHIMP where Galapagos sharks and humans/fishing vessels are most likely to interact (Figure 19).

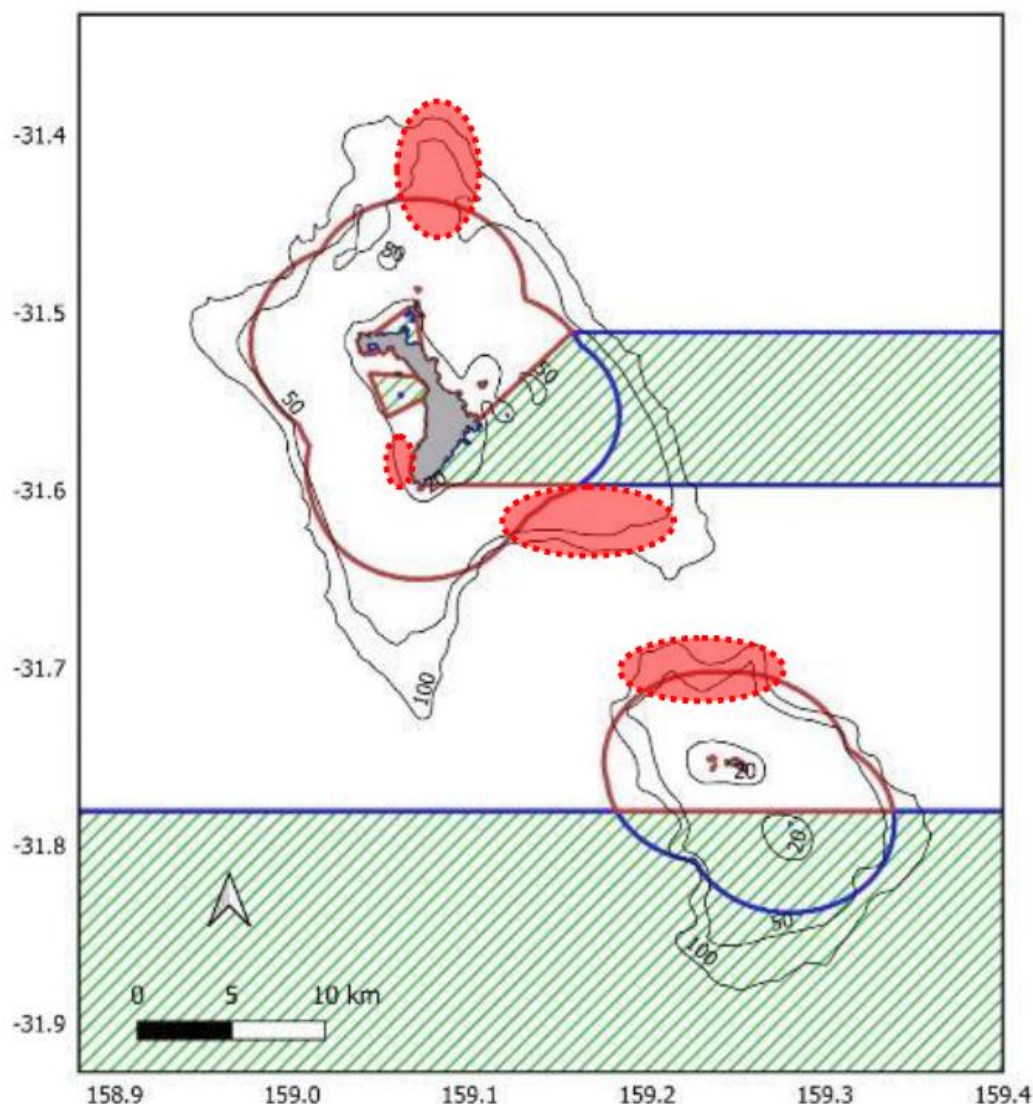


Figure 19: Hotspot areas of overlap between shark presence and fishing activity, as identified previously by the combination of acoustic telemetry data for tagged Galapagos sharks and Vessel Monitoring System (VMS) data from charter fishing vessels. (Source Mitchel et al 2021).

6.3.4.4. Relevant Policy and Guidance

The following policy and guidance documents are useful for the conservation management of the Galapagos shark at LHI;

- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022)
- Galapagos Sharks Lord Howe Island Marine Parks (Parks Australia 2024)

6.3.4.5. Threats and Pressures

The Galapagos shark is not identified within the TEMB Plan to be assessed for existing threats and pressures. However, this species is at risk from human interactions including vessel interactions and habitat modification which may threats relevant to the LHI CIP. It is also considered to be a key indicator species within the LHIMP(Mitchel et al 2021, Harasti et al 2022).

6.3.4.6. Relevance to the Project area

Likelihood of Occurrence: **High**

This species is not threatened under State or Commonwealth legislation; however, it has an IUCN listing status of Near Threatened. The Galapagos shark is an iconic and locally important species for LHI and represents a key representative species within the island's ecosystem. It is present year-round in high numbers.

6.3.5. Lord Howe Abalone

6.3.5.1. Population

The Lord Howe Abalone (*Haliotis rubiginosa*) is a small abalone species that is endemic to the shallow waters of the LHMP. It is a rare and cryptic species that is present under rocks, dead coral rubble and in small holes and crevices in the reef (DPI 2024). The Lord Howe Abalone is a critically endangered species under State legislation, with heavy penalties in place for harming, possessing, buying or selling specimens, or for harming their habitat (DPI 2024). The Lord Howe Abalone is also currently on the Priority Assessments List to receive Critically Endangered status under the EPBC Act. A Commonwealth determination for this assessment is due in October 2025 (DCCEE SPRAT ID 92433). It is also listed as Critically Endangered by the IUCN. These threatened species assessments have been made due to this species inherent vulnerability associated with its small size, low abundance and extremely limited distribution range (DPI 2024).



Figure 20: Lord Howe abalone. Image from Justin Gilligan (Source Harasti et al 2022).

6.3.5.2. Distribution

The Lord Howe Abalone has an extremely limited distribution, and its occurrence is limited to shallow reefs between the intertidal zone to 10 m deep within the LHIMP with confirmed sightings being recorded within the LHI lagoon (Figure 12). The species distribution is restricted to carbonate reefs around LHI, and its abundance is considered to be low (Harasti et al 2022, Woods, 2022).

6.3.5.3. Habitat use and life history

This small cryptic mollusc species is uniquely adapted for its reef environment. The Lord Howe Abalone is distinguished by a rusty-orange, ovate, convex shell ~30–56 mm in length. It has a cream-coloured muscular foot with lime-green mantle and tentacles, with red eyestalks, and a frilled, banded epipodium. The shell is ridged with a row of six irregular open respiratory pores (called ‘tremata’) (DPI 2024). Limited life history information is available for this rare species, but it is assumed that the Lord Howe abalone has a herbivorous diet and reproduces sexually. It has been suggested that studies focusing on adaptability and resilience of this species due to threats associated with increasing water temperatures including endemic species would be valuable (Harasti et al 2022).

6.3.5.4. Relevant Policy and Guidance

The following policy and guidance documents are useful for the conservation management of the Lord Howe abalone;

- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022)
- NSW DPI Primefact 577: Elegant wrasse (*Haliotis rubiginosa*) (DPI 2024)

6.3.5.5. Threats and Pressures

The Lord Howe Abalone is not identified within the TEMB Plan to be assessed for existing threats and pressures. However, this species is at risk from climate change impacts including marine heatwaves, ocean acidification and habitat modification (Harasti et al 2022).

6.3.5.6. Relevance to the Project area

Likelihood of Occurrence: **High**

Threatened endemic species under State legislation with sightings near the North Project boundary and within the lagoon. Currently under Priority Assessment by the TSSC for EPBC listing status of Critically Endangered. Decision due 30/10/2025. Due to highly localised occurrence and habitat presence within the North Zone boundary, this species is highly likely to occur.

6.3.6. McCulloch's Anemonefish

6.3.6.1. Population

McCulloch's Anemonefish (*Amphiprion mccullochi*) is an Australian endemic species and currently listed as Critically Endangered under the EPBC Act and FM Act and Vulnerable by the IUCN Red List. LHI lagoon supports approximately 75% of the remaining population and represents critical habitat for this species, and it is considered rare at its other occupied locations at Elizabeth and Middleton Reefs (TSSC 2024). However, recent surveys have revealed a decline of more than 50% over the past decade, attributed primarily to habitat loss, particularly bleaching and mortality of host anemones driven by climate change and rising sea temperatures (TSSC 2024, Lei et al 2025). Genetic analysis underscores the species' vulnerability, showing markedly lower genetic diversity and effective population sizes compared to its closest relatives—an outcome of its restricted distribution and isolation (Lei et al 2025).

6.3.6.2. Distribution

The McCulloch's anemonefish has a highly limited distribution, and its presence is restricted to LHI, Middleton Reef and Elizabeth Reef. It was also formerly present at Norfolk Island, however recent surveys of more than 2500 bubbletip anemone hosts failed to record and observations of this fish and confirming local extinction at Norfolk Island and critically low numbers at the other reef sites (TSSC 2024). During long term monitoring at LHI, the abundance of McCulloch's anemonefish has declined substantially due to the decline in the abundance of host anemones. High levels of anemonefish mortality occur following bleaching events due to rapid mass mortality of host anemones which are the primary habitat for this species (Hobbs 2022, TSSC 2024). Suitable habitat is still present within the LHI lagoon, and confirmed sightings of the McCulloch's anemonefish have been recorded (Figure 12).

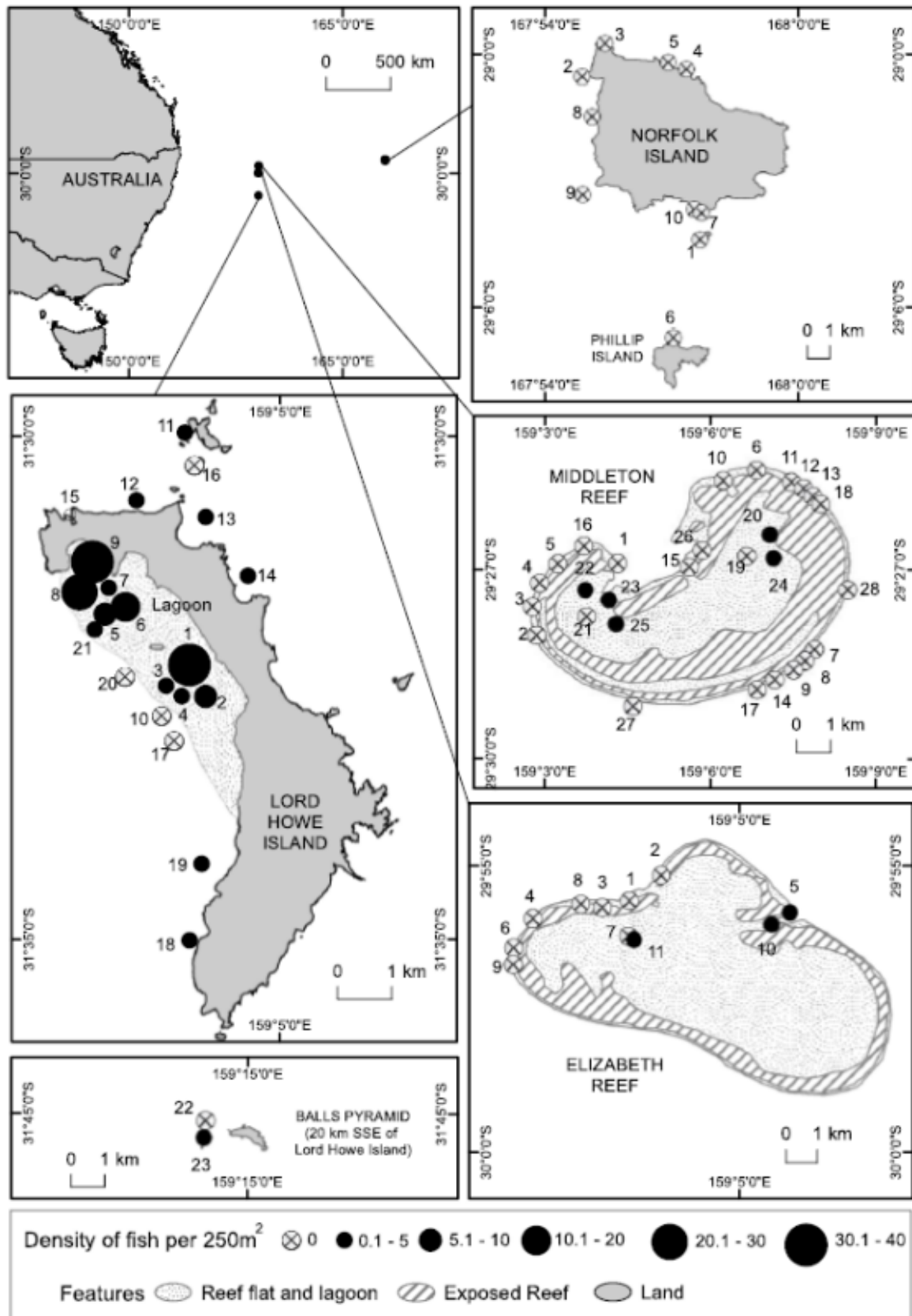


Figure 21: Study sites across the four regions that comprise the geographic range of the endemic species McCulloch's anemonefish. The size of the circle corresponds to the mean density of McCulloch's anemonefish per 250 m² at that site. (Source: Hobbs (2022)).

6.3.6.3. Habitat use and life history

Adult McCulloch's anemonefish are dark brown to black with a whitish snout and a single white bar on the cheek that does not connect over the top of the head (TSSC 2024). The maximum size for the McCulloch's anemonefish is 120 mm in length.

Many coral reef species are reliant on specific microhabitats and occupy defined niches within the reef ecosystem. Anemonefish are among the most specialised coral reef fishes because of their mutualistic relationship with anemones (TSSC 2024). Survival of anemonefish is reliant on their ability to find and retain a host anemone. There are possibly two potential host anemones have been recorded within the range of McCulloch's anemonefish, it appears to be an inhabitant of only *Entacmaea quadricolor* bubbletip anemones (Hobbs 2022, DPI 2024b). Additionally, the abundance of McCulloch's anemonefish is positively linked to the abundance of bubbletip anemones, and population size for this species is constrained by the number of host anemones (Hobbs 2022).

McCulloch's anemonefish lay a clutch of eggs on the substrate next to their host anemone, which hatch after about 7 days into a larval fish for a planktonic stage of about 10 days. At around days 19-24 the larval fish will settle onto the reef and with a host anemone. Once settled with a host anemone, the McCulloch's anemonefish loses its larval transparency, and develops adult-like colouration, which is fully developed when the fish is about 5 cm in length (TSSC 2024),

6.3.6.4. Relevant Policy and Guidance

Due to this species' having an extremely limited distribution, the threats facing the entity, and the recovery actions needed are well-understood, there is no Recovery Plan in place for the McCulloch's anemonefish. Conservation management can be effectively guided via an approved conservation advice. The relevant policy and guidance is;

- Conservation Advice *Amphiprion mccullochi* McCulloch's anemonefish, whitesnout anemonefish (TSSC 2024)
- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022)
- NSW DPI Primefact 57: McCulloch's anemonefish (*Amphiprion mccullochi*) DPI 2024b)

6.3.6.5. Threats and Pressures

The McCulloch's anemonefish is not identified within the TEMB Plan to be assessed for existing threats and pressures. However, this species is at risk from climate change impacts including marine heatwaves, and habitat modification, due to the bleaching of host anemones (Harasti et al 2022, TSSC 2024). Continuing loss of this species essential habitat is resulting in a declining trend for the McCulloch's anemonefish.

6.3.6.6. Relevance to the Project area

Likelihood of Occurrence: **High**

McCulloch's anemonefish is a Critically Endangered species, listed under State and Commonwealth legislation. It is also listed as Critically Endangered by the IUCN. This species is present in close proximity to the North Zone Boundary, with high number of sightings within the lagoon (Figure 12). The LHI lagoon supports the majority of the population for this threatened species, and it is highly likely to be present in this location.

6.3.7. Sygnathids

The Sygnathidae family includes all species of seahorses, sea dragons and pipefishes, which are small bony fishes with a unique elongated body shape covered with bony plates instead of scales. In Australia, there are approximately 125 species of sygnathids and all are listed as ‘Marine’ with some species having a further threatened status listing under the EPBC Act. In NSW, sygnathids have been protected under the FM Act since 2004.

Due to cryptic nature of seahorses, sea dragons and pipefishes, there are few specific studies to determine the ecological traits at a species level which creates ecological uncertainty for their presence and use of habitats. This group of threatened marine fishes is considered at the family taxonomic level due to their ecological traits being broadly similar. Further, management implications are similar for all bony fishes and may be applied to all marine (bony) fishes.

The PMST results for the broad search area identified five (5) sygnathids with a ‘May’ PMST rank and were assessed to have a Moderate likelihood of occurrence due to limited availability of data and cryptic nature. (Table 12, Appendix C). The identified species potentially present within the LHIMP are Booth’s pipefish (*Halicampus boothae*), Duncker’s pipehorse (*Solegnathus dunckeri*), Kellogg’s seahorse (*Hippocampus kelloggi*), Lord Howe pipefish (*Cosmocampus howensis*) and the White’s seahorse (*Hippocampus whitei*).

These species are discussed in Table 15 to Table 17 below, to provide some characterisation of the Sygnathidae which may be present in the LHIMP.

6.3.7.1. Population

Population estimates and trends for sygnathids identified as being potentially present within the LHIMP are detailed here in Table 15.

Table 15: Population information for identified sygnathid species.

Common Name (<i>Scientific name</i>)	Population
Booth’s pipefish (<i>Halicampus boothae</i>)	No population estimate is available for this species, however it is considered rare with a low abundance. The threat of habitat modification for the Booth’s pipefish is the reason for its protected status in NSW. 14 sightings were identified for Booth’s pipefish in the ALA database.
Duncker’s pipehorse (<i>Solegnathus dunckeri</i>)	No population estimate is available for this species. It is listed as Data Deficient by the IUCN. There isn’t enough information to assess this species’ risk of extinction. 4 sightings were identified for the Duncker’s pipehorse in the ALA database.
Kellogg’s seahorse (<i>Hippocampus kelloggi</i>)	There isn’t a population estimate available for the Kellogg’s seahorse, however it is suspected to be decreasing. Until 2016, there were no confirmed sightings of this species in Australian waters (Harasti 2017). Currently there are 25 Australian records for the Kellogg’s seahorse, with 3 sightings of this species being recorded within LHIMP (ALA 2025). This species is listed as Vulnerable by the IUCN and considered threatened due to overfishing.
Lord Howe pipefish (<i>Cosmocampus howensis</i>)	No population estimates are available for the Lord Howe pipefish, although at least 2 populations may exist in NSW, with one at Lord Howe Island and Middleton Reefs, and other in mainland NSW between Wollongong and

Common Name (<i>Scientific name</i>)	Population
	Merimbula (DCCEEW 2025c). 5 sightings were identified for the Lord Howe pipefish in the ALA database.
White's seahorse (<i>Hippocampus whitei</i>)	A single population estimate for White's seahorse is not available, however significant declines in local populations have been reported at Port Stephens (90%-98%) and Sydney (40%). Overall population decline is estimated to be between 60-70% (DPI 2019). No sightings of this species are recorded within LHIMP. Whites seahorses are listed as Endangered under the EPBC Act, FM Act and by the IUCN.

6.3.7.2. Distribution

Ranges of distribution and preferred habitats for sygnathids identified as being potentially present within the LHIMP are detailed here in Table 16.

Table 16: Distribution information for information for identified sygnathid species.

Common Name (<i>Scientific name</i>)	Distribution
Booth's pipefish (<i>Halicampus boothae</i>)	Booth's pipefish is found on reefs in the Coral Sea, and the Great Barrier Reef Townshend Island, QLD. This species is also LHI and Norfolk Island in the Tasman Sea. Booth's pipefish is also known from other areas in tropical and temperate waters in the Western Pacific from Japan, Fiji and Tonga. This species inhabits coral reef and dense algae rocky reef habitats in depths to 30 m (Bray & Thompson 2024).
Duncker's pipehorse (<i>Solegnathus dunckeri</i>)	Duncker's pipehorse is endemic to eastern Australia, from Fraser Island in Queensland, south to central New South Wales, including at LHI. This species can be found inhabiting reefs in association with gorgonian and black corals, algae or sponges in deeper waters from 30 m to 140 m depth (Bray & Thompson 2020).
Kellogg's seahorse (<i>Hippocampus kelloggi</i>)	Kellogg's seahorse has a wide Indo-Pacific range from east Africa, across to Japan and south to Australia. In Australia this species distribution ranges across northern Australia extending to the north east. (Lourie et al 2016). Recently, the Kellogg's seahorse has had a southwards range extension documented into NSW (Harasti 2017). It inhabits reefs and soft-bottomed habitats with gorgonian corals, sea whips and has been recorded at 152 m depth. (Bray 2017)
Lord Howe pipefish (<i>Cosmocampus howensis</i>)	The Lord Howe pipefish is found at LHI and Middleton Reef in the Tasman Sea, and from southern Queensland to Jervis Bay, NSW. Elsewhere, the species occurs in subtropical and temperate waters of the southwest-central Pacific. This species is found inhabiting inshore reefs (Thompson and Bray 2025). This species is named after the type location of LHI.
White's seahorse (<i>Hippocampus whitei</i>)	White's seahorse is endemic to southern Queensland (Hervey Bay) to Sussex Inlet NSW where it inhabits estuaries, bays and harbours, living in association with seagrass beds, macroalgae, soft corals, gorgonians, sponges, piers, jetties, and the netting enclosing seaside pools in depths of 1 m to 18 m (DPI 2019, Bray & Thompson 2025).

