NCIS-5 HMAS Coonawarra

Dredging and Disposal Management Plan

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List of abbreviations

ACOPV	Arafura Class Offshore Patrol Vessels
AHD	Australian Height Datum
AHS	Australian Hydrographic Service
ANZECC	Australian and New Zealand Environment Conservation Council
ASLP	Australian Standard Leachate Procedure
ASS	Acid Sulphate Soils
BTEX	Benzene, Toluene, Ethyl benzene and Xylenes
CBD	Central Business District
CSD	Cutter Suction Dredge
DDMP	Dredging and Disposal Management Plan
DENR	Department of Environment and National Resources
DEPAC	Director or Environmental Planning, Assessment and Compliance
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
LAT	Lowest Astronomical Tide
LoR	Limit of Reporting
MNES	Matters of National Environmental Significance
NAGD	National Assessment Guidelines for Dredging 2009
NT EPA	Northern Territory Environment Protection Authority
NT	Northern Territory
NTC	National Tide Centre
OC	Organochlorine Pesticides
OP	Organophosphorus Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PFAS	Per- and Poly-fluoroalkyl substances
PFOS	Perfluorooctanesulfonic acid
PMCA	Project Manager and Contract Administrator
PMST	Protected Matters Search Tool
PSD	Particle Size Distribution
RAN	Royal Australian Navy
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
TBT	Tributyltin
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons

1 Introduction

1.1 PROJECT BACKGROUND

This Dredging and Disposal Management Plan (DDMP) has been prepared on behalf of the Approval holder, Commonwealth Department of Defence (Defence), to manage and monitor dredging and dredged material management activities at HMAS *Coonawarra*, located approximately 2 km north-west of Darwin city centre (Figure 1.1).

The Defence SEA1180 Phase 1 (SEA1180-1) project is delivering a fleet of 12 Arafura Class Offshore Patrol Vessels (ACOPV) for the Royal Australian Navy (RAN). The N2263 project is delivering the facilities to support the introduction into service and sustainment of the new ACOPVs including upgrades of wharf facilities. A number of the ACOPVs will be homeported at HMAS *Coonawarra*. The proposed dredging and dredged material disposal activities are essential to provide all tide navigation of the basin for the new ACOPVs as they have a deeper draft than the vessels which currently use the basin. These works are part of the Navy Capability Infrastructure Sub-program 5 (NCIS-5) which forms part of the overall SEA1180-1 Project.

In addition, the planned dredging is also required to enable the visitation and utilisation of the HMAS *Coonawarra* basin by a new navy vessel class currently being designed which will provide improved capabilities in the region.

At HMAS *Coonawarra* the first priority is to upgrade the existing Fremantle Wharf to suit the ACOPVs and to undertake associated dredging and dredged material disposal to deepen the existing navigable basin. This dredging campaign is referred to as the current NCIS-5 Project works and is the subject of this DDMP.

It is expected that further dredging will be undertaken to maintain the basin and to provide access to additional wharves/facilities located elsewhere in the basin (i.e. referred to as 'future Eastern Wharf development' dredging), however these latter works would be done as a separate campaign at a later stage at least two to three years after the completion of the first priority NCIS-5 dredging campaign. This DDMP and the management and monitoring measures it contains will also be effective for future campaigns, although this revision has been drafted with a focus on the NCIS-5 Project works as these will be delivered first.

Numerous dredging and dredged material disposal campaigns have been conducted at HMAS *Coonawarra* since it was first constructed in the 1980s the most recent in 2013. Given the nature of dredging proposed and the site constraints, the intention is to employ a dredging and dredged material disposal methodology which has previously been used successfully at this site.

This DDMP has been based on site specific investigations, the results of previous similar dredging contracts undertaken at HMAS *Coonawarra*, and the outcomes from the assessment undertaken for the Referral and Supplementary Environmental Report (SER).

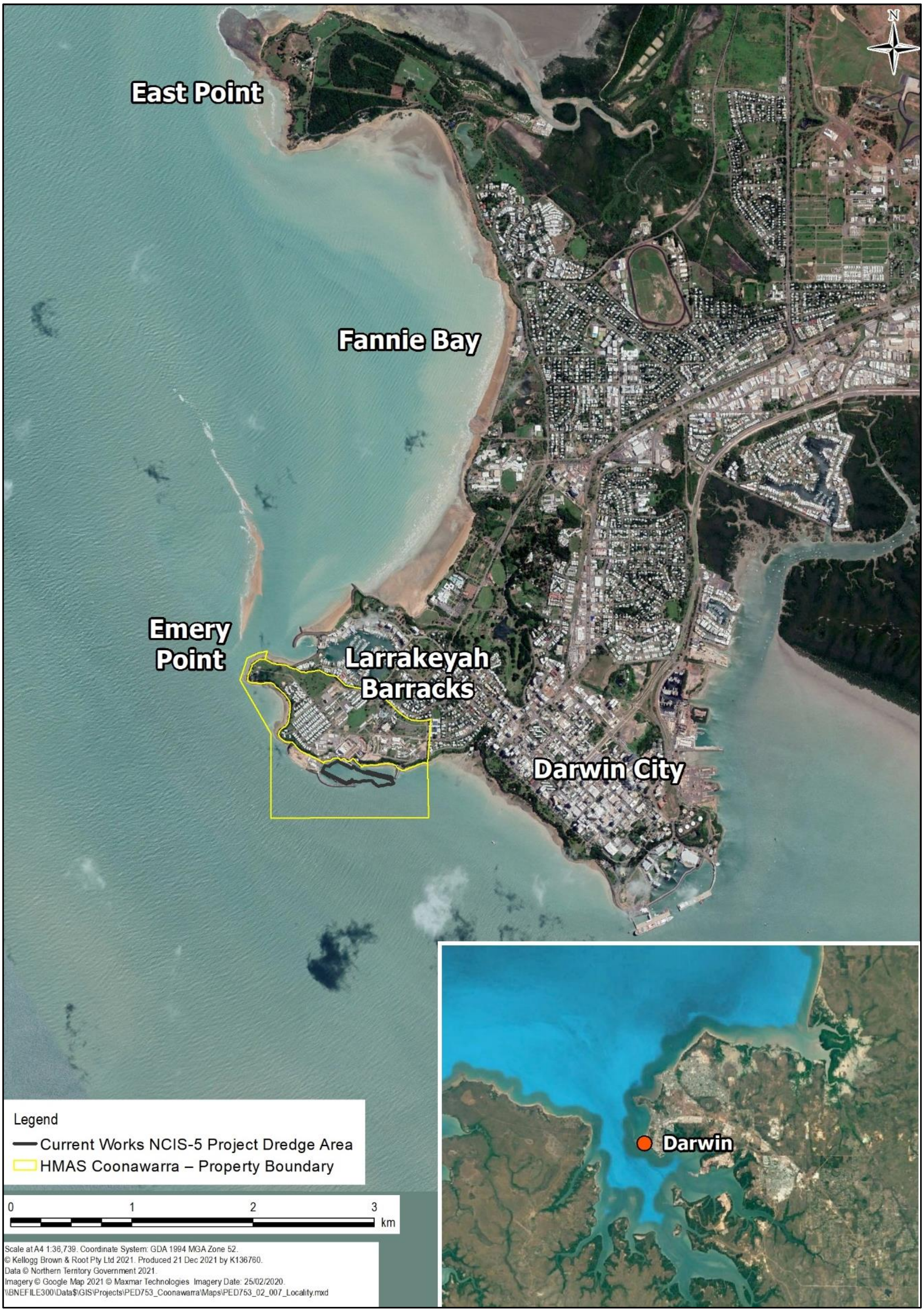

Figure 1.1 Project Location

1.2 PURPOSE OF THIS PLAN

This document is the DDMP for the required dredging and dredged material disposal activities to be conducted for the current NCIS-5 Project works. The purpose of this DDMP is to provide the framework through which the proposed dredging campaign will be managed and monitored to meet the conditions of the Environmental Approval (EP2022/015-001).

This Plan supported the approvals process for the dredging campaign and once approved will form part of the contract documentation for the dredging works.

1.3 OBJECTIVES AND SCOPE

The objective of this Plan is to provide the framework for the environmental management of the dredging and dredged material disposal activities to minimise environmental risks by ensuring:

- Dredging works are carried out in accordance with applicable environmental legislation and standards;
- Potential environmental risks are identified and managed, and that the following environmental objectives as outlined in Condition 2-1 of the Environmental Approval are achieved:
  - No material harm to the environmental values and declared beneficial uses of water in Darwin Harbour beyond the zone of high impact, including but not limited to ecosystem health, cultural, aesthetic, recreational aquaculture;
  - No material environmental harm to benthic habitats and communities beyond the zone of high impact
  - Risks of physical injury, mortality, behavioural changes and health impacts on marine megafauna are minimised.
- Measures to monitor and control the dredging works are implemented effectively;
- Communication with Government, community and other relevant stakeholders in relation to environmental issues associated with the dredging and dredged material disposal works are managed appropriately; and
- There are clear responsibilities for environmental management.

This DDMP presents the management measures, objectives and actions that will be implemented throughout the dredging activities and contains proposed monitoring programs to assess the environmental impacts of the project. It addresses the conditions outlined in the Environmental Approval (EP2022/015-001) and the requirements of Condition 3-2 of the Approval.

1.4 REPORT STRUCTURE

Table 1.1 provides an overview of the structure of this DDMP.

Table 1.1 DDMP Structure

DDMP Section	Description
Section 1	Introduction including project background, purpose of the plan, approval holder, legislative framework and review/approval of the DDMP.
Section 2	Description of dredging and dredge material disposal activities to be undertaken at HMAS *Coonawarra*.
Section 3	Environmental management and resourcing including roles and responsibilities, inductions/training, environmental documents and records management, performance management and management review.

DDMP Section	Description
Section 4	Existing environment including a description of the existing physical environment, climate, marine sediment characteristics, coastal processes, water quality and key environmental receptors, and a conceptual model based on the existing environment and the dredging and disposal activity.
Section 5	Dredge sediment plume modelling and water quality impact assessment.
Section 6	Environmental risk assessment, including conceptual model of the dredging and dredge material disposal activities, overview of the risk assessment methodology applied and outcomes of the assessment.
Section 7	Environmental management and monitoring programs to be implemented during the dredging operations with a key focus on water quality, marine fauna, noise and waste.
Section 8	Reporting requirements for the duration of dredging and dredge material disposal activities.
Section 9	References.
Appendix A	Coastal Processes Modelling Results – Timeseries outputs for representative reporting locations and water quality monitoring locations.

1.5 APPROVAL HOLDER AND DREDGING CONTRACTOR

The Approval holder for the Project is Defence. Defence is responsible for the delivery of the proposed dredging and associated upgrades to existing maritime structures and systems to provide fit for purpose facilities and infrastructure to accommodate the ACOPVs at HMAS *Coonawarra*. RPS Group are the Project Manager and Contract Administrator (PMCA) who are responsible for managing the project on Defence's behalf.

For the proposed dredging campaign, a Dredging Contractor (hereafter 'Contractor') will be appointed; this entity will be required to comply with the DDMP during execution of the dredging works.

1.6 LEGISLATIVE FRAMEWORK

There is both Commonwealth and Northern Territory Government legislation which is relevant to the location and works proposed.

The NCIS-5 HMAS *Coonawarra* Project, including dredging and dredged sediment disposal, have been assessed by Defence's Director of Environmental Planning, Assessment and Compliance (DEPAC) in accordance with the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) which apply to projects undertaken by Commonwealth agencies and/or on Commonwealth land.

In addition, the dredging and dredged material disposal component of the works triggered assessment under Northern Territory legislation. These activities were therefore referred under the *Environment Protection Act 2019* and associated Environmental Assessment Administration Procedures. This requirement was confirmed during consultation undertaken with the NT EPA.

This DDMP was initially prepared to support the Referral to the NT EPA, and was subsequently updated based on the direction to provide additional information in the form of a Supplementary Environmental Report (SER).

The proposed works were approved on 12 September 2023. This DDMP has therefore been updated to address the conditions specified in the Environmental Approval (EP2022/015-001) and achieves the requirements outlined in Condition 3-2 of the Approval.

In addition, this plan has also been prepared with reference to the following:

- Guidelines for the Environmental Assessment of Marine Dredging in the Northern Territory (NT EPA November 2013, Version 2.0) (NT EPA, 2013);
- Referring a proposal to the NT EPA – Environmental impact assessment, Guidance for proponents (NT EPA 2021, Version 1.0) (NT EPA, 2021);
- Guideline for the Preparation of an Environmental Management Plan (NT EPA, May 2015, Version 1.0) (NT EPA, 2015);
- Guidelines on Mixing Zones (NT EPA, January 2013, Version 1.2) (NT EPA, 2013b);
- National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009);
- International best practice (e.g. PIANC 2006, 2008; CEDA 2011, 2015);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018); and
- Guidance provided in the Western Australian Marine Science Institution (WAMSI) Dredge Science Node.

1.7 DDMP REVIEW AND APPROVAL

The Approval holder is responsible for submitting this updated DDMP to the NT EPA.

The appointed Contractor will be required to comply with the DDMP during execution of the dredging works.

Should circumstances require amendment to the DDMP, this will be the responsibility of the Approval holder.

The Environmental Approval (EP2022/015-001) outlines the requirements for any revisions to the DDMP.

For any revised DDMP, a copy must be provided to the Minister at least 10 business days prior to any amendment(s) being implemented and is to be accompanied by:

- A tabulated summary of the amendment(s) with document references
- Reasons for the amendments
- An assessment of environmental risks and potential impacts associated with the amendment(s)

A review of the implementation of the DDMP will be undertaken by the Approval holder at the completion of the dredging campaign.

Prior to the commencement of capital dredging for the Future Eastern Wharf Dredge Area, a revised DDMP will be required in accordance with the conditions of approval.

2 Dredging and Disposal Activities

2.1 SITE DESCRIPTION AND LOCALITY

HMAS *Coonawarra* is located on the eastern shore of Darwin Harbour, within the Port of Darwin. It is situated approximately 2 km west of the Darwin Central Business District (CBD) and is co-located with Larrakeyah Barracks on the Larrakeyah Peninsula. The overall base covers approximately 80 ha.

The Larrakeyah Peninsula is a flat plateau with steep rocky cliffs and a rocky foreshore. HMAS *Coonawarra* covers approximately 12 ha on the lower south side of the Larrakeyah Barracks base, partly within a former quarry cut out of the cliff.

The base is generally flat but the foreshore grades steeply to the water's edge along the western and southern foreshores. The HMAS *Coonawarra* basin is bounded to the north and west by a land-backed rock revetment wall, and to the east and south by rock armoured breakwaters. The harbour entrance and navigation channel are located to the south-east.

The base property boundary includes an area of water to the south-east and west of the basin, and within this area, water depths gradually increase from approximately –9.1 mAHD to approximately –21 m AHD. Beyond the base property boundary, the City Channel joins with the Outer Harbour Channel providing access to and from the Beagle Gulf. The sections of these navigational channels adjacent to HMAS *Coonawarra* typically extend to depths in the order of –24 mAHD to –31 mAHD.

Within the harbour basin, two wharves run in a north-west to south-east alignment to allow vessels to berth at HMAS *Coonawarra*, including:

- The Attack Wharf to the north; and
- The Fremantle Wharf to the south.

A ship lift facility (the 'synchrolift') is also located to the north-east of the Attack Wharf.

The layout of the harbour basin is shown in Figure 2.1.

Current and historic activities conducted at the site include ship maintenance, fuel and oil storage, previous dredging and operational activities related to logistical and administrative support of Australian Navy vessels and visiting warships in the region.

The base provides accommodation for service personnel in facilities located on the northern portion of the site (Larrakeyah Army Barracks), along with office buildings and service areas for staff involved with general administration located within the same area.

Staff involved in industrial and service activities associated with ship maintenance are located on topographically lower areas close to the harbour. Administrative activities occur in buildings near the wharf area.

Figure 2.1 **HMAS *Coonawarra* Basin – Existing Layout**

2.2 REQUIREMENT FOR DREDGING

Through the design process for the NCIS-5 Project a number of wharf options were considered which would provide the user requirements and design vessel parameters. These options included:

- Option 2B – Upgrade of existing Fremantle Wharf, with reduced mooring line tending;
- Option 4 – Fremantle Wharf with Frontal Pontoon, which involves the addition of a floating pontoon in front of Fremantle Wharf; and
- A number of options involving a new wharf in the eastern area of the basin.

These options were further assessed, and the decision was made to proceed with Option 4 as the selected design option.

