Draft Dredging and Spoil Disposal Management Plan

New Marine Facilities to Service Mandorah and Cox Peninsula

ZMD01890

Prepared for

Department of Infrastructure, Planning and Logistics

20 February 2022

Cardno

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Stantec

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1 Introduction

1.1 Project Description

The Northern Territory Government (NTG) has identified the need to develop a safe, Disability Discrimination Act 1992 (Cwth: DDA) compliant and more weather-resistant ferry berthing facility at Mandorah, to improve transport connectivity between Cox Peninsula and Darwin. The proposed facility uses two large breakwaters to form a safe harbour around new ferry berthing and passenger boarding infrastructure. The project is located adjacent the existing Mandorah Jetty, which currently services the transfer of ferry passengers, but does not comply with access requirements for persons with a disability. Key components of the proposed facilities are:

- A safe harbour formed by rock armoured breakwaters – large northern breakwater and smaller southern breakwater;
- Capital dredging of an access channel, turning basin and berthing areas for the ferry and recreational vessels;
- A new single lane boat ramp within the harbour, connecting to the existing carpark at the site;
- A new floating pontoon, gangway, jetty (TBC) and rock armoured pedestrian causeway inside the harbour, to allow passengers to access the ferry from land. These facilities will provide a DDA compliant access solution for people who need mobility assistance and may include a mechanical lift (to be confirmed in the D&C stage);
- A ferry terminal building established by repurposing an existing building at the site (Lot 50) and new carpark with a short road connecting it to the existing carpark, as well as pedestrian paths and minor onshore amenities; and
- Minor modification to the existing carpark to incorporate access and manoeuvring for the new boat ramp, as well as allow additional trailer parking.

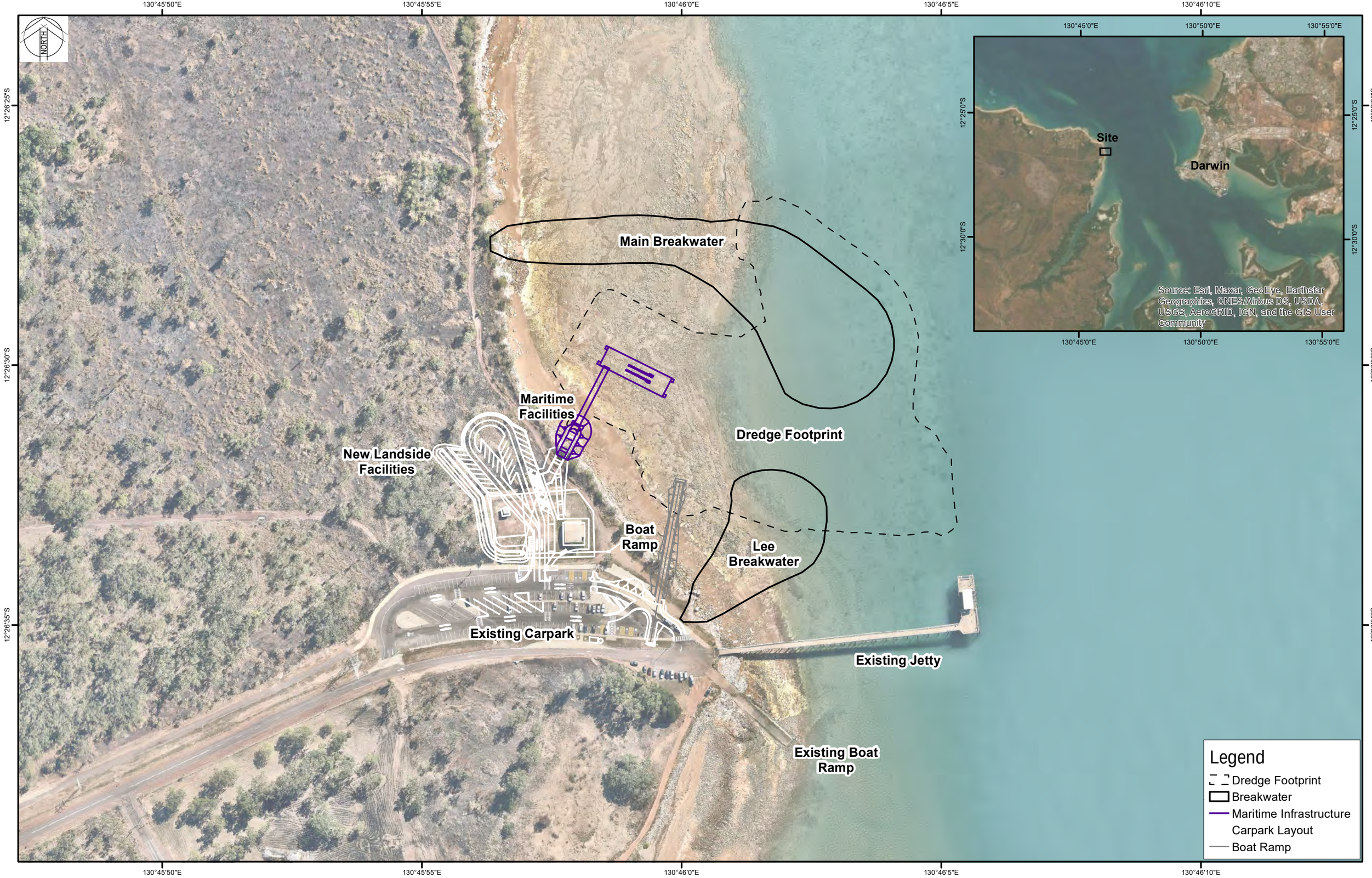
1.1.1 Project Location

Mandorah is located near the eastern tip of the Cox Peninsula in the Northern Territory, approximately six kilometres to the west of Darwin (**Figure 1-1**). Access to Mandorah from Darwin is via the regular ferry service, or by driving approximately 120 km along the road network.

1.1.2 Proposed Dredging and Disposal Actions

The proposed dredging program is presented in detail in **Section 2**. In summary, the dredging and disposal actions proposed for the project are:

- Dredging by cutter suction dredger (CSD) and offshore disposal by piping (dispersed in water column) of up to approximately 15,000 m^3 of unconsolidated marine sediments; and
- Dredging of approximately 70,000 m^3 of rock material by back hoe dredger (BHD). Dredged rock material will be used in the project construction (core material for breakwaters, causeway, boat ramp and general fill). Any excess dredged rock material will be utilised on other Darwin projects as fill.



Cardno

Darwin, Northern Territory

Date
11/01/2022

Size
A3

Scale
0 100 Meters

SITE LOCALITY

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 1-1

1.2 Legislative Context

This *Draft Dredging and Spoil Disposal Management Plan (DSDMP)* has been prepared to demonstrate the management controls for dredging and spoil disposal, that will allow the project to conform with relevant environmental legislation. Northern Territory and Commonwealth legislation is in place to stipulate the requirement for environmental risk assessment and management associated with dredging and disposal actions.

The NT *Environment Protection Act 2019* (EP Act) aims to protect the environment through sustainable development and manage significant disturbances through an environmental approval process. Under the act, the NT EPA regulates the environmental impact assessment process to identify potential environmental impacts of development proposals. This *Draft DSDMP* outlines a portion of the environmental risk mitigation measures required for the project to achieve approval under the EP Act.

Territory and Commonwealth legislation relevant to the project and this *Draft DSDMP* is summarised in **Table 1-1** and **Table 1-2**, respectively.

Table 1-1 Relevant Territory Legislation

Document	Purpose / Objectives	Agency
Environment Protection Act 2019 (EP Act) and *Regulations 2020* (EP Regulations)	> Protect the environment of the Territory; > Promote ecologically sustainable development so that the wellbeing of the people of the Territory is maintained or improved without adverse impact on the environment of the Territory; > Recognise the role of environmental impact assessment and environmental approval in promoting the protection and management of the environment of the Territory; > Provide for broad community involvement during the process of environmental impact assessment and environmental approval; > Recognise the role that Aboriginal people have as stewards of their country as conferred under their traditions and recognised in law, and the importance of participation by Aboriginal people and communities in environmental decision-making processes.	Department of Environment, Parks and Water Security
Northern Territory Environment Protection Authority Act 2012 (NT EPA Act)	> Promote ecologically sustainable development; > Protect the environment, having regard to the need to enable ecologically sustainable development; > Promote effective waste management and waste minimisation strategies; and > Enhance community and business confidence in the environmental protection regime of the Territory.	Department of Environment, Parks and Water Security
Waste Management and Pollution Control Act 1998 and *Regulations 1998*	> Protect, and where practicable to restore and enhance the quality of, the Territory environment by: - Preventing pollution; - Reducing the likelihood of pollution occurring; - Effectively responding to pollution; - Avoiding and reducing the generation of waste; - Increasing the re-use and re-cycling of waste; and - Effectively managing waste disposal; > Encourage ecologically sustainable development; and	Department of Environment, Parks and Water Security

Document	Purpose / Objectives	Agency
	> To facilitate the implementation of national environment protection measures made under the National Environment Protection Council (Northern Territory) Act 1994 (described below).	
Marine Pollution Act 1999 and *Regulations 2003*	The overall purpose of this Act is to protect the Territory's marine and coastal environment by minimising intentional and negligent discharges of ship-sourced pollutants into coastal waters. This purpose is to be achieved primarily by giving effect to relevant provisions of the following annexes of MARPOL: > Annex I (which deals with pollution by oil); > Annex II (which deals with pollution by noxious liquid substances in bulk); > Annex III (which deals with pollution by harmful substances in packaged form); > Annex V (which deals with pollution by garbage). The purpose is also to be achieved by: > Providing an approach to protecting the Territory's marine and coastal environment from ship-sourced pollutants complementary to the approach of the Commonwealth and the States of the Commonwealth; > Making provision about the discharge of sewage from ships; > Enabling shipping casualties that are polluting, or threatening to pollute, coastal waters, to be dealt with; and > Imposing severe penalties on persons who pollute the Territory's marine and coastal environment in contravention of this Act.	Department of Environment, Parks and Water Security
National Environment Protection Council (Northern Territory) Act 1994	The object of this Act is to ensure that, by means of the establishment and operation of the National Environment Protection Council: > People enjoy the benefit of equivalent protection from air, water or soil pollution and from noise, wherever they live in Australia; and > Decisions of the business community are not distorted, and markets are not fragmented, by variations between participating jurisdictions in relation to the adoption or implementation of major environment protection measures.	Department of Environment, Parks and Water Security
Territory Parks and Wildlife Conservation Act 1976 (TPWC Act) and *Regulations 2001*	> Provides for the protection, conservation and sustainable utilisation of wildlife; and > Provides protection of listed threatened species for which proponents must consider direct and indirect impacts on a listed threatened species or place covered under this Act.	Department of Environment, Parks and Water Security
Water Act 1992 (Water Act) and *Regulations 1992*	> Provides for the investigation, allocation, use, control, protection, management and administration of water resources, including extraction of groundwater, waste water management and water pollution; and > Provides for water allocation plans, drilling licences, bore construction permits, water extraction licences, waste discharge licences, fees and charges, and penalties for offences against the Act.	Department of Environment, Parks and Water Security

Document	Purpose / Objectives	Agency
Ports Management Act 2015	> To provide for the control, management and operation of ports, and for related purposes.	Department of Infrastructure, Planning and Logistics
Ports Management Regulations 2015	> Details regulations under the *Ports Management Regulations 2015.*	Department of Infrastructure, Planning and Logistics
Heritage Act 2011 and *Heritage Regulations 2012*	The object of this Act is to provide for the conservation of the Territory's cultural and natural heritage. The object is achieved by: > Declaring places and objects of heritage significance to be heritage places and objects; > Declaring classes of places and objects of heritage significance to be protected classes of heritage places and objects; > Establishing the Heritage Council; > Providing for heritage agreements to encourage the conservation, use and management of heritage places and objects; > Regulating work on heritage places and objects; and > Establishing enforcement and offence provisions.	Department of Territory Families, Housing and Communities
Northern Territory Aboriginal Sacred Sites Act 1989 and *Sacred Sites Regulations 2004*	Facilitates the protection and registration of sacred sites, through: > Providing entry onto sacred sites and the conditions to which such entry is subject; > Procedures for avoidance of sacred sites when developing and using land; > Establishing an Authority for the purposes of the Act; and > Procedures for the review of decisions of the Authority by the Minister.	Aboriginal Areas Protection Authority

Table 1-2 Relevant Commonwealth Legislation

Document	Purpose / Objectives	Agency
Environment Protection and Biodiversity Conservation Act 1999	> Provides for the protection of the environment and conservation of biodiversity, particularly species and places of national significance. > Invoked only if a development is likely to have environmental impacts of national significance	Australian Government Department of Agriculture, Water and the Environment
Environment Protection (Sea Dumping) Act 1981	> Regulates the loading and dumping of waste at sea and the placement of artificial reefs within Australian Waters. Australian Waters stretch from the low water mark of the Australian shoreline out to 200 nautical miles, but does not include waters within the limits of a state or territory. > The Act, therefore, does not need to be adhered to when disposing of dredge spoil within Darwin Harbour limits. However, the same assessment process and methods should generally be applied.	Australian Government Department of Agriculture, Water and the Environment

National Environment Protection Measures (Implementation) Act 1998 and *Regulations 1999*	The objects of this Act are: > To make provision for the implementation of national environment protection measures in respect of certain activities carried on by or on behalf of the Commonwealth and Commonwealth authorities; and > To protect, restore and enhance the quality of the environment in Australia, having regard to the need to maintain ecologically sustainable development; and > To ensure that the community has access to relevant and meaningful information about pollution.	Australian Government Department of Agriculture, Water and the Environment
National Environment Protection (Assessment of Site Contamination) Measure 1999	The purpose of the Measure is to establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community which includes regulators, site assessors, environmental auditors, land owners, developers and industry. The desired environmental outcome for this Measure is to provide adequate protection of human health and the environment, where site contamination has occurred, through the development of an efficient and effective national approach to the assessment of site contamination.	Australian Government Department of Agriculture, Water and the Environment

1.2.2 EP Act – Environmental Referral

As the dredging and disposal actions have the potential to lead to significant environmental impact, they require risk assessment and referral to the NT EPA, as per the *EP Act*. This risk assessment and referral has been undertaken for the project as a whole. The assessment of environmental risk relating to dredging and disposal actions has been summarised in this *Draft DSDMP* (**Section 4**) and is further detailed in the project's *Environmental Referral Report* (Cardno, 2022a). Dredging cannot take place without EPA approval.

1.2.3 *EPBC Act* and *TPWC Act*

Actions that have the potential to impact matters of national environmental significance require assessment under the *EPBC Act*. The proposed actions have been self-assessed as part of risk assessment for the project, which has included self-assessment with respect to the *Territory Parks and Wildlife Act*, which provides similar safeguards for matters of environmental significance at the Territory level. With appropriate management and mitigation, the actions are not expected to have a significant impact on matters described by these Acts

1.2.4 *Sea Dumping Act*

As spoil is proposed to be disposed within Darwin Harbour (or on land) the *Sea Dumping Act* does not apply to the disposal activities. Nevertheless, the required investigations (e.g. NAGD) and assessment prescribed by the *Sea Dumping Act* to obtain a sea dumping permit have been adhered to for the proposed disposal actions.

1.2.5 *Water Act* – Waste Discharge Licence

A Waste Discharge Licence is required for the proposed actions pursuant to Section 74 of the *Water Act*. This has yet to be obtained and dredging and disposal cannot commence until this is in place.

1.3 Purpose and Structure of this *Draft DSDMP*

The purpose of this *Draft DSDMP* is to outline the management and monitoring activities required to minimise the environmental impact of dredging and spoil disposal activities associated with the project. It provides management frameworks and specific methods, locations and thresholds for monitoring, as well as assigning responsibility for the activities. This operational document accompanies referral of the project under the *EP Act*, to demonstrate tangible mitigation measures to reduce environmental impact and risk. It also supports

application for a Waste Discharge Licence under the Water Act. The *Draft DSDMP* should be incorporated into the contractors final Dredging and Disposal Management Plan (DDMP).

The *Draft DSDMP* has been structured as follows:

- This section (**1**) introduces the project, legislative context and document purpose;
- **Section 2** outlines the details of the dredging and disposal activities;
- **Section 3** describes the environmental setting in which the actions will take place;
- **Section 4** details the relevant environmental factors and assessment of environmental risk associated with dredging and disposal actions;
- **Section 5** details the management framework for the dredging and disposal activities;
- **Section 6** details monitoring requirements before, during and after dredging and disposal; and
- **Section 7** details the requirements for reporting to demonstrate adherence to this *Draft DSDMP* and assigns responsibilities.

1.4 Reference Documents

Various investigations and studies have been carried out as part of the overall development and design project to date. This report documents a component of these investigations. The following documents are referenced in, or should be given due consideration when reading, this report:

- *Environmental Referral Report* (Cardno, 2022a): This document provides the necessary details to refer the project to the NT EPA. This *Draft DSDMP* is an appendix to the referral document, detailing management measures to minimise environmental risk associated with dredging and disposal;
- *Sediment Transport Report* (Cardno, 2022b): Details siltation, sedimentation and plume dispersion investigations associated with the project. The results of sedimentation and plume dispersion investigations are used to characterise potential risk and impact associated with dredging and disposal;
- *Marine Environment Report* (Cardno, 2022c): Details the marine environment ecology relevant to the project site. This establishes the sensitive environmental receptors to which impact must be minimised for dredging and disposal activities;
- *SAP Implementation Report* (Cardno, 2022d): Details marine sediment quality investigations undertaken to understand any contamination within the dredging and disturbance area and guide proper handling and disposal of dredge material;
- *Draft Construction Environmental Management Plan (CEMP)* (Cardno, 2022e): Defines likely construction activities and controls required to avoid or minimise environmental impact. The plan details management for actions not covered by the *Draft DSDMP*, including marine actions such as piling and rock placement;
- *Design Report* (Cardno, 2022f): Details the design requirements, basis, inputs, calculations and outcomes for the new proposed infrastructure. Includes details of the dredge design;
- *Geotechnical Report* (Cardno, 2022g): Details the geotechnical information and investigations for the project site that inform design of the new proposed infrastructure. Important to understand the geology of the dredge area; and
- *Metocean Report* (Cardno, 2022h): Details the metocean information and investigations for the project site that inform design of the new proposed infrastructure and underpin processes such as dredge plume dispersion.

2 Dredging Program

2.1 Scope and Volumes

The dredging works shall see a total volume of approximately 85,000 m^3 dredged. The volumes and nature of material associated with each dredging stage are expected to be as follows.

Stage 1

Up to approximately 15,000 m^3 of unconsolidated marine sediments.

Stage 2

Approximately 70,000 m^3 of varying strength rock material.

The dredge layout design is depicted in **Figure 2-1** and dredging design drawings with setout points are provided in **Appendix A**, for reference. The dredging and disposal localities are presented in **Figure 2-2**. The dredging layout showing the depth below seabed is depicted in **Figure 2-3**.