6.3.7.3. Habitat use and life history

Descriptions of species, and biological traits including life history information, for sygnathids identified as being potentially present within the LHIMP are detailed here in Table 17

Table 17: Habitat use and life history for information for identified sygnathid species.

Common Name (<i>Scientific name</i>)	Habitat use and life history
Booth's pipefish (<i>Halicampus boothae</i>)	Booth's pipefish is a small sygnathid, growing to 17 cm in length. It is light tan to dark brown in colour with evenly-spaced pale bars along the back and upper side, and a pale tip on the snout. Like all sygnathids, males brood the eggs before hatching up to 120 eggs per brood. Newly hatched juveniles resemble adult colouration. Interestingly, specimens from LHI are observed to have slightly higher fin ray and tail ring counts compared to specimens from other locations. This feature is likely to limited mixing of individuals within the genetic population (Bray and Thompson 2024).
Duncker's piperhorse (<i>Solegnathus dunckeri</i>)	This medium sized sygnathid grows to 50 cm and is pale brown or black with 10-11 irregular, diffuse, pale or dark bands on the surface of body. The snout tip often pale in dark specimens. Like most sygnathids, its diet consists of small crustaceans. Eggs are pear-shaped and brooded by males which can carry 20-120 eggs. The smallest pregnant male recorded with eggs measured 33.7 cm in length (Bray & Thompson 2020).
Kellogg's seahorse (<i>Hippocampus kelloggi</i>)	Kellogg's seahorses are one of the largest seahorse species growing to 28 cm in length. It is variable in colouration from yellow to brown with black, white or brown splotches and stripes and may vary colour depending on the surrounding environment or mood. It also has a prominent eye spine and backwards pointing cheek spine (Harasti 2017). Like all seahorses, males give birth to live young, with parents providing vital parental care with high site fidelity. Diet is believed to consist of a variety of benthic and/or planktonic crustaceans (Pollom 2017)
Lord Howe pipefish (<i>Cosmocampus howensis</i>)	The Lord Howe pipefish is a pale coloured pipefish wither with a plain head or heavily blotched with dark brown. The dorsal body surface sometimes shows 10-11 pale bars;. Otherwise, the body is patterned with numerous dark streaks and spots; dorsal and pectoral fins sometimes shaded with brown Males brood the eggs in rows of 2-17 inside a pouch on the underside of the body behind the anus, which protects the developing eggs. Males may begin brooding at 72 mm in length.
White's seahorse (<i>Hippocampus whitei</i>)	White's seahorse is a colourful species with highly variable colouration as it is known to change colour depending on their mood and the habitat colouration it is living on. It grows to a length of 16 cm. Males can be identified by their brood pouch on the belly. Breeding pairs display long-term monogamy, and the male pregnancy lasts about 3 weeks. The male seahorse gives birth to 100 – 250 babies per brood and can reproduce up to 8 times during the breeding season (DPI 2019).

6.3.7.4. Relevant Policy and Guidance

Booth's pipefish (*Halicampus boothae*), Duncker's pipehorse (*Solegnathus dunckeri*, Kellogg's seahorse (*Hippocampus kelloggi*) and Lord Howe pipefish (*Cosmocampus howensis*) are EPBC Act species listed as Marine and protected under the FM Act in NSW. White's seahorse (*Hippocampus whitei*) is listed as Endangered under both the EPBC Act and FM Act. Relevant EPBC Act, FM Act or other documents are

- Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012)
- Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPac 2011)
- Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022)
- Conservation Advice *Hippocampus whitei* White's Seahorse (TSSC 2020)
- NSW DPI Primefact 1702: White's seahorse (*Hippocampus whitei*) (DPI 2019)

6.3.7.5. Threats and Pressures

The following threats or pressures have been identified which may be considered as relevant to potential Project impacts:

- Habitat modification
- Pollution (Marine debris, oil spill and chemical dumping)
- Underwater noise from construction activities

6.3.7.6. Relevance to the Project area

Likelihood of Occurrence: **Moderate**

It is likely the patch reef, coral bommies and algae reef areas within the lagoon is suitable habitat for this species, and sightings have been recorded. However, due to the cryptic nature of this marine fish group, there is some level of uncertainty regarding their presence. Sygnathids located within the lagoon may be potentially impacted by underwater noise from project related construction.

7. Conclusion

In consideration of the threatened and protected aquatic species listings under State and Commonwealth legislation, and thorough analysis of all available desktop sources, this desktop assessment has determined a key species list for the LHI CIP. 72 marine fauna species were included in this conservation significant assessment with 10 marine fauna species ultimately being determined as key (mammals (2), reptiles (2) and fishes (6)). Sygnathids are considered at the family level, due to the cryptic nature of these marine fishes and several species potentially occur in the LHIMP.

Of these key species, those within the lagoon are at closest proximity to the construction activity these include:

- Green turtle
- Hawksbill turtle
- Black rockcod
- Doubleheader wrasse
- Elegant wrasse
- Lord Howe abalone
- McCulloch's anemonefish
- Sygnathids

The remaining key species have a higher likelihood of occurrence outside of the fringing reef flat are less likely to be found within the lagoon:

- Bottlenose dolphin
- Humpback whale
- Galapagos shark.

The ecological windows for these species have been identified, providing opportunities to schedule construction activities outside of these periods to minimise potential impacts. The key species identified in this assessment can be considered umbrella species, as their protection provides broader conservation benefits to other marine fauna within the same groups. Implementing management and mitigation strategies to protect these key species will therefore also safeguard non-key species that share similar habitats, behaviours, or exposure pathways. This approach ensures that conservation outcomes extend beyond the identified key species, contributing to the overall protection of the diverse marine fauna values of the LHI region.

Sygnathids (seahorses, pipefishes, and seadragons) are an important component of the lagoonal ecosystem, contributing to the marine park's diverse fish assemblages, though no key species were identified during this desktop assessment process, the group as a whole is considered key. Booth's pipefish is commonly observed in the lagoon, while the cryptic Duncker's, Kellogg's and Lord Howe pipefishes, have only been recorded a few times. White's seahorse, listed as Endangered in NSW, has not been observed at LHI. Sygnathids generally occur at low densities, with small home ranges, limited

dispersal, and low mobility, and many species are restricted to specific habitats, making them highly vulnerable to habitat loss and degradation.

In addition to the key species relevant to the LHI CIP, a number of other important species were identified including Bryde's whale (*Balaenoptera edeni*), Flatback (*Natator depressus*) and Loggerhead turtles (*Dermochelys coriacea*), Australian and New Zealand fur seals (*Arctocephalus pusillus* and *A. forsteri* respectively), Ballina angelfish (*Chaetodontoplus ballinae*), Bluefish (*Girella cyanea*), Giant manta ray (*Mobula birostris*) and White shark (*Carcharodon carcharius*). These marine species have Commonwealth or State level (or both) threatened status listings, and their assessments are included in Appendix D as a precautionary measure due to the contributions of these species to the biodiversity values of LHIMP.

When evaluating potential underwater noise impacts, it would be prudent to consider all marine fauna hearing groups that may occasionally occur in affected waters, including otariids, medium-frequency cetaceans, and low-frequency cetaceans.

A precautionary approach has been applied in recognition of the significant marine conservation values of the LHI World Heritage Area and the limited availability of species-specific data. The island's remoteness, unique seamount and canyon geomorphology, and the convergence of tropical and temperate waters support exceptionally high marine biodiversity. However, dedicated research in such remote locations is difficult to fund and undertake, resulting in data gaps—particularly for marine mammals (Figure 7 and Figure 8), and for those that may be visiting from east of LHI, outside of Australia.

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Appendix A. Existing pressures and threats

Appendix A1. Marine Bioregional Plan for the Temperate East Bioregion

Table 18: Existing pressures and threats for key species as per the TEMB Plan (C: Of concern, PC: Potential concern, LC: Least concern, NC: No concern).

Marine Fauna	Sea level rise	Sea temperature change	Changes in oceanography	Ocean acidification	Sand temperature changes	Chemical pollution	Nutrient pollution	Marine debris	Noise pollution	Light pollution	Habitat modification	Human presence	Extraction of living resources	Bycatch	Oil pollution	Vessel strike	Invasive species	Hydrological changes
Key species																		
Black rockcod	LC	PC	PC	LC	Not Assessed	PC	PC	LC	NC	NC	PC	NC	PC	PC	LC	NC	NC	Not Assessed
Syngnathids	LC	PC	PC	LC	Not Assessed	LC	NC	LC	NC	NC	PC	NC	LC	PC	LC	NC	LC	Not Assessed
Hump-back whale	NC	PC	PC	PC	Not Assessed	LC	NC	PC	LC	NC	NC	LC	NC	NC	LC	NC	NC	Not Assessed
Indo-Pacific bottlenose dolphin	PC	PC	PC	PC	Not Assessed	PC	PC	PC	PC	NC	C	LC	NC	C	PC	PC	NC	PC
Green turtle	PC	PC	PC	LC	PC	PC	PC	PC	LC	PC	PC	LC	PC	C	PC	C	PC	LC
Hawksbill turtle	NC	PC	PC	LC	NC	NC	PC	PC	LC	LC	LC	LC	PC	PC	PC	C	LC	LC
White shark	NC	PC	PC	NC	Not Assessed	LC	NC	LC	LC	NC	NC	NC	NC	C	LC	NC	NC	Not Assessed

Appendix A2. Recovery Plans

Recovery plan	Reason for plan and objectives	Threats
Conservation management plan for the blue whale (2015–2025):	The long term recovery plan objective is to minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list There are four interim objectives of the recovery plan; 1. The conservation status of blue whale populations is assessed using efficient and robust methodology. 2. The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales in Australian waters is described. 3. Current levels of legal and management protection for blue whales are maintained or improved, and an appropriate adaptive management regime is in place; and 4. Anthropogenic threats are demonstrably minimised.	Whaling—The impacts of commercial hunting on blue whales are well documented. While currently banned under the IWC moratorium on commercial whaling due to the classification of all blue whale populations as Protected Stocks, the potential for commercial whaling on large baleen whale species to recommence exists and pressure to take blue whales may well increase as the population recovers. Climate variability and change—Climate variability and change may cause distribution and migratory timing changes and decreased health of individuals in a population. Climate change can lead to ocean temperature increases, changes in ocean heat transfer resulting in changes to circulation patterns (e.g. upwellings), ocean acidification and melting of Antarctic sea ice. This may impact krill availability, the major food source for blue whales. Noise interference—Blue whales rely on sound to find prey and mates. Man-made noise can potentially result in injury or death, masking of vocalisations, displacement from essential resources (e.g. prey, breeding habitat), and behavioural responses. Potential sources of man-made underwater noise interference in Australian waters include seismic surveys for oil, gas and geophysical exploration, industrial development activities (such as drilling, pile driving, blasting and dredging), gas processing and shipping. Vessel disturbance—Vessel disturbance can occur in the form of collisions or by disrupting the behaviour of animals. Vessel collision can lead to mortality or significant injury, and could impede recovery of blue whale populations. Vessel disturbance or collisions can result from industrial, recreational or commercial activities including whale watching

Recovery plan	Reason for plan and objectives	Threats
National Recovery Plan for the Southern Right Whale <i>Eubalaena australis</i> (DCCEEW 2024b)	The recovery plan has five objectives: 1. Current levels of Commonwealth and State legislative and management protection for southern right whales are implemented, maintained, or improved, so threats continue to be managed and reduced over the life of the plan. 2. Anthropogenic threats are managed consistent with ecologically sustainable development principles to facilitate recovery of southern right whales. 3. Population dynamics, including demographics, distribution, residency, and coastal movement across the species range are monitored and quantified using robust, standardised, best-practice methodology to assess population recovery 4. The population structure of southern right whales in Australian waters is clearly characterised, including the level of interchange of individuals among coastal reproductive areas, to evaluate the degree to which the western and eastern populations are separate populations and inform the degree of connectivity with other southern right whale populations (e.g. NZ). 5. Capability of First Nation Australians, research, citizen science, and general community groups is improved to assist in addressing recovery actions of southern right whales in Australia. Very high priority actions for assess and address threats for the western population include: Maintain, implement, and improve efficacy of current legislative and management protection Address habitat degradation impacts from coastal and offshore marine infrastructure developments Understand impacts of climate variability and anthropogenic climate change on population recovery Manage and mitigate the threat of entanglements from commercial active of discarded fishing gear High priority actions: none Moderate priority actions: Assess, manage, and mitigate impacts from anthropogenic noise Managed, minimise, and mitigate the threat of vessel strike	Anthropogenic climate change and climate variability Southern right whale feed on krill in high latitude foraging areas, and variation in calving rate may be influenced by climate factors impacting changes to calving intervals. Modelling the links between krill and whale population dynamics with climate change, including changes in ocean temperature, primary productivity, and sea ice, suggests future ocean conditions are likely to have a negative impact on krill populations and in association the baleen whale species that feed on them Entanglement Sublethal and lethal impacts. Sublethal include energetic cost, poorer body condition, and reduced reproductive success Marine debris Land-sourced garbage, fishing gear from recreational and commercial fishing abandoned or lost to the sea, and vessel-sourced, solid, non-biodegradable floating materials disposed of or lost at sea. Habitat degradation Physical modification of habitat can degrade the quality and reduce the quantity of available habitat and may be caused by the construction of ports and marinas, oil and gas infrastructure, marine aquaculture facilities, marine (offshore) renewable energy infrastructure and coastal development. It has the potential to spatially displace individuals or modify behaviour. Key consideration for environmental impact assessments: Actions that will likely compromise the recovery of southern right whales and have a significant impact on the species must be managed to reduce risk, which includes, but is not limited to, actions that:

Recovery plan	Reason for plan and objectives	Threats
		Increase southern right whale mortality and may likely result in declines in population abundance Disrupt the breeding cycle, such as by reducing the reproductive success of breeding southern right whale females Reduce the area of occupancy in the species, including preventing the re-occupation of historic high use areas Adversely affect habitat critical to the survival to the species, potentially through decreasing the availability or quality of the habitat.
Recovery Plan for the White Shark (<i>Carcharodon carcharias</i>) (DSEWPaC 2013b)	There are 10 objectives identified in the plan: 6. Develop and apply quantitative measures to assess population trends and any recovery of the white shark in Australian waters and monitor population trends 7. Quantify and minimise the impacts of commercial fishing, including aquaculture, on the white shark through incidental (illegal and/or accidental) take, throughout its range in Australian waters 8. Quantify and minimise the impacts of recreational fishing on the white shark through incidental (illegal and/or accidental) take, throughout its range in Australian waters 9. Where practicable minimise the impact of shark control activities on the white shark 10. Investigate and manage (and where necessary reduce) the impact of tourism on the white shark 11. Quantify and minimise the impact of international trade in white shark products through implementation of CITES provisions 12. Continue to identify and protect habitat critical to the survival of the white shark and minimise the impact of threatening processes within these areas 13. Continue to develop and implement relevant research programs to support the conservation of the white shark 14. Promote community education and awareness in relation to white shark conservation and management 15. Encourage the development of regional partnerships to enhance the conservation and management of white shark across national and international jurisdictions.	Principal threats: Mortality related to being caught accidentally (bycatch) or illegally (targeted) by commercial and recreational fisheries, including issues related to post release mortality Mortality related to shark control activities such as beach meshing and drumlining (east coast population).

Recovery plan	Reason for plan and objectives	Threats
Recovery Plan for Marine Turtles in Australia (DoEE 2017a)	Reason for Plan: Review of the previous recovery plan (2003) found that numerous emerging and cumulative threats were not addressed. Monitoring of key nesting and foraging sites had not been adequately achieved. There are four interim recovery objectives with associated targets: 16. 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. a. Domestic and international legislation and other agreements that support the recovery of Australian marine turtles are maintained, and, where possible, strengthened b. Robust scientific information is available and used to support decision making. 17. The management of marine turtles is supported a. The sustainable management of marine turtles by Aboriginal and Torres Strait Islander communities and ranger groups to maintain long-term cultural, spiritual and economic associations with marine turtles is supported b. The capacity of programs throughout northern Australia to conduct effective monitoring, management and research of marine turtles at nesting beaches and feeding grounds is maintained and increased. 18. Anthropogenic threats are demonstrably minimised a. Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place. b. Threat mitigation strategies are supported by high quality information 19. Trends in nesting numbers at index beaches and population demographics at important foraging grounds are described a. Effective monitoring programs are implemented and maintained at index beaches and foraging areas for each of the six species. Measures of success identified for each stock are achieved within the life of the plan.	Threats of concern: Coastal development including residential, industrial and tourism development degrade both nesting beaches and foraging habitat. Acute chemical and terrestrial discharge Light pollution on nesting beaches impacting nesting behaviour and hatchling success Climate change both direct and indirect impacts on the turtle. Sex is determined by incubation temperature of the eggs. Rising sea levels and an increase in climatic events intensities could result in nesting beach erosion Green turtle (southern Great Barrier Reef) High risk: - Climate change and variability - Ingestion of marine debris - Chemical and terrestrial discharge – chronic Hawksbill turtle (north Queensland) Very High risk - Entanglement with marine debris - International take outside Australia's jurisdiction High risk - Climate change and variability - Terrestrial predation

Appendix A3. Threat Abatement Plans

Threat abatement plan (TAP)	Objective and Priorities	Species
Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018)	This plan has 5 objectives to prevent and mitigate the impacts of harmful marine debris on vertebrate marine life 1. Contribute to long-term prevention of the incidence of marine debris 2. Understand the scale of impacts from marine plastic and microplastic on key species, ecological communities, and locations 3. Remove existing marine debris 4. Monitor the quantities, origins, types, and hazardous chemical contaminants of marine debris, and assess the effectiveness of management arrangements for reducing marine debris 5. Increase public understanding of the causes and impacts of harmful marine debris, including microplastic and hazardous chemical contaminants, to bring about behaviour change. Criteria for success remain consistent with those in the previous TAP and with national indicators for estuarine, coastal, and marine ecosystems: 1. Monitor the quantities, origins, types, and hazardous chemical contaminants of marine debris, and assess the effectiveness of management arrangements for reducing marine debris 2. A general decline in the presence and extent of harmful marine debris in Australia's marine environment 3. A general decline in the number of marine vertebrates dying and being injured from ingestion of and/or entanglement in harmful marine debris.	Key species of this desktop within this TAP: Humpback whale Indo-Pacific bottlenose dolphin Green turtle Hawksbill turtle

Appendix B. Databases

This desktop study was informed by multiple database (See Section 4) using the search area shown in Figure 4 ('Proposal search area').

Protected matters search tool

The Protected matters search tool (PMST) is provided by DCCEEW and was used to identify MNES within the search area. MNES are defined as 'nationally significant' animals, plants, habitats, and places listed under the EPBC Act. The PMST identifies listed species and communities that have a 'moderate potential to occur' based on broad species ranges, bioclimatic modelling and scientific expert advice. The database search results include the species, listing categories and probability of species presence, including a ranked order (DCCEEW 2025a).

BioNet threatened species database

BioNet provides a database search and download service for the sighting and identification of threatened and priority plants, animals and ecological communities at or near an area of interest, made and reported to the Office of Environment and Heritage (NSW). The database search results include coordinates and available information relevant to all sightings from this search area.

Australian marine spatial information system

Biologically Important Areas (BIAs) and areas of habitat critical to the survival of marine turtle areas for conservation significant species were identified from the PMST results and a search on the Australian Marine Spatial Information System (AMSIS; Geoscience Australia n.d.). BIAs are spatially defined zones where aggregations of individuals of a particular species are known to display biologically important behaviours such as breeding, foraging, resting or migrating (DCCEEW 2025d). BIAs were first identified on a regional basis as they were developed as part of the Commonwealth Marine Bioregional Plans and have been identified using expert scientific knowledge about species' distribution, abundance, and behaviour in the region, to inform decisions made under the EPBC Act. BIAs and areas identified as critical habitats are important components of Species' Recovery Plans, where those plans exist. Additionally, nesting and inter-nesting areas are identified by the AMSIS as habitats critical to the survival of marine turtles, derived from the Recovery plan.