This DDMP addresses the dredging and dredged sediment management components of Option 4, the current NCIS-5 Project works.

2.3 DREDGE DESIGN

A design dredge depth of –9.4 mAHD (–5.3 mLAT) was initially proposed to accommodate the ACOPV based on a draft of 4.1 m to the underside of the vessel propeller plus an under-keel clearance of 1.2 m (1.0 m navigation clearance and 0.2 m siltation allowance). The additional requirement for the basin to accommodate a new navy vessel class currently being designed then led to a revised design dredge depth of –9.8 mAHD (–5.7 mLAT).

Dredging to the proposed design depth within the existing navigable area of the basin will result in a dredge cut of generally less than 1.4 m deep, and up to approximately 2.3 m at localised high spots.

The proposed dredge area and dredged sediment release location are shown in Figure 2.2.

2.4 SEDIMENT TYPE AND DREDGE VOLUME

The material in the proposed dredge area meets the requirements for sea disposal in accordance with the National Assessment Guidelines for Dredging 2009 (NAGD) and is considered suitable for nearshore marine disposal. Most of the material to be dredged will be comprised of very soft to soft, organic marine clay sediments some with a trace of silt or sand. In a number of locations in the middle of the basin there are isolated 'patches' of hard material (a weathered pegmatite) which will need to be dredged. This hard material is described as a quartz rich, very dense sandy gravel to fragmented rock. The predicted areas of hard material are shown on Figure 2.2.

The soft surface sediments can be readily dredged by cutter suction dredge and with the addition of a cutter head suitable for quartz rich, fragmented to closely fractured rock, it may also be possible to remove the weathered upper layer of the pegmatite using this method. However, based on discussions with a locally experienced dredge contractor it is anticipated that a powerful backhoe dredge may be needed for hard unweathered pegmatite material which may be encountered.

The estimated volume of material to be removed above the design dredge depth is approximately 85,000 m^3 (including batter slopes). Based on the data available this is made up of approximately 79,000 m^3 of soft clay material and 6,000 m^3 of hard material.

Given the tolerances of the dredge plant proposed and the need to ensure that no high points remain above the design depth, an additional 0.3 m of material may also be removed representing an additional volume of up to approximately 16,000 m^3. Some of this would be hard material which would be removed by the backhoe dredge.

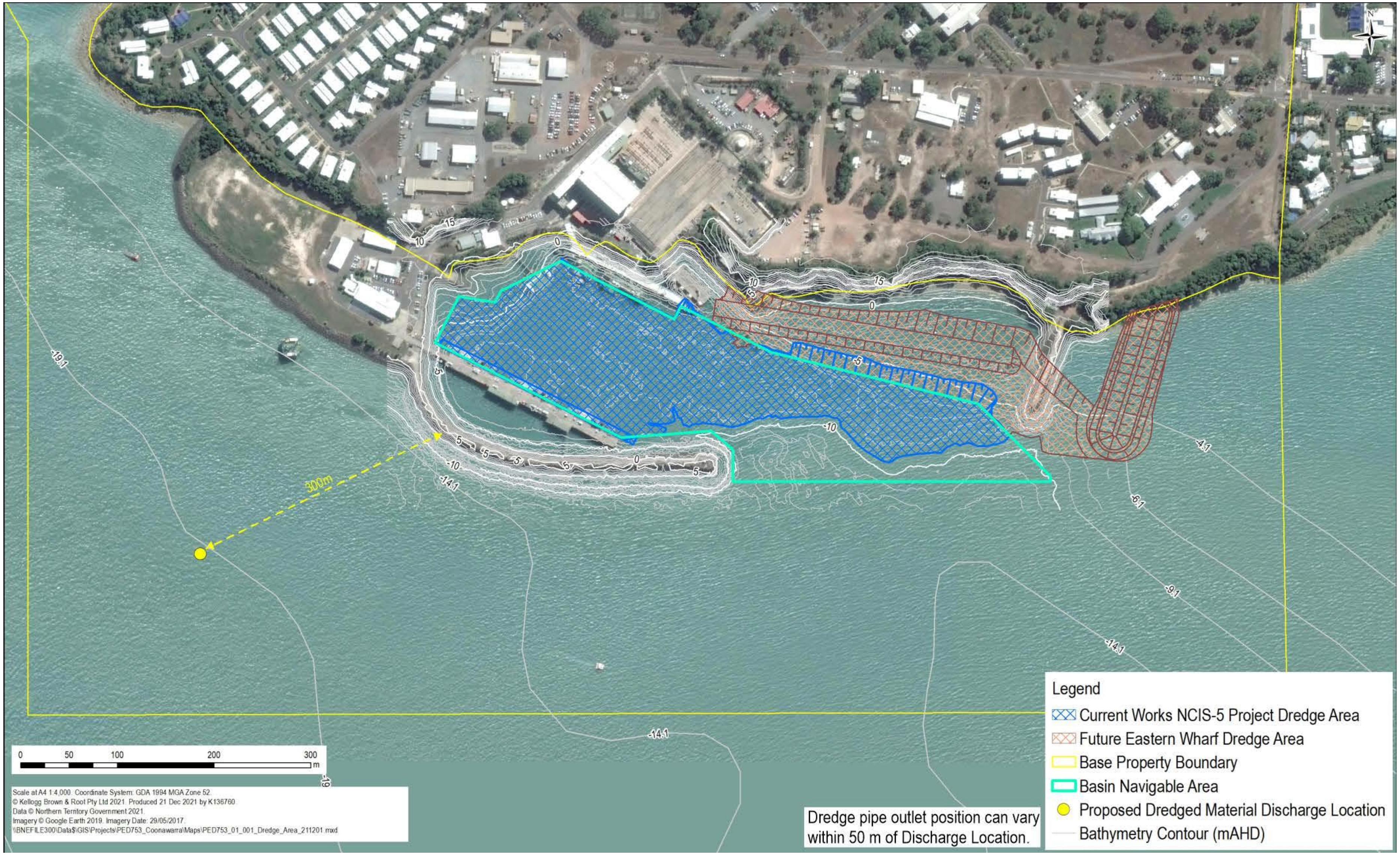

Figure 2.2 **Current NCIS-5 Project dredge area and dredged sediment release location**

2.5 DREDGING METHOD

2.5.1 Equipment

Cutter Suction Dredge (CSD)

It is proposed that a medium sized CSD will undertake the majority of the dredging.

The CSD is a hydraulic dredge which functions by initially cutting the seabed material with a cutter head, before pumping water and sediment ('slurry') through a suction head and discharging the material via hydraulic pipeline.

A key advantage of the CSD is its ability to dredge a wide range of material types compared with other dredge types. This method of dredging has been successfully utilised for past dredging campaigns at HMAS *Coonawarra*.

Based on the site's sediment characteristics, the majority of the materials to be dredged are 'soft' and can be readily removed by CSD. With the addition of a cutter head suitable for quartz rich, fragmented to closely fractured rock, it may also be possible to slowly remove the underlying harder weathered upper layer of pegmatite using this method.

Backhoe

Based on previous dredging experience in the basin it is expected that a powerful backhoe dredge (e.g. 350 t) may be needed for the harder less weathered pegmatite which may be encountered. The backhoe dredge is a mechanical dredge with a fixed hydraulic backhoe (similar to a land-based hydraulic backhoe excavator).

Hard material dredged by backhoe will be placed in a barge and transported to East Arm where it can be unloaded on-shore for land-based storage in one of the Darwin Port ponds or other suitable location.

2.5.2 Dredged material management

CSD to a designated nearshore disposal location

There are no practical re-use options for the soft clay dredged material due to its extremely poor engineering properties and there is no feasible options available for land-based handling (pond facility). Some more competent, usable quartz gravel material is likely to be retrieved from the weathered layer of the hard underlying material. Although some of this weathered material may be taken by the CSD along with the soft material, the remainder will be removed by backhoe.

There is insufficient space available at HMAS *Coonawarra* for landing or rehandling dredged material. The entire site is severely constrained by established uses and the requirement for continued Navy operations.

It is therefore proposed that material dredged by CSD will be discharged via pipeline to a discharge location within the HMAS *Coonawarra* base property boundary (and naval waters) as has been done for previous basin dredging.

The dredge release location is to be located approximately 300m south-west of the western breakwater, which is the discharge location previously used for basin dredging (Figure 2.2). The coordinates of the location are Zone 52 697658 E, 8621578 S (GDA 94) and the pipeline outlet will be kept within 50m of that point and at approximately 5m depth.

The position of the pipe outlet will be monitored using GPS during discharge to ensure the release point is within 50 m of the coordinates above.

Backhoe dredging for disposal at an onshore facility

The removal of 'hard' material that remains following the initial CSD works, will be by backhoe and placed in a barge for transport to East Arm where it can be unloaded onshore and transported by truck to land based storage.

Discussions have been held with Darwin Port in relation to unloading the dredged hard material at East Arm wharf and transporting it a short distance by truck for placement in one of the established dredged sediment ponds at East Arm. The Port is amenable to this proposal, on the proviso that their requirements for material type and management of the unloading and placement activity are met. Further negotiation will be required between Darwin Port and Defence in order to reach a formal agreement to facilitate this.

All material unloading, handling and placement activities undertaken at Darwin Port would be done in accordance with the environmental approvals and management requirements which the Port has in place.

2.6 PROGRAM OF WORKS

At the time of the Draft DDMP, dredging was expected to commence in September 2023 in late dry season. Since then, a Contractor has been appointed and dredging is now scheduled to commence in December 2023 and will extend into the Wet season.

Based on the size of the CSD commissioned, the CSD dredging is predicted to take approximately three to four months. Material dredged via CSD will be disposed via pipeline at the nearshore marine disposal location which has been used during previous dredging campaigns.

CSD operations are planned to occur during daylight hours (6:30am to 6:30pm) six days a week excluding Sundays and public holidays. During dredging operations there will be normal stoppages, for example for repositioning equipment and maintenance. The contractor will also need to make provision for vessels to enter and leave the basin and manoeuvre on and off wharves which may also require periods of no dredging.

The timing of backhoe dredging to remove isolated patches of hard material would be after the completion of dredging by CSD. The rate of dredging via backhoe will be highly dependent on how hard the material is. Backhoe dredging would be limited to the same work hours as the CSD with periods of no dredging for repositioning, manoeuvring attendant barges, maintenance and other vessel movements. Longer hours may be required for unloading barges at the Darwin Port and this would be done in accordance with standard Port requirements.

It is anticipated that the overall dredging program would be completed over a period of approximately four to six months. The duration of dredging will be influenced by the proportion of hard material present within the dredge area, which will result in slower dredging rates.

3 Environmental Project Management and Resourcing

3.1 KEY ROLES AND RESPONSIBILITIES

The roles and responsibilities of the parties involved in the dredging are presented in Table 3.1.

Table 3.1 Roles and responsibilities

Role	Responsibility
Approval holder (Defence)	As the Approval holder, Defence will: • Ensure that project environmental objectives and targets are achieved; • Ensure that all required approvals have been obtained; • Liaise with regulatory authorities where appropriate; • Undertake regular reviews of contractor environmental performance; • Require formal adherence to the DDMP as a condition of contract/employment at the site; and • Report all significant non-compliance and incidents to the relevant authorities and ensure that remedial actions have been implemented.
Project Manager Contract Administrator (PMCA)	Responsible for being the Project Manager Contract Administrator for the construction phase including but not limited to: • Responsible for liaising with the Contractor; • Ensure the Contractor(s) complies with the DDMP; • Arrange auditing of environmental responsibilities and ensure they are carried out during the construction phase; • Arrange auditing for all contractors to ensure they are appropriately inducted, including understanding of their environmental responsibilities; • Regular surveillance and site inspections of all environmental management measures; and • Reviewing non-conformance and complaints and arranging audits of corrective action.
Contractor	Responsible for carrying out all work consistent with the contract requirements including, but not necessarily limited to: • Implementation of the DDMP; • Training of Contractor staff on environmental management and monitoring requirements; • Achieving environmental objectives and targets associated with dredging; • Monitoring and reporting of all environmental elements associated with dredging; • Ensure that records of all site inductions are maintained; and • Regular inspection, implementation and maintenance of all DDMP management measures: – Recording and addressing dredging related corrective action in relation to complaints and non-compliance and passing information to the Superintendent;

Role	Responsibility
	– Maintaining a non-conformance and complaints register and ensuring corrective action has been undertaken; and – Ensuring that all site workers and external contractors are aware of the DDMP, its contents and the impacts on their working methodology prior to the commencement of works.
Design Services Consultant (DSC) - Environmental Monitoring Specialist/Environmental Advisor	The DSC – Environmental Monitoring Specialist/Environmental Advisor will be responsible for: • Supporting Defence in the preparation of environmental and design documentation as required; • Providing relevant technical support to Defence; • Carrying out specialist environmental monitoring tasks and periodic audits throughout the duration of the dredging contract to review environmental compliance; • Reporting results of monitoring to the PMCA; and • Providing audit results and reports to the PMCA for review and implementation of corrective actions, as required.

3.2 INDUCTIONS AND TRAINING REQUIREMENTS

Inductions and training requirements will be determined by the PMCA and the Contractor on appointment and will be in accordance with Defence and the Contractor's policies and procedures. All relevant inductions will be completed by all personnel before they begin work on the project.

A training and inductions register will be maintained by the Contractor.

3.2.1 Environmental inductions

Specific environmental inductions provided by the Contractor will include the following topics:

- Overview of key environmental issues and personnel responsibilities;
- Promoting awareness of significant environmental issues and personnel responsibilities;
- Reporting of environmental incidents - which will include how an event is to be reported and to whom the event is reported to (all incidents are to be reported, including near misses);
- Emergency procedures - which will cover the procedure for an emergency and for evacuation of the site in the event of a catastrophic situation arising; and
- Contingency plans - e.g. for hydrocarbon or chemical spills.

3.2.2 Environmental awareness

Daily prestart/toolbox meetings will be conducted by the Contractor and will primarily be aimed at operational staff. Contractor and relevant subcontractor personnel will be required to attend. Toolbox meetings will focus on environmental and safety items relevant for the dredging and disposal activities during that time and will be used as the main tool to increase awareness of significant environmental and safety issues, and to communicate the relevant items contained in the Environmental Management Plans.

Typical items discussed in these toolbox meetings include environmental items such as new procedures or reinforcement of existing procedures relating the handling of hazardous chemicals, management of waste/recycling, and the need to report all incidents and hazards/near misses at the time of the event.

3.2.3 Training

Qualified and experienced personnel will be engaged on the project. All personnel will have appropriate qualifications and experience for their role on the project. Relevant training required to undertake environmental management or monitoring during dredging will be provided by the Contractor, including but not limited to marine megafauna observation (MMO) training.

3.3 ENVIRONMENTAL DOCUMENTS AND RECORDS MANAGEMENT

The Contractor appointed will have in place, or will develop before the start of dredging, a document management system. Project records, including subcontractor project records, will be maintained to provide evidence of conformity and commitments in this DDMP.

Such records include, but are not limited to:

- Permits, licenses and approvals;
- Induction training records;
- Inspection and test documentation (including calibration);
- Non-conformance and corrective action/complaints;
- Correspondence to/from the Darwin Port and interested parties;
- Environmental incidents;
- Audits and inspections;
- Monitoring records; and
- Delivery/waste dockets.

3.4 PERFORMANCE MANAGEMENT

Performance management includes activities to ensure that DDMP objectives are consistently being achieved.

A key component of the environmental management process is the development and implementation of measures to ensure that the environmental risks arising from the dredging and disposal activities are minimised. These requirements are implemented by inclusion in the Technical Specification Contract Documentation prepared by the PMCA. This identifies what environmental mangement and performance objectives are required to be met by the Project team including the Contractor. The Contractor then prepares detailed mangement plans setting out how the performance objectives will be met and how the required measures will be implemented. These plans are reviewed and approved by the PMCA prior to the commencement of dredging.

3.4.1 Environmental objectives

Key environmental objectives for managing the dredging and disposal campaign are to:

- Limit impacts of dredging and disposal activities on water quality and marine life;
- Ensure that protected marine species, including dolphins, dugongs, turtles and sawfish are not significantly adversely affected by dredging and disposal activities;
- Limit sediment plumes to an extent consistent with predictions;
- Reduce the potential for impacts from noise generated by dredging equipment; and
- Ensure that dredging and disposal activities are undertaken in accordance with regulatory approvals, licenses, permits or authorisations.