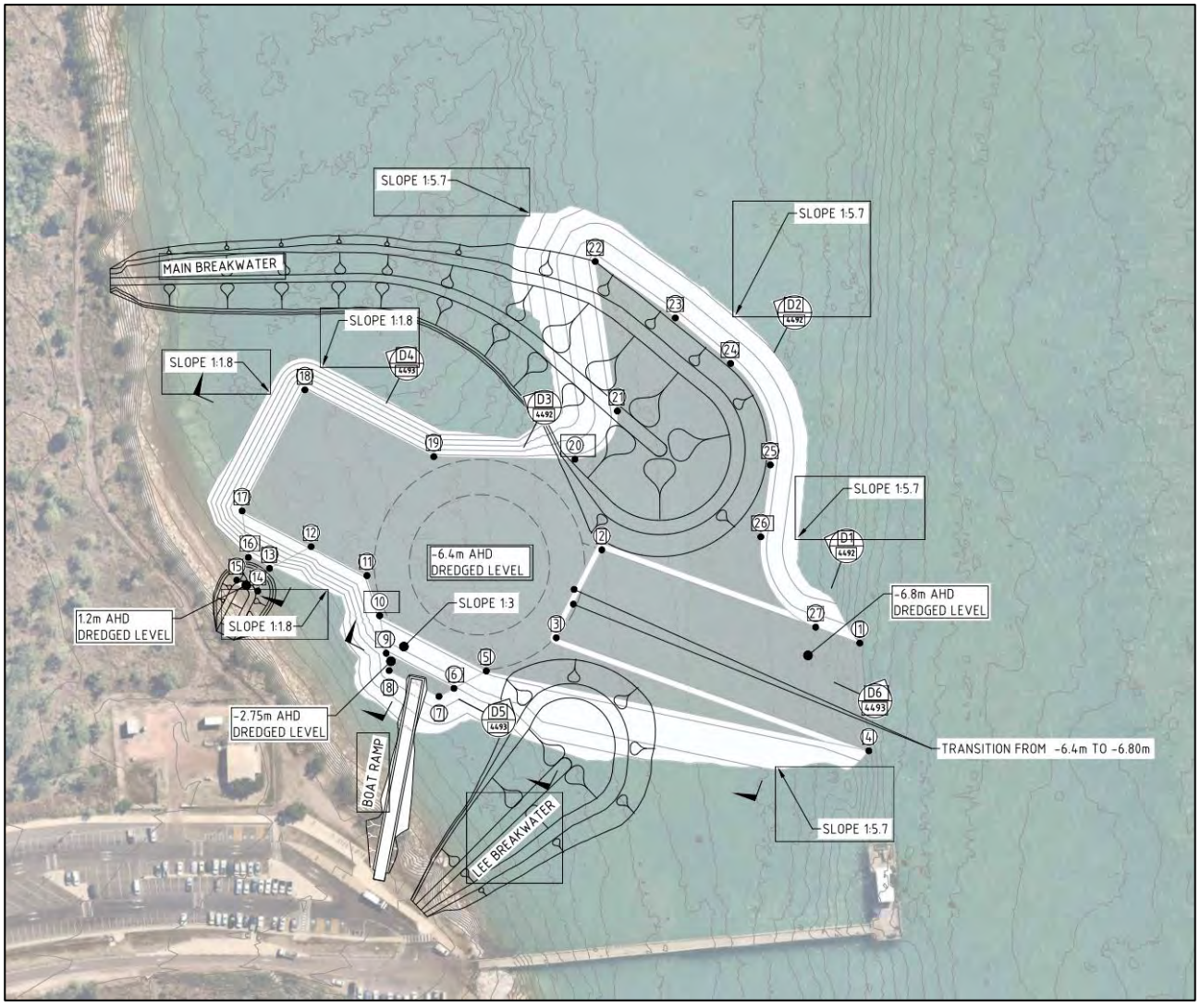


Figure 2-1 Dredge design layout (Design drawing R21-4491)

130°46'0"E

12°26'0"S

692284, 8625178

692334, 8625178

692284, 8625100

692334, 8625100

NORTH

691867, 8624045

691969, 8624042

691867, 8623966

691970, 8623932

12°26'30"S

RWA1

RWA2

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Onshore Handling Area (Rock)
- Offshore Disposal Area (Sediments)
- Breakwater
- Dredge Area
- Restricted Work Area 1 (AAPA)
- Restricted Work Area 2 (AAPA)
- Exclusion Zone (Aboriginal Sacred Site)

130°46'0"E

Cardno

Darwin, Northern Territory

Date
19/01/2022

Size
A3

Scale
1:4,500

0 100 200Meters

DREDGING AND DISPOSAL AREAS

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 2-2

130°45'55"E
130°46'0"E
130°46'5"E
12°26'30"S
12°26'35"S

NORTH

Stage 2
(May also extend
beneath Stage 1)

Stage 1

Legend

Breakwaters

Dredge Stages

Stage 1 (approx 15,000m3)

Stage 2 (approx 70,000m3)

Depth Below Seabed (m)

-7.5 - -7
-7 - -6.5
-6.5 - -6
-6 - -5.5
-5.5 - -5
-5 - -4.5
-4.5 - -4
-4 - -3.5
-3.5 - -3
-4 - -2.5
-2.5 - -2
-2 - -1.5
-1.5 - -1
-1 - -0.5
-0.5 - 0

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
13/01/2022

Size
A3

Scale
1:1,106

0 0.015 0.03km

DREDGING LAYOUT

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 2-3

2.2 Sequence

The proposed sequence and estimated timeframes of dredging and related activities are outlined below. A precise dredging schedule will be developed by the dredging contractor and incorporated in the DDMP.

Preliminaries and setup

- Submission of final Dredging and Disposal Management Plan (DDMP), supporting HSE and management documentation - 2 months prior to mobilisation;
- Initial hydrographic survey - at least 1 month prior to dredging commencement;
- Confirm templates for daily/weekly logs, incident reporting, environmental monitoring - 1 month prior to dredging commencement; and
- Setup of environmental monitoring equipment and activities (baseline data collection) – 1 month prior to dredging commencement.

Mobilisation of dredgers and equipment to Darwin Harbour

- CSD - already expected to be available within Darwin Harbour - 1 month prior to commencement;
- CSD disposal pipeline and booster pump/barges if necessary - 1 month prior to commencement;
- BHD and transport barges (as required) - 1 month prior to commencement; and
- Initial hydrographic survey – within 1 month prior to commencement.

Stage 1

- Dredging of unconsolidated sediments using CSD – estimated to take approximately 10-14 days, based on daytime operations, assuming operational production rate of 200 m^3/hr and accounting for downtime; and
- Transfer and disposal of material to offshore disposal area via a hydraulic pipeline.

Stage 2

- Dredging of rock material using BHD to required dredge design – estimated to take approximately 2-3 months, based on daytime operations, assuming operational production rate of 120 m^3/hr and accounting for downtime. Note that this may need to be revised based on the handling process/time from extraction to placement within the breakwater cores;
- Note that Stage 2 can commence concurrently with Stage1 within the Stage 2 area only (see **Figure 2-3**). Removal of rock within the Stage 1 area (i.e. beneath sediment) cannot commence until all unconsolidated sediments have been removed; and
- Transfer of dredged rock onshore for reuse in breakwater cores for this project or for use in other Darwin projects.

Demobilisation

- Final hydrographic survey to confirm completion of works – with 2 weeks of completion;
- Demobilisation of dredging vessels and transfer systems – once final completion of the works is confirmed; and
- Cease environmental monitoring and remove monitoring equipment – 2 weeks after confirmation of completion.

2.3 Hydrographic Survey

An initial hydrographic survey will be undertaken preceding the dredging works, comparison of which with the proposed dredge footprint will allow for an accurate estimate of total volume to be dredged. Upon the completion of dredging works, a second hydrographic survey is to be undertaken to ensure the dredge footprint and finished levels have been achieved. Additional surveys may be required as per the construction contract documents. The hydrographic surveys may also be used to calculate final dredge volumes.

2.4 Methodology

2.4.1 Equipment

2.4.1.1 Cutter suction dredger

Unconsolidated sediment is expected to be dredged using a CSD, it is likely a compact CSD is already positioned in Darwin Harbour. CSDs are a hydraulic dredge. They may be self-propelled or stationary and use a rotating cutter head to loosen the seabed before drawing the sand/water mixture to the surface. A network of pipes will pump the slurry to the offshore disposal location (see **Figure 2-1**). Due to the dredging area's relatively close proximity to the disposal site, it is not expected that booster pumps will be required. Only pipes near the dredge and boosters will be floating, the majority of the line can be sunk below the surface. **Figure 2-4** shows an artistic cross section of a CSD.

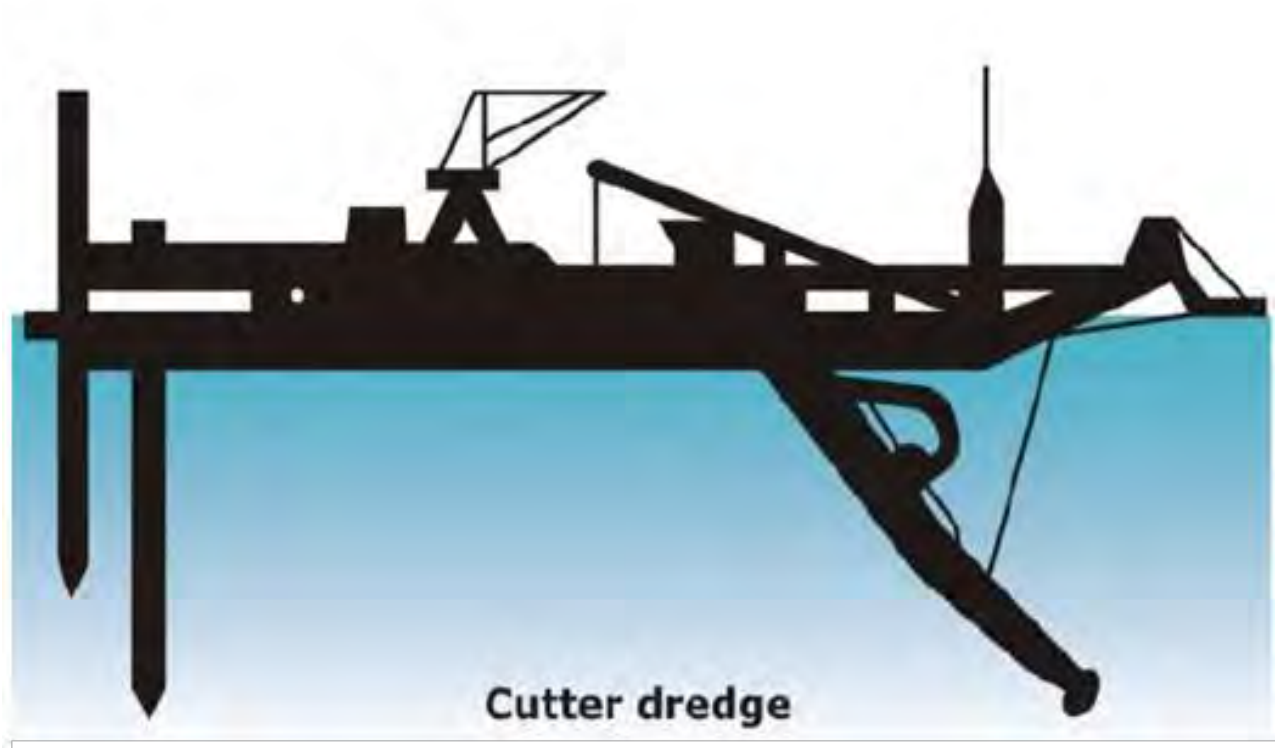


Figure 2-4 Cutter suction dredger (Vasblom, 2003)

2.4.1.2 Backhoe dredger

Dredging of rock is expected to be undertaken with a BHD due to its ability to 'rip' the capstone present in the dredge area. The majority of this material will be reused as core material in construction of the breakwaters, causeway and boat ramp. BHDs are mechanical dredgers that use a hydraulic arm and bucket system to excavate material from the sea floor. The dredger is fixed in place during dredging works using a number of spuds driven into the seabed, preventing movement due to wind, waves and currents. BHDs are capable of achieving precise finished level but are limited in achievable dredge depth and have relatively slower production rates when compared to hydraulic, suction-based dredgers. The BHD will unload dredged rock onto barges for handling and transport onshore (see **Figure 2-2**). **Figure 2-5** shows a backhoe dredge with spuds fixed and mid grab.

Figure 2-5 Backhoe dredger

2.4.1.3 Long-reach excavator

There is potential for a portion of the dredging area to be dredged by a land-based long reach excavator. Such equipment is likely to be operating as part of the overall project and this would be at the discretion of the contractor. The actions and effects of a long-reach excavator would be comparable to a BHD, without the marine mounting barge.

2.4.2 Schedule Constraints

The works are to adhere to the following time constraints:

- Dredging activities are limited to daylight hours between 7am and 7pm;
- Dredging activities are to include a pause during slack tide of 60 minutes (to avoid excessive sediment plume concentrations); and
- BHD and CSD may operate simultaneously, noting that certain areas require removal of marine sediments prior to dredging of rock by BHD.

2.5 Dredge Material Management

Dredging can lead to physical effects such as increased suspended sediment concentration and sedimentation, at both the dredging and disposal site. These effects have been modelled in detail in the *Sediment Transport Report* (Cardno, 2022b) and their potential impacts to the environment are discussed further in **Section 4**, below.

Dredged sediment will be disposed of at an offshore location shown in **Figure 2-2**. The spoil ground location was determined through analysis of benthic habitat mapping, bathymetry, hydrodynamic conditions and plume modelling. The offshore disposal site is located approximately 1.2 km north east of the dredge site with an average depth of -13.5 mAHD. Current speeds at the site are relatively high, reaching approximately 1.5 m/s in a spring tide ebb flow and 0.5 m/s in a spring tide flood flow - favourable conditions for the dispersal of sediment through the water column. Benthic habitat mapping shows the disposal site to be above sponge habitat with seagrass to the north and bare sediment to the south (Galaiduk et al, 2019).

Dredged caprock is to be transferred onshore directly from the backhoe dredger or via barge, dependant on dredging location. Dredged rock will be assessed onshore to determine its suitability for reuse in breakwater cores. If suitable, rock can then be transferred to a stockpile or directly to the breakwater cores.

Once material has been deposited on land, its handling is considered to be covered by the project's *Draft Construction Environmental Management Plan* (CEMP) (Cardno, 2022e).

3 Environmental Setting

3.1 Climate

Darwin has a tropical climate with distinct wet and dry seasons and a similar average maximum temperature throughout the year. The driest period of the year, with an average of approximately 5 mm of monthly rainfall on average, is between May and September. The extreme temperature range at Darwin airport station is between 10.4 °C and 38.9 °C. Mean annual maximum and minimum temperature at the Darwin Airport station are 32.1 °C and 23.2 °C, respectively. The average temperature of the sea ranges from 25.8 °C in July to 31.5 °C in December.

The wet season is associated with tropical cyclones and monsoon rains. The majority of rainfall occurs between December and March (the southern hemisphere summer), when thunderstorms are common and afternoon relative humidity averages over 70 percent during the wettest months. The dry season runs from about May to September, during which nearly every day is sunny, and afternoon relative humidity averages around 30%.

3.2 Wind Conditions

The average wind speed at Darwin Airport is relatively constant throughout the year, ranging from 6.7 m/s in April to 7.7 m/s in January and February. The average annual wind speed is 7.2 m/s. The maximum wind speeds during the wet season (1st of November to 30th of April) are generally higher than those during the dry season (1st of May to 31st of October). This is to be expected due to the cyclonic activity and tropical lows that occur during the wet season. The wind direction also varies throughout the year, displaying a seasonal variation. The winds are predominantly from the west to north (270-360 °N) from the start of September to the end of February (spring and summer) and predominantly from the east to the south east (90-135 °N) from the start of March to the end of August (Autumn and Winter). The months of March, August and September show the transition from the easterly winds to the westerly winds. This variation in winds is consistent with the formation of the Indo – Australian monsoon. See **Figure 3-1** for seasonal wind roses.

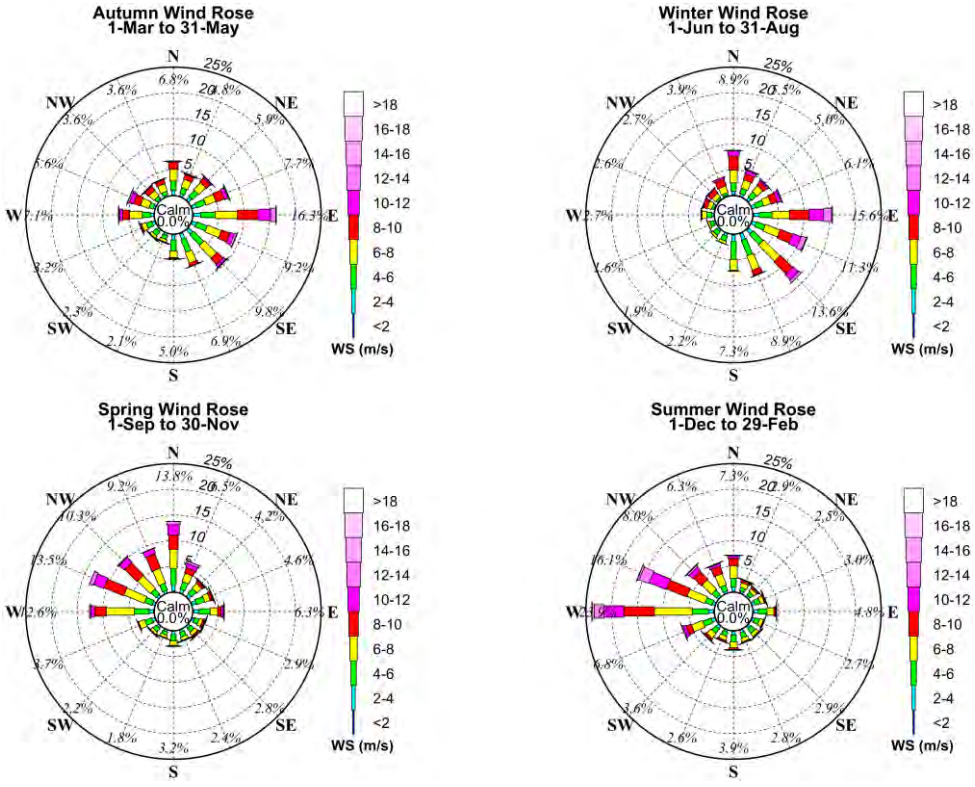


Figure 3-1 Seasonal wind roses based on Darwin airport wind data (1985 to 2019)

3.3 Metocean Climate

3.3.1 Water Levels

Coastal water levels in the study area are dominated by the astronomical tide. Tides in Darwin Harbour are semi-diurnal, which means the location experiences two high tides and two low tides per day. Tidal planes for Darwin Harbour (National Tides Centre, pers. comm 2020) are presented in **Table 3-1**, relative to Australian Height Datum (AHD) and Chart Datum (CD).

Table 3-1 Tide planes for Darwin Harbour (National Tides Centre, 2020)

Tidal Plane	Level (m, CD)	Level (m AHD)
Highest Astronomical Tide (HAT)	8.17	4.07
Mean High Water Springs (MHWS)	7.05	2.94
Mean High Water Neaps (MHWN)	5.13	1.02
Mean Sea Level (MSL)	4.24	0.13
Australian Height Datum (AHD)	4.10	0.00
Mean Low Water Neaps (MLWN)	3.34	-0.76
Mean Low Water Springs (MLWS)	1.42	-2.68
Lowest Astronomical Tide (LAT)	-0.01	-4.11

3.3.2 Waves

Wave conditions at Mandorah are governed by two simultaneously occurring sets of wave conditions:

- Longer period oceanic swell waves from the Beagle Gulf that penetrate into the Darwin Harbour (Mandorah project area); and
- Shorter period local wind waves generated locally by winds blowing across Darwin Harbour.

An annual wave rose for Mandorah is provided in **Figure 5-6**.

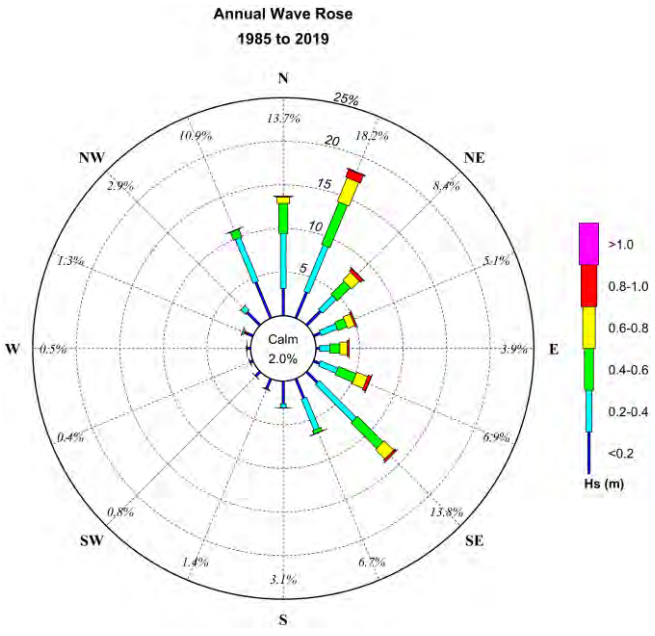


Figure 3-2 Annual total wave rose at Madorah site (1985 to 2019)

The following wave conditions are present at the site:

- Swell waves typically approach the site from the north to north east, however wind sea waves approach the site from different directions, ranging from north-north-west to south-east.
- The seasonal distribution of swell waves is almost the same throughout year, but the wind sea waves typically approach the site from the north-north-east to south east during autumn and winter, and from the north-north-west to north-north-east during spring and summer.

3.3.3 Cyclones

Being close to equator, much of the Northern Territory coastline is in a region where cyclones tend to form. This can be advantageous, as a cyclone forming near the coast will often cross the coast before it has a chance to substantially intensify, however, this also reduces available warning time. Tropical cyclones in the region mostly form from lows within the monsoon trough, between November and April. There are on average 7.7 days per season when a cyclone exists in the Northern Territory Region. The north western Gulf of Carpentaria near Gove has the highest concentration of cyclone days. The Gulf of Carpentaria averages two cyclones a year, while the Arafura and Timor Seas average one a year. Cyclones in the Gulf of Carpentaria move very erratically, whereas those in the Arafura and Timor Seas tend to follow more regular tracks to the southwest. Over half the cyclones generated in the Northern Region move either southwest or southeast into adjoining regions.

3.3.4 Currents

The major causes of currents in the Darwin harbour are the tides. Typically, in the vicinity of the site, currents are directed towards the north during an ebb tide and towards the south during a flood tide. Generally, ebb currents are stronger than flood currents. Ebb tidal currents are predicted to reach up to 1.1 m/s during a spring tide and flood currents approach 0.4 m/s. Vector plots of peak flows for flood and ebb, during the spring tides, are provided in **Figure 3-3**.

3.3.5 Water Quality

Baseline water quality, in terms of turbidity or suspended sediment concentration, is well understood at the project site, with monitoring being conducted continuously at Mandorah for over 2 years during the INPEX Nearshore Environmental Monitoring Program (Inpex Browse, 2011a). Changes to suspended sediment concentrations at the site are associated with tidal flow, wave action and seasonal rainfall runoff from Woods Inlet. Background concentrations have been considered when modelling sediment transport processes and are detailed in the *Sediment Transport Report* (Cardno, 2022b).