These areas should be considered when assessing significance of potential impacts, but they are not listed as 'Critical Habitat' as defined under Section 207A of the EPBC Act (Register of Critical Habitat).

Species profile and threats database

DCCEEW's SPRAT database was consulted to confirm the current status of Threatened and Migratory species and identify relevant documents relating to the EPBC Act for protection of those species (DCCEEW 2025c).

International Union for Conservation of Nature red list

Species global (non-statutory) listing by the International Union for Conservation of Nature (IUCN) Red (IUNC 2025) list status was compiled during the likelihood of occurrence assessment.

Atlas of living Australia

The Atlas of Living Australia (ALA) is a collaborative tool that collates Australian biodiversity information from multiple sources. The ALA was consulted to note the dated last sighting of a species and an estimated count. It is utilized as an additional source for species sightings/occurrence within the region.

Appendix C. Summary of all PMST Results

Marine Mammals

Table C 1: All marine mammal PMST results, listing status (EPBC, BC, and IUCN), and likelihood of occurrence ranking

Common Name	Scientific Name	EPBC Act	Listing Status (BC Act)	IUCN (non-statutory)	PMST Rank	Likelihood of Occurrence
Andrew's beaked whale	<i>Mesoplodon bowdoini</i>	Cetacean	-	Data Deficient	May	Low
Antarctic minke whale	<i>Balaenoptera bonaerensis</i>	Migratory Cetacean		Near Threatened	Likely	Low
Australian fur seal	<i>Arctocephalus pusillus</i>	Marine	Vulnerable	Least Concern		High
Blainville's beaked whale	<i>Mesoplodon densirostris</i>	Cetacean	-	Least Concern	May	Moderate
Blue whale	<i>Balaenoptera musculus</i>	Endangered Migratory Cetacean	Endangered	Endangered	May	Low
Bryde's whale	<i>Balaenoptera edeni</i>	Migratory Cetacean		Least Concern	Likely	Moderate
Common bottlenose dolphin	<i>Tursiops truncatus</i>	Cetacean		Not Listed	May	High
Common dolphin	<i>Delphinus delphis</i>	Cetacean		Least Concern	May	Low
Cuvier's beaked whale	<i>Ziphius cavirostris</i>	Cetacean		Least Concern	May	Low
Dwarf sperm whale	<i>Kogia sima</i>	Cetacean		Least Concern	May	Low
False killer whale	<i>Pseudorca crassidens</i>	Cetacean		Data Deficient	Likely	Low
Fin whale	<i>Balaenoptera physalus</i>	Vulnerable Migratory Cetacean		Vulnerable	Likely	Low
Gray's beaked whale	<i>Mesoplodon grayi</i>	Cetacean	-	Least Concern	May	Low
Humpback whale	<i>Megaptera novaeangliae</i>	Migratory Cetacean		Least Concern	May	High
Killer whale	<i>Orcinus orca</i>	Migratory Cetacean		Data Deficient	May	Low
Leopard seal	<i>Hydrurga leptonyx</i>	Marine		Least Concern	May	Low

Common Name	Scientific Name	EPBC Act	Listing Status (BC Act)	IUCN (non-statutory)	PMST Rank	Likelihood of Occurrence
Long-finned pilot whale	<i>Globicephala melas</i>	Cetacean	-	Least Concern	May	Low
Long snouted spinner dolphin	<i>Stenella longirostris</i>	Cetacean		Least Concern	May	Low
Melon-headed whale	<i>Peponocephala electra</i>	Cetacean	-	Least Concern	May	Low
Minke whale	<i>Balaenoptera acutorostrata</i>	Cetacean	-	Least Concern	May	Low
New Zealand fur-seal	<i>Arctocephalus forsteri</i>	Marine	Vulnerable	Least Concern		High
Pygmy killer whale	<i>Feresa attenuata</i>	Cetacean	-	Least Concern	May	Low
Pygmy sperm whale	<i>Kogia breviceps</i>	Cetacean	-	Least Concern	May	Low
Risso's dolphin	<i>Grampus griseus</i>	Cetacean	-	Least Concern	May	Low
Rough toothed dolphin	<i>Steno bredanensis</i>	Cetacean		Least Concern	May	Low
Sei whale	<i>Balaenoptera borealis</i>	Vulnerable Migratory Cetacean		Endangered	Likely	Low
Short-finned pilot whale	<i>Globicephala macrorhynchus</i>	Cetacean	-	Least Concern	May	Low
Southern right whale	<i>Eubalaena australis</i>	Endangered Migratory Cetacean	Endangered	Least Concern	May	Low
Southern right whale dolphin	<i>Lissodelphis peronii</i>	Cetacean	-	Least Concern	May	Low
Sperm whale	<i>Physeter macrocephalus</i>	Migratory Cetacean	Vulnerable	Vulnerable	May	Low
Spotted dolphin	<i>Stenella attenuate</i>	Cetacean		Least Concern	May	Low
Strap-toothed beaked whale	<i>Mesoplodon layardii</i>	Cetacean	-	Least Concern	May	Low
Striped dolphin	<i>Stenella coeruleoalba</i>	Cetacean	-	Least Concern	May	Low
Sub-Antarctic fur seal	<i>Arctocephalus tropicalis</i>	Endangered Marine		Least Concern		Low
True's beaked whale	<i>Mesoplodon mirus</i>	Cetacean	-	Least Concern	May	Low

Marine turtles

Table C 2: Summary of all reptile PMST results, listing status (EPBC, BC, and IUCN), and likelihood of occurrence ranking

Common Name	Scientific Name	EPBC Act	BC Act	IUCN (non-statutory)	PMST Rank	Likelihood of Occurrence
Flatback turtle	<i>Natator depressus</i>	Vulnerable Migratory Marine		Vulnerable	Likely	Low
Green turtle	<i>Chelonia mydas</i>	Vulnerable Migratory Marine		Endangered	May	High
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Vulnerable Migratory Marine		Critically Endangered	Likely	High
Leatherback turtle	<i>Dermochelys coriacea</i>	Endangered Migratory Marine	Endangered	Vulnerable	Likely	Low
Loggerhead turtle	<i>Caretta caretta</i>	Endangered Migratory Marine	Endangered	Vulnerable	Likely	Low

Marine fishes

Table C 3: Summary of all fish PMST results, listing status (EPBC, FM, and IUCN), and likelihood of occurrence ranking

Common Name	Scientific Name	EPBC Act	FM Act	IUCN (non-statutory)	PMST Rank	Likelihood of Occurrence
Ballina angelfish	<i>Chaetodontoplus ballinae</i>		Protected	Least Concern		Low
Black rockcod	<i>Epinephelus daemeli</i>	Vulnerable	Vulnerable	Near Threatened	Likely	High
Bluefish	<i>Girella cyanea</i>		Protected	Not Evaluated		Moderate
Booth's pipefish	<i>Halicampus boothae</i>	Marine	Protected	Least Concern	May	Moderate
Doubleheader wrasse	<i>Coris bulbifrons</i>			Vulnerable		High
Duncker's pipehorse	<i>Solegnathus dunckeri</i>	Marine	Protected	Data Deficient	May	Moderate
Eastern blue devil	<i>Paraplesiops bleekeri</i>		Protected	Not Evaluated		Moderate
Elegant wrasse	<i>Anampses elegans</i>		Protected	Least Concern		High
Galapagos shark	<i>Carcharhinus galapagensis</i>			Near Threatened		High
Giant manta ray	<i>Mobula birostris</i>	Migratory		Endangered	Known	Low
Gold spot rock cod	<i>Epinephelus coioides</i>		Protected	Near Threatened		Low
Great hammerhead	<i>Sphyrna mokarran</i>		Vulnerable	Critically Endangered		Low
Grey nurse shark (east coast population)	<i>Carcharias taurus</i>	Critically Endangered	Critically Endangered	Critically Endangered		Low
Kellogg's seahorse	<i>Hippocampus kelloggi</i>	Marine	Protected	Vulnerable	May	Moderate
LHI abalone	<i>Haliotis rubiginosa</i>		Critically Endangered	Critically Endangered		High
Longfin mako	<i>Isurus paucus</i>	Migratory		Endangered	Likely	Low
Lord Howe pipefish	<i>Cosmocampus howensis</i>	Marine	Protected	Least Concern	May	Moderate
McCulloch's anemonefish (Whitesnout)	<i>Amphiprion mccullochi</i>	Critically Endangered	Critically Endangered	Vulnerable	Known	High
Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	Migratory	Migratory	Critically Endangered	May	Low

Common Name	Scientific Name	EPBC Act	FM Act	IUCN (non-statutory)	PMST Rank	Likelihood of Occurrence
Orange roughy	<i>Hoplostethus atlanticus</i>	Conservation Dependent		Vulnerable	Likely	Low
Porbeagle	<i>Lamna nasus</i>	Migratory	Migratory	Vulnerable	May	Low
Queensland groper	<i>Epinephelus lanceolatus</i>		Protected	Data deficient		Moderate
Reef manta ray	<i>Mobula alfredi</i>	Migratory		Vulnerable	Known	Low
Sand tiger shark	<i>Odontaspis ferox</i>		Protected	Endangered		Low
Scalloped hammerhead	<i>Sphyrna lewini</i>	Conservation Dependent	Endangered	Critically Endangered	Likely	Low
School shark	<i>Galeorhinus galeus</i>	Conservation Dependent	-	Critically Endangered	May	Low
Shortfin mako	<i>Isurus oxyrinchus</i>	Migratory		Endangered	Likely	Low
Southern bluefin tuna	<i>Thunnus maccoyii</i>		Endangered	Endangered		Low
White shark	<i>Carcharodon carcharias</i>	Vulnerable Migratory	Vulnerable	Vulnerable	Known	Moderate
White's seahorse	<i>Hippocampus whitei</i>	Endangered Marine	-Endangered	Endangered	May	Moderate

Appendix D. Other species likelihood of occurrence assessment and review of non-key marine fauna species

Appendix D1: Marine Mammals

Nine additional conservation significant marine mammal species have been identified as relevant for consideration as they are Known or Likely to occur within or near the Project area. However, for a variety of reasons, these marine species are considered to have a Moderate or Low likelihood of occurrence. Summary information for the following marine mammals is provided in Table D 1 below.

- Australian fur seal
- Antarctic minke whale
- Blainville's Beaked whale*
- Bryde's whale
- False killer whale
- Fin whale
- New Zealand fur seal
- Sei whale
- Sub-Antarctic fur seal

Table D 1: Other mammals that are Known or Likely to be present in the Proposal area,

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
Antarctic minke whale <i>(Balaenoptera bonaerensis)</i>	Migratory Cetacean	Antarctic minke whales are listed as 'Cetacean' and 'Migratory' under the EPBC Act. Their global (non-statutory) listing by the IUCN is 'Near Threatened'. Relevant EPBC Act documents are: - Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017b) - EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DEWHA 2008a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures: There is no recovery plan or conservation advice for Antarctic minke whales specifically, however it is a species of interest in the - Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018).	Population: There are no current population estimates available for the Antarctic minke whale in Australian waters, however all Australian waters occur within it's migratory range. (DCCEEW 2025c) Distribution: This species has been recorded in all states of Australia, except for the Northern Territory. Being a migratory cetacean, they can be found between 55° S in the summer, north to 21° S in the winter (DCCEEW 2025c) Habitat use and life history: Antarctic minke whales occupy primarily offshore and pelagic habitats within cold temperate to Antarctic waters between 21° S and 65° S (DCCEEW 2025c). Antarctic minke whales migrate annually between polar high latitudes in the summer to feed and warm lower latitudes in winter to breed (Bannister 2018). Like many baleen whales, their main diet is Antarctic krill (Bannister 2018). Males reach sexual maturity at about 7.3 m and eight years old and females at 7.9 m and between seven to eight years. Gestation last for 10 months and usually there is a single calf, although twins and triplets have been observed. There is very limited information on life histories for this species in Australian waters (DCCEEW 2025c).	BioNet: 0 ALA: 0	Low This migratory cetacean species was not identified to be present from sightings in the broader search area, although it likely utilises the offshore waters around LHI during periods of migration between polar and lower subtropical latitudes. It is therefore considered to have a low likelihood of occurrence.

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
Australian fur seal	Vulnerable Marine	Australian fur seals are listed as 'Vulnerable' and 'Marine' under the EPBC act and 'Vulnerable' under the BC Act. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant EPBC Act documents are: • Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) • Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018). • Australian Fur-seal - vulnerable species listing - NSW Scientific Committee - final determination (NSW (NSW DECCW), 2002 • The Action Plan for Australian Seals (Shaughnessy 1999) • Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022) Threats and Pressures: There is both a recovery plan and conservation advice in place for sub-Antarctic fur seals. for sperm whales; however, Threats that may be relevant to consider when assessing impacts of the Project are: • Marine debris	Population The most recent population estimate for this species, based on a combination of survey techniques including aerial photography, direct ground counts and capture-mark-resight, placed the total number of Australian Fur-seal pups at 26,000 (Kirkwood 2010. DCCEEW 2025c). Whilst population increases have been observed, there are fluctuations between many of the breeding sites, suggesting that whole of population recovery is yet to take place for this species. Live pup births have remained at ~16,000 pups since 2013 (McIntosh et al 2022). In NSW, a recent monitoring program identified 834 seals were across 11 sites in southern NSW, with anecdotal reports this species is increasing in the state (DEH 2024). Distribution The Australian fur seal is distributed has a very limited global distribution, confined entirely to southeastern Australia. It is one of two subspecies of the <i>Arctocephalus pusillus</i> species—the other being the Cape fur seal (<i>A. p. pusillus</i>), found in southern Africa. In Australia. it breeds principally on rocky islands, with 10 current breeding populations being establishes across Bass Strait, Tasmania, Victoria, South Australia, and occasionally in coastal New South Wales. The historic breeding sites in NSW have not recovered from historic hunting activity, although pups have been born occasionally at Montague Island on the southern NSW coast, and many non-breeding animals are known to congregate there (DCCEEW 2025c). Few sightings of this species are documented at LHI (Figure 9), this species is reportedly an occasional visitor to LHI (Harasti et al	BioNet: 1 ALA: 1	Moderate The Australian fur seal is listed as 'Marine' under the EPBC Act, 'Vulnerable' under the BC Act and 'Least Concern' by the IUCN. Few sightings of this species have occurred at LHI (Figure 9) and it may be impacted by Project activities if it is present during construction. Although not primary habitat LHI likely represents an important rest site during oceanic foraging trips.

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Noise pollution	2022), and the location may represent an important site for resting on long oceanic foraging trips. Habitat use and life history Adult female-seals (cows) average 125—170 cm in length and 50—120 kg. Cows are slender, silvery-grey on the back, with a creamy-yellow chest, and chocolate brown belly. Adult males (bulls) are larger, averaging 200—225 cm in length and weighing 220—360 kg. Bulls are dark grey with a mane of coarse hair on their neck and shoulders. Pups are very dark, almost black (DCCEEW 2025c). Australian fur-seal colonies are occupied year-round, breeding occurring the summer months from October to late December. Females sexually mature between 3—6 years old and males begin holding territories between ages 8—13 years. Birthing can occur annually, with an 8 month gestation following delayed implantation of about three to four months from the breeding time (Speakman et al 2024, DCCEEW 2025c).		
Blainville's beaked whale <i>(Balaenoptera edeni)</i>	Migratory Cetacean	Balinvile's beaked whales are listed as 'Cetacean' and 'Migratory' under the EPBC. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant EPBC Act documents are: - Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017b) - EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines DEWHA 2008a)	Population It is suspected that there is a single global population of the Blainville's beaked whale, given there are no physical barrier likely to cause speciation in deep offshore environments. There is no estimate of global population size. Distribution Blainville's beaked whale is oceanic and circumglobal in low to midlatitudes in all oceans in both hemispheres occupying deep (>500m) oceanic waters along canyons. In Australia, it's presence is mainly known from strandings, which have been recorded in all states except South Australia and Northern Territory. It has	BioNet: 7 ALA: 0	Moderate This migratory cetacean has been identified as a unique cetacean contributing to LHI's biodiversity. Both stranded and live observations of this species have occurred within the broader search area. Suitable habitat occurs within the broader search area and this species is likely be present, and it is

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) Threats and Pressures: There is no recovery plan or conservation advice for Antarctic minke whales; however, the following threats have been identified: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution - Vessel strike	been observed to occur within the LHIMP (Harasti et al 2022). Primary habitat (migration, breeding and foraging) and life history: Almost all knowledge for this species exists from stranding records. The Australian Museum holds five specimens of collected from LHI. The species has previously been reported to be more common around oceanic islands and local fishermen have indicated that small pods (up to 4 individuals) of this species were regularly sighted in the waters around the Island. One collection of stranded animals from LHI consisted of 2 females and 1 male (Elridge et al 2017) which is consistent with the theory that this species forms small harem pods of up to 3 females and a single male. Sightings of groups up to 10 individuals are likely to be 2 harem pods together (Macleod 2014). Blainville beaked whales have been detected as a prey species of Orca (DCCEEW 2025c).		therefore considered to have a moderate likelihood of occurrence,
Bryde's whale (<i>Balaenoptera edeni</i>)	Migratory Cetacean	Bryde's whales are listed as 'Cetacean' and 'Migratory' under the EPBC act and Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant EPBC Act documents are: - Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017b) - EPBC Act Policy Statement 2.1 - Interaction between offshore	Population: There is no global population estimate and little information about population trends for the Bryde's whale. It has been estimated that the tropical Pacific population is 13,000 individuals (DCCEEW 2025c). Distribution: Bryde's whales are found in tropical and sub-tropical environments in waters ~20°C. In Australia, they have been recorded on all coastlines, except in the Northern Territory (DCCEEW 2025c). They are considered the only 'tropical' baleen whale.	BioNet: 0 ALA: 0	Moderate This migratory cetacean species was not identified to be present from sightings in the broader search area, although it likely utilises the island's offshore waters

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		seismic exploration and whales: Industry guidelines (DEWHA 2008a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures: There is no recovery plan or conservation advice for Bryde's whales; however, the following threats have been identified: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution - Vessel strike	Habitat use and life history: It is thought that there are both coastal and pelagic populations of Bryde's whales, due to varying diets observed in animals from each of these environments. Coastal populations have been observed to 'surf feed' catching small fish in coastal waters, where as offshore populations use lunge feeding techniques to catch zooplankton and krill. Sightings of Bryde's whales tend to be of individual animals or those travelling in pairs but larger group sizes have been recorded in South Africa and the Gulf of California. In Australia, Bryde's whales are thought to actually not be fully migratory from polar environments like other baleen whales, but present year round and continuously feeding as local resources allow (Pirotta et al 2024). The coastal form of the species Bryde's whales are thought to live for over 50 years and have a 2-year reproductive cycle. Females of the offshore form reach sexual maturity between 11.6-11.8 m and males between 11-11.4 m, and for the inshore form females between 11.3- 1.5 m and males between 10-10.4 m (DCCEEW 2025a).		
False killer whale (<i>Pseudorca crassidens</i>)	Cetacean	False killer whales are listed as 'Cetacean' under the EPBC Act. Their global (non-statutory) listing by the IUCN is 'Data Deficient'. EPBC Act documents are: - Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017b) - EPBC Act Policy Statement 2.1 - Interaction between offshore	Population: There are no population estimates available for Australian waters. However it is likely the population is <10,000 due to the average number recorded during stranding events being 100 individuals (DCCEEW 2025c) Distribution: False killer whales are globally distributed in deep tropical and temperate waters between 45°S and 45°N. The distribution of this species is not considered fragmented due to preference for deep water	BioNet: 0 ALA: 0	Low This cetacean species was not identified to be present from sightings in the broader search area, although it likely utilises the deep offshore waters around LHI and may be present in this location at times. It is therefore