3.4.2 Performance criteria

This DDMP identifies actions and commitments to be followed by the Contractor and its subcontractor personnel throughout dredging operations. The performance criteria of the DDMP are:

- Compliance with the DDMP by all project personnel and activities;
- Compliance with water quality criteria;
- No adverse impact on marine megafauna;
- No complaints received in relation to noise; and
- Response to all registered complaints and completion of Complaint Record and/or Incident Report; appropriate corrective actions taken within the timeframe stipulated.

Where performance criteria are not met, this will form a trigger for review, in addition to initiating corrective actions specific to the scenario.

3.4.3 Environmental management outcomes

Section 7 describes specific objectives and performance criteria for each significant environmental aspect.

General objectives and targets are:

- All personnel working on site have undergone an environmental induction;
- Audit score of 100% compliance with the DDMP;
- No activity in breach of the provisions of any environmental legislation;
- Investigation and reporting of all environmental incidents; and
- 100% compliance with management measures required by this DDMP.

3.4.4 Environmental incident report

All Contractor and subcontractor site personnel will be required to report all environmental incidents immediately to the appropriate supervisor in accordance with their incident reporting procedures. The Contractor engaged will have (or will develop prior to the start of dredging) an Incident Reporting and Investigation Procedure.

Incidents shall be tracked through to close-out using an incident tracking system or register. Complaints will be investigated by the Contractor and action taken to enable satisfactory closeout. Any incidents that have caused environmental harm, or that have the potential to cause environmental harm, will also be reported to the PMCA and to the NT EPA within 24 hours.

3.5 MANAGEMENT REVIEW

3.5.1 Inspections/monitoring

Daily inspections of the dredging and disposal activities will be conducted by the Contractor's site supervisors. Any corrective actions resulting from inspections will be recorded and the progress tracked completion.

3.5.2 Contractor's audits

Internal audits of this DDMP will be undertaken during dredging and disposal activities to assess the effectiveness of the Plan in the field, to ensure that the Contractor's monitoring and management regimes are aligned with those in the DDMP, and to identify any opportunities for improvement.

3.5.3 Environmental advisor audits

The project DSC Environmental Advisor will periodically conduct audits to ensure activities are being undertaken in compliance with the relevant environmental requirements for the works. Results from any audits conducted by the DSC Environmental Advisor will be reviewed by the PMCA, with any necessary corrective actions assigned to Project personnel to ensure appropriate and timely closeout. Any corrective actions will be recorded, and the progress tracked for completion.

3.5.4 Project corrective actions register

Any environmental non-conformance (e.g. incidents, audit-related non-conformance, complaints, NTG notices, etc.) will be recorded in a Project Corrective Actions Register, or similar, to be developed by the Contractor.

The Corrective Actions Register will detail the non-conformance, the corrective action(s) required, the person(s) responsible for the action(s), timeframes within which each action is to be completed, and the actual completion date. Each non-conformance will be reviewed by the PMCA and it will be established if there are any actions available to reduce the severity or likelihood of re-occurrence.

3.5.5 Continuous improvement

The Contractor will have in place mechanisms to review performance and to identify opportunities for improvement.

A systematic review of objectives and targets of this DDMP will be undertaken when any of the following occurs:

- Changes in Defence environmental management requirements;
- Changes in relevant legislation that impacts on environmental controls;
- Enforcement action by a government agency;
- Where requested or required by an Authority;
- Relevant environmental objectives have been met;
- Status/conditions and or land uses change; and
- Identification that environmental objectives have not been met.

The purpose of this is to ensure that objectives and targets remain relevant for maintaining and improving environmental performance.

4 Existing Environment

This section of the Plan provides an overview of the aspects of the existing environment that are pertinent to the consideration of impacts from dredging and dredge material disposal activities at HMAS *Coonawarra*. This information provides the context for the management strategies and monitoring programs detailed in Section 7.

4.1 EXISTING PHYSICAL ENVIRONMENT

4.1.1 Topography and bathymetry

Larrakeyah Peninsula consists of a flat plateau with steep rocky cliffs leading to a rocky foreshore. HMAS *Coonawarra* includes flat areas at approximately 17 to 18 mAHD, but grades to the water's edge along its northern and western boundaries. HMAS *Coonawarra* is partially located within a former quarry cut out of the cliff, with excavation of the escarpment resulting in a series of level platforms stepping down to the harbour. To the west there is a reclamation area which is being developed.

The HMAS *Coonawarra* basin navigable area currently has an approximate bed level of –8.6 mAHD (–4.5 mLAT), providing a water depth of approximately 4.5 m at all levels of the tidal range.

Bathymetric surveys of the harbour basin undertaken in 2017 and 2020 show a seabed level generally in the range of approximately –8.7 mAHD (–4.6 mLAT) to –9.1 mAHD (–5.0 mLAT), with ridges protruding above about –8.6 mAHD.

Bathymetry at the entrance to the basin is approximately –10.1 mAHD (–6.0 mLAT) with depths gradually increasing to –16 mAHD (approximately –12 mLAT) 150 m south of the entrance to depths greater than –29 mAHD (approximately –25 mLAT) over 1.3 km south of the entrance within the City Channel.

Within the vicinity of the dredged material discharge location which is approximately 300 m south-west of the western breakwater, bed level is approximately –19 mAHD (–15 mLAT).

4.2 CLIMATE

4.2.1 Temperature and humidity

The climate of Darwin is characterised by a hot, humid wet season usually between October to April, and a hot dry season from May to September, separated by transitional periods.

Based on the Darwin Airport historical data, November (transition to wet season) is the hottest month with a monthly average minimum temperature of 25.3^{o}C and a monthly average maximum temperature of 33.3^{o}C maximum. Temperatures remain in a relatively narrow range throughout the year, with monthly average minimum temperatures ranging between 19.3^{o}C (July) to 25.3^{o}C (November/December) and monthly average maximum temperatures ranging between 30.6^{o}C (July) to 33.3^{o}C (October/November).

4.2.2 Rainfall

The mean annual rainfall of 1722.2 mm is highly seasonal, varying from an average monthly rainfall of 1.1 mm in July to an average monthly rainfall of 429.8 mm in January. High precipitation rates are commonly experienced during storm events in the wet season. Average relative humidity at 9.00 am varies from 60% in both June and July to 83% in February. Average relative humidity at 3:00pm varies from 37% in July to 72% in February. Mean daily evaporation ranges from 5.7 mm (in February and March) to 7.9 mm (in October), with an average annual evaporation of 6.7 mm.

4.2.3 Wind direction and speed

Synoptic winds during the dry season are dominated by the southeast trade winds, and light west to north-westerlies are predominant during the wet season.

Mean afternoon wind speeds tend to be stronger than morning wind speeds all year round. Morning wind speed is typically stronger during the dry season, whereas afternoon wind speed increases during the late dry, build up and wet season periods which is most likely associated with the formation of mid to late afternoon storm cells during this time of the year.

4.2.4 Cyclone activity

Darwin and the NT coastline are in a region regularly affected by cyclones. On average, there are 7.7 days per season when a cyclone exists in the northern region of Australia. The Gulf of Carpentaria averages two cyclones per year, while the Arafura and Timor Seas average one per year (BoM, 2019). Cyclones which form in the Gulf of Carpentaria tend to be quite erratic in movement, whereas those which form in the Arafura and Timor Seas tend to follow more regular tracks to the southwest. In the northern region of Australia over half the cyclones generated typically move either southwest or southeast into adjoining regions.

4.3 MARINE SEDIMENT CHARACTERISTICS

In June 2018, marine sediment sampling and analysis was undertaken to determine the physical and chemical characteristics of the sediment within the current NCIS-5 campaign dredge area (GHD 2019). Further marine sediment sampling and analysis was also undertaken in 2020 to confirm material properties of the hard material and those within the vicinity of the future eastern wharf development area (GHD, 2021).

The development of the sediment sampling approaches, sample handling, the transit and analysis of samples were undertaken in line with the guidance provided in the NAGD.

The 2018 sediment sampling locations and the earlier geotechnical investigation boreholes are shown on Figure 4.1.

A summary of the findings from the marine sediment sampling and analysis investigation is presented below.

Physical characteristics

Most of the material to be dredged is comprised of very soft to soft, organic marine clay sediments some with a trace of silt or sand. In a number of locations in the middle of the basin there are isolated ‘patches’ of hard material (a weathered pegmatite) which will need to be dredged. This hard material is described as a quartz rich, very dense sandy gravel to fragmented rock. The predicted areas of hard material are shown on Figure 4.1.

The soft sediments can be readily dredged by cutter suction dredge and with the addition of a cutter head suitable for quartz rich, fragmented to closely fractured rock, it may also be possible to remove the weathered upper layer of the pegmatite. However, based on experience from previous dredging it is anticipated that a powerful backhoe dredge may be needed to remove the hard unweathered pegmatite material.

Figure 4.1 **Current NCIS-5 Project Dredging Geotechnical Investigation Boreholes and Marine Sediment Sampling and Magnetic Anomaly Locations**

Chemical characteristics

As part of the marine sediment sampling campaign undertaken in 2018, sediment samples were recovered and analysed to characterise these dredge sediments within the current NCIS-5 dredge area. All sediment cores were retrieved via vibracorer which recovered 'soft' to 'stiff' sediment but refused on the 'hard' underlying materials. As such the analysis presented below reflects the softer surface sediments that are proposed to be removed by the CSD and discharged at the nearshore location.

It is unlikely that the hard underlying materials would contain any contaminants. This is based on outcomes of the recent sediment sampling investigation which investigated the hard material, the physical properties of the material (i.e. weathered pegmatite), the fact that it is undisturbed residual material and the low levels of contaminants identified in the overlying softer sediments. Additionally, as this material will be transported by barge for onshore disposal there is low risk of contaminants being release into the marine environment.

Sediment samples were recovered and analysed for a range of parameters including metals, total recoverable hydrocarbons (TRH), total petroleum hydrocarbons (TPH), benzene, toluene, ethyl benzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs) and phenols, organochlorine (OC) and organophosphorus (OP) pesticides, tributyltin (TBT), acid sulphate soils (ASS), total organic carbon and nutrients. Per- and poly-fluoroalkyl substances (PFAS) were also a potential contaminant of concern and were therefore added to the list of constituents analysed, although not specifically listed in the NAGD.

Analysis results for metals, TRH and BTEX, PAHs and phenols, OC and OP pesticides were all below the relevant NAGD Screening Levels. Total concentrations of PFAS compounds were all 'not detected' at the conservatively low laboratory limits of reporting which were selected (i.e. < 0.0002 mg/kg of PFAS) (i.e. not detected).

Traces of TBT were detected in eight of the 34 samples analysed across the dredge area. Of these only two samples, collected at locations SD005 and SD013, showed normalised TBT (as Sn) concentrations above the NAGD screening level of 0.009 mg/kg.

The 95% upper confidence limit (UCL) of the mean for normalised TBT (as Sn) concentrations was 0.0279 mg/kg and also exceeds the NAGD Screening Level. Elutriate analysis of these two samples resulted in TBT concentrations which, once adjusted for estimated initial dilution (as described in the NAGD) were below the ANZG marine water guideline for 95% species protection.

All sediment analysis results were compared with the relevant NAGD screening levels. Based on laboratory analysis results, and assessment against the criteria in the NAGD, all material is considered suitable for unconfined sea disposal.

Acid sulphate soils

An assessment of ASS risks was undertaken using action criteria detailed in the National Acid Sulfate Soils Guidance – National acid sulfate soils sampling and identification methods manual (Sullivan et. al., 2018).

A total of 25 sediment samples were analysed for the full Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) suite. The SPOCAS results indicated the presence of pyrite but show no sign of acid production on oxidation. There is no potential for acid generation associated with nearshore sea disposal.

The harder underlying material is not ASS and has no acid generating potential. This was confirmed by sampling and analysis and is consistent with geological origin and physical properties.

4.4 COASTAL PROCESSES

4.4.1 Wave climate

The wave climate in Darwin Harbour is primarily wind driven which in turn is heavily influenced by seasonal conditions (e.g. the NW monsoon and tropical cyclones). Typically, wind generated waves inside Darwin Harbour are fetch-limited (as opposed to duration limited as often found in larger water bodies), with low wave energies. The wind fetches range from 6 km to 15 km at the project area (from 115°N to 295°N directions). There is a narrow sector at the Darwin Harbour entrance between 297°N and 310°N exposed to large fetch across the Timor Sea and into Beagle Gulf, however due to refraction, shoaling and diffractive effects, very little swell generated from this sector enters Darwin Harbour. In consideration of this, very little swell enters the HMAS *Coonawarra* basin due to sheltering by the main (western) breakwater.

Outside the basin within Darwin Harbour, wave heights during non-cyclonic conditions are typically well below 1 m. However, during inclement weather events, waves can typically be up to 2 m in height.

Waves experienced at the basin entrance are generated by wind from the south-west (210°TN sector), with a fetch distance of approximately 12.5 km.

4.4.2 Tidal currents

Currents within the project area are primarily dominated by tides and have a strong diurnal cycle.

Currents outside the HMAS *Coonawarra* basin, close to the entrance, are typically in the order of 1.3 m/s (2.5 kts) on a flood tide and 2.3 m/s (4.5 kts) on an ebb tide. Current direction is close to parallel with the western breakwater for both incoming and outgoing tides.

The basin is largely protected by the western breakwater, and therefore the magnitude of internal currents is much less, and are unlikely to exceed 10% of the current magnitudes outside the basin.

Overall ebb currents trend towards the west and north-west directions and flood currents trend toward the east and south-east however the directions within the harbour are highly variable, particularly due to shadowing effects and flow separation on the lee side of the eastern breakwater.

4.5 WATER QUALITY

Within the HMAS *Coonawarra* basin, water quality is largely influenced by the tidal regime and the resuspension of sediments from vessel movements. There is also the potential for pollutants from soils and paved surfaces surrounding the vessel maintenance area to enter the basin with stormwater. Although water quality data within the basin area has not specifically been captured, studies have been conducted in the broader project area which capture the ambient water quality conditions of the harbour.

The project area is located within the Middle Harbour Zone, which receives urban and industrial stormwater runoff from the city of Darwin and developments throughout the region. The harbour's main shipping channel transverses this zone and it receives dispersed discharge from the Ludmilla wastewater treatment plant at the East Point outfall.

The water quality of Darwin Harbour varies greatly with the tides, wave conditions, season and location. As an example, over each tidal cycle, and between neap and spring tides, turbidity and suspended sediment levels in the Harbour change substantially. This is most noticeable in the upper reaches of the Harbour, where there is almost an hourly change as water carrying sediment flows into and out of the mangrove areas of the Harbour (Padovan, 2003).

Previous studies show no evidence of widespread water or sediment pollution in the Harbour, although there is some localised pollution associated with various industrial activities (Padovan, 2003). Potential sources of pollution in the harbour include stormwater runoff from rural, urban and industrial catchment diffuse sources during the wet season, sewage treatment plant wastewater discharges and other licensed wastewater discharges (DLRM, 2014).

Turbidity and suspended solids concentration are important water quality parameters for planning and managing dredging campaigns. Turbidity is a useful indicator of suspended solids concentrations which can be measured in real time in the field. Turbidity data can be linked to the key dredging and dredged sediment disposal impact mechanisms and is routinely used in both impact prediction and monitoring. Other parameters such as temperature, dissolved oxygen and salinity are also useful in understanding the physical conditions of a project area.

4.5.1 DEPWS Water Quality Monitoring

The 2022 Darwin Harbour Report Card (DEPWS, 2022) describes the Middle Harbour Zone as having very good water quality with regard to water clarity, dissolved oxygen, nutrients and algae.

To better understand water quality conditions within proximity to the HMAS *Coonawarra* project area, available water quality data associated with relevant estuarine monitoring sites and continuous flow monitoring locations up to the end of 2020 was obtained from DEPWS.

Where available, water quality parameters including dissolved oxygen (DO), pH, salinity, nutrients turbidity, and wet/dry season variations in turbidity were analysed for each relevant monitoring location.

Analysis of water quality data collected from the most relevant DEPWS estuarine and continuous flow monitoring (CFM) locations identified that average turbidity values are typically 3 NTU during the dry season and approximately 5 NTU during the wet season. The limited data set also shows that variations in turbidity are commonly observed, with turbidity levels ranging between approximately 1 NTU and 29 NTU with slightly higher turbidity levels observed during the wet season. Larger fluctuations in turbidity levels are observed at the estuarine site closest to HMAS *Coonawarra* (G8155136), located approximately 2 km west of the base. At this location turbidity levels are typically in the order of 3 NTU to 6 NTU with periodic seasonal fluctuations ranging between 17 NTU and 29 NTU during the dry and wet season, respectively.

Physiochemical parameters including dissolved oxygen, pH and salinity were also analysed, with all parameters typical of those recorded in coastal environments.