Ongoing water quality monitoring of Darwin Harbour is undertaken by the Department of Environment, Parks and Water Security's (DEPaWS) Aquatic Health Unit. The water quality monitoring has been ongoing since 2009 and includes the following categories/parameters:

- Algae – Chlorophyll-a;
- Dissolved Oxygen;
- Water Clarity – Turbidity (NTU); and
- Nutrients – Filterable Reactive Phosphorus, Ammonia as N and NO_x.

Supplementary parameters include:

- Salinity;
- Temperature; and
- pH.

Mandorah lies within 'Zone 5 – Middle Harbour' for the monitoring program, which was reported as 'very good for all parameters except nutrients ('good') for the annual 2020 report card (DEPaWS, 2022). Historically, water quality has been reported as 'very good' overall for the zone, sporadically dropping to 'good'. None of the field monitoring locations are in close proximity to the project location.

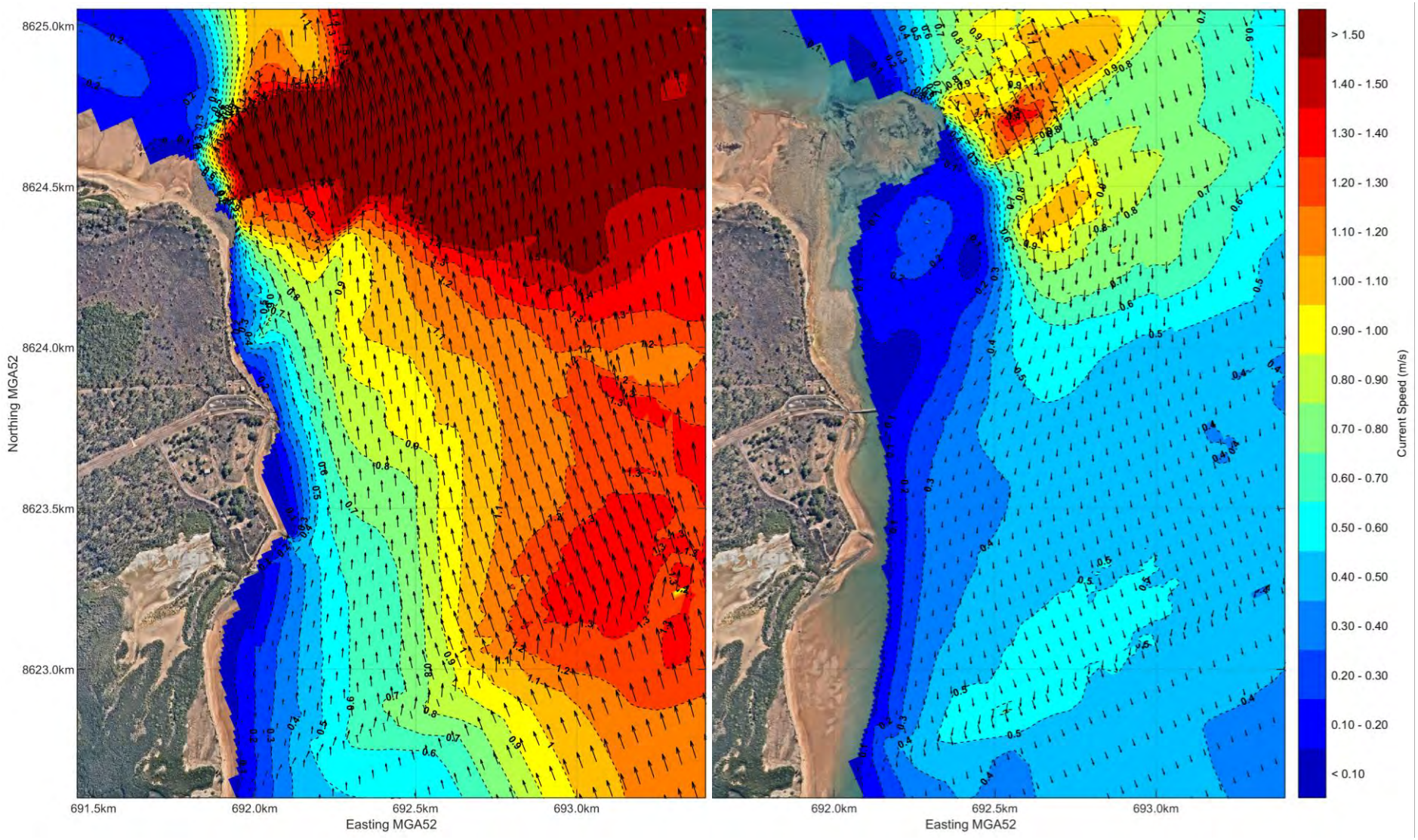


Figure 3-3 Spring tide ebb (left) and flood (right) flow vector plot

3.4 Bathymetry

In 2017, a hydrographical survey was undertaken of the project site area by Astute Surveying. The hydrographic survey covered the marine area footprint of the proposed facility. The nearshore area of the site is relatively flat and shallow (approximately LAT or -4 m AHD) for approximately 150m offshore. After this flat, intertidal area the seabed drops off steeply into deeper water.

The proposed marine facilities are within the shallow intertidal region of Darwin Harbour. Whilst Darwin Harbour is greater than 20 m deep in the main channel, the footprint of the main breakwater extends to approximately -4 m AHD with the dredge footprint (access channel) extending to approximately -7 m AHD. Bathymetry is presented in **Figure 3-4**.

3.5 Geology

Previous geotechnical investigations, and geotechnical investigations and seismic refraction survey undertaken as part of this project (as detailed in the *Geotechnical Investigations Report* [Cardno, 2022g]) have been interpreted to develop a preliminary geological site model (**Figure 3-5**).

Geological observations of the site are as follows:

- A thin Porcelanite 'shelf' (generally 1 to 1.5 metres thick, up to 3 metres thick) is present at the surface of the site's nearshore area, extending offshore to where the seabed bathymetry is between -3.2 m AHD and -3.4 m AHD;
- Underlying this caprock is weathered rock that should be relatively easy to dredge and will also be suitable for reuse as core fill. A portion of the underlying geology may comprise softer materials;
- There is a small portion of the site that may contain high strength rock to depth; and
- Directly offshore (east) of the edge of the Porcelanite shelf is a deep layer of soft muds / marine deposits, extending from the seabed surface to depths between -6 m AHD and -9 m AHD.

3.5.1 Marine Sediments

Detailed assessment of the physical and chemical properties of sediments sampled in the project area are found in the *SAP Implementation Report* (Cardno, 2022d).

3.5.1.1 Profile Description

- There is limited marine bed sediment in the area, the deepest refusal depth for push coring was 0.8 metres and for most sample locations the refusal depth was less than 0.5 metres;
- Field observations did not identify any visual signs of contamination;
- Field observations noted unconsolidated sediment largely as marine SAND, dark grey; and
- Field pH testing reported material between 8.7 and 9.1 (alkaline).

A summary of the laboratory results of sediment chemical testing is presented in the following sub-sections.

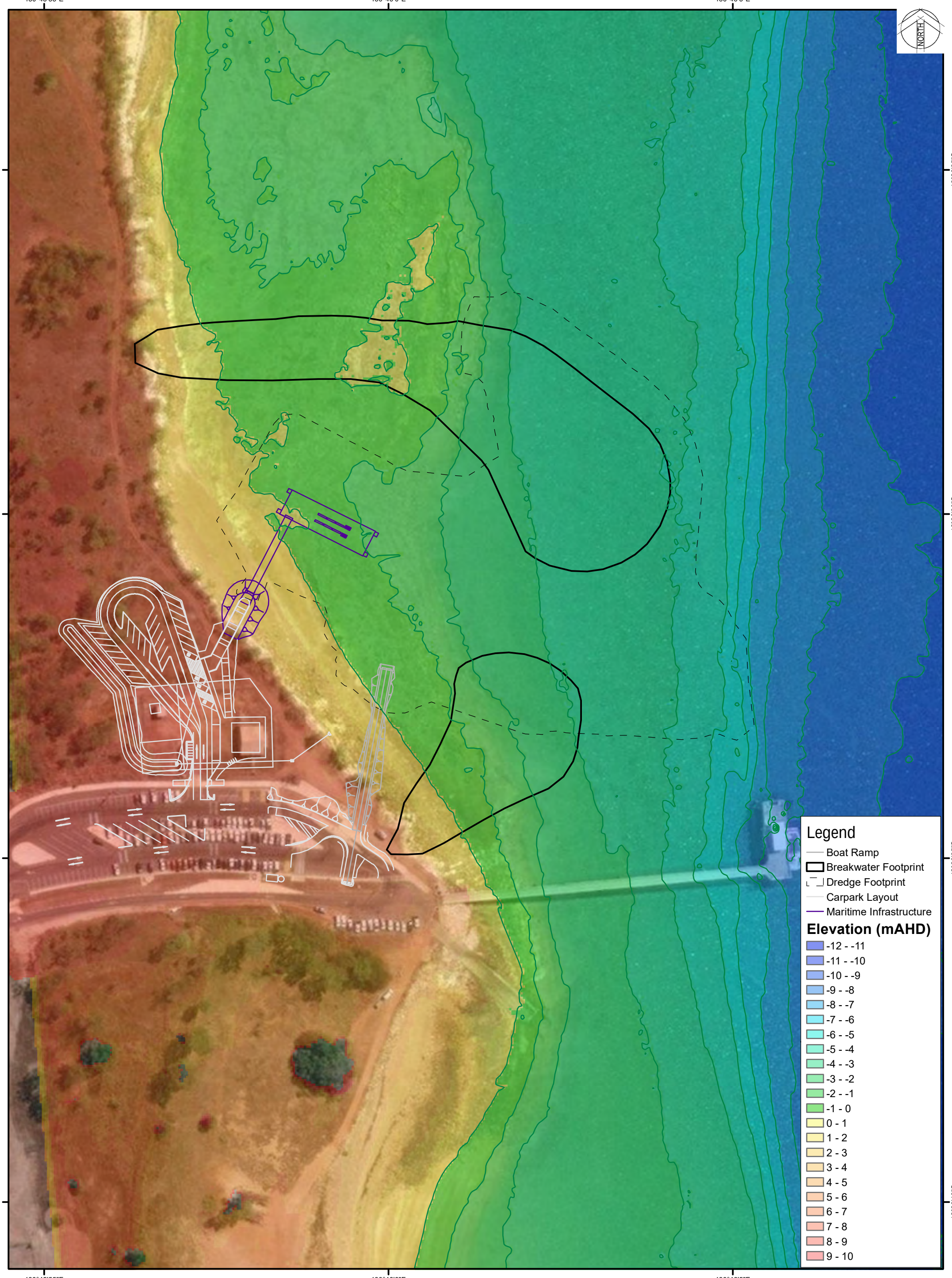
3.5.1.2 Sediment Quality

A dedicated sediment quality sampling campaign was undertaken, based on the guidance prescribed in NAGD (2009) with respect to the proposed dredge area and volume. A total of nineteen (19) sediment quality cores were advanced to a maximum depth of 0.8 m below the seabed, with a full range of contaminants of potential concern (CoPC) analysed for by NATA accredited laboratories. Initial testing showed elevated concentration of TBT at one site within the dredge footprint. Further sampling and analysis around this site demonstrated that it was an isolated event, rather than representative of a contamination hotspot.

The sampling and analysis concluded that the unconsolidated layer of soft sediments, overlaying natural geological material, is considered to be 'clean' and, therefore, suitable for open ocean disposal. The underlying geological material is considered 'clean natural material', suitable for the intended reuse as core material for the breakwaters.

130°45'55"E
130°46'0"E
130°46'5"E
12°26'25"S
12°26'30"S
12°26'35"S
12°26'40"S

NORTH



Legend

- Boat Ramp
- Breakwater Footprint
- Dredge Footprint
- Carpark Layout
- Maritime Infrastructure

Elevation (mAHD)

- -12 - -11
- -11 - -10
- -10 - -9
- -9 - -8
- -8 - -7
- -7 - -6
- -6 - -5
- -5 - -4
- -4 - -3
- -3 - -2
- -2 - -1
- -1 - 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10

Cardno

Date
22/12/2021

Size
A3

Scale
1:1,500

0 12.5 25 50 m

SITE TOPOGRAPHY AND BATHYMETRY

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 3-4

130°45'55"E
130°46'0"E
130°46'5"E
12°26'25"S
12°26'30"S
12°26'35"S

NORTH

Porcelanite caprock to approximately 1.5m below seabed. Weathered rock anticipated below this

Approximate extent of porcelanite shelf

Area potentially contains high strength rock to depth

Soft alluvial mud between -5m and -9m

Main Breakwater

Boat Ramp

Lee Breakwater

Area potentially contains softer materials below porcelanite

Legend
- Dredging Footprint
- New Infrastructure
- Bathymetry mAHD

Cardno

Darwin, Northern Territory

Date
1/12/2021

Size
A3

Scale
1:1,500

0 50Meters

PRELIMINARY GEOLOGICAL SITE MODEL

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 3-5

3.6 Marine Ecosystems

A detailed assessment of marine ecosystems in the region and relevant to the project site is provided in the *Marine Environment Report* (Cardno, 2022c), with information derived from both desktop review and field investigations. Key components of the marine ecosystem are detailed in the sub-sections below.

3.6.1 Benthic Communities and Habitats

A benthic communities and habitats (BCH) map has been developed for the project area and surrounds (**Figure 3-6**). The map contains a combination of field mapped BCH within the project footprint and near vicinity and recently developed interpreted BCH mapping (Galaiduk, 2019). The mapping demonstrates the presence of:

- An assemblage of very low-density seagrass lies within the direct project footprint;
- An assemblage of low-density seagrass lies in close proximity, directly to the north of the project footprint;
- Significant coral coverage is present to the north, north east of the project footprint; and
- Assemblages of sponges and mixed filter feeders are present in the vicinity of the project footprint.

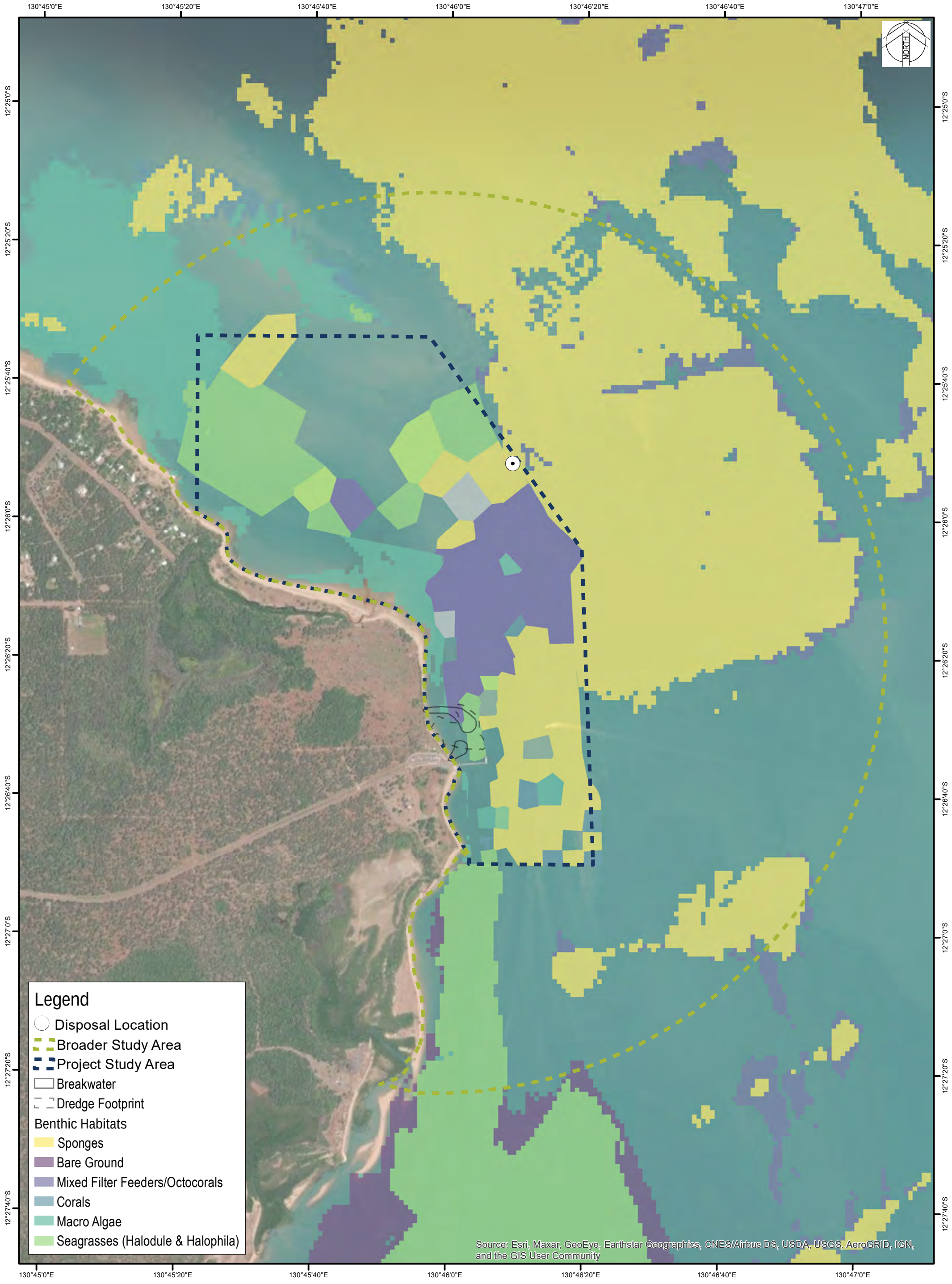
BCH mapping suggests that the following sensitive environmental receptors will be, or have the potential to be, impacted by the project:

- Seagrasses (*Halodule* and/or *Halophila*); and
- Corals.

3.6.2 Marine Fauna

Hundreds of species of marine fauna have the potential to be present in the project area. The species that require further environmental risk assessment ('species of concern') for the project are those that are listed as Threatened or Migratory and have moderate to high likelihood of occurring in the study area (refer to *Marine Environment Report* [Cardno, 2022c]). **Table 3-2** lists these species and their listed status. Specifically, these species identified include:

- 20 species of Migratory bird, seven of which are Threatened;
- The Green Sawfish (*Pristis zijsron*), listed as Threatened and Migratory;
- The Dugong (*Dugong dugon*), listed as Migratory;
- Three Migratory species of dolphin:
  - Australia Snubfin Dolphin (*Orcaella heinsohni*);
  - Indo-pacific Humpback Dolphin (*Sousa chinensis*); and
  - Indian Ocean Bottlenose Dolphin (*Tursiops aduncus*);
- Four species of Threatened and Migratory turtle:
  - Green Turtle (*Chelonia mydas*);
  - Hawksbill Turtle (Eretmochelys imbricata);
  - Olive Ridley Turtle (*Lepidochelys olivacea*); and
  - Flatback Turtle (*Natator depressus*); and
- The Saltwater Crocodile (*Crocodylus porosus*), listed as Migratory.



Cardno

Perth, Western Australia.
(08) 9273 3888

Date
6/12/2021

Size
A3

Scale
1:15,000

BENTHIC HABITAT MAP (BROADER STUDY AREA)

MANDORAH MARINE FACILITIES
DRAFT DSDMP
FIGURE 3-6

0 300Meters

Table 3-2 Marine species of concern for the project

Scientific name	Common name	EPBC Act	TPWC Act
Birds			
Actitis hypoleucos (M)	Common Sandpiper	-	-
Arenaria interpres (M)	Ruddy Turnstone	-	-
Calidris acuminata (M)	Sharp-tailed Sandpiper	-	-
Calidris alba (M)	Sanderling	-	-
Calidris canutus (T, M)	Red Knot	E	V
Calidris ferruginea (T, M)	Curlew Sandpiper	C	V
Calidris melanotos (M)	Pectoral Sandpiper	-	-
Calidris tenuirostris (T, M)	Great Knot	C	V
Charadrius leschenaultia (T, M)	Greater Sand Plover, Larger Sand Plover	V	V
Charadrius mongolus (T, M)	Lesser Sand Plover, Mongolian Plover	E	V
Charadrius veredus (M)	Oriental Plover, Oriental Dotterel	-	-
Fregata ariel (M)	Lesser Frigatebird, Least Frigatebird	-	-
Hirundo rustica (M)	Barn Swallow	-	-
Limosa lapponica baueri (M)	Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed	V	V
Limosa limosa (M)	Black-tailed Godwit	-	-
Numenius madagascariensis (T, M)	Eastern Curlew, Far Eastern Curlew	C	V
Numenius phaeopus (M)	Whimbrel	-	-
Pandion haliaetus (M)	Osprey	-	-
Pluvialis squatarola (M)	Grey Plover	-	-
Sternula albifrons (M)	Little Tern	-	-
Tringa nebularia (M)	Common Greenshank, Greenshank	-	-
Fish, Sharks & Rays			
Pristis zijsron (T, M)	Green Sawfish, Dindagubba, Narrowsnout Sawfish	V	V
Mammals and Cetaceans			
Dugong dugon (M)	Dugong	-	-
Orcaella heinsohni / brevirostris (M)	Australian Snubfin Dolphin, Irrawaddy Dolphin	-	-
Sousa chinensis (M)	Indo-Pacific Humpback Dolphin	-	-
Tursiops aduncus (M, C)	Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	-	-
Reptiles			
Chelonia mydas (T, M)	Green Turtle	V	-
Crocodylus porosus (M)	Salt-water Crocodile, Estuarine Crocodile	-	LC
Eretmochelys imbricata (T, M)	Hawksbill Turtle	V	V
Lepidochelys olivacea (T, M)	Olive Ridley Turtle, Pacific Ridley Turtle	E	V

Scientific name	Common name	EPBC Act	TPWC Act
Natator depressus (T, M)	Flatback Turtle	V	DD

Key:

C = Critically endangered, DD = Data deficient, E = Endangered, LC = Least concern, N = Near Threatened, V = Vulnerable, *EPBC Act:* M = Migratory, T = Threatened

3.6.3 Invasive Marine Pests

Marine pests are plants or animals that are not native to a region, usually introduced from overseas, that have a significant impact on our marine industries and environment. Marine pests can grow or reproduce quickly and out-compete other native species by preying directly on them or competing for food. The most common way marine pests are introduced is via boats and other large vessels, either attached to the submerged surfaces of ships ('biofouling') or in the ballast water carried by modern vessels to maintain stability. Marine pests considered a significant threat to NT waters include:

- Asian bag mussel (*Arcuatula senhousia*);
- Asian green mussel (*Perna veridis*); and
- Black-striped mussel (*Mytilopsis sallei*).