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		seismic exploration and whales: Industry guidelines (DEWHA 2008a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures: There is no recovery plan or conservation advice for False killer whales. However the following threats have been identified which may be considered d=for Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution - Vessel strike	environments with few physical barriers to their distribution (DCCEEW 2025c) Habitat use and life history: This species is known to strand in all coastal states, with WA and Tasmania having the highest incidence of stranding records. Stranding groups may be large and consist of >100 individual whales. They have been observed offshore in super groups of 100-800 which may be an aggregation of several smaller herds. Male killer whales are larger than females (6m length for males and 5m for females). There are no known calving patterns in Australian waters, but breeding is thought to occur throughout the year. Diet consists of fish and cephalopods (DCCEEW 2025c)		considered to have a low likelihood of occurrence
Fin whale <i>(Balaenoptera physalus)</i>	Vulnerable Migratory Cetacean	Fin whales are listed as “Vulnerable”, ‘Cetacean’ and ‘Migratory’ under the EPBC Act. Their global (non-statutory) listing by the IUCN is ‘Vulnerable’. Relevant EPBC Act documents are: - Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017b) - EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales:	Population: Fin whales were once highly abundant with population estimated to be 400,000 in 1920. However fin whales were highly impacted by whaling and there are no current population estimates for Australian waters. Antarctic populations are estimates at 13,500 (TSSC 2015) Distribution: Fin whales are considered a cosmopolitan species and occur from polar to tropical waters, and rarely in inshore waters. The Australian extent of their distribution is	BioNet: 0 ALA: 0	Low This Vulnerable migratory cetacean species was not identified to be present from sightings in the broader search area, although it likely utilises the deep offshore waters around LHI and may be present in this location at times during migration. It is therefore

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Industry guidelines (DEWHA 2008a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures: There is no recovery plan, however a conservation advice is in place for Fin whales, due to this species being severely impacted by whaling last century and most of this decline occurred in the southern hemisphere - Conservation Advice <i>Balaenoptera physalus</i> (fin whale)	uncertain, but they occur in both Commonwealth and State waters with records in most States (TSSC 2015) Habitat use and life history: Despite this species threatened conservation status, little detail is known about its presence and use of Australian waters. On Australia's east coast, fin whale calls have been detected in NSW from June to September/October which aligns with observed migratory movements of South Pacific fin whales (New Zealand and Tonga seasonal movements in June to October) (Aulich et al 2019). The fin whale is the second-largest whale, after the blue whale, growing to 27m in length. They are often seen in group of 6-10, but super groups of >100 individuals have been observed feeding. Fin whale diet consists of krill, some fish and cephalopods (DCCEEW 2025c)		considered to have a low likelihood of occurrence
New Zealand fur seal (<i>Arctocephalus forsteri</i>)	Marine	New Zealand fur seals are listed as 'Marine' under the EPBC act and 'Vulnerable' under the BC Act. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant EPBC Act documents are: Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018).	Population In Australia, New Zealand fur seals occur off South Australia (97,000 individuals) (Louise Chilvers 2018) and off the south coast of Western Australia (17,000 individuals) (Campbell et al 2014). Smaller populations have recently become established on several Bass Strait Islands, Tasmania, Victorian, and New South Wales coasts. Whilst there is evidence of New Zealand fur seal colonies becoming established in NSW, details on the persistence and abundance for this species remains a knowledge gap in NSW, with a recent and ongoing	BC	Moderate The New Zealand fur seal is listed as 'Marine' under the EPBC Act, 'Vulnerable' under the BC Act and 'Least Concern' by the IUCN. Sightings of this species have occurred in the lagoon in the lagoon (Figure 9). Although not primary habitat the island likely represents an important

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- New Zealand Fur-seal - vulnerable species listing - NSW Scientific Committee - final determination (NSW) (NSW DECCW 2002a) - The Action Plan for Australian Seals (Shaughnessy 1999) - Environmental values of the Lord Howe Island Marine Park (Harasti et al 2022) Threats and Pressures: There is both a recovery plan and conservation advice in place for sub-Antarctic fur seals. for sperm whales; however, Threats that may be relevant to consider when assessing impacts of the Project are: - Marine debris - Noise pollution	program, the Great Seal Reveal attempting to investigate seal populations in the state (DEH 2024). Distribution The New Zealand fur seal is found in coastal New Zealand and subantarctic islands, while a significant and expanding population now exists along southern and southwestern Australia, including Tasmania, SA, WA and occasionally parts of south-east Australia. Individual seals have been sighted far from the main colonies in locations such as New Caledonia, the Cook Islands and LHI (Figure 9, Chilvers 2018). The presence of these vagrant individuals is suggestive of their ability to undertake foraging trips of significant distance and duration. considered a nonmigratory species although males move distances of 200–500 km between breeding colonies and nonbreeding haul-out sites (Louise Chilvers 2018) Habitat use and life history New Zealand fur seals haul out and breed on rocky coastlines. Breeding colonies usually have some protection from heavy seas and areas with shallow rocky pools for cooling are favourable. Males come ashore and establish well-defined territories in late October/early November with females following ashore early to mid-November after the males have arrived and claimed a territory. Pups are born from prior year mating from mid-November to late January, with the majority being born in December (Kirkwood and Goldsworthy, 2013). Diet consists of cephalopods, fishes, and occasional sea birds such as little blue penguins and petrels (Fea et al, 1999)		rest site during oceanic foraging trips.

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			while the seals themselves are prey for Orcas, sharks and possibly leopard seals (Louise Chilvers 2018).		
Sei whale (<i>Balaenoptera borealis</i>)	Vulnerable Migratory Cetacean	Sei whales are listed as 'Vulnerable', 'Cetacean' and 'Migratory' under the EPBC. Their global (non-statutory) listing by the IUCN is 'Endangered'. Relevant EPBC Act documents are: - Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017b) - EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DEWHA 2008a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEE 2024a)	Population: The abundance and population for Sei whales in Australian waters is unknown. The southern hemisphere population was originally ~100,000, but in 1980 was decreased to a~24,000 individuals (TSSC 2015b) Distribution: Sei whales are a cosmopolitan species, ranging from polar to tropical waters, but further offshore than other large whale species. Their similarity in appearance to Bryde's whales may have created confusion in the northern distribution limits, as the Bryde's whale is more common in warmer waters. Sei whales have been infrequently recorded in Australian waters, however there are reports of presumed sei whale sightings by fishermen around the shelf edge (50 km offshore) off the coast of NSW. (DCCEE 2025c)	BioNet: 0 ALA: 0	Low This Vulnerable migratory cetacean species was not identified to be present from sightings in the broader search area, although it likely utilises the deep offshore waters around LHI and may be present in this location at times during migration. It is therefore considered to have a low likelihood of occurrence

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Threats and Pressures: There is no recovery plan, however a conservation advice is in place for Sei whales due to this species being severely impacted by whaling last century and most of this decline occurred in the southern hemisphere Conservation Advice <i>Balaenoptera borealis</i> (sei whale) (TSSC 2015)	Habitat use and life history: Like other baleen whales, this specie undergoes a north-south migration between the polar regions and the tropics. Sei whales also feed on krill, but amphipods and copepods make up the majority of their diet. Males are smaller than females (17 m for males and 21 m for females). Breeding and calving is suspected to take at low latitudes, however no locations have been identified. Calving takes place every 2-3 years, and this low reproductive cycle has contributed to slow population recover from whaling (TSSC 2015).		
Sub-Antarctic fur seal (<i>Arctocephalus tropicalis</i>)	Endangered Marine	Sub-Antarctic fur seals are listed as 'Endangered' and 'Marine' under the EPBC act and 'Vulnerable' under the BC Act. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant EPBC Act documents are: - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - Sub-Antarctic Fur Seal and Southern Elephant Seal Recovery Plan 2004-2009 (DEH 2003)	Population: Globally, the sub-Antarctic fur seal population is estimated to be ~277,000. However only a single breeding colony is present in Australian waters and consists of 90-130 mature adults, with ~10 pups born each year (DCCEEW 2025c) Distribution: In Australian waters, the Sub-Antarctic fur seal is mainly confined to Macquarie Island, but individuals can travel widely and occasionally reach the beaches of Tasmania and Australian mainland. Very few immigrant seals from larger colonies in the western Indian Ocean visit Australia (DCCEEW 2025c). This species has been observed to occur within the LHIMP (Harasti et al 2022)	BioNet: 2 ALA: 1	Low This Endangered marine species was identified to be present from 2 sightings at LHI within the broader search area. It is likely these sightings are a rare occurrence and this species, may be present in this location at times during extended foraging trips. It is therefore considered to have a low likelihood of occurrence

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- The Action Plan for Australian Seals (Shaughnessy 1999) - Conservation Advice <i>Arctocephalus tropicalis</i> (sub-Antarctic fur seal) (TSSC 2016) Threats and Pressures: There is both a recovery plan and conservation advice in place for sub-Antarctic fur seals. for sperm whales; however, Threats that may be relevant to consider when assessing impacts of the Project are: - Marine debris - Noise pollution	and the island likely is an important rest location during oceanic roaming. Habitat use and life history: Sub-Antarctic fur seals were extensively hunted, and the population was almost reduced to extinction in the early 1900's. The Australian population did not begin to recover until the 1950's and is currently increasing at 8% each year (DCCEW 2025c). The sub-Antarctic fur seal has distinct colouring than other fur seals, with chocolate brown fur and a yellowish face. Male and female pups can be distinguished by males showing richer fur colouring and a 'mane'. Pups are glossy-black with a dark chocolate brown belly. They forage mainly at night, hunting mainly fish and cephalopods (DCCEW 2025c)		

Appendix D2: Marine Reptiles

Three additional conservation significant marine turtle species have been identified as relevant for consideration as they are Known or Likely to occur within or near the Project area. However, for a variety of reasons, these marine species are considered to have a Moderate likelihood of occurrence. Summary information for the following marine turtles is provided in Table D 2 below.

- Flatback turtle
- Leatherback turtle
- Loggerhead turtle

Table D 2: Other turtles that are Known or Likely to be present in the Proposal area,

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
Flatback turtle <i>(Natator depressus)</i>	Vulnerable Migratory Marine	Flatback turtles are listed as 'Vulnerable' and 'Migratory' and 'Marine' under the EPBC Act. Their global (non-statutory) listing by the IUCN is 'Vulnerable'. Relevant EPBC Act documents are: - Recovery Plan for Marine Turtles in Australia (DoEE 2017a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012) - Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures: The following threats have been identified which may be considered as relevant to potential Project impacts: : Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution - Vessel strike	Population: The global population estimate and trends for the flatback turtle is unknown. In Australia, there are five genetically distinct stocks. The southern most stock in WA is the Pilbara coast stock, the status of this stock is unknown (DoEE 2017a). There are no genetic stocks nesting locations present within the Project area and surrounding environment. Distribution: There are five distinct genetic stocks of flatback turtles recognised in Australia. The five described stocks are known as the: eastern Queensland, Arafura Sea, Cape Domett, south-west Kimberley and Pilbara stocks. Flatback turtles are distributed across the Australian continental shelf and into the continental waters off Indonesia and Papua New Guinea (CoA 2017) Habitat use and life history: Flatback turtles are primarily carnivorous, feeding on soft-bodied invertebrates such as sponges found in epibenthos. Adult flatback turtles foraging grounds are strongly associated with geomorphology, with the species having a preference for terraces, deep holes and valleys (DCCEEW 2025c; Thums et al. 2017). When foraging flatback turtles through the water column, with recent tagging studies showing foraging in water depths ranging from zero to 730 m, although the median and mean depths indicate a preference for shallower foraging habitats (typically <50 m; 28 m and 34 ± 29.6 m, respectively) (Peel et al. 2024). Flatback turtles migrate from nesting beaches to foraging areas and foraging	BioNet: 0 ALA: 0	Low This threatened species was not identified as present in the broader search area, although it may be a rare visitor to the island

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			habitats along the WA shallow waters (<130 m) and within 315 km of the shore (DoEE 2017a). While migrating flatback turtles tend to occupy shallow, inshore waters with a median water column depth of 25 m (Peel et al. 2024). Juveniles utilise shallow coastal waters, likely in waters close to their natal beaches. Juvenile turtles prefer soft sediment habitats which support benthic invertebrates (DoEE 2017a).		
Leatherback turtle (<i>Dermochelys coriacea</i>)	Endangered Migratory Marine	Leatherback turtles are listed as 'Endangered' and 'Migratory' and 'Marine' under the EPBC Act and 'Endangered' under the BC Act. Their global (non-statutory) listing by the IUCN is 'Vulnerable'. Relevant EPBC Act documents are: - Recovery Plan for Marine Turtles in Australia (DoEE 2017a) - Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012) - Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures:	Population Global population estimates are not available, but the populations has been declining (Wallace et al. 2013). Globally, there are seven biologically described regional management units, three potentially being in the Indo-pacific region. Leatherbacks in WA are part of the WA stock which is thought to be part of the leatherback subpopulation that nests in Andaman and Nicobar Island (India). The leatherback turtle population trend in Australia is unknown (DoEE 2017a) Distribution Leatherback turtles have a circumglobal distribution. Leatherback turtles nest on tropical beaches and forage in temperate and sub-polar latitudes (Wallace et al. 2013). In Australia, leatherback turtles are known to occur in coastal waters in northern Australia, distributed right around Australia, encompassing longitudes from 105.4°E to 165.1°E and latitudes from 43.7°S to 10°S (Hazel et al. 2024), in central eastern Australia, south-east Australia, and in south-western Australia. Leatherback turtles have a wide geographical range and offshore distribution in Australia (Hazel et al. 2024).	BioNet: 0 ALA: 0	Low This threatened species was not identified as present in the broader search area, although it may be a rare visitor to the island

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		The following threats have been identified which may be considered as relevant to potential Project impacts: • : Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution • Vessel strike	Hotspots are present across the Australian coastline between December and March in the southeast region, and in the temperate and subtropical regions hotspots are present from June to August (Hazel et al. 2024). Primary habitat (migration, breeding and foraging) and life history: There are no discrete genetic stocks, breeding aggregations, defined areas of critical habitat, or BIAs for leatherback turtles in NSW. Leatherback turtles are an oceanic species, feeding on jellyfish and large planktonic ascidians (e.g. sea squirts) in the water column (DoEE 2017a). Leatherback turtles do not nest at LHI, with nesting throughout Australia being rare, therefore the species uses the waters around Australia for migration and foraging (Hazel et al. 2024). Juvenile leatherbacks that are < 100 cm are only found in water temperatures > 26°C, and it is thought that they reach the temperate east marine region using the EAC and Tasman Front eddy (DNP 2018).		
Loggerhead turtle (<i>Caretta caretta</i>)	Endangered Migratory Marine	Loggerhead turtles are listed as 'Endangered' and 'Migratory' and 'Marine' under the EPBC Act and 'Endangered' under the BC Act. Their global (non-statutory) listing by the IUCN is 'Vulnerable'. Relevant EPBC Act documents are: • Recovery Plan for Marine Turtles in Australia (DoEE 2017a) • Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012)	Population: Global population estimates of loggerhead turtles are difficult to ascertain as they are a highly migratory species. Within Australia loggerhead turtles have two distinct genetic stocks, the eastern Australian stock and WA stock. The east Australian loggerhead turtle population has significantly declined from about 1,000 nesting females in the 1970s to approximately 500 in 2000 (DCCEEW 2025c). Distribution: Loggerhead turtles have a global distribution across tropical and subtropical seas. They occur in coral reefs,	BioNet: 0 ALA: 0	Low This threatened species was not identified as present in the broader search area, although it may be a rare visitor to the island

Common Name (Scientific name)	EPBC Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018) - National Guidelines for the Survey of Cetaceans, Marine Turtles and the Dugong (DCCEEW 2024a) Threats and Pressures: The following threats have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution - Vessel strike	bays and estuaries in tropical and warm temperate waters off the coast of Queensland, Northern Territory, Western Australia and New South Wales. The eastern Australian population nests on the southern Great Barrier Reef and adjacent mainland coastal areas, including Mon Repos, Wreck Rock, Wreck Island, Erskine Island, and Tryon Island (DCCEEW 2025c). Habitat use and life history: Loggerhead turtles nest on open sandy beaches, with hatchlings emerging to enter the open ocean and move around with ocean currents. There is evidence in eastern Australia that this life period persists for up to 15 years. Before choosing a foraging area across a wide variety of tidal and sub-tidal habitat types. Sexual maturity is estimated to be 32 years (DCCEEW 2025c). Diet of adult loggerhead turtles is carnivorous, consisting of benthic invertebrates, while juveniles feed on algae, pelagic crustaceans and molluscs (DSEWPac 2012b)		

Appendix D3: Marine Fishes

Sixteen (16) additional conservation significant marine fish and elasmobranch species have been identified as relevant for consideration as they are Known or Likely to occur within or near the Project area or protected under State legislation. However, for a variety of reasons, these marine species are considered to have a Moderate likelihood of occurrence. Summary information for these additional species is provided in Table D 3 below.

- Ballina angelfish
- Bluefish
- Eastern blue devil
- Giant manta ray
- Gold spot rock cod
- Great hammerhead shark
- Grey nurse shark
- Long fin mako shark
- Orange roughy
- Queensland groper
- Reef manta ray
- Sand tiger shark
- Scalloped hammerhead shark
- Shortfin mako shark
- Southern blue fin tuna
- White shark

Table D 3: Other Fishes and Sharks that are Known or Likely or protected under State legislation to be present in the Proposal area.

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
Ballina angelfish (<i>Chaetodontoplus ballinae</i>)	EPBC Act N/A FM Act Protected	The Ballina angelfish is a Protected species under the FM Act. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant FM Act or other documents are - NSW DPI Primefact 163: Ballina angelfish (<i>Chaetodontoplus ballina</i>) (DPI 2006) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	Population: No population estimate is available for this species, however it is considered rare with a low abundance. The rarity of the Ballina angelfish is the reason for its protected status in NSW. Distribution: This species is known to occur in northern New South Wales (Coffs Harbour, Ballina and North Solitary Islands) and the Balls Pyramid area of LHI. record was identified in database searches, in an offshore area ~5 km west of LHI (Figure 12) Habitat use and life history: Ballina angelfish generally inhabit coral and rocky reefs at depths of 25–125 m, and when they are rarely observed, it is either singly or in pairs. Each pair of angelfish has a territory range of ~2500m². At Ball's Pyramid, observations have been associated with coral encrusted rock pinnacles. Diet is unknown., but other species within the genus feed on sponges, tunicates and algae (Parker 1994, Pogonoski et al 2002)	BioNet: 0 ALA: 1	Low This species is considered to have a low likelihood of occurrence due to it's low abundance and preference for deep reefs. This type of habitat is not found within the Project boundaries and both species observations and literature indicate localized ranges for fish pairs.
Bluefish (<i>Girella cyanea</i>)	EPBC Act N/A FM Act Protected	The Bluefish is a Protected species under the FM Act. Except at LHI. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant FM Act or other documents are NSW DPI Primefact 159: Bluefish (<i>Girella cyanea</i>) (DPI 2006b)	Population Bluefish are rarely seen along the NSW mainland coast; with a preference for deeper waters over algal reefs, often in areas of high energy (DPI 2006). it is more common around offshore areas, especially Lord Howe Island, where they have been observed to be locally abundant. As such, while this species is protected in NSW waters, however they may be caught at LHI.	BioNet: 0 ALA:	Moderate Bluefish have a moderate likelihood of occurrence, due to their localised abundance at LHI, however no sightings of the species have been recorded in

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution	Overfishing is the cause of suspected population decline across mainland NSW waters. Distribution Bluefish is found in the inshore waters of NSW, Elizabeth and Middleton Reefs, LHI, Norfolk Island, the Kermadec Islands and northern New Zealand (Pogonoski et al 2002) Primary habitat (migration, breeding and foraging) and life history: Bluefish inhabit coastal and offshore rocky reefs in waters 5 m-30 m and has been commonly observed on reef slopes at Elizabeth and Middleton Reefs. Juveniles utilise tidal pool habitats, and adults form large schools over reef areas. They are a strong swimming fish growing to 76 cm, and at 52 cm fork length are ~39 years old (DPI 2006b), and known to spawn in December during the summer. This fish species has a carnivorous diet consisting of crustaceans, small fish, molluscs and calcified seaweeds (Pogonoski et al 2002).		either the broader search area or North Zone boundary.
Eastern blue devil (<i>Paraplesiops bleekeri</i>)	EPBC Act N/A FM Act Protected	The Eastern blue devil is a Protected species under the FM Act. Their global (non-statutory) listing by the IUCN is 'Least Concern'. Relevant FM Act or other documents are • NSW DPI Primefact 165: Eastern blue devil (<i>Paraplesiops bleekeri</i>) DPI 2006c) Species Conservation	Population: No population estimates for Eastern blue devils are available, however this species is protected due to its low abundance and natural rarity (DPI 2006). Distribution: The Eastern blue devil is an inshore, warm-temperate endemic species which occurs on the east coast from southern Queensland to Montague Island, but is most common south of Sydney in NSW (Pogonoski et al 2002). They are found in similar areas to the Elegant wrasse, including at LHI (DPI 2006c)	BioNet: 0 ALA: 0	Moderate The Eastern blue devil has a moderate likelihood of occurrence, due to preferred habitat being available both in the broader search and North Zone boundary areas.