It is recognised that the DEPWS monitoring programs are somewhat biased to the dry season and neap tidal conditions and are not designed to detect short-term, spatially specific water quality changes (Makarynska, 2019).

4.5.2 Other Baseline Data Sources

As part of an assessment of seagrass habitat within Fannie Bay, to the north of the proposed discharge location, turbidity readings (NTU) were collected over a month-long period (Cardno, 2013) to assess potential impacts from dredging and/or spoil disposal activities associated with the INPEX Project. Turbidity monitoring was undertaken during the dredging and disposal campaign with results showing that no suspended sediment plume entered the bay as a result of dredging or spoil disposal activities.

The turbidity data collected for Fannie Bay therefore provides an indication of the turbidity conditions experienced within the bay. Table 4.1 provides a summary of the turbidity data collected at the two monitoring locations in Fannie Bay between 9 November and 9 December 2012.

Table 4.1 Summary of Fannie Bay Turbidity monitoring data (9 November to 9 December 2012)

Location	Turbidity (NTU)				
	Minimum	20th %ile	Mean	80th %ile	Maximum
Fannie Bay Site 01	2.5	3.6	7.8	12.0	19.0
Fannie Bay Site 02	1.8	2.6	5.6	7.6	14.5

In addition, and as part of the INPEX project, turbidity at four locations within Darwin Harbour was measured from 2010 to 2011 which reported ranges from 10 to 40 NTU within the dry season and 80 to 180 NTU in the wet season (INPEX, 2012). Summary data from across the harbour is presented in Table 4.2.

Table 4.2 Turbidity Values in Darwin Harbour 2010 to 2011 (INPEX, 2012)

Location	Typical Peak Turbidity Values measured during the 2010 – 2011 Measurement Campaign (NTU)	
	Dry Season	Wet Season
Channel Island	20-40	120-160
Weed Reef	10-40	140-180
North-east Wickham Point	20-40	90-120
South Shell Island	20 -30	80-120

A study (Andutta et al., 2019) undertaken during the 2012-2013 and 2013-2014 wet season identified that turbidity levels varied across the harbour and depending on the location and tidal phase. During these monitoring periods values of above 40 NTU were regularly recorded during active monsoons (which frequent this region) in the vicinity of the HMAS *Coonawarra* project area. This study found that high turbidity values recorded in near shore areas correlate closely with increased wind and wave height due to the resuspension of fine sediments in these systems.

The ambient monitoring undertaken by the NT Government does not capture these sorts of elevated turbidity measurements as these sites are located further from the shore where the resuspension of fine sediments due to wind and wave mechanisms is not as prevalent.

In addition, studies by Padovan (1997) analysed the effects of season, water depth, harbour location and tidal movements on various water quality parameters within Darwin Harbour. Many parameters, such as pH, total organic ammonium and nitrogen, were found to be relatively stable throughout the year. Water temperature and oxidised nitrogen concentrations changed with season while turbidity and total suspended solids were affected by location in the harbour and tidal activity.

There is also no evidence of hydrocarbon or pesticide pollution in the Harbour (DHAC, 2007).

4.5.3 Baseline water quality data from previous dredging campaigns

Baseline water quality monitoring data was captured prior to the commencement of dredging for both the 2006 and 2013 dredging campaigns. The data is representative of the natural variability in water quality conditions experienced within the nearshore setting in HMAS *Coonawarra* project area.

Further discussion of baseline water quality conditions monitored prior to the 2006 and 2013 dredging campaigns is provided in the following sections.

Baseline water quality monitoring data – Prior to 2006 dredging campaign

Baseline monitoring conducted prior to the commencement of the 2006 dredging campaign showed periods of naturally high turbidity within the shallow nearshore environment of the project area. Monitoring of turbidity was carried out on a daily basis for nine days prior to dredging at a number of ambient water quality monitoring locations in the project area. Other parameters including pH, temperature, conductivity and percent (%) oxygen saturation were also recorded.

Monitoring locations of most relevance include the nearshore sites at Mindil Beach and Cullen Bay Beach to the north, and Doctors Gully to the south (Figure 4.2).

Average turbidity levels recorded at each location prior to dredging are outlined in Table 4.3. Averages were based on replicate measurements which involved multiple readings taken at the same location at the same time.

At the Cullen Bay Beach location turbidity ranged between 2 NTU to 36 NTU, while during the same period turbidity at Doctors Gully ranged between 13 NTU and 363 NTU and similarly at Mindil Beach turbidity varied from 4 NTU to 225 NTU.

This data shows substantial variability in turbidity across both time and location, with turbidity peaks of varying magnitudes evident at all sites. Fluctuations in turbidity were most pronounced at Doctors Gully, albeit substantial variations in turbidity was evident across all three nearshore sites.

On the day prior to the commencement of dredging turbidity levels recorded at the discharge location were up to 45 NTU (Table 4.4), with turbidity levels recorded at the Doctors Gully shallow nearshore monitoring site, approximately 1.5 km east of HMAS *Coonawarra,* of up to 127 NTU.

Weather records show that no rainfall occurred during the month of June, which indicates that these shallow nearshore locations experience naturally high turbidity variability, which (in the absence of rainfall) is strongly influenced by wind and wave fine sediment resuspension.

Table 4.3 Average turbidity levels recorded during baseline water quality monitoring prior to 2006 dredging campaign

Date	Mindil Beach – Avg. Turbidity (NTU)	Cullen Bay Beach – Avg. Turbidity (NTU)	Doctors Gully – Avg. Turbidity (NTU)
15/06/2006 (PM)	99	28	100
16/06/2006 (PM)	80	31	210
19/06/2006 (PM)	38	24	363
20/06/2006 (AM)	16	2	182
21/06/2006 (PM)	5	3	13
22/06/2006 (AM)	143	4	118
22/06/2006 (PM)	4	3	50
23/06/2006 (AM)	6	9	30
23/06/2006 (PM)	72	36	17
26/06/2006 (AM)	35	29	39
28/06/2006 (PM)	225	31	127
SUMMARY DATA (NTU)			
Min	4	2	13
20th %ile	6	3	30
Median	38	24	100
80th %ile	99	31	182
Max	225	36	363
No. of monitoring events	11	11	11

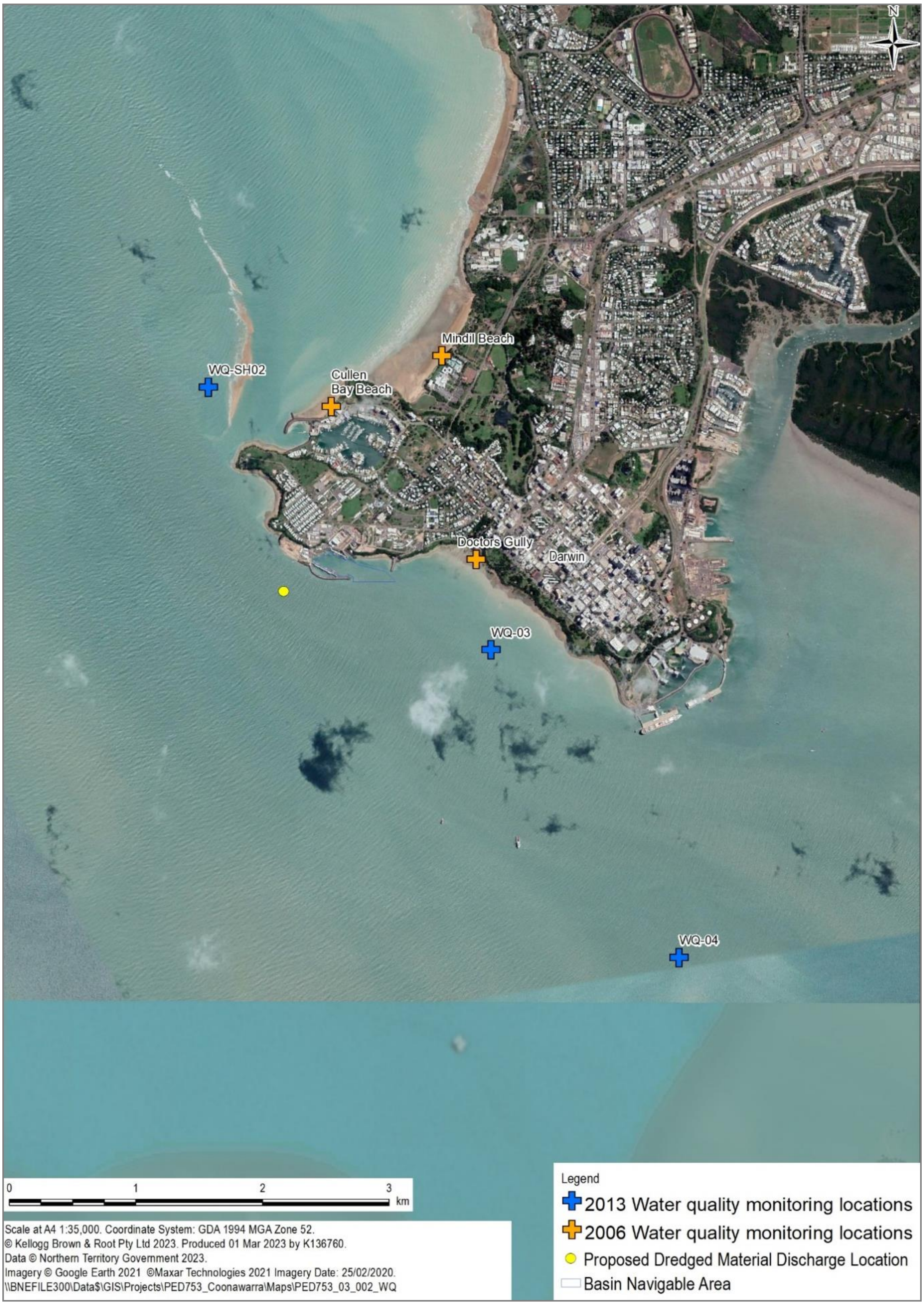

Figure 4.2 **Baseline water quality monitoring locations during previous dredging campaigns**

Table 4.4 Turbidity levels recorded at the discharge point the day prior to the commencement of dredging (28 June 2006)

Depth from surface	Turbidity (NTU)
Surface	45
10 m	7
20 m	9

Baseline Water Quality Monitoring Data – Prior to 2013 Dredging Campaign

Prior to the commencement of the 2013 dredging campaign, unattended water quality monitoring loggers were deployed at a number of locations within proximity to HMAS *Coonawarra* (Figure 4.3). The instruments were mounted on bed frames with sensor approximately 1 m off the bed. The instruments were deployed to collect time series turbidity data every 30 minutes during the deployment period. All loggers were deployed in depths ranging from 10m to 18m.

The time series data captured baseline turbidity conditions from 10 to 15 September 2013 and was representative of near bed conditions during the transition from a spring to neap tide. Figure 4.3 shows the time series data recorded prior to the commencement of dredging.

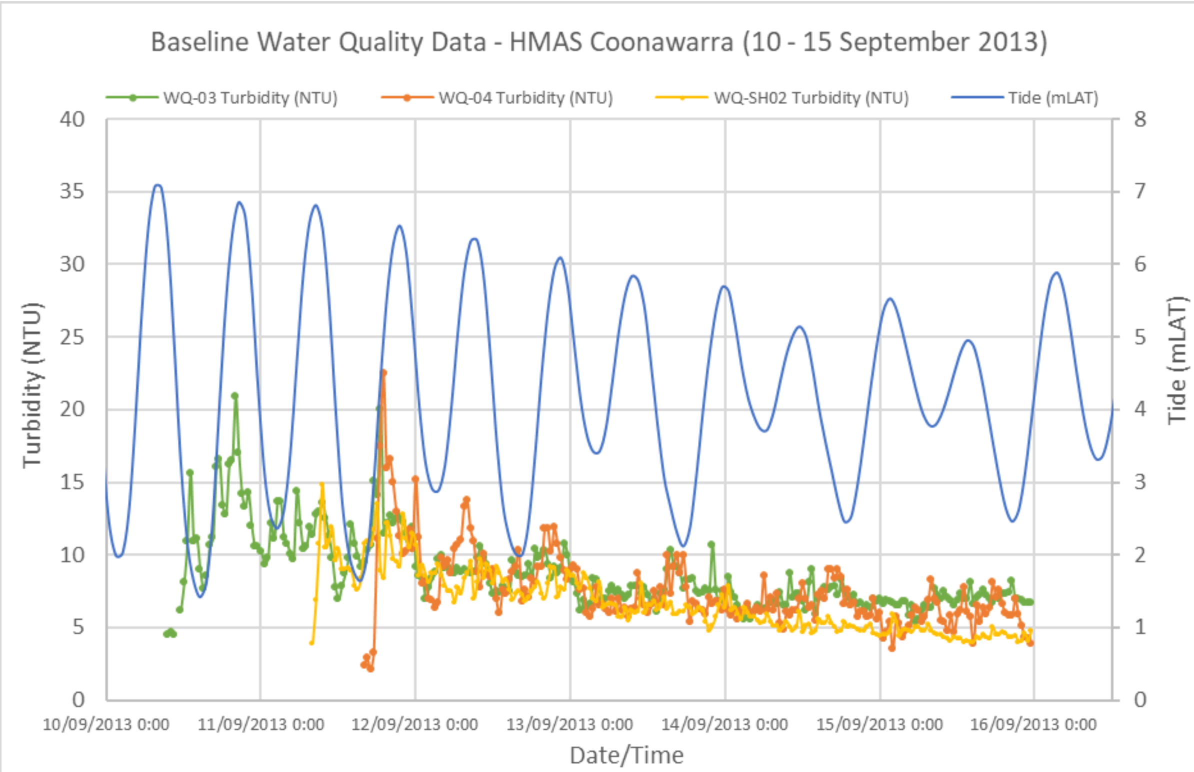

Figure 4.3 Timeseries baseline water quality data recorded between 10 – 15 September 2013

As shown in Figure 4.3, each of the three monitoring locations exhibited similar variations in turbidity, over time and in magnitude. A summary of turbidity values recorded at each location is provided in Table 4.5.

Median turbidity levels for all three locations were approximately 7 NTU. However fluctuations greater than 10 NTU were regularly observed at all three locations and typically coincided with mid-tide. Naturally high turbidity peaks of 20 NTU or greater were also observed on occasion at sites WQ-03 and WQ-04.

Table 4.5 Timeseries baseline water quality monitoring summary prior to 2013 dredging campaign

Turbidity (NTU)	Water Quality Monitoring Location		
	WQ-03	WQ-04	WQ-SH02
Min	4.5	2.1	3.9
20th %ile	6.8	5.8	4.8
Median	7.9	6.8	6.25
80th %ile	10.6	9.0	8.6
Max	20.9	22.5	14.8
No. of Measurements	268	208	224
Duration	10 - 15 Sep 2013	11 - 15 Sep 2013	11 - 15 Sep 2013

During this baseline monitoring period, no rainfall was recorded, nor was there any substantial rainfall in the months leading up to the deployment of instruments. With the lack of catchment inputs to the system, the natural variations in turbidity are attributable to the large tidal range and strong tidal currents within this area of the harbour.

The baseline monitoring period captures the end of a spring tide and extends into the early stages of a neap tidal cycle. Slightly higher turbidity levels recorded towards the beginning of the monitoring period suggests that the larger tides and currents experienced during this time are the principal mechanisms driving sediment movement and resuspension in the water column. Similarly, these processes are still evident during the neap tide however are not as strong and therefore the effect of the tide and velocity of currents is not as pronounced.

4.5.4 2023 baseline water quality data monitoring program

A project specific dry season baseline water quality monitoring program was undertaken by the Australian Institute of Marine Science (AIMS) between 27 April 2023 and 30 May 2023. The primary purpose of the monitoring program was to obtain representative turbidity (NTU), total suspended sediment (TSS), photosynthetically active radiation (PAR), temperature and conductivity data, which would be both temporally relevant and available prior to the commencement of dredging.

The program involved the deployment of monitoring instruments to capture water quality data over a one month period, spanning two spring and neap tide cycles at three locations including WQ1, WQ3 and WQ4, as shown in Figure 4.4.

Baseline monitoring locations

The monitoring locations were based on the predicted behaviour of sediment plumes and the type and extent of benthic habitats known to occur within the project area.

Monitoring location WQ1 was positioned within the entrance to Fannie Bay as this location provides data representative of the shallow nearshore areas of the bay which are influenced by wind/wave resuspension (and at times have been known to support potential seagrass habitat). In addition, during dredging, this water quality monitoring location will provide an early warning of dredge related suspended sediment plume that may enter the Fannie Bay area (noting that data from previous dredging and updated modelling do not predict this will occur).