These species are found overseas in countries frequently visited by boats that travel to the NT (NT Government 2021). The black-striped mussel is of particular concern as it invaded Darwin Harbour marinas in 1999 but was successfully eradicated. The mussel spreads on the hulls and in the internal seawater plumbing of commercial or recreational vessels and multiplies rapidly to form dense groups that can reduce local biodiversity. It can also cause fouling on wharves, marinas and seawater systems, and can damage marine farms.

Marine pests were surveyed extensively as part of the INPEX Nearshore Monitoring Program (2012 – 2014), however, the only pest species detected were a few individuals of the Asian green mussel, reported in 2012.

3.7 Social Environment and Communities

There are two communities in proximity to the project site, Wagait and Belyuen, with small commercial operations including the Wagait Beach Supermarket and Cox Country Club. The resident population of Cox Peninsula is estimated at around 600 people. Commercial opportunities are currently limited due to poor potable water supply infrastructure and the area's isolation. Previously, the Mandorah Beach Hotel operated to the south of the site, approximately 350 m from the jetty, from the 1970s until it's closure in 2013.

3.7.1 Ferry Operations

The Mandorah Ferry, operated by Sealink, services the area with at least a dozen ferry services per day, with more frequent servicing in the morning and afternoon for patrons to get to and from work and school. The service is essential for many Cox Peninsula residents to complete everyday activities in Darwin.

3.8 Cultural Heritage

Aboriginal sacred sites exist directly to the south of the project site which are protected under the *Northern Territory Sacred Sites Act* (1989). DIPL has received an Authority Certificate from the Aboriginal Areas Protection Authority (AAPA) for works associated with the Project (**Appendix C**). The Authority Certificate identifies two Restricted Works Areas (RWA's) that protect known Aboriginal Sacred Sites. Both sites and RWAs are located on land south of the existing jetty.

- Registered Sacred Site 5073-81, protected by RWA1;
- Sacred Burial Site 5073-42A, protected by RWA2; and
- Recorded Sacred Site 5073-42B.

The defined RWAs have the following conditions:

- *RWA1* – No works shall take place or damage can occur within this area; and
- *RWA2* - No ground disturbing works is permitted beyond the depth of 600mm.

Recorded and registered sacred sites also exist to the north of the project area, associated with water flows from the tidal creek approximately 500 metres to the north of the project site. One of these is located in the nearshore zone and should be avoided (including buffer zone) as part of the project. The zones were depicted above in **Figure 2-2**.

The proposed project area does not intersect any sites listed under the NT Heritage Register. Nearby heritage sites include World War II Gun Emplacements at Wagait Beach and the Delissaville (Belyuen) Cemetery. Although not listed, the existing Jetty itself is considered by many local residents to have heritage value. The project does not plan to impact the jetty.

4 Environmental Risk Assessment

4.1 Risk Assessment Framework

An environmental risk assessment has been carried out for the project to meet the requirements of the *EP Act* and to inform self-assessment under the *EPBC Act*. This overall project risk assessment is detailed in the *Environmental Referral Report* (Cardno, 2022a). The NT EPA's environmental factors have been used to determine project actions with the potential to impact the environment. Factors have been developed to improve certainty and transparency within the environmental impact assessment process and have been grouped into five themes; Land, Water, Sea, Air and People. Themes, and underlying factors, relevant to dredging and disposal actions are listed in **Table 4-1**.

Table 4-1 Relevant NT EPA environmental factors for dredging and disposal

Theme	Factor	Environmental Objective
SEA	Marine environmental quality	*Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.*
	Marine ecosystems	*Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.*
PEOPLE	Cultural heritage	*Protect sacred sites, culture and heritage.*
	Human health	*Protect the health of the Northern Territory population.*

A risk assessment has been carried out under each environmental factor, identifying:

- Environmental aspect;
- Risk pathway(s);
- Potential impacts;
- Likelihood, consequence and derived risk rating;
- Risk management and mitigation measures; and
- The residual risk rating and level of certainty for this.

The full environmental risk assessment table is provided in **Appendix B** and the assessment is discussed in detail in the *Environmental Referral Report* (Cardno, 2022a). A summary of the table, for environmental aspects relevant to dredging activities, is provided below in **Table 4-2**. The nature of these environmental risks, and the investigations undertaken to inform the risk assessment, are summarised in the sub-sections below.

Table 4-2 Risk assessment summary table relevant to dredging and disposal actions

Environmental Aspect	Risk Pathway(s)	Potential Impacts	Risk Rating	Risk Management / Mitigation	Residual Risk Rating
Environmental Factor: Marine Environmental Quality					
Disturbance of marine sediments (fines)	Dredging actions, spoil transfer and disposal, rock placement and piling	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	**High**	> Model dredging and disposal actions to properly understand dredge plume dispersion > Gain an understanding of sensitive marine environmental receptors and their tolerance > Control actions to maintain water quality below appropriate thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.)	**Low**
Release of contaminants from marine sediments	As per actions above - predominantly dredging and disposal	> Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	**Medium**	> Characterise material to be disturbed to understand locations and levels of contamination > Assess levels of contamination against appropriate thresholds, given the nature of the receiving environment > Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	**Low**
Introduction of contaminants/pollution to marine environment	Construction activities - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	**Medium**	> Inspection / audit / washdown of vessels and plant, outlined in DSDMP and CEMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	**Low**
Environmental Factor: Marine Ecosystems					
Dredger/vessel movement	> Vessel strike of marine fauna such as dugongs, turtle, dolphins > Underwater noise impacts due to dredging and piling	> Vessel strike of marine fauna > Injury to marine fauna > Damage to ecosystems	**Medium**	> Vessel movement controls, speed limits, no-go zones > Marine fauna observation and avoidance > Piling controls (soft start) to allow fauna to leave area	**Low**

	> Direct impact to seabed - marine ecosystems				
Dredging	Direct removal of benthic communities and habitat	Permanent removal/destruction of BCH such as seagrass and coral	**Very High**	> Characterise BCH in direct impact footprint Minimise footprint and avoid sensitive receptors/important BCH where possible	**High**
Dredging	Elevated suspended sediment concentration (turbidity) in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	**Low**
Dredging	Sedimentation of seabed in vicinity of project	Impact to sensitive BCH such as coral and seagrass (smothering)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.).	**Low**
Dredge spoil disposal	Elevated suspended sediment concentration (turbidity) at disposal site	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging disposal controls and reactive monitoring to maintain levels below thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.).	**Low**
Dredge spoil disposal	Sedimentation of seabed at disposal site	Impact to sensitive BCH such as coral and seagrass (smothering)	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna	**Low**

				> Implement dredging controls and reactive monitoring to maintain levels below thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.).	
Environmental Factor: Culture & Heritage					
Cultural heritage sites / artefacts	Dredging, disposal and associated actions	Disturbance of known or unknown cultural heritage areas during dredging	**Medium**	> Gain understanding of cultural heritage of the site and establish no work areas around heritage sites > Response and reporting procedures should a site or object be encountered	**Medium**
Environmental Factor: Human Health					
Dredging and disposal of contaminated sediments	> Disturbance/release during extraction, transport and placement stages > Release to the marine environment following placement, then bioaccumulation and biomagnification in the food chain	> Dermal contact > Inhalation > Ingestion	**Medium**	See management measures relating to marine environmental quality. These apply to risk to humans also, with risk to human health considered a lower risk.	**Low**
Dredging and disposal of fine sediments	Disturbance/release during extraction, transport and placement stages	> Dermal contact > Inhalation	**Medium**	> Sediments to remain wet or be contained as part of disposal > Segregation of work area and material from general public	**Low**

4.2 Marine Environmental Quality

4.2.1 Marine Sediment Quality

Marine sediments in the dredging footprint were comprehensively sampled and analysed for physical and chemical properties as per the guidance of the National Assessment Guidelines for Dredging (NAGD, 2009). The investigation is detailed in the *SAP Implementation Report* (Cardno, 2022d). The investigation led to the following findings:

- All concentrations of metals and metalloids for the site were below all assessment criteria for offshore and onshore disposal of sediments;
- Two locations returned a concentration of Tributyltin (TBT) above the limit of reporting (LOR) – one of these was outside of the proposed dredge footprint;
- The 95% UCL for Tributyltin corrected for 1% TOC (9.5 µg/kg), for samples collected within the proposed dredge footprint, marginally exceeded the NAGD low screening level of 9 µg/kg;
- No other samples recorded concentrations of organotin compounds above the LOR;
- Additional investigations at 12 samples sites surrounding the site with elevated TBT found all to be below the LOR. This suggested the previous detection was an isolated occurrence, not representative of a contamination hotspot. The recalculated 95% UCL for TBT, incorporating the additional sampling, was well below the NAGD low screening level;
- No organic compounds were detected, with all BTEX, TRH, PAH and organochlorine pesticide concentrations were below their respective LORs in all samples; and
- Two samples were found to have Net Acidity values above the recommended management action criteria (Simpson et al., 2018) for the dredging of sands to loamy clays; > 1000 tonnes.

Given a low CSD dredge spill rate (see *Sediment Transport Report* [Cardno, 2022b]) the potential for contaminants in sediments resuspended during dredging or in the dredge return water to bio-accumulate in aquatic organisms is considered negligible. Additionally, only low levels of contamination were recorded, the potential for the proposed works to increase the risk to aquatic biota over a long period is considered to be very low.

Analysis shows that PASS is present at the site and likely to be present in surface-level seabed sediments rather than in those at depth. It should be conservatively assumed that all sediments within the top 0.5m contain PASS and be managed as such. It should be noted that when saturated the opportunity for oxidisation of dredged material is negligible as the available supply of oxygen necessary for a significant rate of acid formation is too low.

The required investigations into the contamination status of unconsolidated marine sediment to be dredged by the project has been undertaken, finding it suitable for offshore disposal. This, combined with the relatively small volume and proposed dispersion method, indicates that risk to marine environmental quality associated with sediment chemistry is low.

4.2.2 Marine Water Quality

Changes to marine water quality, in terms of elevated turbidity/SSC have been modelled based on the proposed dredging and disposal actions. The methodology and results of this are presented in detail in the *Sediment Transport Report* (Cardno, 2022b). Typically, the elevated turbidity is predicted to be short-term (temporary) and limited to the near-field. The peak total suspended solids (TSS) concentrations, above background, for dredging during spring and neap tides (95% exceedance) are presented in **Figures 4-1** and **4-2**, respectively.

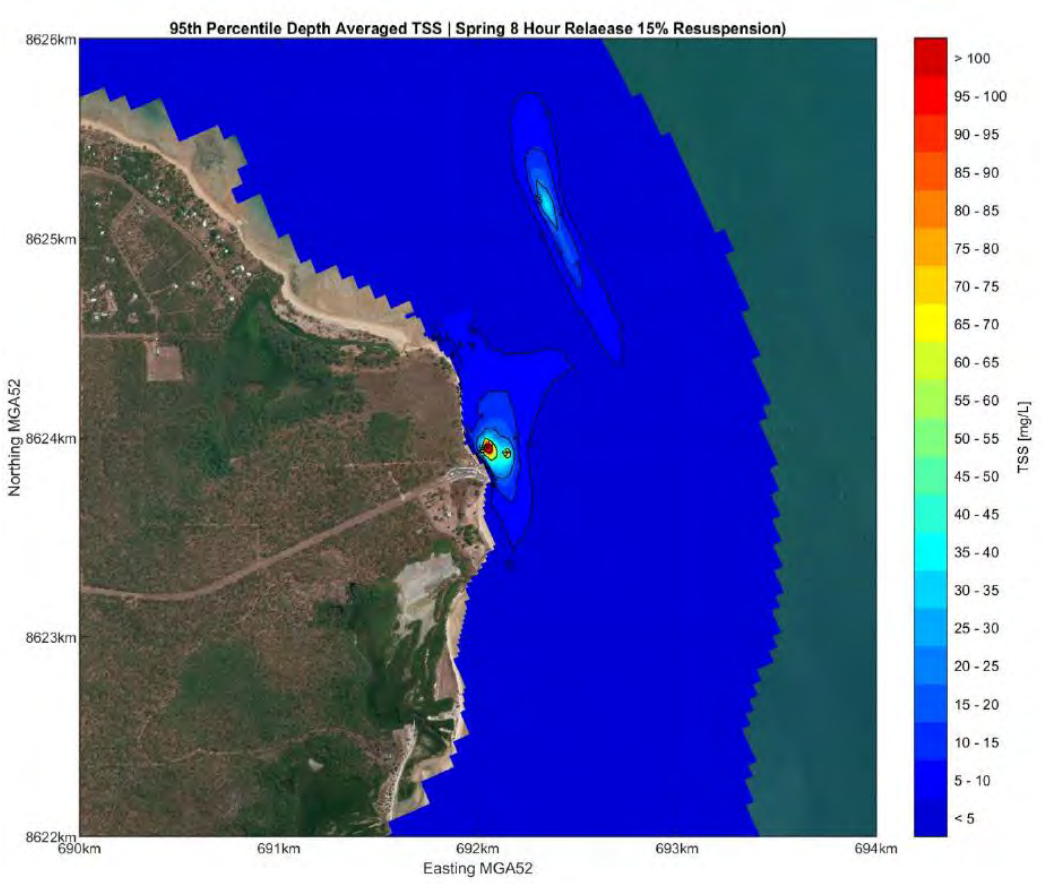


Figure 4-1 95th percentile TSS (depth-averaged) concentration – spring tides

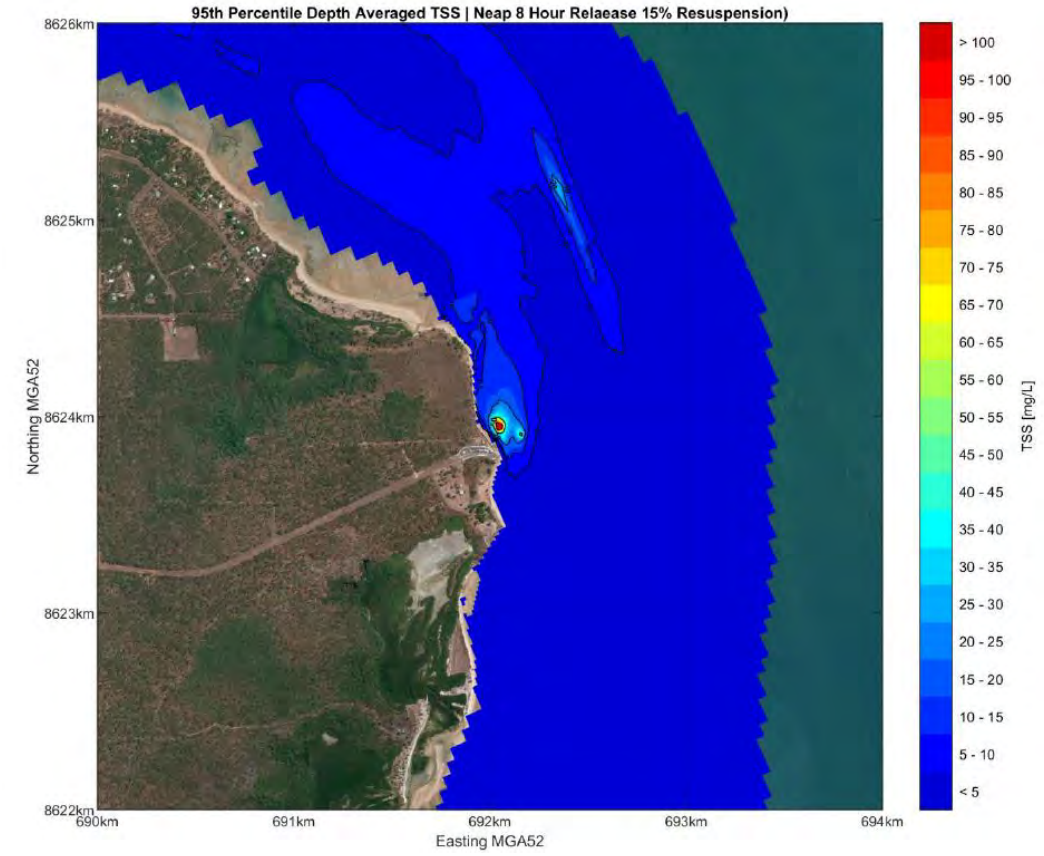


Figure 4-2 95th percentile TSS (depth-averaged) concentration – neap tides

Overall, magnitudes of suspended sediment concentrations are greater at the dredge site when compared to the disposal site. For all scenarios, 95th percentile suspended sediment concentrations of greater than 50 mg/L are localised within the dredge footprint. This outcome is mainly attributed to the fact that current speeds in those areas are relatively low, so the suspended fine sediment does not disperse, and remains within the project area until the dredging works stop for the day. To understand the level of environmental risk associated with modelled dredge plume dispersion, sensitive environmental receptors and their tolerance must be understood. This is discussed in the next sub-section.

In general, however, modelling indicates that changes to physical water quality (turbidity) associated with dredging is likely to be comparable to natural variability in background turbidity, for all areas outside of the dredge footprint and immediate point of disposal.

4.3 Marine Ecosystems

4.3.1 Impacts to Benthic Communities and Habitats

4.3.1.1 Modelled Zones of Influence and Impact

Dredge plume modelling was interpreted with respect to the NT EPA's (2013) requirement of assessing potential impacts of dredging on the marine environment. The assessment requires a spatially-based zonation scheme described by the Western Australian (WA) EPA (2016), which acts as a common basis when describing predicted extent, severity and duration of impacts due to dredging. The three zones each represent a level of impact as outlined by WA EPA (2016) and are described below:

- Zone of High Impact (ZoHI) "is the area where impacts on benthic communities or habitats are predicted to be irreversible";
- Zone of Moderate Impact (ZoMI) "is the area within which predicted impacts on benthic organisms are recoverable within a period of five years following the completion of the dredging activities"; and
- Zone of Influence (ZoI) "is the area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the dredging operations, but where these changes would not result in a detectible impact on benthic biota".

In order to determine the three zones of influence, thresholds for sedimentation and turbidity due to dredging activities are required. Adopted thresholds have been developed based on ambient turbidity conditions monitored at Mandorah across a 2.5-year period, as part of the INPEX Ichthys Nearshore Environmental Monitoring Program (INPEX Browse, 2014).

Typically, dredge plume modelling calculates TSS above background concentrations, to account for this, median background concentrations from baseline data have been subtracted from thresholds, resulting in thresholds for TSS of 11 mg/L during Dry season and 49 mg/L during Wet Season. Thresholds for real-time monitoring of dredging and disposal activities have also been derived from turbidity data at Mandorah (see **Section 6.1.2**).

The zones have been calculated for the project and are presented, considering seasonality, tides and the distribution of BCH, in **Figure 4-3** to **4-6**. Various plots are necessary to define zones during both Wet and Dry Season (due to very different background concentrations), as well as during neap and spring tide (due to different hydrodynamic dispersion). Full details of the calculation of these zones are detailed in the *Sediment Transport Report* (Cardno, 2022b).

Sediment deposition has also been modelled, with results indicating negligible deposition (< 2mm) outside of the direct project footprint (see Cardno, 2022b). As such, the key risks to BCH due to dredge plume dispersion are those associated with TSS/turbidity.