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution	Habitat use and life history: This species is an inhabitant of the benthic nearshore environment, with juveniles very rarely being seen. Adults may grow to 40 cm in length. It is a shy, secretive fish, spending most of its time under ledges or in caves and becoming more active at night. Eastern blue devils are likely mouth brooders, that breed during the warmer months between October and March (Pogonoski et al 2002).		
Giant manta ray <i>(Mobula birostris)</i>	EPBC Act Migratory FM Act N/A	The Giant manta ray is listed as 'Migratory' under the EPBC Act. Their global (non-statutory) listing by the IUCN is 'Endangered'. No conservation advice or recovery plans are available for this species. Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution • Vessel strike	Population The global population size remains unknown, due to this species migratory behavior and sparse, fragmented distribution. However, regional estimates provide insight into their number, for example the largest aggregation of over 22,000 individuals is found off the coast of Ecuador (NOAA 2024). Just 51 sightings are recorded in the ALA for all of Australia, but none recorded for LHI (ALA 2025) Distribution This species is globally distributed in tropical and subtropical oceans, within Australia their presence is largely confined to the eastern seaboard, with confirmed sightings from northern Queensland to as far south as Montague Island in New South Wales and northeastern Tasmania—marking one of the southernmost records for the species worldwide (DCCEEW 2025c).	BioNet: 0 ALA: 0	Low Limited information exists to suggest that the Project area is suitable habitat for this species. It is therefore considered to have a low likelihood of occurrence..

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			Habitat use and life history: This migratory species utilises productive coastlines with regular upwelling, in oceanic island groups, and near offshore pinnacles and seamounts. Although the giant manta ray tends to be solitary, they aggregate to feed and mate. Manta rays primarily feed on planktonic crustaceans, but some studies have noted their consumption of small and moderately sized fish as well. When feeding, mantas hold their cephalic fins in an “O” shape and open their mouths wide, creating a funnel that pushes water and prey through their mouth and over their gill plates (NOAA 2024)		
Gold spot rock cod (<i>Epinephelus coioides</i>)	EPBC Act N/A FM Act Protected	The Gold spot rock cod is a Protected species under the FM Act. Their global (non-statutory) listing by the IUCN is ‘Near Threatened’. Relevant FM Act or other documents are NSW DPI Primefact 167: Gold spot rock cod (<i>Epinephelus coioides</i>) DPI 2006d) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts:	Population No population estimates for Gold spot rock cod are available, however this species is protected due being susceptible to depletion due to its unusual reproductive cycle, long life, and territorial nature(DPI 2006d). Distribution The Gold spot rock cod occurs in tropical and warm temperate marine waters of the Indo-Pacific including the Persian Gulf, India, the Philippines, and around numerous other islands. In Australia they are most common in Queensland, the Northern Territory and Western Australia; however, they are known to occur as far southwards as the Sydney area (DPI 2006d)	BioNet: 0 ALA: 0	Low Whilst LHI is within the wider distribution area for this protected species, it is unlikely that the that the Project area is suitable habitat for this species. It is therefore considered to have a low likelihood of occurrence.

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	Habitat use and life history: Gold spot rock cod are commonly found in the lower reaches of estuaries and silty reef habitats, although they have been found in waters 100 m deep. Juvenile cod utilise shallow waters of estuaries over sand, seagrass, mud and gravel and among mangroves with adults preferring drop offs, large caves or shipwrecks. Breeding takes place in waters ~30°C between March-June. Diet is varied and consists of fish, shrimp, cuttlefish and crab (DPI 2006d)		
Great hammerhead shark (<i>Sphyrna mokarran</i>)	EPBC Act N/A FM Act Vulnerable	Great hammerheads are listed as 'Vulnerable' under FM Act. Their global (non-statutory) listing by the IUCN is 'Critically Endangered'. No conservation advice is available for this species in: - NSW DPI Primefact 1210: Great hammerhead (<i>Sphyrna mokarran</i>)(DPI 2012) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	Population There is no global population estimate for the Great hammerhead shark, as its population is considered data deficient. However, the species is classified by the IUCN as Critically Endangered due to severe population declines, primarily caused by fishing for its fins and high bycatch mortality rates. In Australia, this species is considered 'Overfished' (SAFS 2019) Distribution The Great hammerhead shark is the largest species of hammerhead in the world. It has a circum-global distribution between the latitudes of 40°N and 35°S. They are generally a solitary and highly migratory species found in both tropical and warm temperate seas. They are found throughout the seas around northern Australia and have been recorded occurring as far south as Sydney (DPI 2012).	BioNet: 0 ALA: 1	Low Limited information exists to suggest that the Project area is suitable habitat for this species. It is therefore considered to have a low likelihood of occurrence.

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			Habitat use and life history: The Great hammerhead shark is a coastal-pelagic and semi-oceanic species, occurring along coastlines, continental shelves and adjacent drop-offs in waters up to 80 m depth. In NSW, this species is most likely to occur north of Sydney during the warmer months (DPI 2012)		
Grey nurse shark (<i>Carcharias taurus</i>)	EPBC Act Critically Endangered FM Act Critically Endangered	The Grey nurse shark is listed as 'Critically Endangered' under both the EPBC Act and the FM Act.. Their global (non-statutory) listing by the IUCN is 'Critically Endangered'.. Relevant EPBC Act, FM Act or other documents are - Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012) - Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPac 2011) - Commonwealth Listing Advice on <i>Carcharias taurus</i>, Grey Nurse Shark (East Coast population) (TSSC 2001) - NSW DPI Primefact 582: Grey Nurse Shark (<i>Carcharias taurus</i>) (DPI 2013)	Population The Grey nurse shark population on the east coast has been greatly depleted by historical fishing and targeted culling activities. The total population is estimated to be between 1146 and 1662 individuals, which was reduced by 77% between the 1950's-1980's (DCCEEW 2025c)	BioNet: 0 ALA: 0	Low Despite this species being listed as Critically Endangered under multiple legislations, available information suggests that the Project area,, and LHI is not suitable habitat for this species. It is therefore considered to have a low likelihood of occurrence.
			Distribution The grey nurse shark has a broad inshore distribution around mainland Australia, primarily in cool temperate waters although they have been recorded north of Yeppoon, QLD on the east coast of Australia (Hoschke et al. 2023). Relatively little is known about the migratory habits of Grey nurse sharks in Australian waters, but there is evidence of some level of site fidelity due to aggregations being observed at the same sites over time (DCCEEW 2025c)		
			Habitat use and life history: Grey nurse sharks are often observed in a variety of habitats from inshore reefs, rocky caves, and deep sandy-bottomed gutters up to 200 m deep (Pollard et al. 1996). Their diet consists of a variety of fish, squid, small sharks and rays, crabs, and lobsters (Compagno		

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Species Conservation The following recovery and conservation plans are in place for the management of Grey nurse shark populations: - Recovery Plan for the Grey Nurse Shark (<i>Carcharias taurus</i>) (DoE 2014) - Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018) The threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	1984). Grey nurse sharks typically occur as solitary individuals or in small schools. Grey nurse shark's display a rare reproductive strategy called intrauterine cannibalism, where embryos feed on other embryos in-utero. This phenomenon contributes to a low reproductive rate (DSEWPac 2012).		
Long fin mako shark (<i>Isurus paucus</i>)	EPBC Act Migratory FM Act N/A	The Long fin mako shark is not a listed threatened species, however it is listed as 'Migratory' under the EPBC Act. Their global (non-statutory) listing by the IUCN is 'Endangered'. No conservation advice or recovery plans are available for this species. Relevant EPBC Act, FM Act or other documents are Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012)	Population There is little population information for the Long fin mako shark regarding population size, structure, or trend for the Long fin Mako. It is common in the Western Atlantic and Central Pacific oceans, although reportedly rare elsewhere (FRDC 2023) Distribution The Long fin mako shark is a widely distributed pelagic species found in tropical and subtropical waters globally. In Australia, it occurs along the coast from Geraldton in Western Australia to Port Stephens in	BioNet: 0 ALA: 0	Low Limited information exists to suggest that the Project area is suitable habitat for this species. It is therefore considered to have a low likelihood of occurrence.

Common Name (Scientific name)	EPBC Act /FMAct Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution	NSW, including and eastward range into the Coral and north Tasman seas (DCCEEW 2025c) Habitat use and life history: The Longfin mako shark is found in tropical, epipelagic waters across a wide range. This species is also likely to occur in deep waters based on its diet Maximum size is at least 425 cm total length. It has a litters of 2–8 pups. Little else is known of its biology (FRDC 2023).		
Orange Roughy (<i>Hoplostethus atlanticus</i>)	EPBC Act Conservation Dependent FM Act N/A	There is no threat abatement plan, listing advice, or adopted recovery plans. The species is listed as Conservation Dependant under the BC Act and not assessed by the IUCN. Other relevant EPBC Act documents are: • Marine bioregional plan for the Temperate East Marine Region (DSEWPaC 2012). • Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPaC 2011) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping)	Population There are no current global estimates of the Orange roughy stock (DCCEEW 2025c). The Australian population is comprised of several different stocks and is assessed by biomass. Distribution Globally, orange roughy is widely distributed cold water species found in the Pacific, Atlantic and Indian Oceans (DoE 2025). In Australia, orange roughy can be found from central New South Wales through to southwestern Australia (DoE 2025). This species is strongly associated with seamounts, including the Lord Howe Rise (DSEWPaC 2012). Habitat use and life history: Orange roughy are a deep sea, long lived fish. Sexual maturity is estimated between 20-40 years of age (DCCEEW 2025c). Annual spawning aggregations of orange roughy occur over a 2-3 week period around seamounts, plateaus, and canyons, such as the Lord Howe Rise (DoE 2025; DSWEWPaC 2012). It is suspected Orange roughy may migrate long distances to join	BioNet: 0 ALA: 0	Low This species prefers deep water habitats surrounding seamounts, so suitable habitat may be present in the offshore environments surrounding LHI. There are no confirmed sightings of Orange roughy in the broader search area and It is therefore considered to have a low likelihood of occurrence.

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		Noise pollution	spawning aggregations. The Orange roughy are opportunistic feeders of mesopelagic and benthopelagic crustaceans, fish, and squids (Lack et al. 2003).		
Queensland groper (<i>Epinephelus lanceolatus</i>)	EPBC Act N/A FM Act Protected	The Queensland groper is a Protected species under the FM Act. Their global (non-statutory) listing by the IUCN is 'Data deficient'.. Relevant FM Act or other documents are - NSW DPI Primefact 165: Eastern blue devil (<i>Paraplesiops bleekeri</i>) DPI 2006c) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	Population No population estimates for Queensland groper are available, however this species is protected due to commercial and recreational fishing activities having the potential to adversely affect populations of Queensland groper(DPI 2006e). Distribution Queensland gropers have are distributed across the Indo-Pacific from Rottneest Island through north-western WA, to Sydney, NSW, including reefs in the Coral Sea; Christmas Island and Cocos (Keeling) Islands in the eastern Indian Ocean, and the Lord Howe Island Province in the Tasman Sea. Queensland groper inhabit shallow inshore waters, including rocky areas, caves, wrecks, estuaries, and lagoons. Large individuals often hover in mid-water, or lie motionless on the bottom (Bray 2021) Habitat use and life history: The Queensland groper is long lived (~40 years) and occupies a variety of habitats depending on their stage of growth (DPI 2006e). This species is a very large fish, growing to a maximum of 2.3 m in length. Females begin producing eggs at 46 cm length, reaching sexual maturing at 96 cm, while males mature at a slightly shorted length of 86 cm (Palma et al 2019). Diet consists of decapod crustaceans such as lobsters and crabs and	BioNet: 0 ALA: 0	Moderate The habitat within the broader search area may support individuals of this species. Although no sightings were recorded from database searches It is therefore considered to have a moderate likelihood of occurrence.

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			fishes including small sharks and rays, and juvenile sea turtles (Bray 2021).		
Reef manta ray <i>(Mobula alfredi)</i>	EPBC Act Migratory FM Act N/A	The Reef manta ray is listed as ‘Migratory’ under the EPBC Act. Their global (non-statutory) listing by the IUCN is ‘Endangered’. No conservation advice or recovery plans are available for this species. Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution • Vessel strike	Population Global population estimates are not available though it is estimated that the global population has declined between 30 and 49% over the last 87-years and is still declining. Reef manta rays occur in small populations of less than 1,000 individuals (Marshall et al. 2022). No population estimates or trends are available for Australia. Reef manta ray populations have low connectivity especially between sites that are widely separated and have a high degree of residency (Armstrong et al. 2020a). Distribution Reef manta rays are found in tropical and subtropical waters, throughout the Pacific and Indian Oceans. In Australia, reef manta rays are found from ~30°S on the east and west coast, with a continuous distribution north from Shark Bay (WA) (26°S) to the Solitary Island Marine Park (NSW) (26°S).. There is limited information available on occurrence of this species in the Tasman Seam however this area does present as suitable habitat for the reef manta ray Habitat use and life history: Reef manta rays inhabit shallow surface and offshore deep waters up to 432 m depth. The species is generally found across coastal shelf waters in water depths of less than 20 m, and most commonly sighted in relatively shallow waters associated with mainland coastlines, offshore islands, and reefs (Marshall et al. 2022). Reef	BioNet: 0 ALA: 0	Low Suitable habitat for this species is present within the broader search area. However the Disturbance footprint is not likely habitat for this species. It may be present at times in the waters surrounding LHI..

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			manta rays have diel movements, where they spend daylight hours inshore in shallow waters, then move offshore into deep waters at night (Marshall et al. 2022). Reef habitat is important for the species reproduction and providing cleaning stations for reef manta rays. Juveniles are often observed using lagoons and shoreline habitats (Marshall et al. 2012). Reef manta rays grow up to 500 cm disc width (DW) and reach sexual maturity between 270 and 300 cm DW and 300 and 350 cm DW for male and females respectively. Female manta rays give birth to a single pup every one to seven years (with a central tendency of a 4 to 5-year reproductive cycle), and across their lifespan (up to 45 years) may have between four to seven pups (Marshall et al. 2022).		
Sand tiger shark (<i>Odontaspis ferox</i>)	EPBC Act N/A FM Act Protected	The Sand tiger shark is a protected species under the FM Act. Their global (non-statutory) listing by the IUCN is 'Endangered'. No conservation advice or recovery plans are available for this species. Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: • Pollution (Marine debris, oil spill and chemical dumping) • Noise pollution	Population Little is known of this species due to the rarity of encounters. Estimates of abundance are lacking; however, assessments suggest low natural densities. Fishery independent surveys have recorded a decline of over 50% in catches along Australia's east coast (FRDC 2019b)	BioNet: 0 ALA: 0	Low Limited information exists to suggest that this species is present in the broader search area. The Disturbance footprint does not represent usable habitat for this species. It is therefore considered to have a low likelihood of occurrence.
			Distribution The Sand tiger shark is a deepwater shark, found worldwide in tropical and warm temperate oceans; IT is known in Australian waters from NSW, Victoria and north WA in depths up to 880 m. It is considered rare in Australia with a patchy distribution.		
			Habitat use and life history: This docile species lives near the bottom, often around oceanic islands and seamounts and consequently it is		

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			occasionally taken as bycatch in commercial trawl fisheries. It may undertake vertical migrations towards the surface (Bray 2020). Very little is known of the Sand tiger sharks biology, however it is presumed to be similar to that of the Grey nurse shark, exhibiting ovoviviparous traits of birthing live young that are sustained in utero by an egg sac and yolk. Males mature at ~2.75 m, and females at 3.6 m while pups are born at ~1 m in length (Bray 2020).		
Scalloped hammerhead shark (<i>Sphyrna lewini</i>)	EPBC Act Conservation Dependent FM Act Endangered	Scalloped hammerheads are listed as 'Coinconservation Dependent under the EPBC Act and 'Endangered' under FM Act. Their global (non-statutory) listing by the IUCN is 'Critically Endangered'.. No conservation advice is available for this species in: - Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012) - NSW DPI Primefact 1218: Scalloped hammerhead (<i>Sphyrna lewini</i>)(DPI 2012b) - Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPac 2011) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts:	Population There is no global population estimate for the Scalloped hammerhead shark, However, this species is under threat from commercial fisheries bycatch and illegal trade. It is particularly susceptible to threats due to its slow growth and longevity. Distribution The Scalloped hammerhead shark is a coastal pelagic species with a circumglobal distribution throughout warm temperate and tropical coastal areas between 45°N and 34°S. This species is found around northern Australia as far south as Sydney NSW and Geopraphe Bay WA They are known to form large migratory schools and in Australia tend to move south during the warmer months (DPI 2012b). Habitat use and life history: Adults of this species inhabit deep waters adjacent to continental shelves, in waters ranging from the surface to at least 275 in depth usually as solitary animals, while juveniles form aggregations and utilise nursery habitats closer to shore. Males reach sexual maturity at around 9 years, with females maturing later at ~15 years of age.	BioNet: 0 ALA: 0	Low Suitable habitat for this species is present within the broader search area. However the Disturbance footprint is not likely habitat for this species. It may be present at times in the waters surrounding LHI..

Common Name (Scientific name)	EPBC Act /FM Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	Adult sharks grow to a maximum of 3.5 m in length and are long lived to at least 30 years of age, but it is possible maximum age could be 50 years. Diet consists of crustaceans, cephalopods and fish (DPI 2012b)		
Short fin mako shark (<i>Isurus oxyrinchus</i>)	EPBC Act Migratory FM Act	The Short fin mako is a Migratory species under the EPBC Act. Their global (non-statutory) listing by the IUCN is 'Endangered'. Relevant EPBC Act, FM Act or other documents are - Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012) - Listing advice <i>Isurus oxyrinchus</i> (TSSC 2014) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	Population There is limited data on global population stocks of shortfin makos and the population estimate of Australia is unknown.	BioNet: 0 ALA: 0	Low Limited information exists to suggest that this species is present in the broader search area. The Disturbance footprint does not represent usable habitat for this species. It is therefore considered to have a low likelihood of occurrence.
			Distribution The shortfin mako shark is a cosmopolitan species with a widespread distribution in global temperate and tropical waters (Stevens 2008). They are found between the surface to 600m deep and occasionally hunt inshore on the narrow continental shelf (Stevens 2008; DSEWPac 2012).		
			Habitat use and life history: Shortfin makos are highly migratory and is recorded to move thousands of kilometres (Stevens 2008). Shortfin makos are viviparous, reproducing every 3 years, an average 12 pups a litter. Shortfin makos primarily consume teleost fish and cephalopods (Stevens 2008)		
Southern bluefin tuna (<i>Thunnus maccoyii</i>)	EPBC Act N/A FM Act Endangered	The Southern bluefin tuna is no longer threatened under the EPBC Act, however is an Endangered species under the FM Act. Their global (non-statutory) listing by the IUCN is 'Endangered'. No conservation advice or recovery plans are available for this species. Relevant EPBC Act, FM Act or other documents are	Population There is a single global population of Southern bluefin tuna across the south-west and south-east Atlantic Ocean, eastern and western Indian Ocean and the south-west Pacific Ocean (DCCEEW 2025c). Within Australia there was 460,000 mature individuals of Southern Bluefin Tuna as of 2009 and the population has been growing at 5% annually (FRDC 2023b). This	BioNet: 0 ALA: 0	Low This species may be present in the broader search area around the Project. However, the Disturbance footprint does not represent usable habitat for this species. It is

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- Listing Advice <i>Thunnus maccoyii</i> Southern Bluefin Tuna (DCCEEW 2024) - NSW DPI Primefact 1382: Southern bluefin tuna (<i>Thunnus maccoyii</i>) (DPI 2014) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	species has historically been heavily impacted by commercial and recreational fishing activities. Distribution Southern bluefin tuna are found in oceanic waters normally on the seaward side of the continental shelf. In NSW, Southern bluefin tuna occur from northern NSW to the Victorian border. They are considered rare within the NSW State Waters boundary of three nautical miles (DPI 2014) Habitat use and life history: Southern bluefin tuna are a long lived highly migratory pelagic fish, living up to 40 years. They are slow growing with late maturity at 8 – 12 years. Southern bluefin tuna can reach a maximum length of 2.35 metres and can attain a weight of around 200kg but rarely exceed 100kg in Australian waters. They only spawn at one location in the tropical waters between Java and north-west Australia which occurs between September and March each year. This species is carnivorous feeding in offshore waters on fish, squid, krill and salps. They also eat small crustaceans and larger fish (DPI 2014)		therefore considered to have a low likelihood of occurrence.
White shark	EPBC Act Vulnerable Migratory FM Act Vulnerable	The White shark is listed as 'Vulnerable' and 'Migratory' under the EPBC Act and 'Vulnerable' under the FM Act. Their global (non-statutory) listing by the IUCN is 'Vulnerable'. Relevant EPBC Act, FMA Act or other documents are	Population It is estimated there are approximately 750 adult white sharks in the eastern Australasian population, from southern Victoria through NSW and into Queensland, as well as across to New Zealand. Including juveniles, the total population size of the eastern population	BioNet: 0 ALA: 0	Moderate The habitat within the broader search area may support individuals of this species. Although no

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
		- Marine bioregional plan for the Temperate East Marine Region (DSEWPac 2012) - Recovery Plan for the White Shark (<i>Carcharodon carcharias</i>). (DSEWPac 2013) - Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act (DSEWPac 2011) Species Conservation The following threats or pressures have been identified which may be considered as relevant to potential Project impacts: - Pollution (Marine debris, oil spill and chemical dumping) - Noise pollution	is estimated to be around 5,460 sharks (Hillary et al 2018) Distribution The White shark is widely distributed across Australian temperate and subtropical waters, occurring from southern Western Australia, across the southern coast, and up the eastern seaboard as far north as central Queensland (Bruce 2008, Hillary et al 2018). It is most commonly observed in continental shelf waters, with individuals frequenting coastal zones, offshore islands, and estuarine environments (Bruce et al 2019). Tagging data show that white sharks undertake long-distance seasonal migrations but also exhibit high site fidelity to key aggregation areas such as the Neptune Islands (SA), Corner Inlet (VIC), and Stockton Beach (NSW) (Bruce & Bradford, 2013, Bruce 2019) Habitat use and life history Juvenile and subadult sharks typically inhabit coastal and shelf waters, surf zones, estuaries, and embayments. Adults utilize offshore and pelagic areas, including deep continental slope habitats, oceanic islands, and long-distance migratory corridors (Bruce & Bradford, 2013). White sharks are an apex predator, with an opportunistic feeding strategy. Diet consists of fish, seabirds, pinnipeds and cetaceans including carcasses (Bruce 2008, Bruce and Bradford 2013). White sharks have been recorded in depredation interactions with fisherman at LHI (Mitchell et al 2021).		sightings were recorded from database searches It is therefore considered to have a moderate likelihood of occurrence.