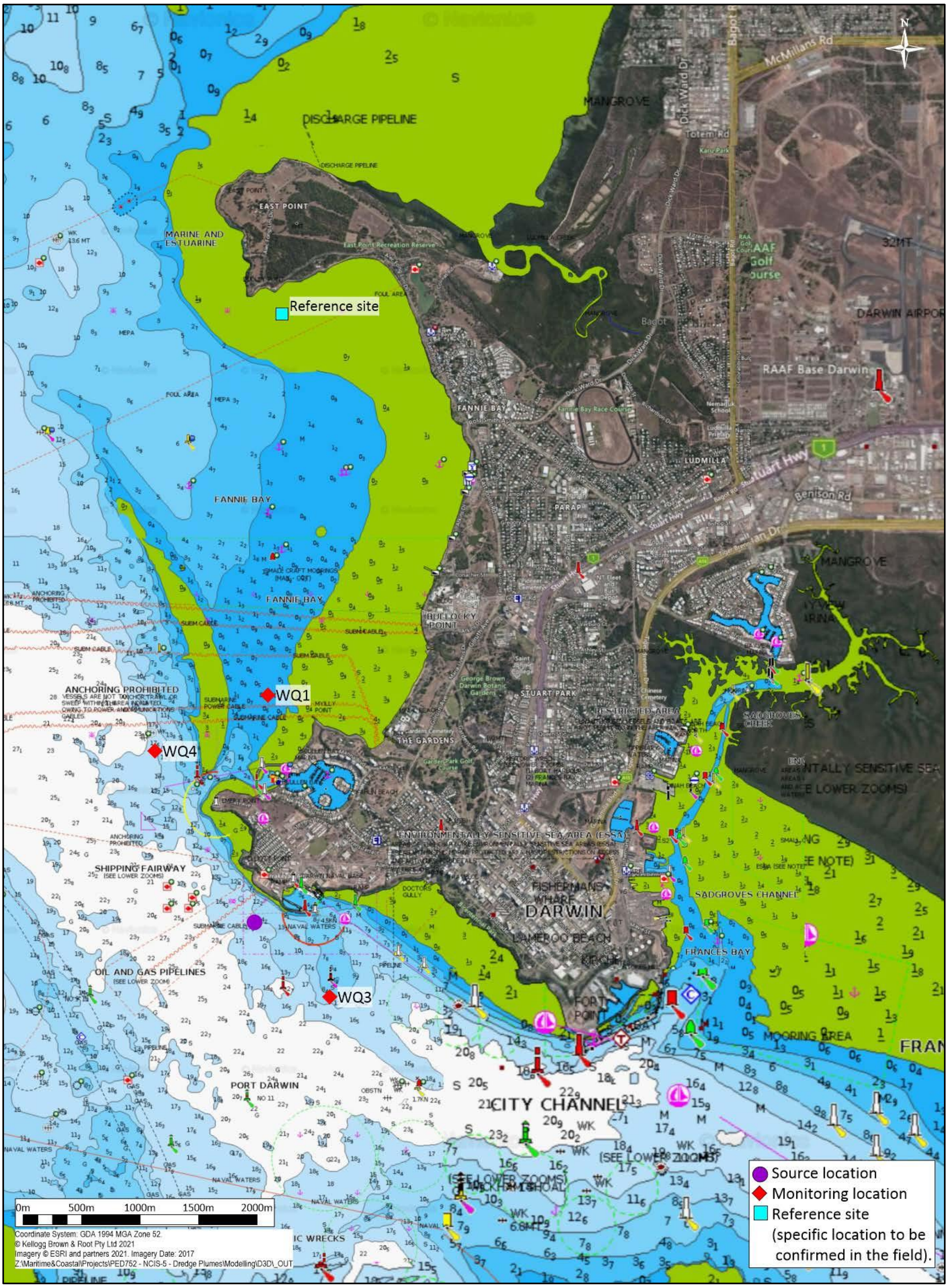

Figure 4.4 **Water quality monitoring locations (WQ1, WQ3 and WQ4)**

The other two monitoring locations were positioned within the harbour to the north and south of HMAS *Coonawarra*. Data from these locations reflect water quality conditions largely influenced by the tide and the broader redistribution of sediment throughout the harbour.

Monitoring location WQ3, was located near Bennett Shoal as recommended by DEPWS. This monitoring location captures flood tide effects. Monitoring location WQ4, was located west of the offshore sand bank as recommended by DEPWS and captures ebb tide conditions. Both of these locations are located within the predicted extent of the sediment plume from the dredged sediment discharge.

Baseline monitoring program

Unattended water quality monitoring

Instruments with PAR and NTU sensors were deployed on bed mounted frames at WQ1, WQ3, and WQ4 locations with sensors approximately 0.5m above the seafloor. The instrumentation deployed at WQ1 also included a tethered surface buoy with a water quality monitoring instrument to measure turbidity at approximately 1.0 m below the surface.

An ‘on land’ PAR reference sensor was deployed at Cullen Bay Marina, adjacent to the lock. This reference station, deployed on top of a shipping container and free of shade, was used to record on land PAR data.

Monitoring parameters were logged at 15 minute intervals at all locations to create a timeseries data record for each location over the deployment period.

Water quality depth profiles and TSS samples

During deployment and retrieval of the instrumentation, conductivity, temperature, depth and turbidity (NTU) profiles were measured at each deployment location and elsewhere within the predicted zone of influence. These measurements were taken at the time of instrument deployment and retrieval which were predominantly timed to occur at/near the turn of the tide and also at approximately half tide on the same day when tidal current velocities were greater.

Similarly, during deployment and retrieval, a series of water samples were collected from locations within the area of interest and analysed for field measured turbidity (NTU) and laboratory determined TSS (mg/L). The collection and analysis of these samples were used to investigate the relationship between NTU and TSS.

Water quality profiles and samples were measured at 14 locations during instrument deployment and at a total of 8 locations during instrument retrieval.

Weather conditions

During the deployment and retrieval periods, metocean conditions were described by AIMS as favourable with light winds and calm seas. During the 34 days of monitoring, there was no rainfall recorded at Darwin Airport (Bureau of Meteorology Station 014015), 77% of days had sustained average wind speeds less than 10 knots resulting in calm seas, and 95% of monitoring days experienced ≥ 9 hours of bright sunlight.

Baseline monitoring results

Turbidity

As shown in Figures 4.5 to 4.7, turbidity levels at all locations displayed a similar behaviour over time, with greater variation in turbidity observed during spring tide periods. Very low turbidity conditions were experienced at all sites during neap tides, which is consistent with published long term average turbidity values recorded for the harbour.

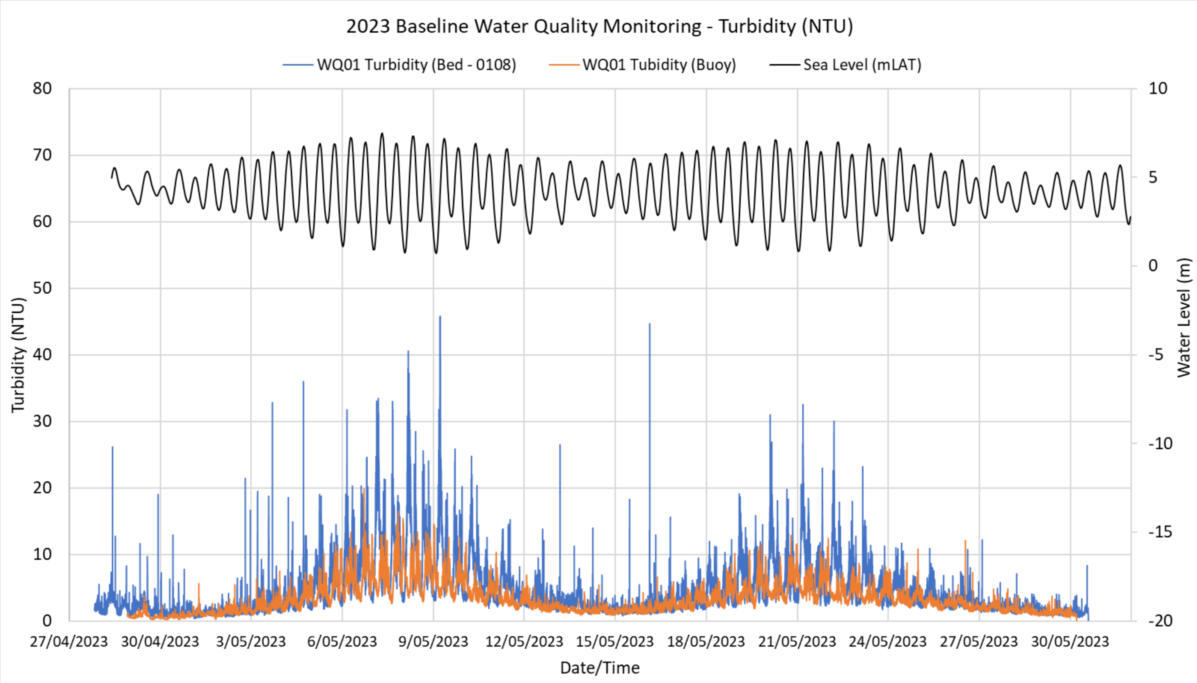

Figure 4.5 WQ1 turbidity time-series data – Comparison of turbidity recorded at surface and seabed

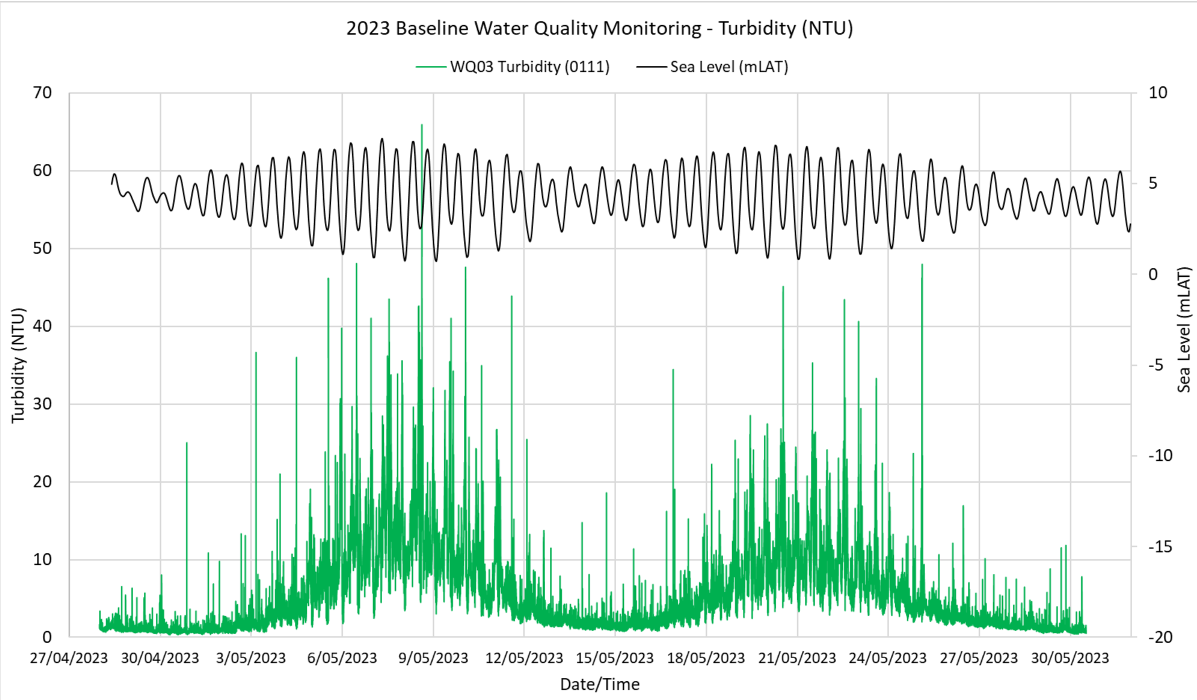

Figure 4.6 WQ3 turbidity time-series data recorded at the seabed

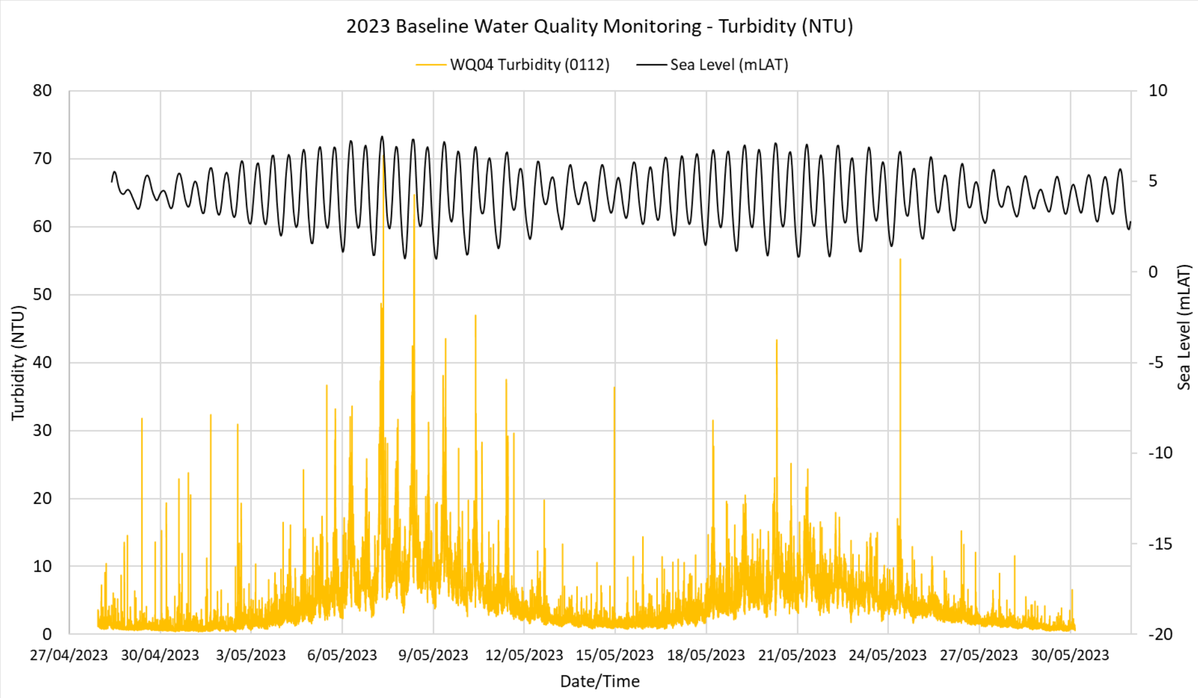

Figure 4.7 WQ4 turbidity time-series data recorded at the seabed

Table 4.6 provides a summary of the turbidity data collected at each of the monitoring locations. Overall median turbidity levels ranged between 2.6 and 3.1 NTU. The highest turbidity values were recorded at WQ3 and WQ4 and were 65.9 NTU and 70.1 NTU, respectively.

Table 4.6 Summary statistics for turbidity data collected at each monitoring location

Turbidity (NTU)	Monitoring Location			
	WQ1 (Seabed)	WQ1 (Surface Buoy)	WQ3	WQ4
Minimum	0.1	0.1	0.3	0.4
20th Percentile	1.5	1.3	1.2	1.2
Median	2.9	2.6	3.1	3.0
80th Percentile	6.2	4.8	8.4	7.0
Maximum	45.6	19.8	65.9	70.1

A review of seabed and surface water quality data recorded at WQ1 demonstrates similar behaviours and fluctuations with the tide, however the magnitude of turbidity values was more pronounced at the seabed (Figure 4.5).

The maximum turbidity value recorded at the WQ1 surface buoy was 19.8 NTU while the maximum turbidity level recorded at the seabed was approximately 45.6 NTU. Comparison of the seabed and surface water quality data indicates a current related near bed resuspension of sediments with turbidity values consistently higher at the seabed than the surface during all stages of the tidal cycle.

Relationship between TSS and PAR

PAR data was collected at WQ1, WQ3 and WQ4 to further understand benthic light availability within the benthic communities within the zone of influence. For each monitoring location representative neap and spring tide turbidity timeseries data was compared with PAR data.

At WQ1, low turbidity values were recorded during the neap tide (Figures 4.8). Typically turbidity near the seabed was slightly higher as would be expected. The depth of water at this location varied between 3 m and 7 m with the tide. PAR recordings at the seabed in the middle of the day ranged between 200-500 µmol/m^2/s (approximately 5 - 20% of available PAR) during neap tides. Analysis of the data indicates a relationship between both water level and turbidity, and PAR at the seabed. Lower water level appears to have the clearest link to slightly higher PAR at the seabed.