130°45'45"E
130°46'0"E
130°46'15"E
12°25'45"S
12°26'0"S
12°26'15"S
12°26'30"S
NORTH

Legend

- Breakwater
- Project Footprint
- Offshore Disposal Area (sediments)
- >2.5mm Sediment Deposition Zone
- ZoHI (Project Footprint & Buffer)
- ZoHI
- ZoMI
- ZoI

Benthic Habitats

- Sponges
- Bare Ground
- Mixed Filter Feeders/Octocorals
- Corals
- Macro Algae
- Seagrasses (Halodule & Halophila)

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
16/12/2021

Size
A3

Scale
1:5,000

0 50 100 150 200 Meters

IMPACT MAP - NEAPTIDE & DRY SEASON

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 4-3

130°45'45"E
130°46'0"E
130°46'15"E
12°25'45"S
12°26'0"S
12°26'15"S
12°26'30"S
NORTH

Legend

- Breakwater
- Project Footprint
- Offshore Disposal Area (sediments)
- >2.5mm Sediment Deposition Zone
- ZoHI (Project Footprint & Buffer)
- ZoHI
- ZoMI
- ZoI

Benthic Habitats

- Sponges
- Bare Ground
- Mixed Filter Feeders/Octocorals
- Corals
- Macro Algae
- Seagrasses (Halodule & Halophila)

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
16/12/2021

Size
A3

Scale
1:5,000

0 50 100 150 200 Meters

IMPACT MAP - NEAPTIDE & WET SEASON

MANDORAH MARINE FACILITIES

DRAFT DSDMP

FIGURE 4-4

130°45'45"E
130°46'0"E
130°46'15"E
12°25'45"S
12°26'0"S
12°26'15"S
12°26'30"S
NORTH

Legend

- Breakwater
- Project Footprint
- Offshore Disposal Area (sediments)
- >2.5mm Sediment Deposition Zone
- ZoHI (Project Footprint & Buffer)
- ZoHI
- ZoMI
- ZoI

Benthic Habitats

- Sponges
- Bare Ground
- Mixed Filter Feeders/Octocorals
- Corals
- Macro Algae
- Seagrasses (Halodule & Halophila)

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
16/12/2021

Size
A3

Scale
1:5,000

0 50 100 150 200 Meters

IMPACT MAP - SPRING TIDE & DRY SEASON

MANDORAH MARINE FACILITIES
DRAFT DSDMP
FIGURE 4-5

130°45'45"E
130°46'0"E
130°46'15"E
12°25'45"S
12°26'0"S
12°26'15"S
12°26'30"S
NORTH

Legend

- Breakwater
- Project Footprint
- Offshore Disposal Area (sediments)
- >2.5mm Sediment Deposition Zone
- ZoHI (Project Footprint & Buffer)
- ZoHI
- ZoMI
- ZoI

Benthic Habitats

- Sponges
- Bare Ground
- Mixed Filter Feeders/Octocorals
- Corals
- Macro Algae
- Seagrasses (Halodule & Halophila)

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
16/12/2021

Size
A3

Scale
1:5,000

0 50 100 150 200 Meters

IMPACT MAP - SPRING TIDE & WET SEASON

MANDORAH MARINE FACILITIES
DRAFT DSDMP
FIGURE 4-6

4.3.1.2 Impact to Benthic Communities and Habitats

There are two key factors that determine the potential scale of plume dispersion impact to BCH from dredging and disposal actions. As can be seen in **Figures 4-3** to **4-6**, these are:

- The seasonal timing of the dredging and disposal actions - wet season or dry season. This is due to the substantially different natural/background turbidity during these two seasons; and
- Whether or not the actions occur during neap tides or spring tides. This is due to the strength of currents and their ability to disperse suspended sediment. This factor is significant at the dredging site, but does not have a strong influence on zones of impact at the disposal site.

Seasonality has the most significant influence on these zones of impact and, as such, environmental risk is discussed separately in the sub-sections below.

4.3.1.2.1 Dry Season

As the ZoIs are calculated against average background suspended sediment concentrations, their extents and severities are highest during the dry season, when ambient turbidity levels are low. For dredging and disposal actions during neap tides (**Figure 4-3**), ZoIs are centred around the dredging and disposal areas, as expected, and also develop in the nearshore areas to the north of the site. The lower tidal current speeds during neap tides lead to elevated suspended sediment concentrations in these shallow areas, compared to during spring tides (**Figure 4-4**).

During both tidal cycles, substantial ZoHI and ZoMI develop at the dredging and disposal sites, which pose a risk to sensitive receptors that have been identified in the vicinity of the project, such as seagrasses (*Halodule* and/or *Halophila*) and corals. However, the zones do not intersect significant portions of these benthic communities, as identified in BCH mapping. The impact is distributed primarily across areas identified as ‘sponges’, ‘bare ground’ and ‘macro algae’. There is a small portion of seagrass directly to the north of the direct project footprint (northern breakwater) that is predicted to be impacted by the ZoMI during both spring and neap tides.

As the dispersion modelling predicts ZoHI and ZoMI to be generated by the dredging and disposal actions, and sensitive environmental receptors such as corals and seagrass are known to be present at the site, environmental risk is initially considered to be high. Given that BCH investigations have demonstrated the majority of the ZoI does not intersect sensitive environmental receptors (owing also to the careful selection of the disposal site) and the relatively short duration of CSD dredging and disposal (≈10 days), residual environmental risk is considered moderate. With additional controls, such as water quality monitoring with appropriate thresholds for reactive changes to dredging and disposal activities, the risk from these actions may be considered low.

4.3.1.2.2 Wet Season

During the Wet Season, the ZoI for dredging and disposal actions undertaken in either neap or spring tides (**Figure 4-5** and **4-6**, respectively) is predicted to be fully contained within the direct project footprint. The concentrations of suspended sediment expected to be generated by the project actions during the wet season, outside of the dredge footprint, are small relevant to background concentrations. The perception of the changes to water quality by sensitive receptors outside of the dredge area and at the disposal site are, therefore, predicted to be negligible. As such, risk to BCH from dredging and disposal plume dispersion undertaken during Wet Season, outside of the direct impact footprint (where removal of BCH is expected), is predicted to be low.

Undertaking dredging and disposal activities during the Wet Season only may be considered as a control to minimise environmental risk from these actions.

4.3.2 Marine Fauna

Potential impacts to marine fauna from dredging and disposal actions are described in the following sub-sections.

4.3.2.1 *Underwater noise impacts*

Sounds and vibrations emitted from vessels and piling activities are transmitted through seabed sediments and the water column, and they might be perceived by marine fauna within a certain distance from the construction site.

Based on the existing information, underwater noise can effect marine animals in a number of ways, including (i) behavioural responses, (ii) masking, (iii) stress and physiological responses, (iv) hearing loss and damage to auditory tissues, (v) structural and cellular damage of non-auditory tissues and total mortality, (vi) impairment of lateral line functions and (vii) particle motion-based effects on eggs and larvae (Popper and Hastings, 2009; Popper et al., 2014).

Death and injury can result from exposure to very high amplitude sounds. In addition, the effects of changes in pressure (barotrauma) must also be considered, especially for impulsive sounds (e.g. Stephenson et al., 2010; Halvorsen et al., 2011, 2012a, 2012b). Rapid changes in pressure can cause blood gases to come out of solution. In fish, rapid pressure changes can also cause gas volumes (i.e. swim bladders) to expand and contract rapidly, thereby damaging surrounding tissues and organs, and sometimes causing rupture of the swim bladder itself.

Piling is considered to be a much higher risk in terms of underwater noise than dredging and disposal activities. As such, risk management associated with piling is considered sufficient to mitigate underwater noise risk associated with dredging also (refer to *Draft CEMP* ([Cardno, 2022e]). Risk of underwater noise to marine fauna from dredging and disposal actions, with appropriate monitoring and management, is considered low.

4.3.2.2 *Direct impact/collision from vessel plant and equipment*

There is a risk of impact to marine fauna, such as dugong and turtles (dolphins being unlikely) during the movement and operation of dredging plant and support vessels. The risk of such impacts is generally minimised by observation and avoidance procedures. E.g. any marine mammal or reptile observed within 100 metres of the dredging operations (high-risk area) would trigger the stop-work procedure until the animal has moved at least 200 metres away from the high-risk area or has not been seen for at least 20 minutes.

It should be noted that dredging plant and their actions are relatively slow, lowering the risk of impact in comparison to fast moving vessels. Risk of direct impact to marine fauna from dredging and disposal actions, with appropriate monitoring and management, is considered low.

4.3.2.3 *Impacts of turbid water*

Although species show variable responses to elevated turbidity that are species-dependent and that fish may avoid the area during construction, the mechanical or abrasive action of elevated turbidity may be harmful to suspension feeders, clogging their feeding apparatus and impairing respiratory and excretory function. However, given that natural levels of turbidity are also very high, plumes would be expected to affect a very small area of soft sediment infauna and epifauna relative to the extent of these habitats in Darwin Harbour. Further, any affected soft sediment biota would recover through natural recruitment of biota within months once construction had finished. Hence, any losses of biota would be temporary and amount to a minor localised impact.

Impacts to marine mammals and reptiles can be avoided with the inclusion of a marine mammal and reptile spotting program during dredging that includes a stop-work procedure upon sighting marine mammal and reptile activity (as described above). Risk of impact to marine fauna from changes to water quality is considered low.

4.3.3 Invasive Marine Species

The potential for introduction of invasive marine species arises when marine vessel and plant are imported from other areas where such species exist. These risks may or may not be present for the project, depending on the plant to be used.

Management of such risks is also not generally the responsibility of the project, but is covered by relevant territory inspection and quarantine requirements. Nevertheless, the project should be aware of such risks and ensure proper import procedures have been adhered to by all equipment operating on the project. The environmental risk associated with invasive marine species for the project is likely to be low.

4.4 Cultural Heritage

Sites of known aboriginal cultural heritage and significance have been identified for the project and permissible work areas (including the dredging footprint, have been captured in an Aboriginal Areas Protection Authority (AAPA) Certificate, provided in **Appendix C**, or defined as exclusion zones for the project (see **Figure 2-2**). Strict avoidance of the restricted work areas (RWA) and exclusion zone will minimise the risk of impact. Only one of the sacred sites is in the marine environment (nearshore area to the north of the project site), with the potential to be impacted by dredging and disposal actions. Sedimentation at this site has been modelled as minimal (less than 2.5 mm) and predicted changes to suspended sediment concertation in the vicinity of the sacred site is expected to be isolated and temporary (i.e. during outgoing tide). Risk to known sacred sites associated with dredging and disposal actions is considered to be low.

There is a risk of encountering an object or area of significance as part of the dredging works. This is unlikely as the dredging area is known to be predominantly rock, with a thin layer of sediment overlain. Nevertheless, appropriate response and reporting of any such encounter is required to minimise risk.

4.5 Human Health

The risk to human health associated with dredging and disposal actions would be due to the release of both fine sediments and contaminated sediments. The potential for this has been detailed **Section 4.2** and **4.3**, with respect to risk to the marine environment. These can impact humans through primary contact and inhalation, or secondary uptake through bioaccumulation in the food chain. The risk of this is considered low, due to the following factors:

- Contaminant levels were found to be low and below relevant thresholds for human health risk;
- Fines will be released but these are to remain waterborne and be dispersed to low concentration rapidly by tidal currents; and
- The work areas are not expected to be in close proximity to the general public (although workers may be exposed).

5 Management Framework

To ensure the management objectives, identified in **Section 4** (see **Table 4-1**), are met, a management framework has been established. Adherence to the framework will be controlled by monitoring activities (see **Section 6**) and independent audit. The framework for managing operational and administrative aspects, as well as to manage risk to each environmental aspect, are detailed in the sub-sections below.

5.1 Operational Controls

5.1.1 Operational Management

Responsibility for the implementation of monitoring and management actions has been assigned to relevant parties. **Table 5-1** contains operational management targets and the details associated with each to ensure they are met. Operational controls for dredging and disposal should be further specified in the contractor's DDMP.

Table 5-1 Management actions to limit dredging to proposed footprint

Management Target	Management Actions	Responsibility	Reporting	Frequency
Dredging activities are confined to the proposed footprint and levels	Dredge vessel to navigate using on-board GPS with appropriate accuracy	Contractor	Navigation equipment inspection and testing	Prior to commencement of dredging operations
			Daily dredge planning	Daily, 24 hours prior in dredge log
			Weekly dredging forecast	Weekly 48 hours prior in dredge log
Dredging activities conform with monitoring and response requirements of *Draft DSDMP*	As defined in this *Draft DSDMP*	Contractor	Daily and weekly conformance reporting Trigger/incident response reporting	As stipulated
	Audit	Principal	Audit report, daily review	Daily

5.1.2 Daily Dredge Log

The dredging Contractor shall submit daily dredge logs to the site superintendent, capturing the previous day's works. Log sheets shall contain, but not be limited to, the following:

- Date;
- Vessel and operator name;
- Commencement and finish times, including breaks during day for slack water etc.;
- Dredged footprint and levels;
- Total production and average production rates;
- Disposal, location and rates;
- Safety incidents or near misses;
- Marine Fauna strikes or near misses;

- Water quality trigger exceedances;
- Significant delays;
- Adverse interactions with public;
- Any environmental incidents such as chemical spills, oil leaking etc.; and
- 48-hour look-ahead dredging plan.

5.1.3 Weekly dredge report

The dredging Contractor shall submit a weekly report to the site superintendent capturing the previous week's works. Reports shall contain, but not be limited to, the following:

- Operating dates and daily commencement and finish times, including breaks during day for slack water etc.;
- Dredged footprint and levels;
- Total production and average production rates;
- Total disposal and average production rates;
- Assessment of progress relative to overall campaign;
- Anticipated delays or changes to the dredge plan;
- Safety incidents or near misses;
- Marine Fauna strikes;
- Significant delays;
- Adverse interactions with public;
- Any environmental incidents such as chemical spills, oil leaking etc.; and
- Weekly look-ahead dredging plan.

The exact details and format of ongoing reporting will be confirmed in the contractors DDMP, must demonstrate reporting of adherence to the management framework and monitoring activities in this *Draft DSDMP*.

5.2 Marine Environmental Quality

Table 5-2 lists the management actions assigned relevant to marine environmental quality.

Table 5-2 Management actions to control impacts to marine environmental quality

Management Target	Management Action	Responsibility	Reporting	Frequency	Contingency
Measured SSC (NTU) concentrations remain within expected range and below exceedance thresholds for sensitive environmental receptors.	Real-time water quality monitoring at appropriate locations across dredging program.	Contractor	Real-time data available to principal. Daily dredge log noting average NTU and any exceedances.	Continuous Daily	Investigate against control monitoring site to determine if dredging/disposal related. Modify dredging activities. Reduce or cease dredging activities.
No pollution, waste discharge, chemical or oil spills associated with dredging and disposal	Vessel in survey and recently inspected Oil/pollution spill response plans in place Appropriate waste management system for all vessels	Contractor	Provision of vessel survey/inspection details Provision of dedicated waste management and incident response plans for all vessels	1 month prior to dredging	Immediately cease operation and commence oil spill response. Report and pollution or spill immediately to Harbourmaster.

5.3 Marine Ecosystems

Table 5-3 lists the management actions assigned relevant to marine ecosystems.

Table 5-3 Management actions to control impacts to marine ecosystems

Management Target	Management Actions	Responsibility	Reporting	Frequency	Contingency
No long-term impact to benthic communities (seagrass coral) outside of direct project footprint.	Real-time water-quality criteria are met at source and disposal site throughout dredging campaign. Compliance reporting.	Contractor	Real-time data available to principal. Daily dredge log noting average NTU and any exceedances.	Continuous Daily	Investigate against control monitoring site to determine if dredging/disposal related. Modify dredging activities. Reduce or cease dredging activities.

No death or injury to marine fauna or significant benthic communities due to direct impact/strike.	Marine fauna observation and avoidance procedures. Maintain vessels and plant in designated dredge area.	Contractor	Encounters to be noted in daily and weekly logs. Weekly dredge report detailing dredger/vessel paths and depths.	Daily / weekly or immediately if strike occurs.	Observer onboard to help sight marine fauna within 300 m of dredge vessel. Reduction in speed of dredge or cease, recommence once marine fauna has cleared.
No introduction of invasive species to Darwin Harbour.	Adherence to Commonwealth Department of Agriculture and Water Resources – Australian Ballast Water Management Requirements. National Biofouling Management Guidelines for commercial vessels.	Contractor	Cleaning report if overseas vessel. Evidence of previous vessel locations, loads and exchanges of ballast water.	Once off, preceding dredging.	Report known or suspected invasive species to Department of Agriculture, Water and the Environment (DAWE).

5.4 Cultural Heritage

Table 5-4 lists the management actions assigned to preserve cultural heritage.

Table 5-4 Management actions to control impacts to cultural heritage

Management Target	Management Actions	Responsibility	Reporting	Frequency	Contingency
No dredge plant, material or workers to enter RWAs or exclusion zone.	No works can occur south of the northern extent of RWA1, this will be implemented in the construction environmental management plan. Complete avoidance of exclusion zone for all vessels, plant and personnel.	Contractor	Breaches to be noted in daily and weekly logs. Vessel paths/logs to be provided.	Daily Immediately if breach.	Stop dredging activities for further investigation.
No damage or destruction of cultural/heritage artefacts within Darwin Harbour.	Immediate investigation if object/artefact encountered.	Contractor	Report detailing detected objects.	Immediately	Stop dredging activities for further investigation.

5.5 Human Health

Table 5-5 lists the management actions assigned to preserve human health.

Table 5-5 Management actions to control impacts to human health

Management Target	Management Action	Responsibility	Reporting	Frequency	Contingency
As per Marine Environmental Quality management actions.					

6 Monitoring Plan

6.1 Marine Water Quality Monitoring

6.1.1 Objectives

To ensure management objectives for Marine Environmental Quality are met, a water quality monitoring program is to be implemented. The program aims to quantify, in real-time, the elevation in suspended sediment concentrations that proposed dredging and disposal activities are contributing. Of particular interest is monitoring in the vicinity of sensitive receptors such as seagrass and corals.

6.1.2 Triggers and Frequency

Suspended sediment threshold levels will trigger responses for dredging activities to mitigate potential impact to sensitive receptors. Real-time turbidity monitoring is to be undertaken at (at least) hourly intervals, at a range of monitoring sites. Nephelometric Turbidity Units (NTU) readings can be used to approximate total suspended solids (TSS), which is not practicable to measure in real-time. Trigger values for TSS can be converted to NTU values (and vice versa) using the relationship developed by Cardno (2013) for Darwin Harbour, from extensive field observations.

Observed TSS versus observed NTU relationship

$$TSS = 0.5\ (-0.13,1.22) + 1.2\ (1.15, 1.30)\ NTU \quad ; R^2 = 0.87. \quad (1)$$

Trigger values have been calculated based on analysis of the long-term (2.5 year) water quality (turbidity) dataset collected at Mandorah during the Ichthys Nearshore Monitoring Program (the location of this monitoring site is included in **Figure 6-1**). The calculation of trigger thresholds assumes that sensitive receptors at the site will be tolerant to extremes in the natural TSS at the site, but will be stressed if there are excessive exceedances of these. The long-term dataset has been analysed to calculate (for distinct wet and dry season):

- 99th percentile concentrations (high intensity, individual exceedances);
- 95th percentile concentrations (frequency and duration exceedances);
- 90th percentile concentrations (frequency and duration exceedances); and
- Median (50th percentile) concentrations (background levels to subtract from exceedance levels).

These statistics, along with the average duration of exceedance, are presented in **Table 6-1**.

Table 6-1 Calculated TSS values for various percentiles at Mandorah – average exceedance duration in brackets (24-hour rolling mean)

Season	Median (50th percentile)	90th percentile	95th percentile	99th percentile
Wet season	7 mg/L	39 mg/L (127 hours)	56 mg/L (62 hours)	142 mg/L (89 hours)
Dry season	3 mg/L	11 mg/L (55 hours)	14 mg/L (31 hours)	18 mg/L (22 hours)

These levels and durations have been applied to develop TSS trigger levels (above background), for both wet season and dry season. These are presented in **Table 6-2**. It must be noted that turbidity measurements collected at Mandorah were near bed (1m above the bed), where levels are generally higher than the depth averaged turbidity (or TSS). As such, it is necessary to translate near bed measurements to depth-averaged measurements (which are output by dispersion modelling). A relationship for this was also developed during the INPEX Ichthys Project (Cardno, 2013). Note MESSC is equivalent to TSS.

$$MESSC = 1.0 \times Bottom\ NTU$$

130°45'45"E
130°46'0"E
130°46'15"E
12°25'45"S
12°26'0"S
12°26'15"S
12°26'30"S

NORTH

DIS01
DIS02
REF01
DRE01
DRE02

Legend

- Water Quality Monitoring Sites
- Maximum Modelled ZoI
- Maximum Modelled ZoMI
- Zone of High Impact
- >2.5mm Sediment Deposition Zone
- Offshore Disposal Area (sediments)
- Breakwater
- Dredge Footprint

Benthic Habitats

- Sponges
- Bare Ground
- Mixed Filter Feeders/Octocorals
- Corals
- Macro Algae
- Seagrasses (Halodule & Halophila)

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cardno

Darwin, Northern Territory

Date
20/01/2022

Size
A3

Scale
1:5,000

0 50 100 150 200Meters

WATER QUALITY MONITORING SITES

MANDORAH MARINE FACILITIES
DRAFT DSDMP
FGURE 6-1

Table 6-2 Proposed water quality triggers (24-hour rolling mean)

Trigger category	Dry Season	Wet Season
	NTU	**NTU**
Intensity	> 18 NTU (99th percentile)	> 56 NTU (95th percentile)
Duration	>14 NTU (95th percentile) over 2 consecutive days	> 39 NTU (90th percentile) over 5 consecutive days
Frequency	> 14 NTU (95th percentile) over >3 days per 5-day period	> 39 NTU (90th percentile) over >5 days per 6-day period

The data collected previously at Mandorah is considered to be a reliable baseline dataset, due to its long duration and high measurement frequency. However, the relationships developed between TSS and NTU, and between near bed NTU and depth averaged TSS, are based on data collected throughout Darwin Harbour. These relationships should generally be developed on a site-specific basis. It has therefore been recommended that initial monitoring activities collect data to refine these relationships and, therefore, the trigger values above. These monitoring activities are defined in **Table 6-3**.