Common Name (Scientific name)	EPBC Act /FMA Act Status	Relevant policy and guidance, threatening processes and reasons for listing	Population, distribution, primary habitat(s) and life history	Surveys and sightings within the broad search area	Likelihood of occurrence in the Proposal area and species justification
			Distribution White's seahorse is endemic to southern Queensland (Hervey Bay) to Sussex Inlet NSW where it inhabits estuaries, bays and harbours, living in association with seagrass beds, macroalgae, soft corals, gorgonians, sponges, piers, jetties, and the netting enclosing seaside pools in depths of 1 m to 18 m (DPI 2019, Bray & Thompson 2025). Habitat use and life history White's seahorse is a colourful species with highly variable colouration as it is known to change colour depending on their mood and the habitat colouration it is living on. It grows to a length of 16 cm. Males can be identified by their brood pouch on the belly. Breeding pairs display long-term monogamy, and the male pregnancy lasts about 3 weeks. The male seahorse gives birth to 100 – 250 babies per brood and can reproduce up to 8 times during the breeding season (DPI 2019)		

Appendix D. Fish Field Study Summary

Appendix D. Fish Field Survey Summary

A fish survey was undertaken to support the Coastal and Marine Ecology Impact Assessment (CMEA) for the Lord Howe Island Critical Infrastructure Project. The survey was undertaken by BMT between February – April 2025 in accordance with a sampling plan designed by BMT and approved by DCCEEW. The data collected during the survey was provided to O2 Marine for analysis and interpretation. This report provides a summary of the baseline fish collected data to support approvals for the Lord Howe Island Critical Infrastructure Project.

1. Methods

A scientific diver from O2 Marine was subcontracted by BMT to conduct the fish and invertebrate biodiversity surveys between in accordance with the Reef Life Survey (RLS) Underwater Visual Census (UVC) methodology (Reef Life Survey 2023). Fifteen (15) transects were placed throughout the study area close to shore and the existing jetty to seaward towards the North Passage (Figure D1). This placement captured the different habitat types (Coral Reef, Sand/rubble/macroalgae and seagrass) found within the study area. Each transect was 50 m in length, distributed randomly throughout the project boundary, and across adjacent seagrass meadow (S05 and S06) and coral reef (S07, S11, S13, S14 and S15). The survey was carried out between 27 February and 2 March 2025.

The aim of the survey was to identify and document the fish and invertebrate species at habitat types throughout the survey area during the survey period and identify any key species. Key species in this context is defined as species identified in the conservation significant marine fauna (CSMF) Desktop Assessment (Appendix C). This information is supplementary to the CSMF Desktop and was used to help assess risk to threatened or vulnerable fish and invertebrate species that may be impacted by the construction activities.

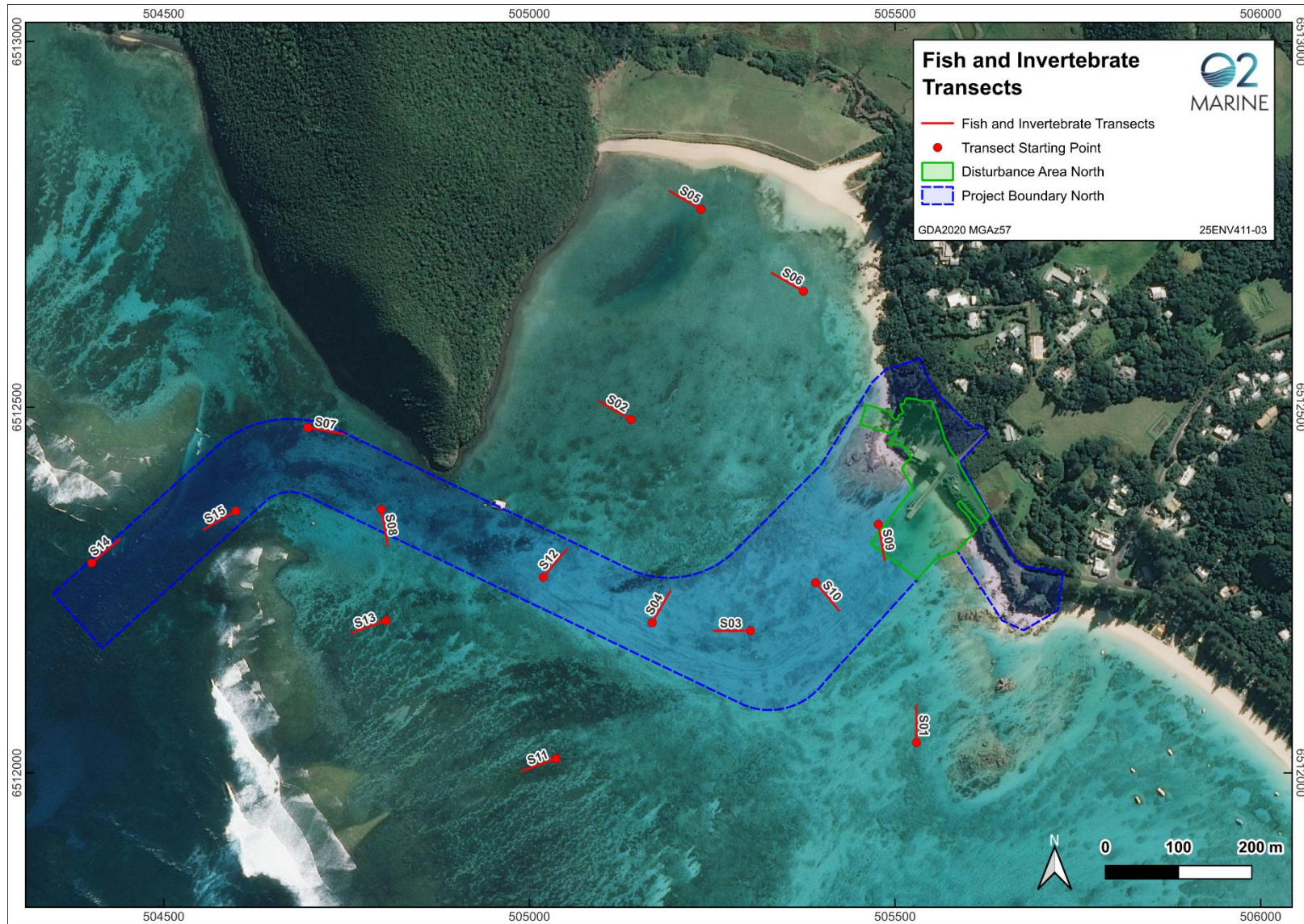


Figure D1: Location and direction of transects within and surrounding the project study area

1.1. Fish Survey

Fish census protocols involved the diver laying out a 50 m transect line on a bearing that followed a consistent depth contour and habitat type. The species and number of all fishes sighted within 5 m either side of the transect line were recorded on underwater paper as the diver swam up and down the line on both sides.

1.2. Invertebrate and Cryptic Fish Survey

Invertebrate and cryptic fish species and abundance were recorded along the same transect line as the fish survey. The diver recorded all mobile macroinvertebrates and cryptic fishes on the reef surface within 1 m of the line. When present, algal canopy was brushed aside to search among corals, along crevices and undercuts, but without moving rocks. Mobile invertebrates including molluscs, echinoderms and crustaceans >2.5 cm were recorded. Cryptic fishes include those from a set of pre-defined families that are inconspicuous and closely associated with the seabed. The list of families defined as cryptic for the purpose of RLS surveys were those as defined in Reef Life Survey (2023).

1.3. Data Analysis

Transects were treated as independent variables. The log ($X + 1$) of the abundance for each species and species richness were calculated for each transect. Multivariate analysis (nMDS) plots were produced as biplots (species vectors superimposed on transects) to identify separation between transects. Dissimilarity in community composition was investigated using SIMPER to identify the species driving the separation between transects. The aim of the analysis was to explore community patterns and characterise fish communities using the habitats within the survey area. Threatened species could then be identified in context to the survey area and proximity to the existing jetty.

2. Results

2.1. Key Species

In total, 82 species of fish were recorded across 15 transects. Species recorded during the survey were checked against the existing RLS species list. No new introduced fish species were identified when compared to previous RLS surveys.

Three Key Species (as per the CSMF Desktop Assessment Appendix C), were recorded during the survey across nine transects (Table D1). Transects over coral reef (S07, S11, S13, S14 and S15) recorded two to three Key Species, while only one Key Species, the Doubleheader (*Coris bulbifrons*), was observed at four transects (S1, S2, S4, and S12) closer to the nearshore Project footprint. The locations of the transects are presented in Figure D3. A list of fish species recorded during the survey is presented in Appendix D.1

Size class estimates reveal sub-adult *C. bulbifrons* (in the size range 10 cm – 20 cm) were present at S01 (n = 1), S02 (n = 3), S04 (n = 1), S11 (n = 1), and S13 (n = 1), whilst the largest adults were recorded at S07 (n = 1, 50 cm TL), S13 (n = 2, 40 cm TL), S14 (n = 3, 50 cm TL), and S15 (n = 2, 40 cm TL). Key Species and International Union for Conservation of Nature (IUCN) listed species observed are shown in Figure D2.



Figure D2: Three key species identified during the survey (top and bottom left) and one IUCN listed species (bottom right). From top left to bottom right, *Amphiprion mccullochi*, *Coris bulbifrons* (Images by Paul Day), *Anampses elegans* (Andrew Green), and *Chaetodon trifascialis* (Ian Shaw).

Table D1: Key Species (species name with *) and species listed by IUCN (species name with **) identified in the survey and the corresponding transect where they were recorded.

Common Name	Species Name	Transect	F Act	IUCN Red List	Threats
Whitesnout anemonefish / McCulloch's Anemonefish	<i>Amphiprion mccullochi</i> *	S07, S11, S13	Critically endangered	Vulnerable (Allen 2022).	Climate change driven heat stress on its host anemones and habitat loss. Underwater noise.
Elegant wrasse	<i>Anampses elegans</i> *	S11, S13, S14, S15	Protected	Least Concern (Choat et al 2010).	Capacity to sustain fishing pressure unlikely due to natural rarity and low abundance. Underwater noise.
Doubleheader	<i>Coris bulbifrons</i> *	S01, S02, S04, S07, S11, S12, S13, S14, S15	NA	Vulnerable (Choat et al 2010b).	Fishing pressure. Has a restricted range and occurs in low densities. Underwater noise
Harlequin Filefish	<i>Oxymonacanthus longirostris</i> **	S07	NA	Vulnerable (Matsuura & Motomura 2016).	Climate change driven heat stress on and destruction of <i>Acropora</i> reefs that the species is dependent on. Underwater noise.
Chevron Butterflyfish	<i>Chaetodon trifascialis</i> **	S07	NA	Near Threatened (Carpenter & Pratchett 2010).	Climate change driven heat stress on and destruction of <i>Acropora</i> reefs that the species is dependent on. Underwater noise.

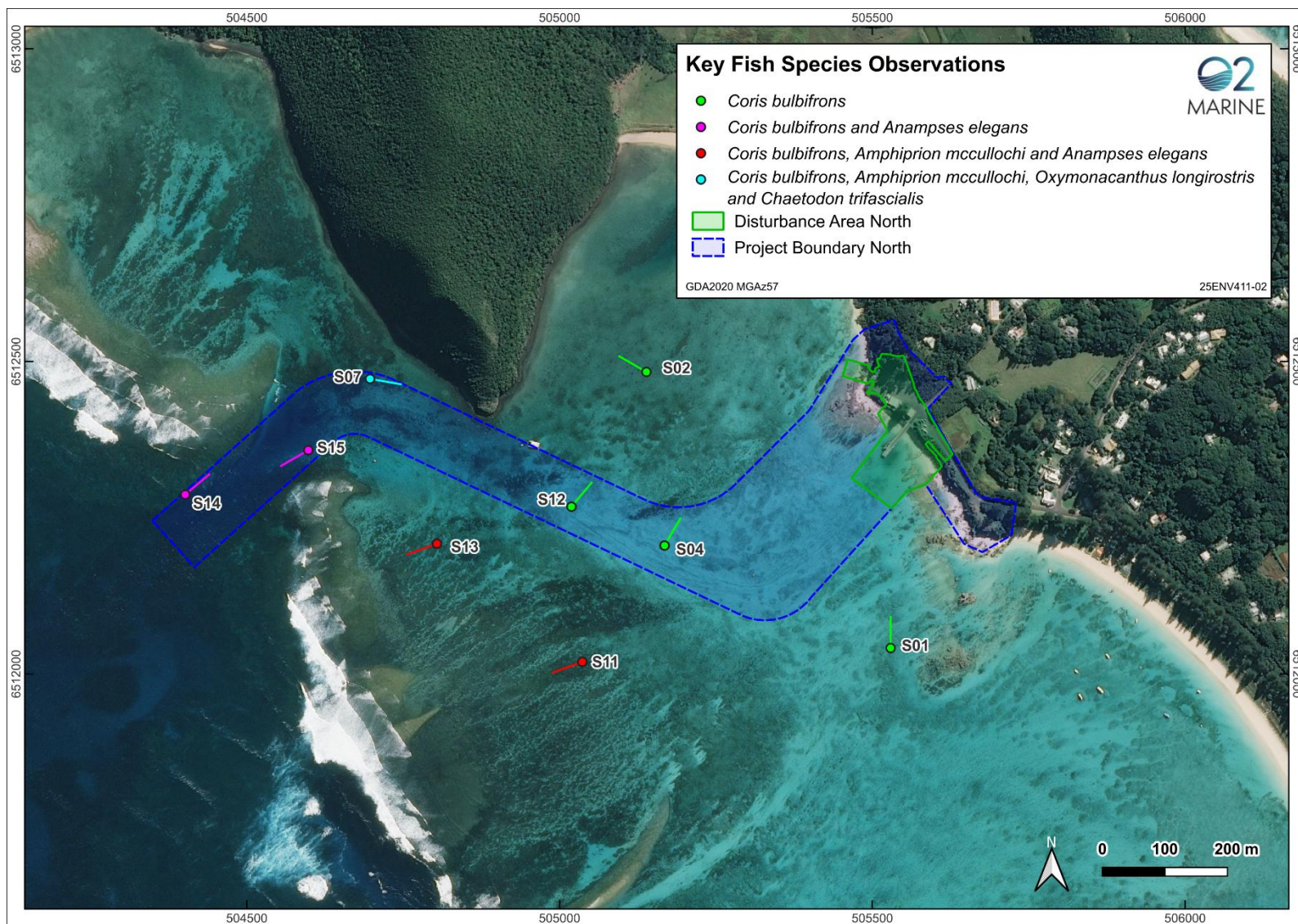


Figure D3: Transects where both Key Species and IUCN listed species observations were made.

2.2. Fish Community Results

Species richness was highest at transects over coral reef, located furthest from the current jetty. The highest species richness was recorded at S15, with 32 species. The mean abundance of transects plotted using nMDS indicates transects with the highest mean abundance were also those over coral reef. The nMDS biplot shows transects (coloured rectangles numbered to indicate transect number) separated by mean abundance with species vectors showing species that are driving the separation. For example, there was low relative abundance at S6 with separation driven by the only sighting of the Blackspot Toby (*Canthigaster bennetti*) and the presence of the Three-spot wrasse (*Halichoeres trimaculatus*) that drives the separation of transects the most (SIMPER ratio = 0.86). Transects with the highest mean abundance of fishes were also those with highest species richness, located over coral reef habitat (S7, S11, S13, S14, and S15, Figure D4).

Transects S03, S06, and S10 are loosely grouped to the right of the nMDS biplot. Abundance and species richness at these transects were relatively low, probably attributed to S03 covering low complexity habitat consisting of sand, coral rubble and sparse macroalgae (in-situ diver observations). S06 was dominated by seagrass habitat and S10 crosses the existing channel, 160 m from the Jetty. The habitat at S10 consisted of coarse sand and scattered coral rubble. Sparse macroalgae with sparse, isolated small *Pocillopora* colonies. Signs of scouring were observed (in-situ diver observations).

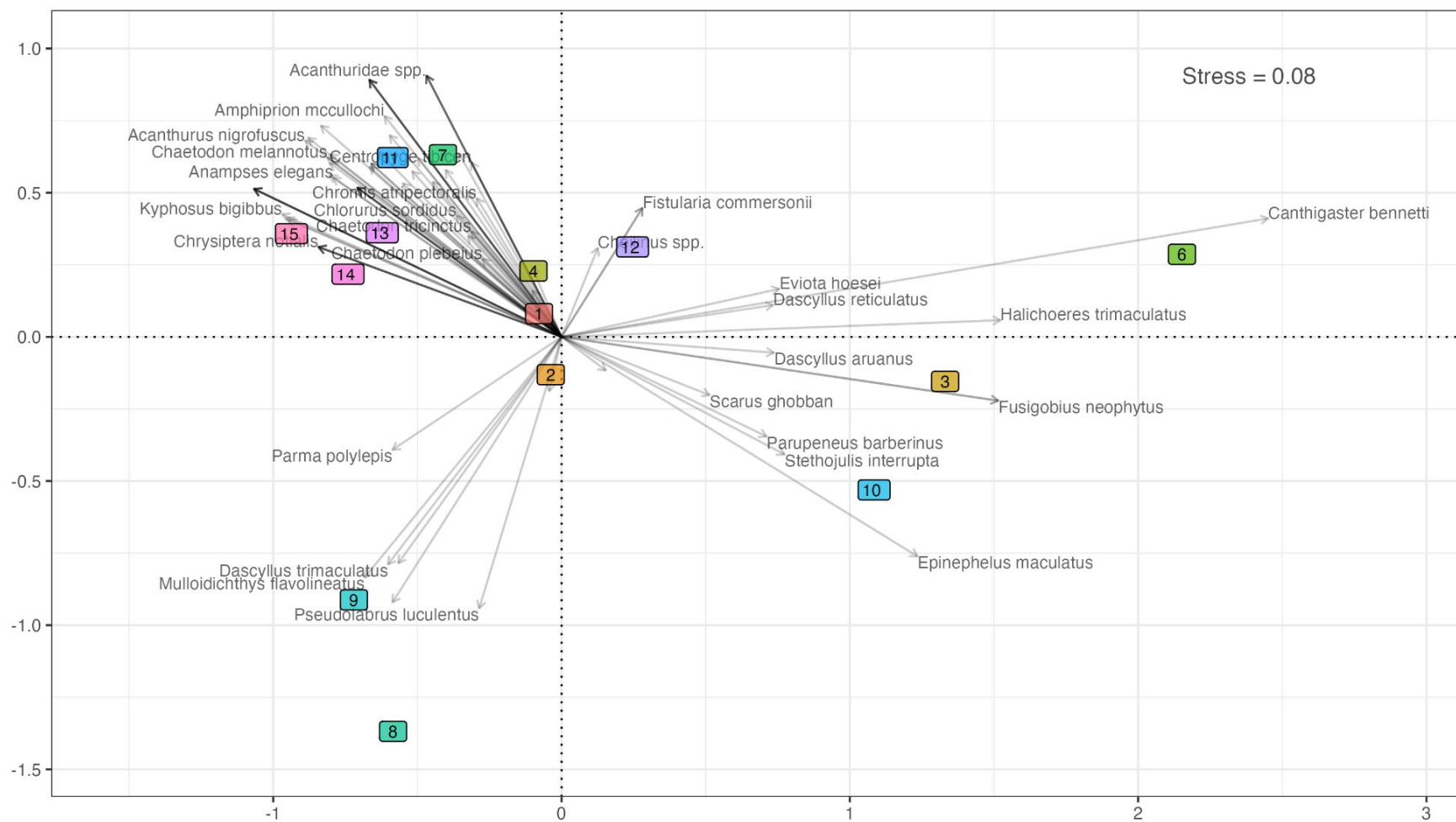


Figure D4: nMDS plot of fish community. Transect numbers are coloured rectangles. Lines represent the species driving dissimilarity between transects.