Figure 4.9 shows a spring tide series for WQ1 with periods of higher turbidity near the seabed, typically associated with 'half tide' periods when currents are the strongest. Analysis of the results show that high turbidity and/or high water level result in less sunlight penetrating the water column and thus lower PAR values at the seabed. PAR recordings at the seabed in the middle of the day ranged between 230-550 µmol/m2/s (approximately 15 - 30% of available PAR) during spring tides. Turbidity peaks at the seabed appear to occur after the turn of the tide during periods of higher current velocity. Turbidity values at the surface are lower than near the seabed and turbidity "peaks" near the surface are out of phase with those recorded near the seabed, presumably because of the time taken for vertical mixing to occur.

A review and analysis of water quality data recorded at WQ3 and WQ4 was also undertaken. A comparison of turbidity and PAR data recorded during both a neap and spring tide for WQ3 is presented in Figures 4.10 and 4.11, with the analysis of a neap and spring tide dataset for WQ4 provided in Figures 4.12 and 4.13.

Data collected at WQ3 and WQ4 shows that even in the very low turbidity conditions experienced during the monitoring period, little or no light is able to penetrate through the water column to the seabed at these deeper locations regardless of how low the turbidity level is, including at low tides (Figures 4.10 to 4.13). PAR is consistently near zero at these locations no matter the available PAR (i.e. whether recorded days are full sunlight or affected by cloud cover, benthic PAR in these locations remains absent or very low). Turbidity concentrations near the bed were elevated during periods of strong current (e.g. at 'half tide').

During monitoring, conditions were ideal with limited days with cloud cover occurring and PAR readings recorded on land exceeding 2,000 µmol/m^2/s, which is approximately the maximum radiation from the sun. Based on the monitoring results and the generally low turbidity conditions experienced during monitoring, it is evident that due to the depths and current related near bed sediment resuspension at monitoring locations WQ3 and WQ4 (i.e. 15 – 25 m), almost no light reaches the seabed.

Relationship between PAR on land and seabed monitoring locations

Due to the shallower depth at WQ1, monitoring results show that a maximum of approximately 20% of available light is capable of reaching the seabed during low turbidity, low water level periods (Figure 4.14). The conditions experienced during the monitoring period were optimal for light penetration of the water column and indicates PAR at the bed is unlikely to exceed 500 µmol/m^2/s.

WQ3 and WQ4 bed frames are in areas of substantially deeper water (15 - 25m) and show zero or near zero PAR in both locations throughout the monitoring period. Figures 4.10 to 4.14 demonstrate that little or no light penetrates the water column to the seabed at these depths, even in optimal "low turbidity" conditions. This indicates that benthic communities at these locations (and other locations with similar depths) are not likely to be reliant on light (photosynthetic) and instead rely on heterotrophic processes.