A reference site has been incorporated so that trigger exceedances can be assessed against background (i.e. unaffected by dredging/disposal) levels (**Table 6-3**). Initial investigation should also be undertaken to determine if the reference site is representative of background levels at the trigger monitoring sites.

6.1.3 Monitoring Locations

Hourly measurements of turbidity are to be taken at a number of sites within and adjacent to dredging footprint and disposal site (**Figure 6-1** and **Table 6-3**). Locations of monitoring sites have been chosen considering calculated zones of influence as well as benthic habitat mapping, specifically considering locations of seagrass and coral colonies.

Monitoring instruments are to be installed a minimum of one month prior to the commencement of dredging allowing for verification, calibration (if needed) and background data to be recorded at each of the monitoring sites.

Table 6-3 Proposed water quality monitoring sites and details

Area	Site ID	Purpose	Parameters	Timing	Compare against	Easting	Northing
Dredging Area	DRE01	Measure turbidity levels in vicinity of dredging activities (north) and nearby sensitive receptors	Realtime turbidity Turbidity profiles and TSS samples	Hourly. Site established 1 month before dredging commences and demobilised 2 weeks after completion of dredging.	Triggers (see **Table 6-1**)	692081	8624146

				Collection of 10 TSS samples in first 24 hours of dredging (alongside profiles)	Develop site specific NTU vs TSS relationship		
				Collection of 5 profiles in first 24 hours of dredging (alongside samples)	Develop relationship between real-time monitoring depth and depth-averaged TSS/NTU		
	DRE02	Measure turbidity levels in vicinity of dredging activities (south) and nearby sensitive receptors	As above			692199	8623733
Disposal Area	DIS01	Measure turbidity levels in vicinity of disposal activities (north)	Realtime turbidity Turbidity profiles and TSS samples	Hourly. Site established 1 month before dredging commences and demobilised 2 weeks after completion of disposal.	Triggers (see **Table 6-1**)	692323	8625224
				Collection of 10 TSS samples in first 24 hours of disposal (alongside profiles)	Develop site specific NTU vs TSS relationship		
				Collection of 5 profiles in first 24 hours of disposal (alongside samples)	Develop relationship between real-time monitoring depth and depth-averaged TSS/NTU		
	DIS02	Measure turbidity levels in vicinity of	As above			692377	8625096

		disposal activities (south)					
Reference / Background	REF01	Provide background data for assessment of natural vs dredging/disposal induced triggers	Realtime turbidity	Hourly. Site established 1 month before dredging commences and demobilised 2 weeks after completion of disposal.	Monitoring sites Develop relationship between ambient conditions at reference site and at trigger sites.	691593	8624969

6.1.4 Response to Trigger Exceedance

Any observed trigger exceedances are to be included in the daily dredge log submitted to the Proponent the following day. An exceedance refers to a recording above the water quality triggers described in **Section 6.1.2** at any of the proposed dredging or disposal monitoring locations. Triggers are to be based on the 24-hour rolling mean. The real-time monitoring system should also have the trigger thresholds imbedded, with automated notification of an exceedance to both the contractor's and the principal's environmental representative. Should a trigger be exceeded, the following response is required:

- Immediately report trigger exceedance to Principal;
- Investigate background levels, data quality, dredging logs/activities and natural conditions to determine if trigger is genuine within 12 hours of exceedance; and
- If trigger is genuine, investigate changes to dredging and disposal activities that will avoid further trigger exceedance. Including:
  - Dredge in different area if related to dredging actions;
  - Dispose in different portion of disposal site if related to disposal actions;
  - Dispose on incoming or outgoing tide only, dependant on the location of exceedance; and
  - Increase designated dredging down-time at slack water to greater than 1 hour.
- If changes to dredge/disposal plans are not effective, discontinue dredging and disposal until the 24-hour rolling mean is below trigger levels – readings must satisfy that none of the trigger types are exceeded.

6.2 Marine Fauna Monitoring

6.2.1 Potential Impacts

Risk of interaction between dredging plant and protected species (and other fauna) within Darwin Harbour exists. Potential impacts include injury, death or behavioural changes. Marine mammals and reptiles are the most likely to be impacted due to their size, speed and reliance on acoustics. Whilst dredging, BHD and CSD remain stationary, travelling slowly between target dredge areas. Due to these operating speeds, risk of vessel strike of marine mammals is low, however, if a strike does occur, death or severe injury is possible (Todd et al., 2014).

Noise pollution from dredging activities has the potential to affect individuals and populations of marine mammals which rely upon acoustics for navigation, hunting and communication. Sound pollution with similar frequencies to those of marine mammals has the potential to temporarily or permanently damage hearing (temporary/permanent threshold shift), change the animals own acoustic signal or induce stress which can affect feeding and reproduction. Todd et al. (2014) notes that noise emitted from dredging is lower energy and unlikely to cause damage to marine mammal auditory systems but may cause behavioural changes.

6.2.2 Monitoring

To lessen the risk of vessel strike and impact to due to noise, it is required that a minimum of one crew member aboard the dredging vessel(s) hold an accreditation to act as a Marine Fauna Observer (MFO). Before the commencement of dredging, the crew member is responsible for undertaking a visual assessment. An exclusion zone of 300 m is to be maintained around the dredging vessel at all times for the following marine fauna:

- Dolphins;
- Whales;
- Turtles;
- Dugongs;
- Sawfish; and
- Sharks.

At half hourly intervals whilst dredging, a visual inspection is also required (dredging can continue through this time).

6.2.3 Frequency

Table 6-4 Visual assessment frequency

Stage	Timing	Responsibility	Observation Radius	Observation Duration
Pre-commencement	Preceding dredging	Contractor (MFO)	300 m	10 minutes
Whilst dredging	Every 30 minutes	Contractor (MFO)	300 m	5 minutes

6.2.4 Response to Sightings or Strikes

Any trigger exceedances are to be included in the daily dredge log submitted to the Principal the following day.

Table 6-5 Response to triggers

Trigger	Response	Cease response
Sighting of marine fauna including whales, sharks, dolphin, dugong, marine reptiles or sawfish within 300 m during transit.	Limit dredge vessel speed to 6 kn and report observance in daily log.	When MFO has sighted fauna leaving the 300 m zone.

Sighting of marine fauna including whales, sharks, dolphin, dugong, marine reptiles or sawfish within 300 m in the 30 minutes before commencing dredging and disposal.	Do not commence dredging.	No sighting within 300 m for 30 minutes.
Marine fauna strike	Halt dredging and report to injured wildlife number immediately. Report incident to DIPL to report to Department for Biodiversity, Conservation and Attractions and Department of Agriculture, Water and the Environment within 48 hours. Report in daily and weekly logs.	Appropriate care has been given to animal and MFO is confident there is no fauna within the 300 m zone. Corrective action undertaken to prevent further incidence.

6.3 Invasive Marine Species Management Framework

6.3.1 Objective

Minimise the risk of invasive species attached to the hull of a dredging vessel or in its ballast water system being introduced to Darwin Harbour.

6.3.2 Management Actions

Table 6-6 contains management options and triggers related to the transfer of invasive marine species by dredging vessels.

Table 6-6 Management actions for the prevention of invasive species

Trigger	Management Action
Any dredging works	• Determine vehicle risk of introducing invasive marine species due to previous dredging activities or movement referring to the National biofouling management guidelines for recreational vessels (Marine Pest Sectoral Committee, 2018). • Regular maintenance of vehicle including the application of biofouling paint within its recommended lifespan. • Maintenance of 10 km buffer between vessel and commercial oyster farms.
Dredger determined to be 'high risk' in risk assessment	• Vessel will require inspection, hull cleaning, dry docking and/or treatment of internal seawater systems dependant on reason for 'high' rating.
Dredger has been overseas	• If vessel has been procured overseas, it is required that it undergoes cleaning in dry-dock before arrival in Australia. • Ballast water from overseas waters must be exchanged at least 200 nautical miles from Australia's coastline in waters > 200 m deep (DAWE, 2020). • Ballast exchange much replace at least 95% of their volume via flow-through or emptying and refilling. To achieve this the IMO (2004) recommends that three times the capacity of ballast tanks is pumped through the system.

6.3.3 Reporting

The following reporting related to invasive marine species is required:

> Inspection report of dry-dock cleaning by specialised consultant (overseas vessels only) is to be submitted to the NT EPA before mobilisation of dredge; and

> Prior to mobilisation, logs detailing vehicle loads, exchanges or discharges of ballast water shall be submitted to the NT EPA.

6.3.4 Corrective actions

Should an invasive species be detected or is suspected, the following actions should be undertaken:

> Notification of the Department of Agriculture Water and the Environment (DAWE) including location of dredger when discovered, suspected species and sample of species; and

> Development of action plan to remove invasive species from vessel and any necessary remediation of the affected marine environment. Plan is to be drafted in consultation with DAWE.

7 Reporting

7.1 General

7.1.1 Daily Reporting

Daily reports (succinct) shall be provided by the Contractor to the Superintendent including:

- Dredge log, as per **Section 5.1.2**;
- Turbidity data recorded at monitoring locations for the 24-hr period preceding reporting, including 24-hour rolling mean (**Section 6.1**);
- Water quality triggers exceeded (**Section 6.1.2**);
- Encounters with marine fauna (**Section 0**); and
- Any changes to weekly dredge plan.

7.1.2 Weekly Reporting

Weekly reporting shall be provided by the contractor to the Superintendent including:

- Weekly dredge report, as per **Section 5.1.3**;
- Turbidity data recorded at monitoring locations for the one-week period preceding reporting, including 24-hour rolling mean (**Section 6.1**);
- Responses to any trigger level exceedances or marine fauna sightings;
- Discussion of marine fauna encountered (**Section 0**); and
- Any changes to overall dredge plan.

7.2 Compliance Monitoring

A Waste Discharge Licence (WDL) will be required for the disposal of soil material in Darwin Harbour. As the proponent of the dredging works, DIPL or its representative is responsible for the submission of any logs, reports or data required by the WDL to NT EPA. DIPL or its representative will also be responsible for reporting any non-compliance with the requirements of the WDL to NT EPA.

7.3 Public Complaints

Complaints by the public made to the Contractor are to be reported to the Superintendent in the daily dredging log with the following information:

- Date and time of complaint;
- Description of complaint;
- Complaint details (may be anonymous); and
- Perceived cause of complaint and proposed action, including complaint owner and action date.

The Superintendent is to determine the validity of the complaint, if deemed valid, the contractor is to initiate proposed action to complaint.

7.4 Summary of Reporting

Table 7-1 summarises required reporting associated with the dredging program.

Table 7-1 Summary of report

Reporting	Responsibility	Timing	Recipient	Content
General				
Daily reporting	Contractor	Daily	Principal	See **Section 5.1.2** and **7.1.1**
Weekly monitoring report	Contractor	Weekly	Principal	See **Section 5.1.3** and **7.1.1**
End of dredging phase reporting	Contractor	Within four weeks of the conclusion of dredging activities	Principal	Summary of dredging activities including footprint, levels, turbidity, exceedances, complaints and environmental and safety incidences.
Compliance reporting	Proponent	As per WDL	NT EPA	As per WDL.
Environmental Reporting				
Water quality data	Contractor	Ongoing, daily and weekly	Principal	Provision of and access to real-time data See **Section 6.1.4**
Water quality exceedance	Contractor	Daily	Principal	Description of trigger exceeded. See **Section 6.1.4**
Death or injury of a protected marine species	Contractor (MFO to assist)	Within 24 hours (with daily dredge log)	Principal	Time, location, species and statement from MFO. See **Section 6.2**
Dredger history	Contractor	Prior to mobilisation	NT EPA	Vehicle locations, loads, exchanges or discharges of ballast water. See **Section 6.3**
Dredger cleaning	Contractor	Prior to mobilisation (if overseas vessel)	NT EPA	Inspection and cleaning report. Statement from qualified inspector. See **Section 6.3**
Invasive species detection	Contractor	Immediately	DAWE	Time, location, suspected species, sample, remedial actions. See **Section 6.3**
Chemical, oil spills etc	Contractor	Immediately	24-hour spill report line	Time, location, substance, quantity, cause, clean up attempts.
		Within 24 hours (with daily dredge log)	Principal	

Complaints Reporting				
Complaints	Contractor	Within 24 hours (with daily dredge log)	Principal	See **Section 7.3**

8 Roles and Responsibilities

To ensure the objectives of this *Draft DSDMP* are met, defined roles and responsibilities for the Principal, Contractor and wider project team are listed in **Table 8-1**.

Table 8-1 Responsibilities

Position	Responsibilities
Principal (DIPL / NTG)	> Comply with the requirements of the *Draft DSDMP.* > Comply with all the legal requirements under the project's approval and relevant legislation. > Ensure environmental factor objectives are met. > Overall responsibility for the project. > Review of ongoing reporting and routine auditing of contractor. > Overall responsibility for complying with relevant legislation, standards and guidelines. > Engagement with stakeholders regarding environmental impacts and progress of dredging plan including reporting and monitoring.
Contractor(s)	> Comply with the requirements of the *Draft DSDMP.* > Comply with all the legal requirements under the project's approval and relevant legislation. > Ensure environmental factor objectives are met. > Complete dredging works as per technical specifications. > Completion of final DDMP incorporating management actions contained in this *Draft DSDMP.* > Compliance with monitoring and reporting requirements of DDMP. > Safety of staff, public and the environment. > Reporting daily/weekly reports, incidents, complaints to the relevant bodies.

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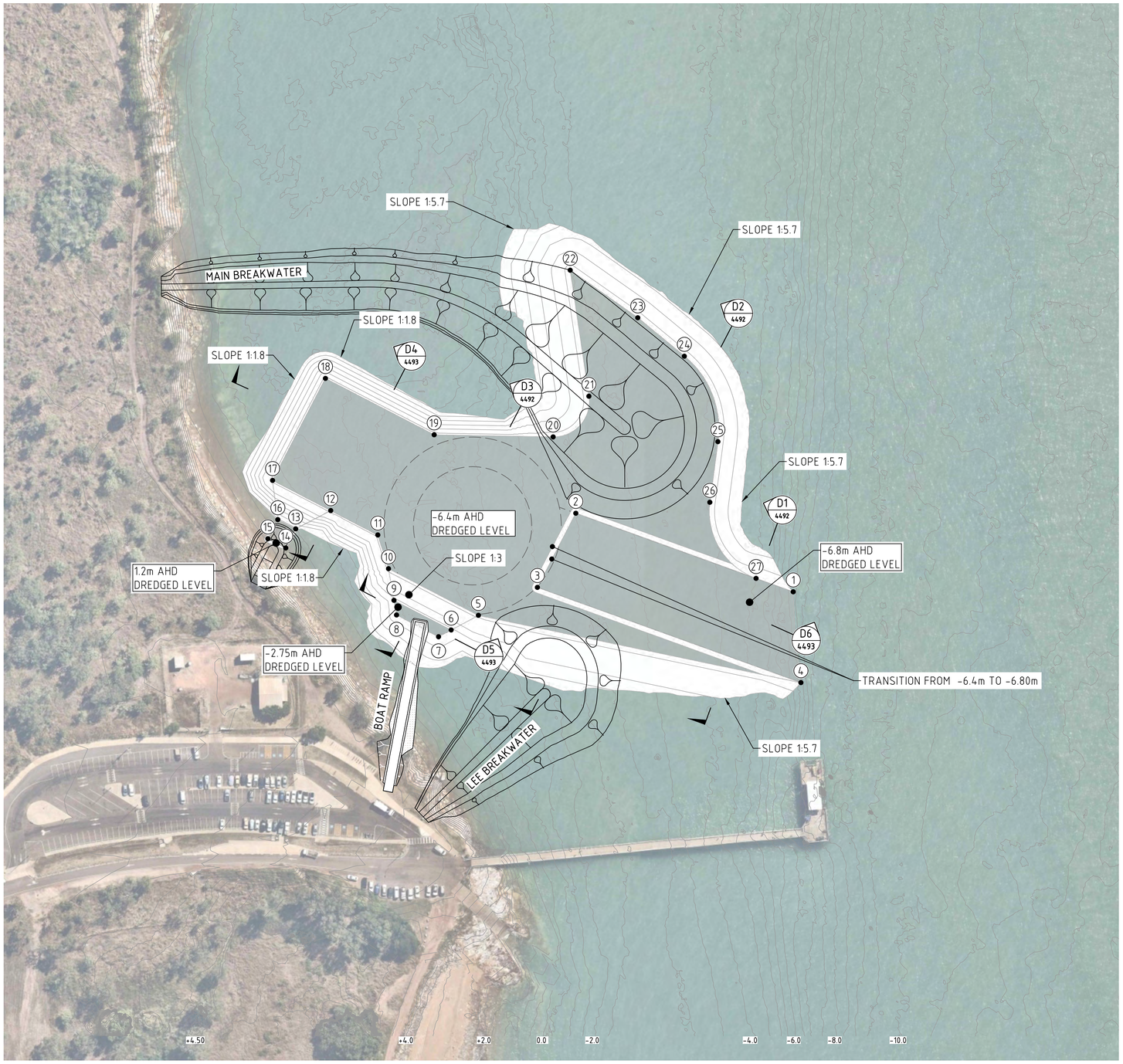
APPENDIX

A

DREDGING DESIGN DRAWINGS

PRINT IN COLOUR



DREDGED LAYOUT
SCALE A

IMAGE SOURCE: WWW.NEARMAP.COM, 2020

LEGEND

-4.0 EXISTING CONTOUR (0.5m) (BATHYMETRIC SURVEY)

NOTES:

1. BATHYMETRIC SURVEY CONTOURS SHOWN m AHD
2. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
3. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

DREDGE SETOUT POINTS

PT No.	EASTING	NORTHING	RL.
1	692183.168	8623912.273	-6.800
2	692091.253	8623945.494	-6.800
3	692075.007	8623914.150	-6.800
4	692186.403	8623873.888	-6.800
5	692050.091	8623902.330	-6.400
6	692038.568	8623896.139	-2.750
7	692033.232	8623893.272	-2.750
8	692015.476	8623902.475	-2.750
9	692014.401	8623908.664	-2.750
10	692012.079	8623922.032	-6.400
11	692007.550	8623936.307	-6.400
12	691987.662	8623946.614	-6.400
13	691972.844	8623938.886	1.200
14	691968.647	8623930.789	1.200
15	691961.101	8623934.700	1.200
16	691965.297	8623942.797	1.200
17	691963.069	8623959.361	-6.400
18	691985.421	8624002.488	-6.400
19	692031.380	8623978.668	-6.400
20	692081.678	8623977.759	-6.400
21	692096.787	8623994.957	-6.400
22	692088.886	8624048.230	-6.400
23	692117.449	8624028.127	-6.400
24	692137.134	8624011.880	-6.400
25	692151.323	8623975.753	-6.400
26	692147.912	8623950.126	-6.400
27	692167.452	8623917.953	-6.800

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No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

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Drawn	A.PEARCE	Date: 19/11/2021	
Checked	P.RODRIGUEZ	Date: 19/11/2021	
Designed	T.STEDMAN	Date: 19/11/2021	
Checked	R.AKROUSH	Date: 19/11/2021	
Design Project Leader	D.STRICKLAND	Date: 19/11/2021	
NTG Project Manager	S. DUNKERTON	Date: 19/11/2021	

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA
DREDGING LAYOUT

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	06 OF 24	R21-4491	0	A1

Version: March 2021

PLOTTED ON: 1/Dec/2021 3:31 PM
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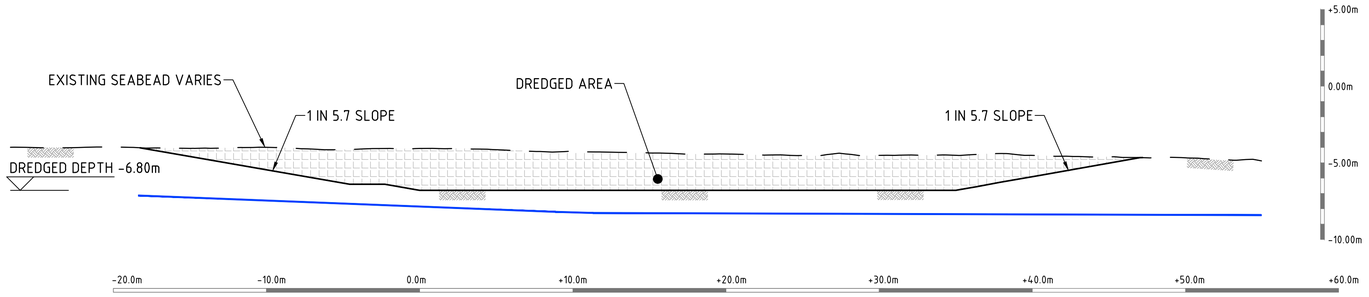
DATUM & TIDAL LEVELS