Table D2 summarises the abundance and species richness of fish for each transect, presented in order of species richness. Transects placed inside the existing channel and over coral reef habitat are identified, along with distance (in meters) from the centre of the 50 m transect to the end of the existing jetty. These results show that transects crossing the channel or run close to it generally have lower species richness and abundance. This is likely driven by a lack of suitable habitat and their proximity to the existing channel and the current jetty. (S03, S09, S10). However, S04 and S12 both had higher species richness (20 per 500 m²) driven by both transects running toward more complex habitat outside of the channel where spill-over effect is the likely driver.

Table D2: Species richness (per 500 m²) and mean abundance (per 250 m²) recorded within transects.

Transect	Species Richness/500 m ²	Mean Abundance/250 m ²	Inside existing channel	Distance to existing jetty (m) straight line
S05	1	0.5	No	525
S06	2	4	No	360
S08	3	18	Yes	715
S09	6	5	Yes	50
S03	7	19	No	285
S10	8	18.5	Yes	163
S02	16	95	No	420
S04	20	92.5	No	360
S12	20	67.5	Yes	490
S01	21	222.5	No	280
S13	27	184	No**	760
S07	29	482	No*	815
S14	29	122.5	No*	1100
S11	32	264	No**	615
S15	32	259.5	No*	945

*Transect over coral reef in shallow water on the edge of the North passage.

**Transect over coral reef in shallow water Southeast of the North Passage.

2.3. Cryptic Fish Community Results

In total, 26 species of cryptic fish species were recorded across the 15 transects. Species recorded during the survey were checked against the existing RLS cryptic fish species list and no introduced cryptic fish species were identified when compared to previous RLS surveys. A list of cryptic fish species recorded during the survey is presented in Appendix D.1

The Lord Howe Island moray (*Gymnothorax annasona*) was recorded on three transects (S01, S07, and S15). The distribution of this species is known from Norfolk and Lord Howe Islands, including the Elizabeth and Middleton reefs. The Norfolk Cardinalfish (*Ostorhinchus norfolcensis*) was recorded on three transects (S07, S13, and S14). This species is only known from Lord Howe, Norfolk and Kermadec Islands and New Caledonia.

The Lord Howe Island moray is categorised by IUCN as Least Concern (Smith et al 2019) and is not listed as a threatened species under the *NSW Fisheries Management Act 1994* (NSW F Act).

The Norfolk Cardinalfish is not evaluated by IUCN and is not a threatened species listed in the NSW FM Act. However, climate change and habitat loss remain a threat to this species due to its limited distribution.

2.4. Invertebrate Community Results

In total, 21 species of invertebrate fauna were recorded from three phyla (Arthropoda, Echinodermata, and Mollusca) across 11 transects. No invertebrates were recorded on transects S05, S09, S10, and S12. At sites S09 and S10 the lack of mobile invertebrates is likely linked to lack of suitable habitat and their proximity to the existing channel and the current jetty.

Species recorded during the survey were checked against the most current RLS invertebrate species list and no introduced invertebrate species were identified.

Species richness was highest at S14 (7 species/100 m²) and jointly lowest at transects S01, S02, S03, S04, and S08 (1 species/100 m²).

Species from the phylum Echinodermata were the most diverse (11 species), including eight species of sea urchin, the most abundant of which was the Long-spined Sea Urchin (*Centrostephanus rodgersii*) recorded at S14 (72 individuals/100 m²) and S15 (1 individuals/100 m²). Other species of urchin recorded include *Breynia australasiae*, *Diadema savignyi*, *Echinometra mathaei*, *Echinostrephus aciculatus*, *Heliocidaris tuberculata*, *Tripneustes gratilla*, and *Echinocardium* spp. (identified to genus).

Other species from the phylum include two species from the family Holothuriidae, *Actinopyga palauensis* and *Stichopus chloronotus* and one Asteroiidae species, *Coscinasterias muricata*.

Six species from the phylum Mollusca were recorded, *Astralium rhodostomum* [species complex], *Drupella cornus*, *Flabellina* spp. (identified to genus), *Halgerda willeyi*, Pinnidae spp. (identified to genus), and *Tridacna Maxima*.

Species from the phylum Arthropoda make up the remainder of the invertebrates recorded. Individuals were separated into four groups, family (Epialtidae and Paguridae), and genus level (*Calcinus* and *Trapezia*).

A list of invertebrate species recorded at each transect during this survey is provided in Appendix D.1.

3. Discussion

3.1. Fish Community

Within the lagoon, branching coral, seagrass, solitary anemones, sand and rubble characterise the diverse habitat that supports a predominantly tropical fish assemblage, and among the highest fish and cryptic fish diversity in the Lord Howe Island Marine Park (Stuart-Smith et al 2025). This diverse habitat supports the highest biomass of benthic invertivore and corallivore fish found within the Lord Howe Island Marine Park, and is a key nursery area for endemic, threatened and protected species including McCulloch's Anemonefish (*Amphiprion mccullochi*), Doubleheader wrasse (*Coris bulbifrons*), Bluefish (*Girella cyanea*) and Black Rockcod (*Epinephelus daemeli*) (Stuart-Smith et al 2025).

The current survey focussed on the immediate area surrounding the existing jetty, in and around the current navigation track of the Island Trader supply vessel and encompassing adjacent seagrass and coral reef habitats.

The results indicate that at least three (3) Key Species (McCulloch's anemonefish (*Amphiprion mccullochi*), Elegant wrasse (*Anampses elegans*) and the Doubleheader wrasse (*Coris bulbifrons*)), were observed across the area. Two IUCN listed species the Chevron butterflyfish (*Chaetodon trifascialis*) Near Threatened, and Orange spotted filefish (*Oxymonacanthus longirostris*) Vulnerable). were also recorded. The distribution of the recorded Key Species was restricted to nine (9) of the 15 transects, five (5) of which contain coral dominated habitat, are not located within the navigation channel, and are furthest from coastal infrastructure.

Site S7 located on the northern edge of the navigation channel through North Passage recorded three (3) Key Species (McCulloch's anemonefish (*Amphiprion mccullochi*), Elegant wrasse (*Anampses elegans*) and the Doubleheader wrasse (*Coris bulbifrons*)), along with Orange spotted filefish (*Oxymonacanthus longirostris*) and Chevron butterflyfish (*Chaetodon trifascialis*) IUCN listed species. The species richness at this transect was high (29 species) and mean abundance was higher than at any other site (482/250 m²). This site is characterised by coral bommies, reef patches and reef flat. The two sites located behind the reef crest to the southeast of North Passage (S11 and S13) are coral dominated habitats, supporting a species rich community that included three (3) Key Species (McCulloch's anemonefish (*Amphiprion mccullochi*), Elegant wrasse (*Anampses elegans*) and the Doubleheader wrasse (*Coris bulbifrons*)). The sites closest to the seaward mouth of North Passage (S14 and S15) supported two (2) key species, Elegant wrasse (*Anampses elegans*) and the Doubleheader wrasse (*Coris bulbifrons*).

Sub-adult Doubleheader wrasse (*Coris bulbifrons*) was present at S01 (n = 1), S02 (n = 3), S04 (n = 1), S11 (n = 1), and S13 (n = 1). Whilst the abundance at these sites is very low, sub-adults of this IUCN listed (vulnerable) species were using the coral rubble/macroalgal habitats at sites closest to the jetty (S01 and S04). The largest adult Doubleheader wrasse (*Coris bulbifrons*) were recorded at transects dominated by coral cover, S07 (n = 1, 50 cm TL), S13 (n = 2, 40 cm TL), S14 (n = 3, 50 cm TL), and S15 (n = 2, 40 cm TL).

Consistent with the long-term monitoring results reported in Stuart-Smith 2025, no new introduced species were observed during this survey.

The outcomes from the CSMF desktop assessment (Appendix C) included the identification of six species of marine fish listed under one or more of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Biodiversity Conservation Act 2016* (BC Act), FM Act, as well as IUCN Redlist. These species were assessed to have a high likelihood of occurrence within the Lord Howe Island Marine Park based on searches of Atlas of Living Australia (ALA), BioNet and RLS databases. Of these six species, three were recorded during the survey along with the IUCN listed Chevron butterflyfish (*Chaetodon trifascialis*) (Near Threatened) and Orange spotted filefish (*Oxymonacanthus longirostris*) (Vulnerable). The result of this survey supports the information derived from the database sources and confirms their occurrence.

3.2. Cryptic Fish Community

Lord Howe Island supports numerous endemic species, among which there are fishes that are restricted to the island marine habitats or surrounding regions such as Elizabeth and Middleton Reef, Norfolk Island, New Caledonia and Kermadec Islands. A number of these species are considered cryptic, tending to reside in caves, under ledges, hidden amongst corals or other sessile organisms that provide cover and make detection less likely.

Whilst no Key Species were recorded during the survey of cryptic fish, locally relevant species with restricted endemism such as The Lord Howe Island moray (*Gymnothorax annasona*) and the Norfolk Cardinalfish (*Ostorhinchus norfolcensis*) were recorded at three transects (S07, S13, and S14). These sites are characterised by coral dominated habitats among the furthest from the coastal infrastructure. Lord Howe Island moray (*Gymnothorax annasona*) is known from Norfolk and Lord Howe Islands, including the Elizabeth and Middleton reefs. Norfolk Cardinalfish (*Ostorhinchus norfolcensis*) is only known from Lord Howe, Norfolk and Kermadec Islands and New Caledonia.

No new introduced cryptic fish were recorded during the survey, consistent with long-long term monitoring results (Stuart-Smith et al. 2025).

3.3. Invertebrate Community

Long-term monitoring of the invertebrate community within the Lagoon has revealed an ecological community characterised by low abundance of most species (Stuart-Smith et al. 2025). Further to this, intertidal reefs in the northern lagoon and adjacent to the existing jetty are known to support the lowest diversity of species and fewer endemics compared to other reefs in the Lord Howe Island Marine Park. The results from this survey tend to align with historical findings. Whilst 21 species of invertebrate fauna were recorded from three phyla (Arthropoda, Echinodermata, and Mollusca) across 11 transects, no invertebrates were recorded on transects S05, S09, S10, and S12. At transects S09 and S10 the paucity of mobile invertebrates is likely linked to lack of suitable habitat and their proximity to the existing channel and the current jetty. The Lagoon shipping channel between North Passage and the jetty has been historically impacted by shipping movement over a multidecadal scale. Vessel driven siltation, scour from vessel drawdown and controlled landings have impacted a 1 km long by 50 m wide area (50,000 m²) (DPIRD 2024).

During this survey, species richness was higher on transects that were placed over coral dominated habitat (S13, S14 and S15) and outside of the shipping channel.

In contrast, the relatively pristine Southern Lagoon sub-tidal and intertidal reefs support a high diversity of marine invertebrates (including crustaceans, sea snails, starfish and sea cucumbers, etc), many of which are endemic. For example, the Lord Howe Abalone (*Haliotis rubiginosa*) is found in greatest numbers in the southern lagoon and listed as Critically Endangered under both the NSW F Act and IUCN Redlist.

Mobile invertebrate species recorded during the survey are not listed as threatened or protected under the NSW FM Act.

The highest density of invertebrate species observed was the Long-spined Sea Urchin (*Centrostephanus rodgersii*), recorded at S14 (72 individuals/100 m²) and S15 (1 individuals/100 m²).

Long-spined Sea Urchins may occur in high densities and can form small urchin barrens in the Lord Howe Island Marine Park. The small barrens were first identified during a survey in 2008 (Edgar et al. 2008) and subsequent surveys in 2011 found increasing frequency of occurrence (Edgar et al. 2011). The increase in the distribution and occurrence of these barrens poses a potential threat to the ecology of the marine park.

The Small Giant Clam (*Tridacna maxima*) was recorded at transect S13 (1 individual/100 m²). The Small Giant Clam is categorised by IUCN as Least Concern (Neo & Li 2024).

Of note is a record of Rosemouth star shell (*Astraliium rhodostomum*) [species complex] from S13 (1 individuals/100 m²). This species complex has been shown to be comprised of at least 30 geographically isolated clades, some across very small spatial scales of ~180 km (Meyer et al. 2005). Future genetic studies may identify the Lord Howe Island examples of Rosemouth star shell (*Astraliium rhodostomum*) population as an endemic clade.

Species recorded during the survey were checked against the most current RLS invertebrate species list and no introduced invertebrate species were identified.

4. Pressures

Threats to marine biodiversity, are diverse, interactive and can be cumulative over time. Marine Park Management strategies at Lord Howe Island address a number of localised threats such as illegal fishing, vessel mooring and anchoring activities, supporting water quality research and monitoring to better understand nutrient inputs from groundwater and runoff, pollution such as vessel or land-based oil spills, and a permitting framework to manage other activities such as fish feeding and organised events.

4.1. Climate change

Coral bleaching and mortality can have serious flow on effects to the reef community such as changes to fish community structure and composition (through loss of habitat structure and food source for select species), and changes to invertebrate community assemblage (many benthic invertebrates are highly susceptible to heat stress which is often the main driver of coral bleaching).

Documented impacts of climate change to reef fishes in the Lord Howe Island Marine Park are presented in Stuart-Smith et al. 2025. They note the decline of corallivores and the McCulloch's anemone fish (*Amphiprion mccullochi*) being attributed to declines in coral and the anemone fish's host anemone.

Climate change impacts have been largely restricted to the shallow lagoon reefs due to low flushing and high solar heat flux (Stuart-Smith et al. 2025).

4.2. Sea urchin overgrazing

Endemic species of macroalgae and complex macroalgae/coral habitats are at risk from overgrazing by sea urchins. Loss of macroalgae will have a flow on effect through the community, impacting herbivorous fish and invertebrates. The specific drivers of sea urchin population booms are still being studied, but sustained increase in abundance of the long-spined urchin (*Centrostephanus rodgersii*), across a growing number of sites at Lord Howe is cause for concern.

4.3. Nutrient input

Nutrient enrichment in coastal waters surrounding Lord Howe Island has been identified as a key ecological threat (Edgar et al., 2008). Anthropogenic sources include groundwater flow and upwellings that transport nutrients from septic systems, as well as runoff from urban and agricultural areas (Davis, 2022a, 2022b). Ecological indicators such as cyanobacteria and epiphytic growth on coral and seagrass have been observed in the northern lagoon since initial surveys (Harriott, 1995; Edgar et al., 2008; Valentine et al., 2008). Similar nutrient-driven ecological shifts have been documented on Norfolk Island, where increased nutrient inputs were linked to transitions from coral to macroalgae dominance and coral disease outbreaks (Ainsworth et al., 2021).

This threat is managed through local wastewater treatment protocols, and Lord Howe Island management is actively supporting research to differentiate nutrient sources and assess their ecological effects. The Lagoon Ecological Community is particularly vulnerable due to its exposure to groundwater upwellings, urban and agricultural runoff—especially near creeks and intermittently closed and open lagoons and reduced water flushing.

4.4. Pollution

Pollution events, including spills of fuel, oil, or chemicals from both land-based and marine sources, have long been recognized as significant threats to shallow reef habitats in the Lord Howe Island Marine Park (Edgar et al., 2008). In addition to major incidents, cumulative impacts from minor leaks associated with routine vessel activity—particularly around the boat ramp and jetty—pose ongoing risks. These threats are most pronounced in the Lagoon Ecological Community due to the concentration of infrastructure and activities in and around the lagoon, coupled with limited water flushing.

Pollution is managed under the *Protection of the Environment Operations Act 1997*, MARPOL regulations governing vessel discharges, and specific management protocols. Long-term ecological monitoring provides a critical baseline for assessing future pollution impacts (Edgar et al., 2008). Targeted monitoring of impact and control sites has also been conducted, including in response to a significant diesel spill in the northern lagoon in 2022 (Woods, 2023).

4.5. Biosecurity

Aquatic biosecurity threats—particularly the introduction of non-native marine pests and diseases—represent one of the most significant risks to shallow reef habitats in the Lord Howe Island Marine Park, as identified in early ecological assessments (Edgar et al., 2008). Among potential vectors, biofouling and ballast water from visiting vessels pose the greatest concern. These risks are currently mitigated through ballast water restrictions, biofouling management requirements, hull inspections, and established response protocols.

The management also implements a long-term marine pest surveillance strategy, incorporating regular monitoring and public education initiatives. As with other threats, the Lagoon Ecological Community remains the most vulnerable to biosecurity incursions.

4.6. Coastal development

Coastal development poses several risks to shallow reef habitats within the Lord Howe Island Marine Park, including habitat degradation, increased sedimentation and turbidity, altered hydrology, pollution from runoff, and intensified human activity linked to infrastructure. These impacts are primarily managed through permit and approval processes for development and associated works. Consistent with other threats, the Lagoon Ecological Community is particularly vulnerable to these pressures.

4.7. Fishing

Fishing and collection activities pose a direct threat to shallow reef ecosystems by removing target species, potentially disrupting fish, invertebrate, and benthic communities. The Lord Howe Island Marine Park supports a small-scale artisanal fishery. Although fishing pressure is relatively low compared to other Australian coastal regions (Edgar et al., 2008), concerns persist regarding its ecological impacts, including illegal fishing within sanctuary zones (SZs) (Stuart-Smith et al., 2019).