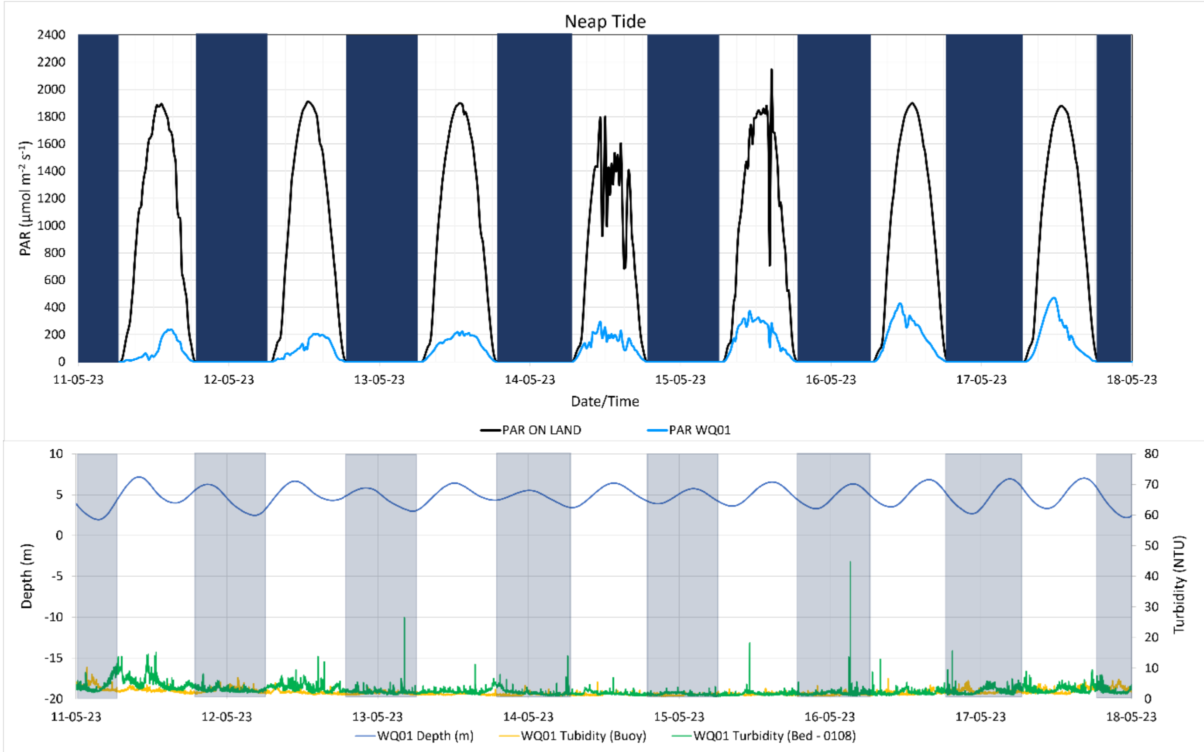

Figure 4.8 **WQ1 neap tide comparison of turbidity and PAR**

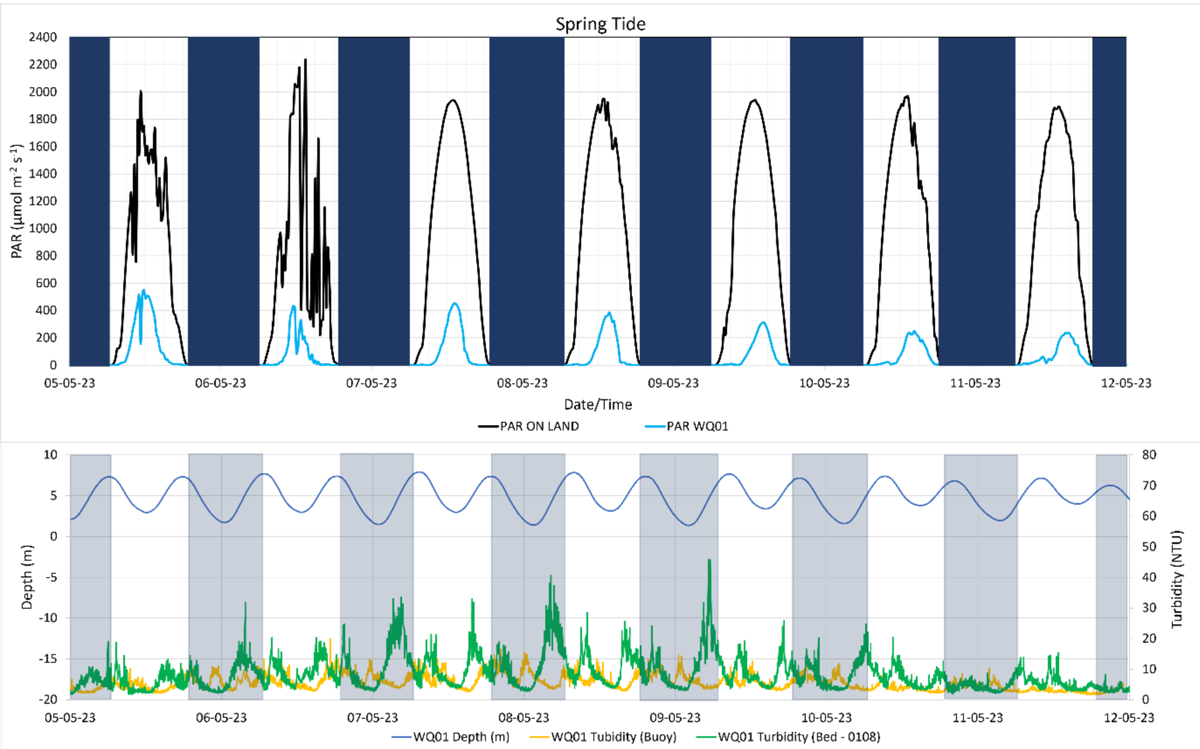

Figure 4.9 **WQ1 spring tide comparison of turbidity and PAR**

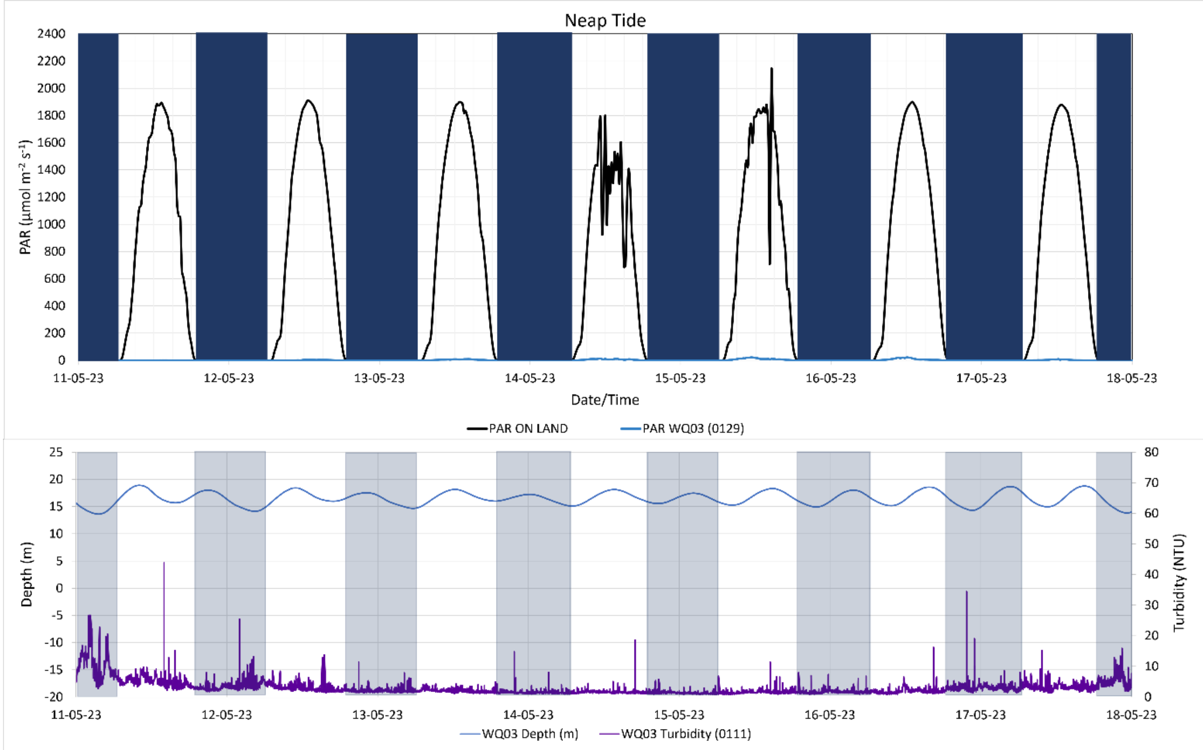

Figure 4.10 **WQ3 neap tide comparison of turbidity and PAR**

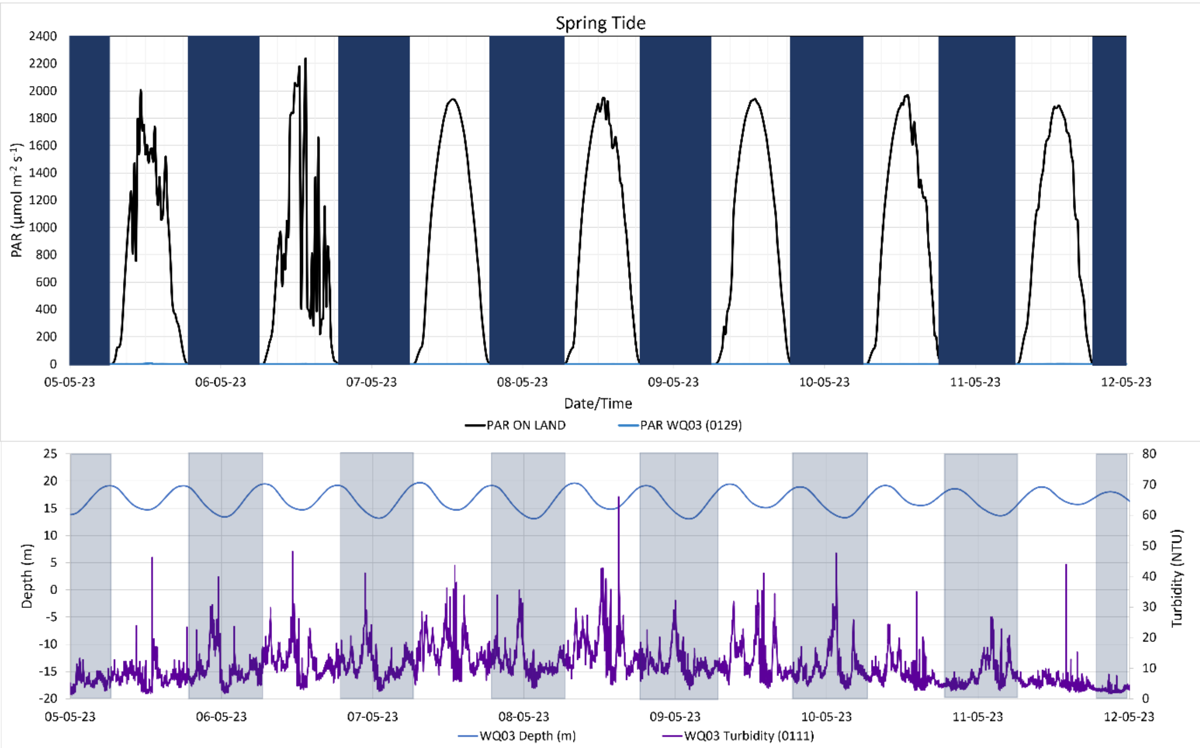

Figure 4.11 **WQ3 spring tide comparison of turbidity and PAR**

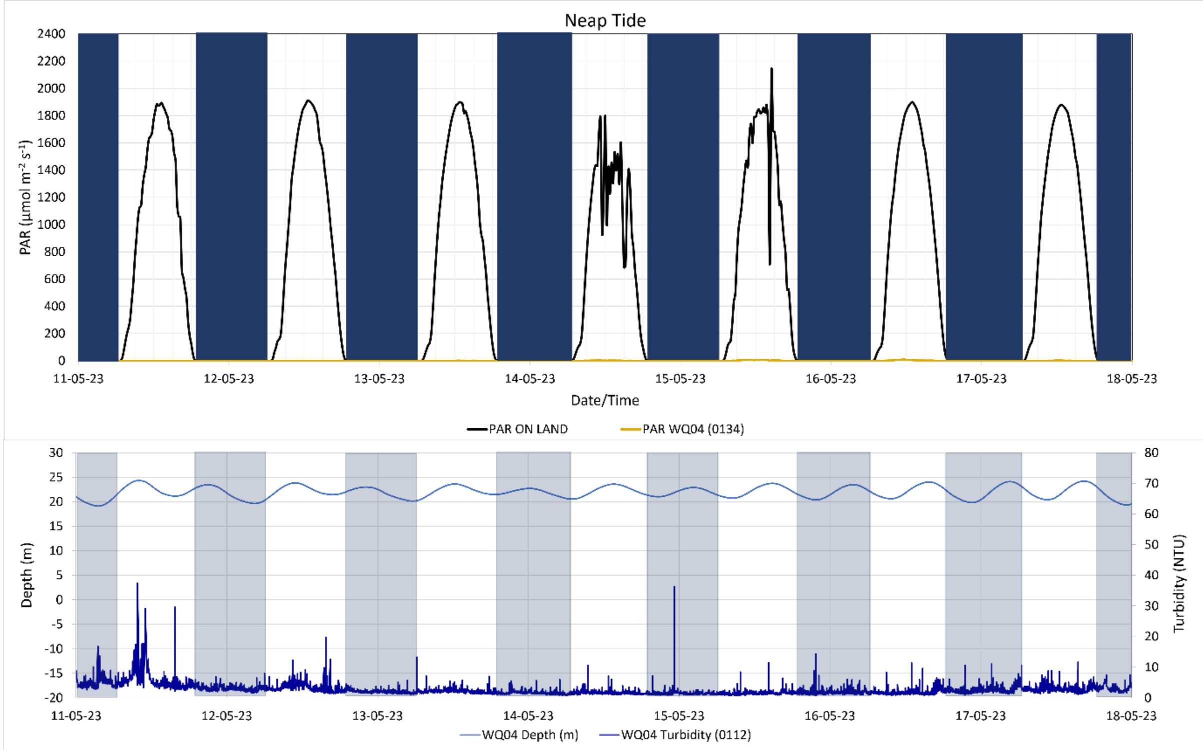

Figure 4.12 **WQ4 neap tide comparison of turbidity and PAR**

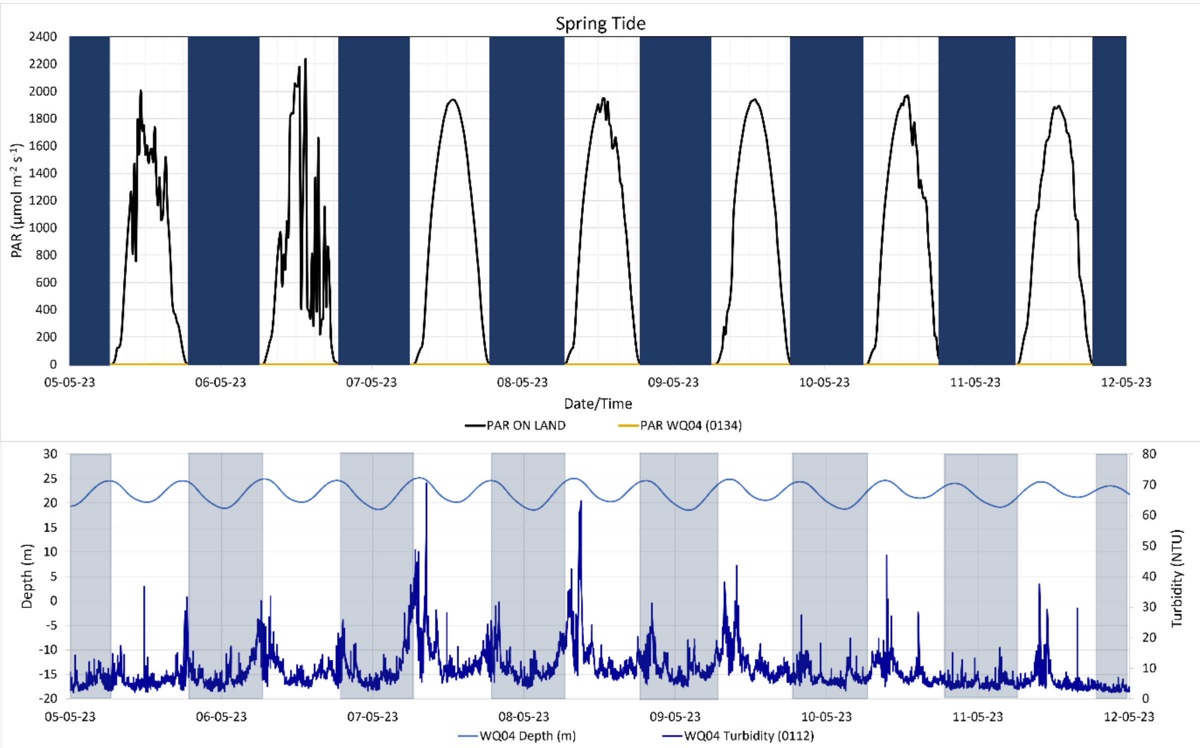

Figure 4.13 **WQ4 spring tide comparison of turbidity and PAR**

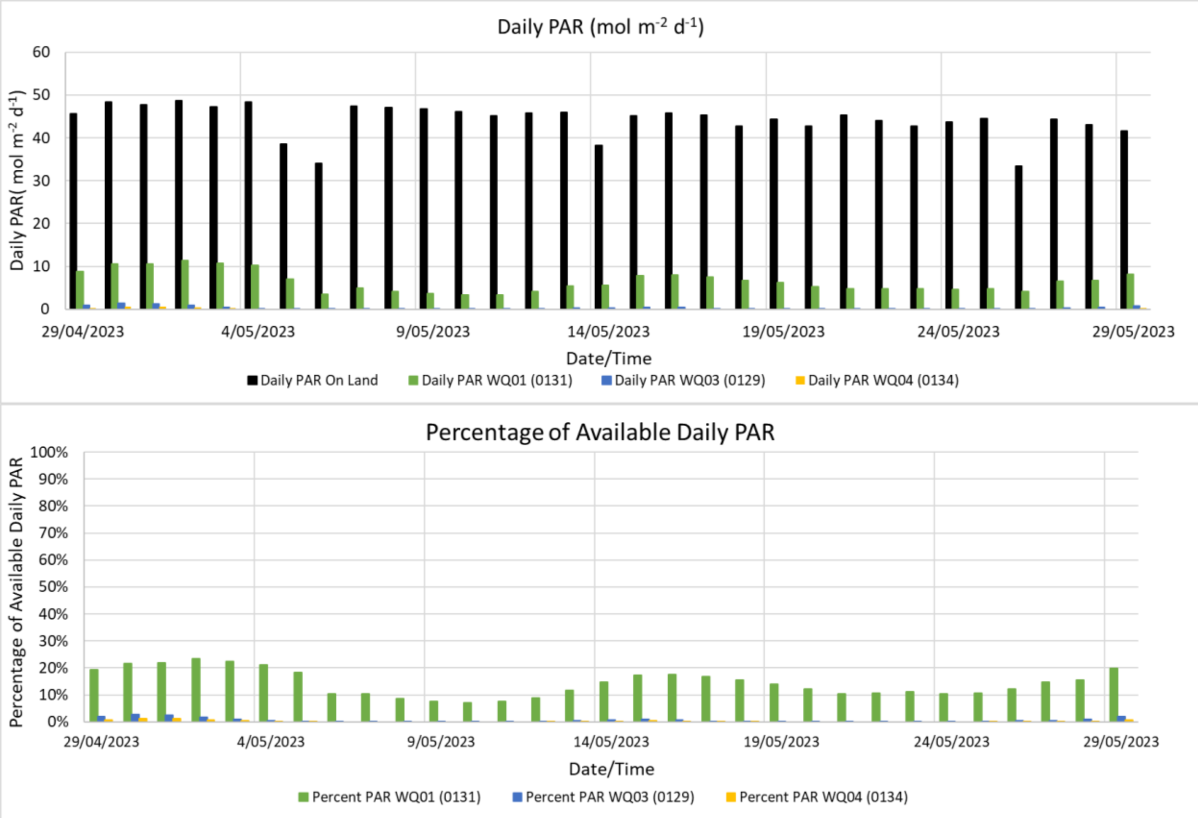

Figure 4.14 Daily PAR (top) and percentage of available daily PAR (bottom)

Relationship between TSS in the water column and at the bed

Water quality depth profiles showed water column turbidity readings below 2 NTU for all locations with the exception of one location to the west of the basin where 10 NTU was recorded at the surface and gradually reduced to 1 NTU at the seabed.

Depth profiles taken in close proximity to the bed frames were also analysed, with turbidity readings taken at the same time and depth from both the depth profile measurements and bed frame recordings being consistent and within <0.7 NTU of each other.

The depth profiles were taken during neap tides which typically results in lower turbidity values than those experienced during spring tides. Due to the conditions experienced at the time of monitoring, the water column profile data collected does not capture periods of high turbidity. The depth profiles did not cover large spring tides and therefore did not provide further insight into turbidity variations experienced throughout the water column when spring tides cause high near bed resuspension of sediments. The strong tidal currents at WQ3 and WQ4 result in very high peaks in near bed turbidity, which are linked to the state of the tide (current velocity). The data indicates though that this is a “near bed” behaviour and that these turbidity peaks do not propagate far into the overlying water column.

Evidence of near bed resuspension of sediments can also be seen at WQ1 (Figure 4.5), during the stronger currents of the spring tides. A review of seabed and surface water quality data recorded at WQ1 demonstrates similar behaviours and fluctuations with the tide, however the magnitude of the turbidity effect is more pronounced at the seabed (Figure 4.5). At this location, turbidity is consistently higher at the seabed than the surface during all stages of the tidal cycle.

Relationship between turbidity (NTU) and total suspended solids (TSS)

During this period of baseline water quality data collection, sea conditions were very benign (flat seas, low wind speeds) and there was no rainfall runoff entering the harbour. Given these conditions, turbidity in the area of interest was in the low range throughout the monitoring period, and consequently it was only possible to collect samples with turbidity and suspended solids concentration in the low range. Therefore there is not yet sufficient data across a broad range of turbidity conditions to confirm the relationship between TSS (mg/L) and turbidity (NTU).

More site specific water quality data (turbidity and suspended solids determined on a series of samples across a range of water quality conditions) will therefore be collected and analysed during upcoming dredging to confirm the relationship and suitability of the turbidity trigger values as outlined in Section 7.3 and to support the assessment and management of future dredging campaigns at HMAS *Coonawarra*.

To date for the HMAS *Coonawarra* dredging assessment, a relationship of 1:1 between NTU and suspended solids concentration has been adopted based on the harbour-wide NTU/TSS relationship of 1:1 which was derived during the INPEX capital dredging program undertaken in 2013, and which has again been applied to the 2023 – 2027 Ichthys LNG Maintenance Dredging Program. This relationship will be re-examined as more data becomes available.

Overall outcomes of baseline monitoring program

The baseline water quality monitoring program was undertaken during dry season weather conditions which represented ‘best case’ conditions for low turbidity and high daily PAR at each of the monitoring locations. The monitoring program confirmed very low turbidity levels at all sites which is representative of neap tide, dry season conditions and is consistent with published long term average turbidity values recorded for the harbour.

The baseline water quality data collected provides a good understanding of conditions characterised by low rainfall, low wind/waves, and minimal cloud cover.

Turbidity was low throughout the water column in most cases and was consistent with bed frame readings taken in the same location at the same time.

Turbidity conditions during this period were not sufficiently variable to provide the data needed to confirm a site specific relationship between TSS and NTU. Further sampling and analysis to confirm this relationship will therefore be undertaken during the dredging program to investigate this relationship further.

The results of the baseline monitoring program showed little or no light reached the seabed in the deeper waters in the vicinity of WQ3 and WQ4, even when turbidity in the water column and water level are low.

At WQ1, the monitoring results indicate that light does reach the seabed, however the amount of available light is impacted by natural fluctuations in water level and turbidity (particularly during a spring tide). Although the WQ1 location is not predicted to be within the zone of influence for the dredging, further monitoring is proposed prior to, and during, dredging to improve the understanding of conditions at this location.

The baseline data indicates that light availability at the seabed in the predicted impact area is not a key impact mechanism, however further monitoring of turbidity and PAR data at WQ3 and WQ4 is proposed prior to, and during, the upcoming dredging contract.

4.5.5 Summary of baseline water quality conditions

The collection of dry season baseline data has been used to establish site-specific, seasonal information on water quality and to assist with further defining the impacts of dredging at HMAS

Coonawarra. The collection of this baseline data will also be used in conjunction with water quality monitoring during dredging to confirm the reliability of sediment plume predictions.

Review and analysis of the project specific dry season baseline data and other baseline data sources confirms the conceptual understanding of sediment related water quality at the site, which is located within a dynamic system with strong currents and sediment transport processes attributable to the large tidal range and pronounced monsoonal climate.

Water column turbidity is principally linked to tidal current velocity with fine sediment resuspended by currents and distributed throughout the harbour as natural sediment 'plumes'. Reanalysis of the available data sets supports the findings previously presented in the Referral and SER documentation, with long term average turbidity values typically in the order of 3 NTU during the dry season and approximately 5 NTU during the wet season.

4.6 MARINE FAUNA AND BENTHIC HABITATS

4.6.1 Marine habitats

At HMAS *Coonawarra*, the intertidal area is characterised by rocky rubble, with soft mobile sediments starting from the lower intertidal to sub-tidal area.

Two to three small patches of mangroves exist around the edges of the harbour, however these are growing on the fringes of the rock walls or disturbed rocky shoreline and are disconnected from mangrove elsewhere in the harbour. Seven mangrove species were identified along the intertidal area, with the most common being *Avicennia marina* (Grey Mangrove).

Marine benthic habitat survey and mapping was undertaken from 16 to 18 January 2023. The survey involved the collection of underwater video transect data within the zone of impact and priority areas within the zone of influence, which incorporated a broad area informed by the results of previous field mapping campaigns and the modelled predictions as presented in the Referral. The survey effort also included Fannie Bay, although it is not predicted to be within the zone of influence. Additional effort was made to assess those areas which have previously been known to support seagrass habitat by capturing supplementary stationary high resolution images. To enhance the detection of any seagrass, including seagrass remnants or root systems.

Results of the benthic habitat mapping show that the majority of the survey area is characterised by bare substrate with sparse coverage of filter feeders, primarily sponges, observed in those areas where some hard substrate, such as rock and gravel, were present. The filter feeders within the project area are resilient to high sediment load, high current and low light conditions and are widespread and well represented within the harbour. The field survey did not identify any strongly light dependent (phototrophic) communities.

Seagrass, hard coral and macroalgae communities were not observed at any point during the survey.

Historically, Fannie Bay has been known to support low density ephemeral seagrass communities (Geo Oceans 2014a) however none was observed during the survey. Previous long term seagrass monitoring, completed for the Ichthys Project Nearshore Environmental Monitoring Plan (NEMP) – Seagrass Monitoring Program, has shown that the *Halophila* beds in Fannie Bay are ephemeral, with seagrass coverage more likely to be present in June/July before a decline moving into the Monsoon season (GeoOceans 2014b). Based on a review of available survey data seagrass is not always present in the dry season, as there have been years when no seagrass has been observed within the Fannie Bay area.

In Darwin Harbour, it is thought that the seed bank for ephemeral seagrass species such as those which have been known to occur in Fannie Bay, lies in the sediment through the wet season (July to January) when light is below compensation level and seeds germinate in April for the dry season where they grow, flower, and set seed until September/October.

Although there is currently no evidence of seagrass occurring within Fannie Bay, the results of previous field surveys and their ephemeral nature suggests that there is the potential for seagrass to occur, within this area of the harbour. Impacts associated with the proposed dredging and dredged material disposal operations are not predicted to extend into Fannie Bay. Despite this, a precautionary approach to monitoring during dredging will be undertaken to confirm the reliability of sediment plume predictions.

The closest hard coral and macroalgae communities are associated with East Point Reef located over 5 km north of HMAS *Coonawarra* at the northern end of Fannie Bay, and occur beyond the predicted zones of impact and influence.

Reproductive data for coral assemblages in the Darwin region is limited. Coral assessments undertaken as a part of the Ichthys Project NEMP indicated that *Faviidae* colonies may have an autumn (April/May) spawning window in Darwin Harbour (Cardno 2015c), while operators of the Darwin-based Indo Pacific Marine (aquarium) have observed coral spawning within their tanks around full moon in October and November (TWP 2006).

In consideration of the proposed works and timing of dredging, no substantial effects on the critical windows of environmental sensitivity as discussed above for coral spawning and seagrass flowering periods are anticipated. Dredging is not scheduled to occur during these critical environmental windows, but nevertheless water quality mangement measures and the monitoring program to be implemented during dredging have been designed to protect these habitats, irrespective of whether the works occur during these critical windows.

A benthic habitat map for the project area is included as Figure 4.15. As previously discussed, Figure 4.15 shows that the project area is predominantly bare substrate with sparse biota largely characterised by low density, low diversity sponges.

4.6.2 Protected marine species

Database searches were conducted for the project area using the E*nvironment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters search tool (including a 5 km buffer). Additional information regarding records of species was sourced from publicly available databases (e.g. Atlas of Living Australia, NR Maps) and previous studies conducted within or in the vicinity of the proposed dredging and dredged material discharge location at HMAS *Coonawarra*.

From this desktop research a number of species were identified including:

- 38 Threatened species listed under Commonwealth which may occur or may have habitat which occurs within the vicinity of the dredge operations, including 14 birds, 11 mammals, seven reptiles, and six sharks.
- 64 Migratory Species listed under Commonwealth legislation which may occur or may have habitat which occurs within the Project area:
- 100 Marine Species listed under Commonwealth legislation which may occur or may have habitat which occurs within the Project area:
  - these 100 species include one mammal, 45 overfly bird species, 27 ray-finned fish, and 27 reptiles
  - of these 100 species, 13 are also threatened species under Commonwealth legislation.
- 12 Whales and Other Cetaceans (namely dolphins) which may occur or may have habitat which occurs within the Project area, two of which are also listed as threatened species under Commonwealth legislation.