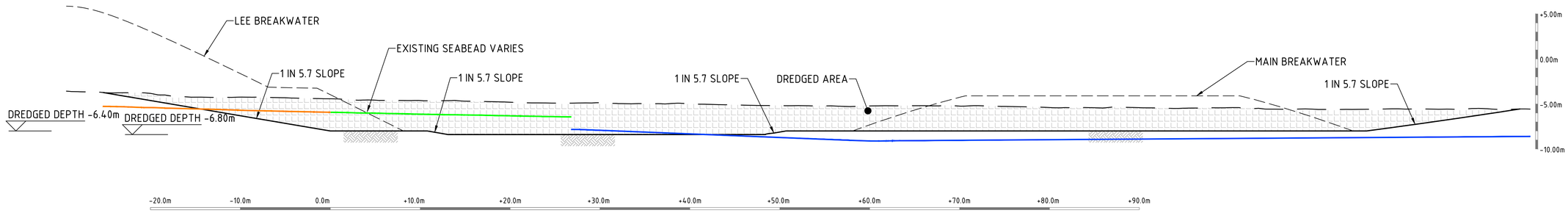
CD	AHD
8.17m (HAT)	4.07m
7.05m (MHWS)	2.94m
5.13m (MHWN)	1.02m
4.24m (MLS)	0.13m
4.105m (AHD)	0.00m
3.34m (MLWN)	-0.76m
1.42m (MLWS)	-2.68m
-0.01m (LAT)	-4.11m

LEGEND

- PORCELANITE CAPROCK (APPROXIMATELY 1.5m BELOW SEABED)
- POTENTIALLY CONTAINS HIGH STRENGTH ROCK BELOW PORCELANITE
- POTENTIALLY CONTAINS SOFTER MATERIALS BELOW PORCELANITE
- BASE OF SOFT ALLUVIAL MUD



SECTION D1
SCALE A 4491



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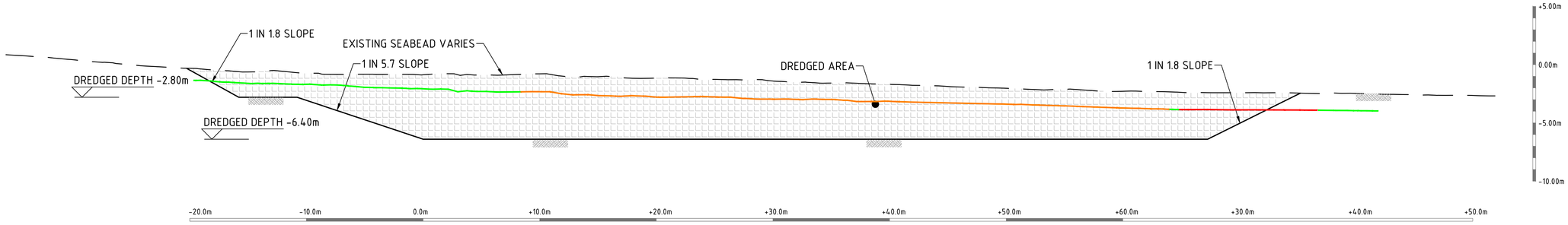

SECTION D3
SCALE A 4491

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SCALE 1:200 @A1

SCALE B
0 5 10 15 20 25m
SCALE 1:250 @A1

NOTES:

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

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Drawn: A.PEARCE Date: 19/11/2021	Checked: P.RODRIGUEZ Date: 19/11/2021
Designed: A.PEARCE Date: 19/11/2021	Checked: R.AKROUSH Date: 19/11/2021
Design Project Leader: D.STRICKLAND Date: 19/11/2021	NTG Project Manager: S. DUNKERTON Date: 19/11/2021

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA

DREDGING DETAILS - SHEET 1

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	07 OF 24	R21-4492	0	A1

Version: March 2021

PLOTTED ON: 1/Dec/2021 3:31 PM
USER: ASHLEY PEARCE
FILE LOCATION: C:\Users\Ashley.Pearce\Cardno\Mandorah Marine Facilities - Documents\Drawings\(1) ACAD\DWG\R21-4492.dwg

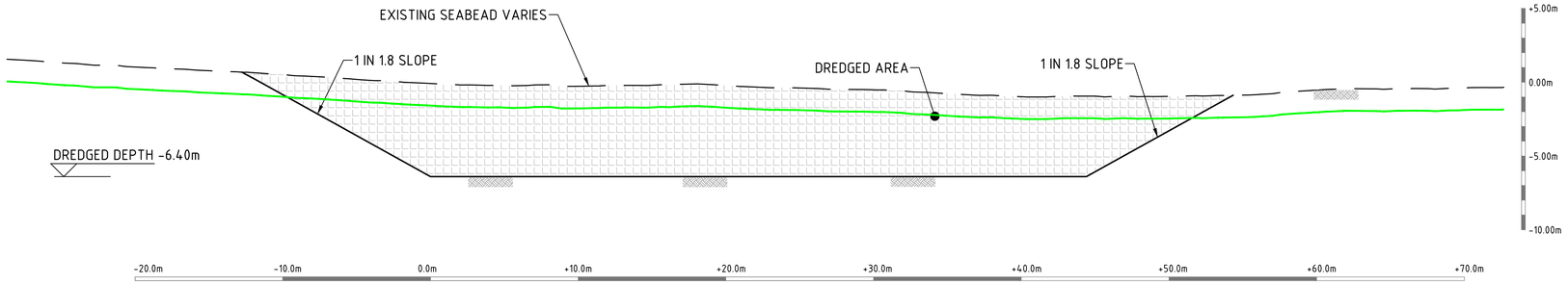
PRINT IN COLOUR

DATUM & TIDAL LEVELS

8.17m (HAT)		4.07m
7.05m (MHWS)		2.94m
5.13m (MHWN)		1.02m
4.24m (MLS)		0.13m
4.105m (AHD)		0.00m
3.34m (MLWN)		-0.76m
1.42m (MLWS)		-2.68m
-0.01m (LAT)		-4.11m
CD		AHD

LEGEND

- PORCELANITE CAPROCK (APPROXIMATELY 1.5m BELOW SEABED)
- POTENTIALLY CONTAINS HIGH STRENGTH ROCK BELOW PORCELANITE
- POTENTIALLY CONTAINS SOFTER MATERIALS BELOW PORCELANITE
- BASE OF SOFT ALLUVIAL MUD



SECTION D4
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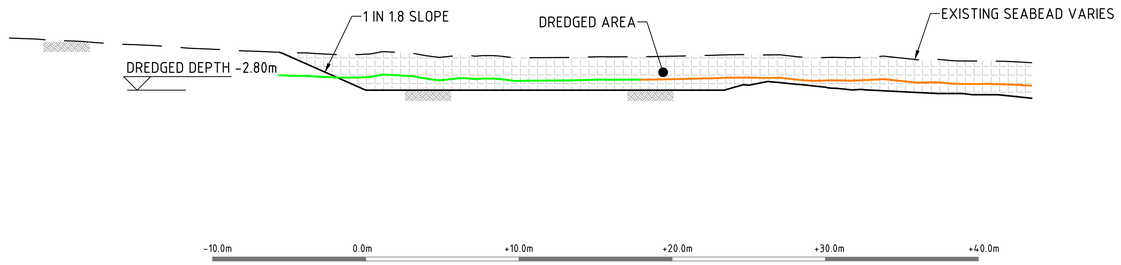
4491



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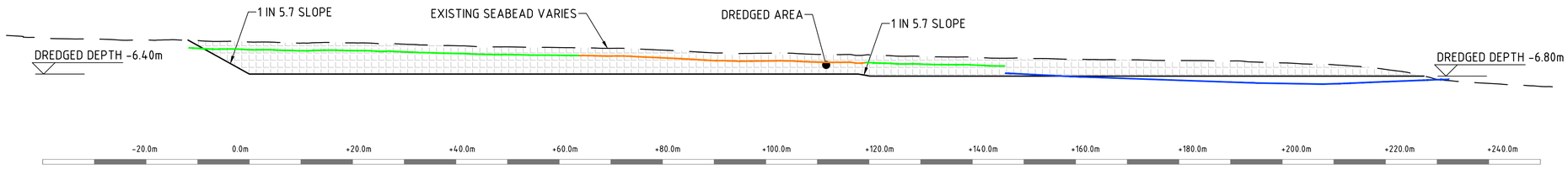

SECTION D6
SCALE B
4491

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SCALE 1:200 @A1

SCALE B 0 10 20 30 40 50m
SCALE 1:500 @A1

NOTES:

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
A	ISSUED FOR 25% DESIGN APPROVAL	30/06/20	I.C	CARDNO

Cardno (NT) Pty Ltd | ABN 78 078 713 934
Level 6, 93 Mitchell Street
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Drawn: A.PEARCE Date: 19/11/2021	Checked: P.RODRIGUEZ Date: 19/11/2021
Designed: A.PEARCE Date: 19/11/2021	Checked: R.AKROUSH Date: 19/11/2021
Design Project Leader: D.STRICKLAND Date: 19/11/2021	NTG Project Manager: S. DUNKERTON Date: 19/11/2021

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA

DREDGING DETAILS - SHEET 2

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	08 OF 24	R21-4493	0	A1

Version: March 2021

PLOTTED ON: 1/Dec/2021 3:31 PM
USER: ASHLEY PEARCE
FILE LOCATION: C:\Users\Ashley.Pearce\Cardno\Mandorah Marine Facilities - Documents\Drawings\(1) ACAD\DWG\R21-4492.dwg

PRINT IN COLOUR

LEGEND

~4.0 EXISTING CONTOUR (0.5m) (BATHYMETRIC SURVEY)

NOTES:

1. BATHYMETRIC SURVEY CONTOURS SHOWN m AHD
2. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
3. ALL LEVELS ARE IN METRES AND RELATIVE TO AHD UNLESS NOTED OTHERWISE.

SITE GEOLOGY LAYOUT

SCALE A

IMAGE SOURCE: WWW.NEARMAP.COM, 2020

SCALE A 0 20000 40000 60000 80000 100000mm
SCALE 1:1000 @A1

No.	AMENDMENT DESCRIPTION	DATE	INIT.	DEPT/COMPANY
0	ISSUED FOR TENDER	30/11/21	A.P	CARDNO
B	ISSUED FOR 50% DESIGN REVIEW	06/08/21	T.S	CARDNO
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Drawn: A.PEARCE Date: 19/11/2021	Checked: P.RODRIGUEZ Date: 19/11/2021
Designed: T.STEDMAN Date: 19/11/2021	Checked: R.AKROUSH Date: 19/11/2021
Design Project Leader: D.STRICKLAND Date: 19/11/2021	NTG Project Manager: S. DUNKERTON Date: 19/11/2021

Northern Territory Government

DARWIN
CHARLES POINT ROAD, MANDORAH
NEW MARINE FACILITIES TO SERVICE MANDORAH AND COX PENINSULA
SITE GEOLOGY LAYOUT

NTG Project No.	NTG Asset No.	Sheet Reference	NTG Drawing No.	Amendment	
ZMD01890	MD067	09 OF 24	R21-4494	0	A1

Version: March 2021

PLOTTED ON: 1/Dec/2021 3:32 PM
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APPENDIX

B

RISK ASSESSMENT TABLE

Table 1: Consequence categories and ratings

Score	Consequence or severity of impacts	Description
5	Severe	A Severe impact has two or more of the following characteristics: Widespread - Impact occurs at a NT, national, international or global scale High Intensity - Impact irreversibly compromises the integrity of environmental values Permanent - environmental values will not recover on human time scales
4	Major	A Major impact has two or more of the following characteristics: Regional - Impact extends to the Darwin/ Palmerston region, and/ or greater Darwin Harbour Moderate - Integrity of environmental values altered but impact can practicably be reversed Long term - Impact that is measurable post-Project
3	Moderate	A Moderate impact has two or more of the following characteristics: Localised - Impact is confined to the Site and areas directly adjacent to the Site, such as other allotments, Elizabeth River, and estuarine watercourses adjacent to the S Low - Impact alters the quality, abundance or distribution of environmental values without compromising their integrity, and can be easily and cheaply reversed Medium term - Impact that is felt up to completion of operations
2	Minor	A Minor impact has two or more of the following characteristics: Limited - Impact limited to the Site Very Low - Impact does not significantly alter the quality, distribution or abundance of environmental values Short term - Impact that is felt up to completion of construction
1	Insignificant	Insignificant No noticeable/ measurable impact to values

Table 2: Likelihood categories

Liklihood Category	Description
Almost certain	The event/ impact will occur or is expected to occur. The impact occurs regularly in association with similar projects and/ or in similar environments.
Likely	The impact will probably occur in most circumstances but there is some uncertainty about the likelihood. The impact has occurred on more than one occasion in association with similar projects and/ or in similar environments.
Possible	The impact could occur in some circumstances. The impact has occurred infrequently on similar projects and/ or in similar environments.
Unlikely	The impact is not expected to occur. The impact occurs very infrequently on similar projects and/ or in similar environments.
Rare	The impact is very unlikely to occur. The impact has not occurred on similar projects and/ or in similar environments.

Table 3: Risk level definitions and responses

Risk Level	Response
Very High	*Risk is unacceptable. Specific action plans required to reduce risk to an acceptable level. Director/ CEO level management attention required.*
High	*Risk is generally unacceptable without action. Specific action plans required to reduce risk to 'as low as is reasonably practicable' (ALARP). Senior management attention r*
Medium	*Risk is generally acceptable. Proactive action is required to reduce risk to ALARP. Requires routine monitoring and adaptive management in accordance with Environmenta Management Plan. Line management attention required.*
Low	*Risk is acceptable. Management by routine policies and procedures.*

Table 4: Risk rating matrix

Likelihood		Consequence				
		1	2	3	4	5
		Insignificant	Minor	Moderate	Major	Severe
5	Almost Certain	Medium	Medium	High	Very High	Very High
4	Likely	Medium	Medium	High	Very High	Very High
3	Possible	Low	Medium	Medium	High	Very High
2	Unlikely	Low	Low	Medium	Medium	High
1	Rare	Low	Low	Low	Medium	High

Table 5: Level of certainty categories

Level of Certainty	Description
High	Risk rating is based on testing, modelling or experiments. Baseline information is complete and an appropriate level of analysis has been undertaken. Proposed mitigation were recommended by technical specialists and are well developed with demonstrated efficacy. Minimal further work is required to adequately understand risk.
Medium	Risk rating is based on similar conditions being observed previously on a similar project and/ or in a similar environment. Baseline information has some gaps that are cons minor, and further work is unlikely to significantly alter the risk rating. While the efficacy of proposed mitigation measures has been demonstrated, some further work is req provide details of implementation prior to commencement of the Project.
Low	Risk rating is based on professional opinion. Limitations in baseline information require that some assumptions are made, which introduces a level of uncertainty. Effectiver proposed controls and/ or the likelihood of implementation cannot be reliably assessed at this point in time. A substantial amount of further work is required to adequately m prior to commencement of the Project.

Consequence or severity of Impacts	Score	Terrestrial Environmental Quality	Terrestrial Ecosystems	Coastal Processes	Marine Environmental Quality	Marine Ecosystems	Community and the Economy	Cultural and Heritage
Severe	5	Soil disturbance, erosion or contamination that is measurably and permanently impacting environmental values that rely on good soil quality throughout the NT	Extinction of terrestrial flora, vegetation or fauna	Permanent and widespread disturbance to the coastal processes within Darwin Harbour, such as tides and currents	Exceedance of baseline water quality that permanently alters the ecological functioning and/ or amenity of Arafura Sea	Complete loss of a benthic habitat or community type	Permanent impact that is felt by the majority of the NT population Unauthorised destruction of Aboriginal heritage item and/ or sites of world or national heritage significance	Unauthorised destruction of Aboriginal heritage item and/or sites of world or national heritage significance
Major	4	Soil disturbance, erosion or contamination that compromises regional environmental values that rely on good soil quality, and would be costly and technically challenging to remediate	Regional scale impacts on terrestrial flora, vegetation or fauna that compromise post-Project biodiversity and/ or ecological integrity	Permanent and localised disturbance to the coastal processes within Darwin Harbour, such as tides and currents	Exceedance of baseline Darwin Harbour water quality that continues for many years post-Project	Regional scale impacts on benthic habitat or community that compromise post-Project biodiversity and/ or ecological integrity	Impact that is felt by a majority of the regional population post-Project Unauthorised damage/ desecration of Aboriginal heritage item and/ or sites of regional heritage significance such that integrity is lost	Unauthorised damage / desecration of Aboriginal heritage item and/or sites of regional heritage significance such that integrity is lost
Moderate	3	Medium term soil disturbance, erosion or contamination in the vicinity of the Site that that alters soil characteristics but with no measurable impact to environmental values that rely on good soil quality, and can be remediated	Localised impact to flora, vegetation or fauna that alters the quality, abundance or distribution but with no measurable impact on biodiversity and/ or ecological integrity within months of the Project concluding	Permanent localised disturbance to the sediment transport within Darwin Harbour, temporary distrubance to tides and currents in Darwin Harbour	Localised exceedances of baseline marine water quality that occurs throughout operations but ceases within months of the Project concluding	Localised impact to benthic habitat or community that alters the quality, abundance or distribution but with no measurable impact on biodiversity and/ or ecological integrity within months of the Project concluding	Impact that is felt by a small number of people during the Project, ceasing within months of the Project concluding Unauthorised activity but with no physical impact to a heritage item, or minor physical impact such that integrity is not lost	Unauthorised acitvity but with no physical impact to a heritage item, or minor physical impact such that integrity is not lost
Minor	2	Short term soil disturbance, erosion or contamination in the vicinity of the Site that is reversible without significant remedial works	Impacts on flora, vegetation or fauna that do not measurably alter environmental values outside of the Site after construction concluding	Short term soil disturbance of coastal	Exceedances of baseline marine water quality at the Site ceasing within months of construction concluding	Impacts on benthic habitat or community that do not measurably alter environmental values outside of the Site after construction concluding	Impact felt by a small number of people at the Site during construction Unauthorised activity but with no physical impact to a heritage item	Unauthorised activity but with no physical impact to a heritage item
Insignificant	1	No measurable soil disturbance, erosion or contamination	No measurable impact on terrestrial flora, vegetation or fauna	No measurable impact on coastal processes	No significant change to baseline marine water quality	No measurable impact on benthic habitat or communities	No noticeable impact to stakeholder or community values No impact to Aboriginal Sacred or other heritage sites	No impact to Aboriginal sacred or other heritage sites

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
LAND	*Environmental Factor: Landforms*											
	Construction of landforms	Breakwaters (and to a lesser degree, causeway and boat ramp) are large structures that could be considered as new landforms	Significant change to the existing nearshore morphology at the site	Almost Certain (5)	Moderate (3)	Very High	> Design to minimise size of breakwaters, causeway and boat ramp limited to maintaining functionality and safety.	Possible (3)	Insignificant (1)	Low	Medium	Operations
	Changes to local shoreline	Construction of breakwaters disrupts the natural longshore drift of sediment down the adjacent coastline	> Disruption of net south migration of sediment > Increase in beach width north of the facilities, smothering the existing benthic communities > Erosion immediately south of the facilities due to blocking of usual sediment feed	Likely (4)	Moderate (3)	High	> Design to maximise natural bypassing mechanism > Understanding (investigation and modelling) of expected sedimentation volumes and locations > Allowance for ongoing sand bypassing that transfers sand past the marine facilities maintaining the net annual sediment transfer volumes	Possible (3)	Insignificant (1)	Low	Medium	Operations
	Environmental Factor: Terrestrial Environmental Quality											
	Exposure of contaminants during earthworks	> Exposure of potential Acid Sulfate Soils (ASS) > Exposure of potential metals or hydrocarbons > Exposure of asbestos containing soil	> Negative impacts to soil quality, stability and fertility > Acidic runoff discharging into Darwin Harbour > Invasion of acid-tolerant water plants and plankton species	Unlikely (2)	Major (4)	Medium	> Stop works if ASS is encountered, implement ASS management measures before works continue > Stop works if suspected asbestos material is encountered, implement asbestos removal management measures before works continue > Limit the area of exposed earth and period of exposure.	Rare (1)	Moderate (3)	Low	Medium	Construction
	Contaminants released during construction activities	Spills/leaks of petrol, oils, lubricants, hazardous materials, paints, thinners and litter	Adverse impact on soil quality within and adjacent to project footprint	Possible (3)	Moderate (3)	Medium	Contractor to develop a Hazardous Material Management Procedure including but not limited to the following: > Ensure stockpiles of bulk materials are well contained separated from exposed soils; > Training for personnel in implementation of safe work practices to minimise risks and impacts of spillage of fuels, chemicals and other contaminants; > Record and report all POL, chemical and hazardous substance spills; and > Ensure personnel have access to spill kits that contain an absorbent material and contaminated disposal sites.	Unlikely (2)	Minor (2)	Low	High	Construction
	Clearing areas of existing vegetation	Removal of vegetation and topsoil leaves area susceptible to erosion	> Loss of topsoil during overland flows > Eroded topsoil causing sedimentation in Darwin Harbour	Possible (3)	Minor (2)	Medium	> All clearing to be undertaken in accordance with Land Clearing Guidelines (DENR, 2019) > Cleared land outside of the direct footprint is to be rehabilitated using appropriate soils and vegetation	Rare (1)	Moderate (3)	Low	Medium	Construction
	Contaminants released during operations	> Chemical toilet leak to environment > Fly tipping	> Hazardous substances contaminating soils	Possible (3)	Moderate (3)	Medium	> Regular maintenance to be carried out on toilets > Adequate lighting and cctv to prevent illegal disposal	Unlikely (2)	Minor (2)	Low	Medium	Operations
	Environmental Factor: Terrestrial Ecosystems											
	Removal of vegetation due to land clearing of site for construction footprint and temporary work areas	Removal of native flora including: Eucalyptus spp over woodland over grassland	Loss of biodiversity on the Cox Peninsula	Unlikely (2)	Moderate (3)	Medium	> Land clearing only to be undertaken in approved areas and as per NT land clearing guidelines > Avoidance of significant and valuable vegetative communities > Any areas temporarily cleared are to be rehabilitated using native seed	Rare (1)	Moderate (3)	Low	Medium	Construction
	Clearing of potential fauna habitat for construction footprint and temporary work areas	Removal of fauna habitat	Injury of death of fauna or destruction of habitat	Unlikely (2)	Moderate (3)	Medium	> Land clearing only to be undertaken in approved areas and as per NT land clearing guidelines > Pre-clearance trapping and relocation of identified fauna	Rare (1)	Moderate (3)	Low	Medium	Construction
	Noise, vibrations and lighting at Mandorah due to construction activities	Noise, vibrations and lighting impacting fauna	Loss of habitable area for fauna	Unlikely (2)	Minor (2)	Low	> Contractor to develop a Noise Management Plan > Lighting only focused on works, not surrounding habitat, light shields if needed	Rare (1)	Minor (2)	Low	Medium	Construction
	Fire ignition due to construction activities	Uncontrolled fire	Loss or damage to terrestrial ecosystems	Possible (3)	Minor (2)	Medium	Contractor to develop a Fire Management Plan	Unlikely (2)	Minor (2)	Low	Medium	Construction
	Dust generation due to construction activities	Generated dust settling on terrestrial ecosystems	Adverse health impacts to local flora if dust settles on foliage	Likely (4)	Minor (2)	Medium	Contractor to develop a Dust Management Plan including but not limited to the following: > Watering of temporary roads and stockpile areas; > Watering down affected vegetation; > Use of dust suppression equipment; and > Speed limits within on site roads.	Unlikely (2)	Minor (2)	Low	Medium	Construction