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Appendix D.1. Fish, cryptic fish and Invertebrate species recorded on RLS transects

Fish species				
Species name	Species name	Species name	Species name	Species name
Acanthuridae spp.	<i>Chaetodon melannotus</i>	<i>Dascyllus reticulatus</i>	<i>Naso unicornis</i>	<i>Pseudolabrus luculentus</i>
<i>Acanthurus dussumieri</i>	<i>Chaetodon mertensii</i>	<i>Dascyllus trimaculatus</i>	<i>Neoglyphidodon polyacanthus</i>	<i>Scarus altipinnis</i>
<i>Acanthurus nigrofusus</i>	<i>Chaetodon pelewensis</i>	<i>Epinephelus maculatus</i>	<i>Ostorhinchus doederleini</i>	<i>Scarus ghobban</i>
<i>Amblygobius phalaena</i>	<i>Chaetodon plebeius</i>	<i>Epinephelus merra</i>	<i>Ostorhinchus norfolcensis</i>	<i>Scarus niger</i>
<i>Amphiprion mccullochi</i>	<i>Chaetodon speculum</i>	<i>Eviota hoesei</i>	<i>Oxycheilinus digramma</i>	<i>Scarus rivulatus</i>
<i>Anampses elegans</i>	<i>Chaetodon tricinctus</i>	<i>Fistularia commersonii</i>	<i>Oxymonacanthus longirostris</i>	<i>Siganus fuscescens</i>
<i>Arothron hispidus</i>	<i>Chaetodon trifascialis</i>	<i>Fusigobius neophytus</i>	<i>Parapercis australis</i>	<i>Stegastes gascoynei</i>
<i>Canthigaster bennetti</i>	<i>Cheilinus spp.</i>	<i>Girella cyanea</i>	<i>Parapercis queenslandica</i>	<i>Stethojulis bandanensis</i>
<i>Canthigaster callisterna</i>	<i>Cheilio inermis</i>	<i>Gomphosus varius</i>	<i>Parma polylepis</i>	<i>Stethojulis interrupta</i>
<i>Canthigaster valentini</i>	<i>Cheilodipterus quinquelineatus</i>	<i>Goniistius vestitus</i>	<i>Parupeneus barberinus</i>	<i>Synodus dermatogenys</i>
<i>Centropyge tibicen</i>	<i>Chlorurus sordidus</i>	<i>Gymnothorax annasona</i>	<i>Parupeneus spilurus</i>	<i>Synodus spp.</i>
<i>Chaetodon auriga</i>	<i>Chromis atripectoralis</i>	<i>Halichoeres trimaculatus</i>	<i>Pervagor alternans</i>	<i>Thalassoma hardwicke</i>
<i>Chaetodon citrinellus</i>	<i>Chromis hypsilepis</i>	<i>Hemigymnus melapterus</i>	<i>Plagiotremus tapeinosoma</i>	<i>Thalassoma lunare</i>
<i>Chaetodon ephippium</i>	<i>Chrysiptera notialis</i>	<i>Kyphosus bigibbus</i>	<i>Plectroglyphidodon johnstonianus</i>	<i>Thalassoma lutescens</i>
<i>Chaetodon flavirostris</i>	<i>Coris bulbifrons</i>	<i>Labrichthys unilineatus</i>	<i>Prionurus maculatus</i>	<i>Thalassoma purpureum</i>
<i>Chaetodon lunulatus</i>	<i>Coris picta</i>	<i>Labroides dimidiatus</i>	<i>Pseudocaranx [dentex]</i> sp.	<i>Trachypoma macracanthus</i>
	<i>Dascyllus aruanus</i>	<i>Mulloidichthys flavolineatus</i>	<i>Pseudocheilinus hexataenia</i>	<i>Zebrasoma scopas</i>

Invertebrate species		Cryptic fish species	
Species name	Species name	Species name	Species name
<i>Actinopyga palauensis</i>	Flabellina spp.	<i>Amblygobius phalaena</i>	<i>Gymnothorax eurostus</i>
<i>Astrarium rhodostomum</i>	<i>Halgerda willeyi</i>	Blenniidae spp.	Gymnothorax spp.
<i>Breynia australasiae</i>	<i>Helicoidaris tuberculata</i>	<i>Cheilodipterus quinquelineatus</i>	<i>Heteropriacanthus cruentatus</i>
Calcinus spp.	Paguridae spp.	Cirripectes spp.	<i>Ostorhinchus apogonoides</i>
<i>Centrostephanus rodgersii</i>	Pinnidae spp.	<i>Diplogrammus goramensis</i>	<i>Ostorhinchus doederleini</i>
<i>Coscinasterias muricata</i>	<i>Stichopus chloronotus</i>	Echinocardium spp.	<i>Ostorhinchus flavus</i>
<i>Diadema savignyi</i>	Trapezia spp.	<i>Enneapterygius howensis</i>	<i>Ostorhinchus norfolcensis</i>
<i>Drupella cornus</i>	<i>Tridacna maxima</i>	<i>Eviota hoesei</i>	<i>Parapercis australis</i>
Echinocardium spp.	<i>Tripneustes gratilla</i>	Eviota spp.	<i>Parapercis queenslandica</i>
<i>Echinometra mathaei</i>	Pinnidae spp.	<i>Fusigobius neophytus</i>	<i>Petroscirtes lupus</i>
<i>Echinostrephus aciculatus</i>	<i>Stichopus chloronotus</i>	<i>Gnatholepis anjerensis</i>	<i>Scorpaena cardinalis</i>
Epialtidae spp.	Trapezia spp.	<i>Gnatholepis cauerensis</i>	<i>Scorpaena jacksoniensis</i>
		<i>Gymnothorax annasona</i>	<i>Synodus dermatogenys</i>

Appendix E. Introduced Marine Pest Survey

Appendix E Introduced Marine Pest Survey

An introduced marine pest (IMP) survey of the submerged piles of the jetty infrastructure was undertaken to support the Coastal and Marine Ecology Assessment (CMEA) for the Lord Howe Island Critical Infrastructure Project. The survey was undertaken by BMT in April 2025 in accordance with a sampling plan designed by BMT and approved by DCCEEW. The data collected during the survey was provided to O2 Marine for analysis and interpretation. This report provides a summary of the IMP data collected to support approvals for the Lord Howe Island Critical Infrastructure Project.

1. Methods

The IMP survey was conducted prior to a recent pile wrapping maintenance program. The submerged jetty piles were surveyed by divers using a GoPro underwater camera to capture both still and video images of the biofouling community which has colonised the submerged jetty piles. Collected imagery showed the full extent of pile lengths from the tidal area above sea level to the seabed. Imagery also showed pile circumference, showing all surface sides for each surveyed pile. Pile location information, such as pier or pile numbers, were not provided with the data set, so a high-level pile location was interpreted from the collected imagery.

For interpretation and reporting of the collected field data, analysis has been framed into three categories corresponding to the location of the biofouling community on the pile, 'Tidal', 'Mid' and 'Seabed'. A written description of the associated biofouling community, including any species of interest, was produced for each pile included in the survey and a representative image showing the biofouling community composition was extracted from each pile video.

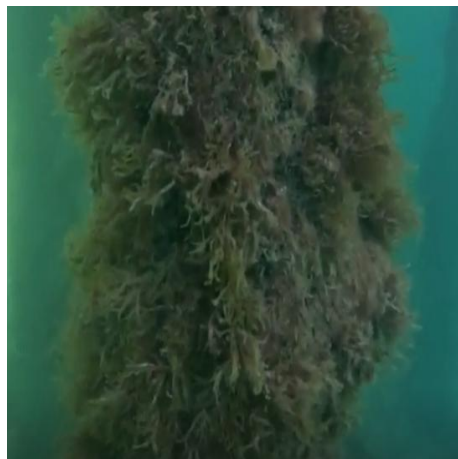
2. Results

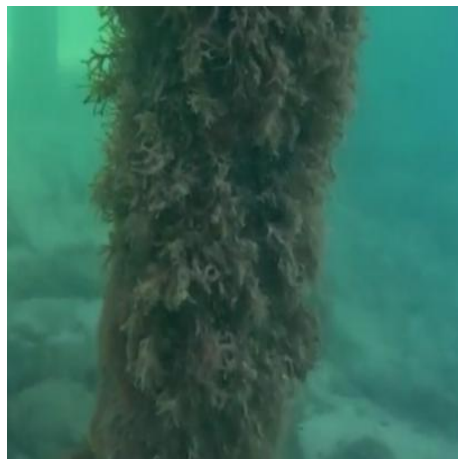
Twenty-five (25) piles around the perimeter of the jetty structure were surveyed for the presence of IMPs. The biofouling community on these piles was dominated by red, green and brown macroalgae, with the brown macroalgae Peacock seaweed (*Padina sp.*) being highly dominant on several piles. No red macroalgae species was identified with accuracy from the imagery. Surveyed piles showed a limited presence of higher order colonisation by organisms such as barnacles, sponges, ascidians or soft corals. Four (4) piles showed higher order colonisation with growths of the green finger sponge and an unidentified white colonial ascidian being observed as small colonies on individual piles. Two (2) piles showed small patches of Sea grapes (*Caulerpa racemosa*) contributing to the green macroalgae community on these piles. No organisms which are listed as declared pests in NSW or as Priority species under Australian Priority Marine Pest List (APMPL) were identified during analysis of the collected imagery from the field.

Results of the imagery analysis are presented in Table E1.

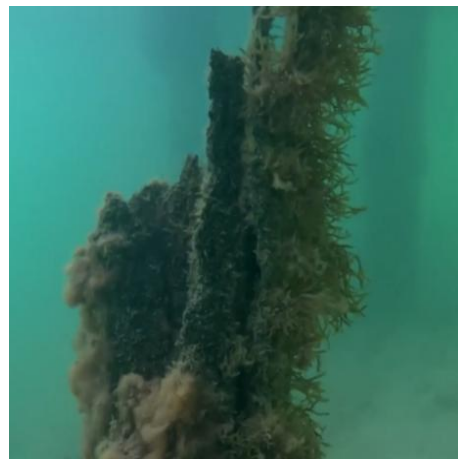
Table E1: Biofouling community analysis for the Lord Howe Island jetty.

File Name	Reference image	Site position	Biofouling description	Additional image
GX10121		Outside jetty timber pile	Tidal: Turf algae and biofilm Mid: Red filamentous algae, 1x 10 cm patch Sea grapes (<i>Caulerpa racemosa</i>) Seabed: Turf algae and biofilm	
GX12126		Outside jetty timber pile and fender	Tidal: Turf algae and biofilm Mid: Red filamentous algae, green and brown macroalgae Seabed: Turf algae, red filamentous algae and biofilm	

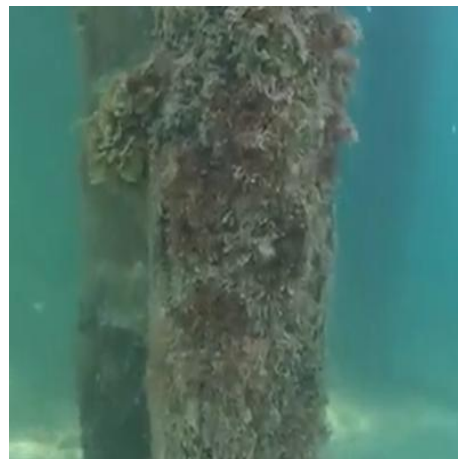
File Name	Reference image	Site position	Biofouling description	Additional image
GX12132		Outside jetty timber pile and fender	Tidal: Red filamentous algae, biofilm Mid: Red filamentous algae, green and brown macroalgae Seabed: Red filamentous algae, green and brown macroalgae	
GX12136		Outside jetty timber pile and fender	Tidal: Red filamentous algae, brown macroalgae Mid: Red filamentous algae, brown macroalgae. 20 cm white colonial ascidian colony Seabed: Red filamentous algae, green and brown macroalgae	

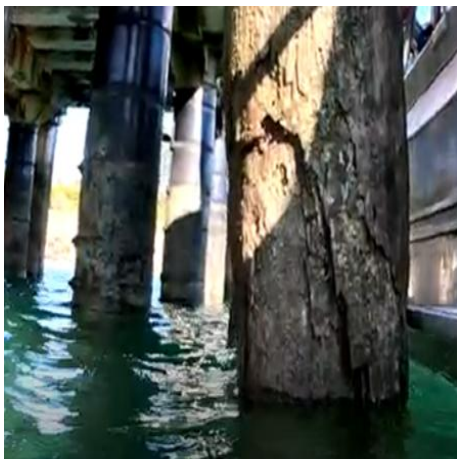
File Name	Reference image	Site position	Biofouling description	Additional image
GX10141 GX10142		Outside jetty timber pile and fender	Tidal: Red filamentous algae, green sponge Mid: Red, green and brown macroalgae. Seabed: Red and brown filamentous and macroalgae. Base of pile scoured.	
GX10143		Outside jetty timber pile and fender	Tidal: Red and brown filamentous and macroalgae Mid: Red and brown filamentous and macroalgae Seabed: Red and brown filamentous and macroalgae	

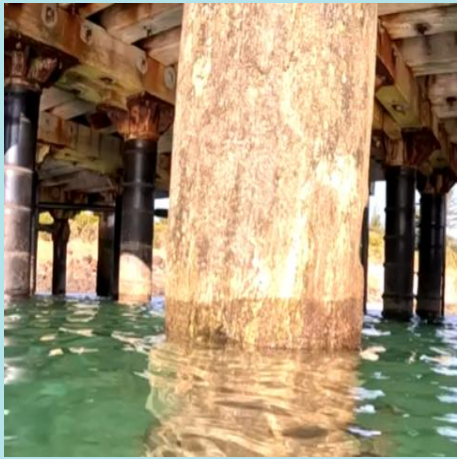
File Name	Reference image	Site position	Biofouling description	Additional image
GX10146 GX10148		Outside jetty timber pile and fender	Tidal: Brown macroalgae, pink/white sponge Mid: Red and brown filamentous and macroalgae Seabed: Brown macroalgae, base of pile scoured	
GX10153		Outside jetty timber pile and fender	Tidal: Red, green and brown macroalgae, red and brown filamentous algae. 20 cm Sea grapes 10 cm patch (<i>Caulerpa racemosa</i>) Mid: Red and brown filamentous and macroalgae Seabed: Red, green and brown macroalgae, red and brown filamentous	

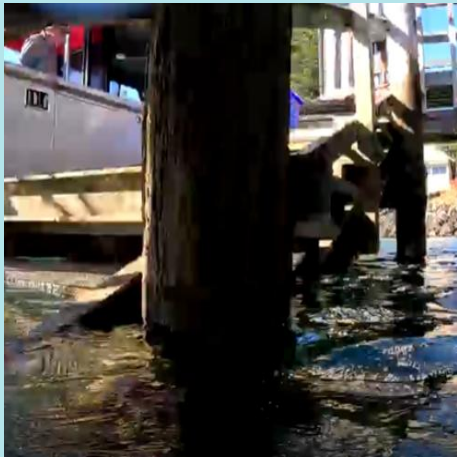
File Name	Reference image	Site position	Biofouling description	Additional image
GX10158		Outside jetty, broken timber mile and fender	Tidal: Biofilm Mid: Rotten out/missing Seabed: Red and brown macroalgae.	
GX10164		Outside jetty, timber mile and fender	Tidal: Biofilm Mid: Red, green and brown macroalgae. Small 10 cm patch white colonial ascidian. Seabed: Red and brown macroalgae. Small 10 cm patch white colonial ascidian, hard purple bryozoan.	

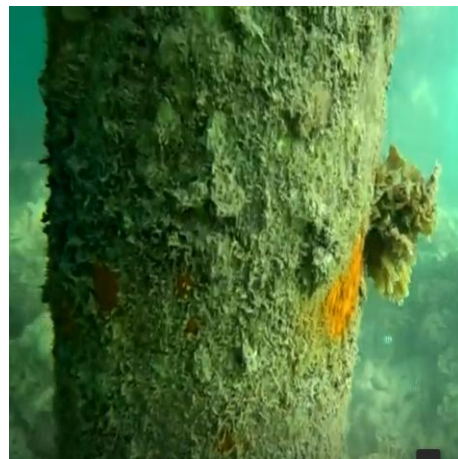
File Name	Reference image	Site position	Biofouling description	Additional image
GX10168		Outside jetty, timber pile and fender	Tidal: Biofilm and brown macroalgae (<i>Padina sp.</i>) Mid: Red filamentous and macroalgae Seabed: Red and brown macroalgae.	
GX10169		Dolphin/mooring steel pile and fender	Tidal: Biofilm Mid: Red and brown macroalgae (<i>Padina sp.</i>) macroalgae Seabed: Red and green macroalgae.	

File Name	Reference image	Site position	Biofouling description	Additional image
GX10176		Outside jetty, timber pile	Tidal: Brown macroalgae (<i>Padina sp.</i>) Mid: Red and brown macroalgae (<i>Padina sp.</i>) Seabed: Red and brown filamentous algae.	
GX10182		End jetty timber pile	Tidal: Turf algae Mid: Red and brown macroalgae (<i>Padina sp.</i>) Seabed: Scoured, red and brown filamentous algae.	

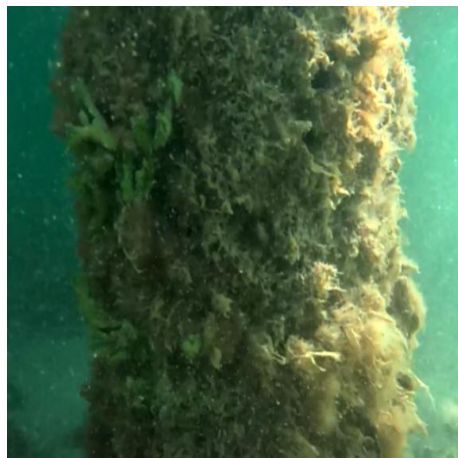
File Name	Reference image	Site position	Biofouling description	Additional image
GX10187		End jetty timber pile	Tidal: Split, biofilm, brown turf algae Mid: Red and macroalgae Seabed: Scoured, red and brown macroalgae.	
GX10192		End jetty timber pile	Tidal: Biofilm, brown turf algae Mid: Red filamentous macroalgae Seabed: Scoured, brown macroalgae (<i>Padina sp.</i>).	

File Name	Reference image	Site position	Biofouling description	Additional image
GX10196		Timber jetty pile near access ladder	Tidal: Biofilm, brown turf algae Mid: Red macroalgae and brown macroalgae (<i>Padina sp.</i>). Seabed: Biofilm, turf algae	
GX10199		Timber jetty pile near access ladder	Tidal: Biofilm Mid: Red macroalgae and brown macroalgae (<i>Padina sp.</i>). Seabed: Biofilm, turf algae	

File Name	Reference image	Site position	Biofouling description	Additional image
GX10203		Corner timber jetty pile	Tidal: Biofilm Mid: Brown macroalgae (<i>Padina sp.</i>) and green sponge Seabed: Biofilm, brown macroalgae	
GX10207		Inside timber pile with concrete casing at stair water access	Tidal: Biofilm Mid: Brown macroalgae (<i>Padina sp.</i>) Seabed: Biofilm and brown macroalgae (<i>Padina sp.</i>)	

File Name	Reference image	Site position	Biofouling description	Additional image
GX10209		Outside timber pile with concrete casing at stair water access	Tidal: Biofilm Mid: Biofilm and brown macroalgae (<i>Padina sp</i>) Seabed: Biofilm	
GX10210		Inside timber pile beneath stair water access	Tidal: Biofilm Mid: Red and brown macroalgae Seabed: Red and brown macroalgae	

File Name	Reference image	Site position	Biofouling description	Additional image
GX10211		Outside timber pile beneath stair water access	Tidal: Biofilm, red turf algae Mid: Red and brown macroalgae Seabed: Red and brown macroalgae	
GX10212		End jetty head, timber pile	Tidal: Biofilm, red turf algae Mid: Brown macroalgae Seabed: Brown macroalgae	

File Name	Reference image	Site position	Biofouling description	Additional image
GX10213		End jetty head timber pile	Tidal: Biofilm Mid: Red filamentous and brown macroalgae Seabed: Brown macroalgae and green sponge	

3. Discussion

No detections of declared IMPs have been recorded during the survey inspection. The fouling community on the Lord Howe Island jetty is dominated by a red and brown macroalgae, with Peacock weed (*Padina sp.*) being dominant on individual piles. Sparsely colonised areas within the tidal zone were mostly colonised by bacterial biofilm, and interestingly no barnacles or mussels were observed on these sections of the surveyed jetty piles. Higher order colonisation was highly limited overall, with just four (4) piles observed with higher order colonisation with small growths of the green finger sponge and an unidentified white colonial ascidian. The green algae, Sea grapes (*Caulerpa racemosa*), was observed on two (2) piles, however this species is native in Australian waters, and likely present at Lord Howe Island. Although *Caulerpa* species have weed like tendencies, *Caulerpa racemosa* is not a priority introduced pest species, although there are documented management actions in NSW for the related species *Caulerpa taxifolia* (Creese et al 2004, Stuart-Smith et al 2025, DPI 2023).

Introduced marine pests pose a significant threat to the unique marine ecosystems surrounding Lord Howe Island. Non-native species, often transported via ballast water or hull fouling from visiting vessels, can outcompete native marine life, alter habitat structures, and disrupt ecological balance. At Lord Howe Island, species which are native to Australian waters, but not necessarily present within the Lord Howe Island ecosystem, may also present biodiversity risks, similar to those for non-native marine species which have been declared as pests. The presence of both native and non-native marine pests not only endangers local biodiversity, including the many endemic species, but also has the potential to impact the island's fishing and tourism industries (DPI 2020). Less common vectors of introduced marine species including marine debris and predator feeding (i.e. seabird feeding) are other ways that introduced marine species may become established in Lord Howe Island's marine ecosystem.

To address this risk, Lord Howe Island Marine Park staff, in collaboration with NSW Department of Primary Industries (DPI) implements targeted monitoring programs as part of a broader biosecurity strategy. These programs involve regular surveys of high-risk areas such as boat moorings and reef zones, along with early detection protocols for priority species like the New Zealand screw shell (*Maoricolpus roseus*) and Red sea lettuce (*Grateloupia turuturu*). Public awareness campaigns and vessel inspection requirements also support introduced marine species prevention and detections.

Fortunately, no significant detections of declared IMPs have been recorded at Lord Howe Island to date (Aquenal, 2006, DPI 2020). Continued vigilance with ongoing monitoring, strict biosecurity measures, and community awareness are essential to prevent further introductions and manage existing threats to this World Heritage-listed marine environment.

4. References

- Creese R, Davis A. & Glasby T (2004) Eradicating and Preventing the Spread of *Caulerpa taxifolia* in NSW. Project No. 35593, NSW Fisheries Final Report Series, No. 64 ISSN 1440-3544
- DPI (Department of Primary Industries New South Wales) (2020) Marine Pest Monitoring and Surveillance Report.
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https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/1629051/18235-NSW-Invasive-Species-Plan-2023-2028-v2-FINAL.pdf
- Stuart-Smith R., Cooper A, Oh E, Clausius E, Schmid J, Edgar GJ. (2025) Lord Howe Island Marine Park Shallow Reef Ecological Assessment Report 2022. Reef Life Survey Foundation Incorporated.