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
LAND	Vehicular movement into site carrying weed species	Introduction of weeds to site	Loss of native biodiversity on the Cox Peninsula due to pressure from introduced species	Possible (3)	Moderate (3)	**Medium**	Contractor to develop a Weed Management Plan including but not limited to the following: > Review and relevant weed mapping and signpost areas of significant weed infestation; > Vehicle washdown stations; and > Routine monitoring of infestations and controls.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Application of water as a dust control measure	Contaminated water from water storage facilities or dust suppression measures adversely impacting vegetation	Loss of vegetation if contaminants leach into soils	Unlikely (2)	Minor (2)	**Low**	> Water storage facilities to be located away from vegetation > Water used for dust suppression shall be of suitable quality	Rare (1)	Minor (2)	**Low**	Medium	Construction
	Increased vehicle traffic during construction activities	Increased likelihood of vehicle strike	Death or injury to fauna	Possible (3)	Moderate (3)	**Medium**	> Training for all drivers and operators on local fauna most likely to be encountered > Suitable speed limits into and around site	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Increased vehicle traffic during operations	Increased likelihood of vehicle strike	Death or injury to fauna	Possible (3)	Moderate (3)	**Medium**	> Signage to watch out for wildlife > Suitable speed limits into and around site	Rare (1)	Moderate (3)	**Low**	Medium	Operations
	Asbestos contamination encountered on Lot 50	Expose asbestos fibres to ecosystems	Adverse health impacts to local fauna	Unlikely (2)	Minor (2)	**Low**	> If asbestos is encountered when clearing Lot 50, material is to be removed and disposed of by trained personnel	Rare (1)	Minor (2)	**Low**	Medium	Construction
	Increase in noise due to increased patronage	Noise impacting fauna	Loss of habitable area for fauna	Possible (3)	Minor (2)	**Medium**	> Fencing/pathways designed to keep pedestrians away from bush	Rare (1)	Minor (2)	**Low**	Medium	Operational
	Increase in litter due to increased patronage	Fauna mistaking little for food source	Death or injury to fauna	Possible (3)	Minor (2)	**Medium**	> Adequate number of well lit bins provided	Rare (1)	Moderate (3)	**Low**	Medium	Operational
	Lighting at extended car park and ferry terminal	Light impacting fauna	Loss of habitable area for fauna	Possible (3)	Minor (2)	**Medium**	> Lights to focus on car park and ferry terminal > Minimise light intrusion into surrounding environment	Rare (1)	Minor (2)	**Low**	Medium	Operational
WATER	*Environmental Factor: Hydrological Processes*											
	Construction of expanded carpark and ferry terminal adding to the impermeable surfaces	Increase in the quantity of surface water runoff	Localised flooding	Rare (1)	Insignificant (1)	**Low**	No treatment needed. Runoff flows directly into Darwin Harbour in pre- and post-development scenarios	Rare (1)	Insignificant (1)	**Low**	Medium	Construction and Operations
	Environmental Factor: Inland Water Environmental Quality											
	Construction activities including earthworks and building works	Construction materials, sediment and / or contaminants entering surface water features or groundwater	No notable surface water features in proximity to works, runoff to be discharged directly to Darwin Harbour and not expected to infiltrate into groundwater	Rare (1)	Insignificant (1)	**Low**	No treatment needed. Runoff flows directly into Darwin Harbour in pre- and post-development scenarios	Rare (1)	Insignificant (1)	**Low**	High	Construction
	Environmental Factor: Aquatic Ecosystems											
	N / A											
	Environmental Factor: Coastal Processes											
	Changes to local coastal processes	> Installation of breakwaters will interrupt nearshore hydrodynamics, wave and sediment transport, altering erosion > Localised changes to nearshore hydrodynamic wave climate due to installation of the harbour	> Changes to local hydrodynamics and wave climate may impact marine ecosystems, flora and fauna.	Possible (3)	Minor (2)	**Medium**	Intended effect of facility. Design to minimise footprint and interruption of coastal processes outside of harbour.	Unlikely (2)	Minor (2)	**Low**	Medium	Operations
	Environmental Factor: Marine Environmental Quality											
	Disturbance of marine sediments (fines)	Dredging actions, spoil transfer and disposal, rock placement and piling	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Likely (4)	Moderate (3)	**High**	> Model dredging and disposal actions to properly understand dredge plume dispersion > Gain an understanding of sensitive marine environmental receptors and their tolerance > Control actions to maintain water quality below appropriate thresholds (i.e. altering dredging activities [e.g. volumes, locations] to limit sediment resuspension, dredging only on certain tides etc.)	Unlikely (2)	Minor (2)	**Low**	High	Construction

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
SEA	Release of contaminants from marine sediments	As per actions above - predominantly dredging and disposal	> Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Characterise material to be disturbed to understand locations and levels of contamination > Assess levels of contamination against appropriate thresholds, given the nature of the receiving environment > Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	Unlikely (2)	Minor (2)	**Low**	High	Construction
	Introduction of contaminants/pollution to marine environment	Construction activities - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Inspection and audit of vessels and plant, controlled via DSDMP and CEMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Release of sediments from land	Disturbance/stockpiling of material on land, lost due to run-off, wind etc.	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Possible (3)	Minor (2)	**Medium**	> Controlled by CEMP > Appropriate stockpiling technique and location > Prevention by bunding, erosion control etc. > Response plan for release of material	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Disturbance of marine sediments (fines)	Rock placement and piling	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Almost Certain (5)	Minor (2)	**Medium**	> Model dredging and disposal actions to properly understand dredge plume dispersion > Gain an understanding of background conditions > Gain an understanding of sensitive marine environmental receptors and their tolerance > Control actions to maintain water quality below appropriate thresholds	Possible (3)	Insignificant (1)	**Low**	High	Construction
	Release of contaminants from marine sediments	Rock placement and piling	> Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Characterise material to be disturbed to understand locations and levels of contamination > Assess levels of contamination against appropriate thresholds, given the nature of the receiving environment > Isolate, remove and confine areas where contamination is potentially toxic to the marine environment	Possible (3)	Insignificant (1)	**Low**	High	Construction
	Introduction of contaminants/pollution to marine environment	Construction activities - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Inspection and audit of vessels and plant, controlled via DSDMP and CEMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Release of sediments from land	Disturbance/stockpiling of material on land, lost due to run-off, wind etc.	> Elevated suspended sediment concentration in marine water > Sedimentation in marine environment > Potential impact to benthic communities and other biota	Possible (3)	Minor (2)	**Medium**	> Controlled by CEMP > Appropriate stockpiling technique and location > Prevention by bunding, erosion control etc. > Response plan for release of material	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Siltation of harbour	Proposed breakwaters lower velocities in the harbour and allow the settlement of suspended particles	> Smothering of seabed with fine particles impacting marine flora / fauna	Almost Certain (5)	Minor (2)	**Medium**	> Siltation modelling undertaken to estimate rates of accumulation > Benthic habitat has already been identified and removed as part of initial dredging campaign	Unlikely (2)	Minor (2)	**Low**	High	Operations
	Introduction of contaminants/pollution to marine environment	Boat ramp use - inappropriate waste disposal, accidental oil/chemical spill	> Toxic contaminants introduced to marine ecosystem for biological uptake and bioaccumulation > Potential impact to ecosystem health	Possible (3)	Moderate (3)	**Medium**	> Inspection and audit of vessels and plant, controlled via DSMP and CMP > Reporting and response protocols should a spill occur - oil/chemical spill response etc.	Unlikely (2)	Minor (2)	**Low**	Medium	Operations
	Environmental Factor: Marine Ecosystems											
	Dredger/vessel movement	> Vessel strike of marine fauna such as dugongs, turtle, dolphins > Underwater noise impacts due to dredging and piling > Direct impact to seabed - marine ecosystems	> Vessel strike of marine fauna > Injury to marine fauna > Damage to ecosystems	Possible (3)	Moderate (3)	**Medium**	> Vessel movement controls, speed limits, no-go zones > Marine fauna observation and avoidance > Piling controls (soft start) to allow fauna to leave area	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredging	Direct removal of benthic communities and habitat	> Permanent removal/destruction of BCH such as seagrass and coral	Almost Certain (5)	Major (4)	**Very High**	> Characterise BCH in direct impact footprint > Minimise footprint and avoid sensitive receptors/important BCH where possible	Likely (4)	Moderate (3)	**High**	High	Construction
	Dredging	Elevated suspended sediment concentration (turbidity) in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	Likely (4)	Moderate (3)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
SEA	Dredging	Sedimentation of seabed in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (smothering)	Likely (4)	Moderate (3)	**High**	> Characterise dredge plume dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredge spoil disposal	Elevated suspended sediment concentration (turbidity) at disposal site	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	Likely (4)	Moderate (3)	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging disposal controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredge spoil disposal	Sedimentation of seabed at disposal site	> Impact to sensitive BCH such as coral and seagrass (smothering)	Likely (4)	Moderate (3)	**High**	> Select disposal area for optimum dispersion and minimum sensitive receptors > Characterise disposal dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Dredger/vessel movement	> Vessel strike of marine fauna such as dugongs, turtle, dolphins > Underwater noise impacts due to dredging and piling > Direct impact to seabed - marine ecosystems	> Vessel strike of marine fauna > Injury to marine fauna > Damage to ecosystems	Possible (3)	Moderate (3)	**Medium**	> Vessel movement controls, speed limits, no-go zones > Marine fauna observation and avoidance > Piling controls (soft start) to allow fauna to leave area	Unlikely (2)	Minor (2)	**Low**	Medium	Operations
	Construction activities including earthworks, building works and transport to site	Construction materials and /or general litter entering marine environment	> Ingestion/injury of waste by marine fauna > Damage to marine ecosystems	Possible (3)	Moderate (3)	**Medium**	> Control of waste as per CEMP > Reporting and response to pollution events > Control of construction access/activities	Rare (1)	Moderate (3)	**Low**	Medium	Construction
	Rock placement and piling	Direct removal of benthic communities and habitat	> Permanent removal/destruction of BCH such as seagrass and coral	Almost Certain (5)	Moderate (3)	**High**	> Characterise BCH in direct impact footprint > Minimise footprint and avoid sensitive receptors/important BCH where possible > Characterise BCH in vicinity of project	Likely (4)	Minor (2)	**Medium**	High	Construction
	Rock placement and piling	Elevated suspended sediment concentration (turbidity) in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (blocking of light) > Impact to marine fauna due to ingestion/dermal contact	Likely (4)	Moderate (3)	**High**	> Characterise dredge plume dispersion to understand changes to water quality with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Rock placement and piling	Sedimentation of seabed in vicinity of project	> Impact to sensitive BCH such as coral and seagrass (smothering)	Likely (4)	Moderate (3)	**High**	> Characterise BCH in vicinity of project > Characterise dredge plume dispersion to understand sedimentation levels with respect to tolerance of BCH/fauna > Implement dredging controls and reactive monitoring to maintain levels below thresholds	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
AIR	*Environmental Factor: Air Quality*											
	Dust generated by construction activities including earthworks, building works and transport to site.	Decrease in local air quality	Impacts to local fauna and human health through inhalation of particles	Almost Certain (5)	Minor (2)	**Medium**	Integration of dust management measures in construction management plan including: > Watering of temporary roads and stockpile areas; > Use of dust suppression equipment; and > Speed limits on site roads.	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Mobile plant at site and trucking of materials to site	Carbon dioxide emissions	Impacts to local fauna and human health through inhalation of emissions	Almost Certain (5)	Minor (2)	**Medium**	Integration of air quality measures in construction management plan including: > Isolating plant from workers where possible; and > PPE	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Environmental Factor: Atmospheric Processes											
	Energy usage during construction of facilities	Direct emissions from mobile plant, dredger, generators etc.	Cumulative impact of carbon emissions to global climate change	Likely (4)	Insignificant (1)	**Medium**	> Effeciency in design to minimise quantity of rock needed in breakwaters, causeway and boat ramp; > Materials should be transported to site with the minimum number of vehicles required; and > Reuse of existing building onsite for ferry terminal to reduce new materials required;	Possible (3)	Insignificant (1)	**Low**	Medium	Construction
	Future power usage at the ferry terminal	Indirect emissions from use of electricity	Cumulative impact of carbon emissions to global climate change	Likely (4)	Insignificant (1)	**Medium**	Integration of electricity reduction measures in construction management plan including: > Energy saving devices; and > Consideration of alternative energy sources where possible	Possible (3)	Insignificant (1)	**Low**	Medium	Operations
	Environmental Factor: Community and Economy											

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
PEOPLE	Construction activities including earthworks and building works	Noise generated	Decrease in liveability for nearby residents, ferry users or tourists	Possible (3)	Minor (2)	Medium	Integrate noise management measures within the construction management plan	Unlikely (2)	Minor (2)	Low	Medium	Construction
	Trucking in of construction materials	Increase in traffic along Cox Peninsula Road and Charles Point Road	Traffic delays and increased risk of accident for local residents of the Cox Peninsula	Likely (4)	Minor (2)	Medium	> Traffic management plan to be implemented to manage any disruptions to local traffic > Staggering of heavy vehicles throughout the day to minimise congestion	Unlikely (2)	Minor (2)	Low	Medium	Construction
	Construction activities including earthworks and building works	Loss of access to existing carpark	Decrease in liveability for users of existing boat ramp or carpark	Almost Certain (5)	Minor (2)	Medium	> Stakeholder engagement with current uses of facilities to inform of access issues during construction	Almost Certain (5)	Minor (2)	Medium	High	Construction
	Environmental Factor: Culture & Heritage											
	Aboriginal sacred sites	Construction activities disturbing or destroying Aboriginal Sacred Sites south of the works	Permanent or temporary damage or contamination of Sites	Possible (3)	Moderate (3)	Medium	> Response and reporting procedures should a site or obje	Rare (1)	Moderate (3)	Low	High	Construction
	Cultural heritage sites / artefacts	Dredging, disposal and associated actions	Disturbance of known or unknown cultural heritage areas during dredging	Possible (3)	Moderate (3)	Medium	> Gain understanding of cultural heritage of the site and establish no work areas around heritage sites > Response and reporting procedures should a site or object be encountered	Unlikely (2)	Moderate (3)	Medium	High	Construction
	Increased patronage in the area due to upgraded marine facilities	Disturbance or destruction of Aboriginal Sacred Sites south of the works	Permanent or temporary damage or contamination of Sites	Unlikely (2)	Moderate (3)	Medium	> Signage to alert the public of private driveways and land to the south of the carpark	Rare (1)	Moderate (3)	Low	Medium	Operations
	Environmental Factor: Human Health											
	Asbestos contamination encountered on Lot 50	Inhalation of airborne asbestos	Adverse health impacts to site workers and users of facility	Possible (3)	Moderate (3)	Medium	> Staff to have sufficient training in handling asbestos > Appropriate PPE provided to all staff working with, or suspected to be working with asbestos	Rare (1)	Moderate (3)	Low	Medium	Construction
	Personnel working outside	Exposure	> Sunburn and heat stress > Injury due to cyclone or storm whilst on site	Likely (4)	Moderate (3)	High	> Staff to have appropriate PPE (long sleeved shirt, pants, hats, sunscreen etc.) to minimise risk of sunburn and heat stress > First aid kits located around site for initial response > Development of a cyclone response plan and regular monitoring of local news channels	Possible (3)	Moderate (3)	Medium	Medium	Construction
	Personnel working outside	Biting insects, snakes, crocodiles	> Injury due to bite/attack > Disease transmitted by biting insect	Possible (3)	Moderate (3)	Medium	> Staff to have appropriate PPE (long sleeved shirt, pants, repellent etc.) to minimise risk of biting insects > Staff to have sufficient training on the identification of reptiles likely to be encountered on site > If a problem crocodile is encountered it should be reported to (08) 8983 2475 > First aid kits located around worksite to provide initial response to incidents	Unlikely (2)	Moderate (3)	Medium	Medium	Construction
	Construction activities including earthworks and building works	Open fire ignited by construction activities	> Minor, serious or fatal burns to personnel > Smoke inhalation	Unlikely (2)	Moderate (3)	Medium	> Staff to have sufficient training in fire management > Fire extinguishers located around site > Smoking and hot works in permitted areas only	Rare (1)	Major (4)	Medium	Medium	Construction
	Proximity to vegetation	Exposure to bushfire	> Minor, serious or fatal burns to personnel > Smoke inhalation	Unlikely (2)	Major (4)	Medium	> Creation of a bushfire evacuation plan > Staff to have sufficient training in fire management > Regular monitoring of local news channels	Rare (1)	Moderate (3)	Low	Medium	Construction
	Public accessing breakwaters and / or jetty during construction	Slip, trip or fall into water above head height	> Accidental entry to deeper water leading to drowning hazard	Unlikely (2)	Major (4)	Medium	> Fencing and signage to prevent public access to breakwater and jetty	Rare (1)	Major (4)	Medium	Medium	Construction
	Dredging and disposal of contaminated sediments	> Disturbance/release during extraction, transport and placement stages > Release to the marine environment following placement, then bioaccumulation and biomagnification in the food chain	> Dermal contact > Inhalation > Ingestion	Possible (3)	Moderate (3)	Medium	See management measures relating to marine environmental quality. These apply to risk to humans also, with risk to human health considered a lower risk.	Rare (1)	Moderate (3)	Low	Medium	Construction
	Dredging and disposal of fine sediments	> Disturbance/release during extraction, transport and placement stages	> Dermal contact > Inhalation	Possible (3)	Moderate (3)	Medium	> Sediments to remain wet or be contained as part of disposal > Segregation of work area and material from general public	Rare (1)	Moderate (3)	Low	Medium	Construction
	Public accessing breakwaters and / or jetty during construction	Slip, trip or fall into water above head height	> Accidental entry to deeper water leading to drowning hazard	Unlikely (2)	Major (4)	Medium	> Fencing and signage to prevent public access to breakwater and jetty	Rare (1)	Major (4)	Medium	Medium	Operations

Theme	Environmental Aspect	Risk Pathway(s)	Potential Impacts	Likelihood	Potential Consequence	Inherent Risk Rating	Risk Management/Mitigation	Residual Likelihood	Residual Consequence	Residual Risk Rating	Level of Certainty	Project Phase
	Emissions from construction plant	Exposure of workers to emissions	Irritation to workers	Possible (3)	Minor (2)	**Medium**	> Avoiding idling of construction plant > Isolating workers from fumes > PPE such as masks and faceshields > Alternative power source	Unlikely (2)	Minor (2)	**Low**	Medium	Construction
	Public access to breakwaters and jetty	Slip, trip or fall into water above head height	> Accidental entry to deeper water leading to drowning hazard	Possible (3)	Major (4)	**High**	> Signage to notify public of dangers and that the breakwaters should not be accessed during dangerous conditions	Unlikely (2)	Major (4)	**Medium**	Medium	Operations

APPENDIX

C

AAPA CERTIFICATE