Those marine species that have the potential to occur within the vicinity of the dredge operations, based on records and their preferred habitat types, are addressed in the following sections.

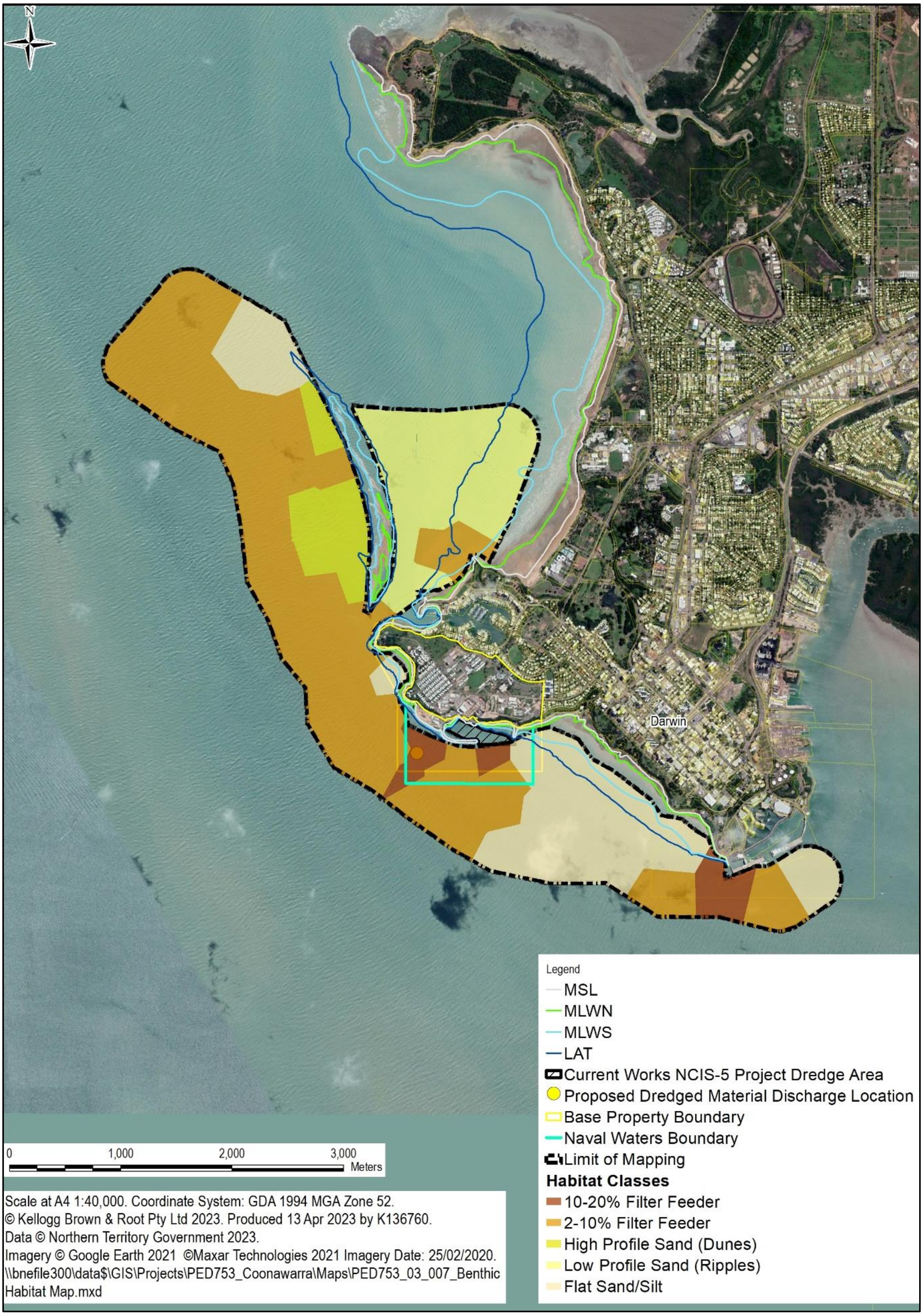

Figure 4.15 Benthic habitat map

Marine Fauna

Shorebirds

A number of critically endangered or endangered shorebirds utilise tidal mudflats within Darwin Harbour. The intertidal flats around Emery Point and Elliot Point, which are closest to HMAS *Coonawarra*, are not known to be important habitat for migratory shorebirds.

At HMAS *Coonawarra*, the only foraging habitat that may be utilised by shorebirds is limited to the narrow intertidal area and breakwater located in the eastern portion of the basin.

A shorebird survey conducted in March 2017 from the eastern breakwater recorded only low numbers of migratory shorebirds and confirmed no roosting sites exist.

Dolphins

Three species of dolphin have been recorded in Darwin Harbour including:

- Australian Snubfin Dolphin (*Orcaella heinsohni*) – Migratory (EPBC Act);
- Indo-Pacific Humpback Dolphin (*Sousa chinensis*) – Migratory (EPBC Act); and
- Spotted Bottlenose Dolphin (Arafura/Timor Sea population) (*Tursiops aduncus*) – Migratory (EPBC Act).

The internal basin area does not provide important habitat for dolphins. These dolphin species are highly mobile and their habitat is widespread within the harbour. There have been instances of Spotted Bottlenose dolphins observed inside the basin, and although they may occur within the basin area this would be as infrequent visitors while they move between more favourable foraging areas.

The Spotted Bottlenose Dolphin and the Australian Snubfin Dolphin have both been recorded within the project area.

Turtles

Due to the limited habitat values and disturbed nature of the internal basin area turtles do not rely on or frequently utilise the waters in HMAS *Coonawarra* basin. Of the species of marine turtles with the potential to occur within Darwin Harbour, Green, Hawksbill, Olive Ridley and Flatback turtles may occur within the project area as transient visitors moving between more suitable foraging areas.

Dugong

The modified nature of the HMAS *Coonawarra* Basin and absence of seagrass means that the basin area does not provide suitable habitat for dugongs. Dugongs which are listed as migratory species under the EPBC Act are however known to occur in Darwin Harbour, albeit in relatively low numbers. Higher densities of dugongs have been recorded at Gunn Point and the Vernon Islands, approximately 30-50 km north-east of the mouth of the harbour. Dugongs are also known to travel long distances, often in excess of several hundreds of kilometres.

In Darwin Harbour dugongs are observed in the East and Middle Arms and in the vicinity of Channel Island. They have been recorded in seagrass areas in Fannie Bay, Talc Head, near Casuarina Beach and the rocky reef flats associated with Channel Island.

Saltwater crocodile

The internal basin area of HMAS *Coonawarra* does not contain suitable habitat for the Saltwater Crocodile nor does it contain any nesting habitat for the species. It is possible that the Saltwater Crocodile could occur within the internal basin area, although this would be infrequent.

The Saltwater Crocodile (*Crocodylus porosus*) which is listed as a migratory species under the EPBC Act does however occur in Darwin Harbour, although its abundance is controlled by a trapping and removal program for public safety. Only limited nesting sites for the Saltwater Crocodile are available inside Darwin Harbour, and therefore the area is not considered critical habitat for crocodile survival in the Northern Territory.

4.7 NOISE

4.7.1 Terrestrial noise

The HMAS *Coonawarra* basin is used only by military vessels and lies adjacent to the base's maintenance facilities. The nearest sensitive receptors are the residences within the base which are located approximately 190 m from the nearest point of the works with most of the dredging works in excess of 500 m from these residences. The nearest sensitive receptors external to the base are located on Larrakeyah Terrace and are approximately 350 m away from the nearest point of the works with the majority of dredging occurring in excess of 500 m from these receptors.

Noise sources at the base are typically related to vehicle and vessel traffic, maintenance activities and other construction related works. Beyond the project area noise sources are largely associated with vehicle movements through residential areas. Within the broader harbour area, vessel traffic associated with movements between East Arm, Darwin City, and Cullen Bay would also add to the overall noise levels in the region.

4.7.2 Underwater noise

The existing underwater ambient noise environment is a complex composite of natural non biological, biological and anthropomorphic noise sources. Natural (i.e. non-anthropomorphic) non biological sources of underwater noise in the study area are anticipated to be from wave turbulence, waves breaking along shorelines, wind-wave interactions, and precipitation. Natural biological noise sources in the area may include dolphins or other marine fauna in the broader Darwin Harbour area. However, it is unlikely that these will be found within the HMAS *Coonawarra* basin due to the highly modified nature of the project area.

Vessel traffic and movements within the HMAS *Coonawarra* basin and general maintenance activities on vessels would contribute to the level of underwater noise experienced at the site. Within the waters of the harbour underwater noise sources would typically be associated with vessel movements, wharf operations, and construction related activities.

4.8 RECREATIONAL AND TOURISM USES

There are no recreational or tourism uses within the HMAS *Coonawarra* basin or the associated Naval water area. Recreational and tourism uses within the broader project area include recreational boating, fishing and scuba-diving and visual amenity. Additionally, there is a high tide fish feeding tourist attraction, located approximately 600 m to the east of the NCIS-5 works dredge area.

Mechanisms with the potential to impact the aesthetics and recreational values of the waters are closely correlated to the mechanisms associated with water quality. Therefore, the management and monitoring measurements proposed to address the impacts to the recreational values of the water will be the same as those presented in the following sections for impacts to water quality.

4.9 CONCEPTUAL MODEL

Conceptual models are used in the preliminary phases of the impact assessment process to identify the linkages between hazards (i.e. sources of/mechanisms for potential harm), exposure pathways/routes and receptors. Further, they can be used to eliminate impossible or implausible hazards in scenarios where there is no exposure pathway/route or receptor.

The development of the conceptual model for dredging and dredged material disposal activities at HMAS *Coonawarra* has relied upon the activity description as presented in Section 2, with information about the existing environment and those habitats within the project area as presented in this section of the DDMP, used to determine the mechanisms/sources of potential environmental impact and the key receptors.

A conceptual site model, as presented in Figure 4.16, has been developed and focusses on those components of the dredging program with the potential to affect key receptors, being the nearshore disposal of fine sediment within Darwin Harbour, the deposition of 'heavy material' within the vicinity of the discharge location, as well as potential impacts associated with dredge and other supporting vessel movements.

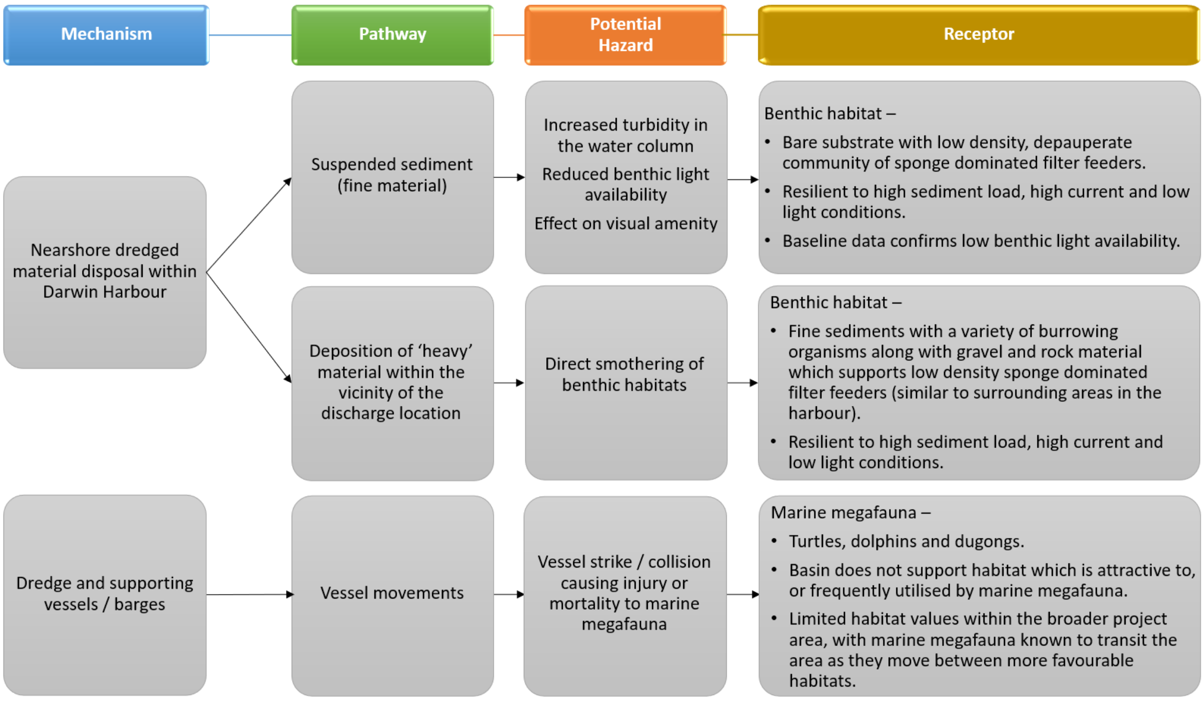

Figure 4.16 **Conceptual model for key impact mechanisms associated with dredging and dredge material discharge at HMAS *Coonawarra***

As outlined in Figure 4.16, potential impact mechanisms associated with nearshore disposal are principally associated with direct sediment load, including:

- the effects of suspended sediment concentrations on sparse, low diversity sponge dominated filter feeders which occur within the zones of impact and zone of influence, and;
- the impact of heavy material sediment deposition within the immediate vicinity of the discharge location (zone of high impact).

Monitoring and modelling results show that 'heavy' material settles within the immediate vicinity of the discharge location (i.e. Zone of high impact). Fine sediments travel beyond this area but stay in suspension long enough to be dispersed, hence no measurable accumulation of material on the bed, or adverse impact to benthic habitats.

The only habitat type present within the zone of impact and zone of influence is a low density depauperate community of sponge dominated filter feeders. The nature of the filter feeder species present shows a level of resilience to the dynamic current and sediment transport processes experienced within this section of the harbour. Based on the results of the recent benthic habitat assessment it is also evident that these species are capable of recovering from disturbances with the deposition of heavy material within the vicinity of the discharge location during the last dredging campaign in 2013 now showing signs of recruitment and growth of filter feeders.

The adaptive management approach proposed in Section 7.3 therefore focusses on confirming the adequacy of sediment plume predictions by monitoring and collecting water quality data to improve modelled predictions for future dredging campaigns.

The exception to this is Fannie Bay, which has the potential to support seagrass in the future. A precautionary approach will be adopted to manage the potential for seagrass habitat within Fannie Bay to be affected. Additional field data was collected during the baseline water quality monitoring program and will be collected during dredging to further refine the relationship between TSS (mg/L) and turbidity (NTU) and the light intensity relationship at the seafloor by measuring PAR. The collection of this data and refinement of these relationships will be used to support the management of current and future dredging and discharge related activities.

5 Dredge Plume Modelling and Water Quality Impact Assessment

5.1 SYNTHESIS OF ASSESSMENT APPROACH

Initially a suspended sediment model was developed to assess the potential impacts of the proposed dredging and dredge material discharge operations on local water quality, and potential sedimentation impacts in the local area. The assessment of potential environmental impacts from the dredging works was informed by:

- A two-dimensional hydrodynamic model that incorporated water levels, currents and waves;
- Sediment sampling and analysis results;
- A sediment transport model that determined suspended sediment dispersion; and
- GIS analyses to identify potential impacts on habitats on the basis of tolerance limits.

To address comments received on the Referral, supplementary dredge modelling was undertaken to expand on the initial modelled outcomes. The supplementary modelling responded to the requirements of the SER process, considered the guidance provided in the Western Australian Marine Science Institution (WAMSI) best practice guidelines for modelling for environmental impact assessments (EIAs), and provided updated sediment plume predictions.

The model update expands upon previous studies undertaken, capturing the following key revisions:

- Development of 3-dimensional (3D) modelling as a refinement to the previous 2-dimensional (2D) modelling
- Presentation of additional available datasets for review and validation of the modelling
- Included modelling of sediment deposition and fate
- Review of dredge program based on further contractor advice

5.2 HYDRODYNAMIC AND SUSPENDED SEDIMENT TRANSPORT MODEL

A key mechanism associated with dredging that has the potential to impact marine environmental quality is the suspension of fine sediment in the water column as a result of dredging and dredged material disposal. Therefore, to quantify these impacts, the transport of suspended dredge material has been assessed through the development of a hydrodynamic and sediment transport model which uses the modelling package Delft3D. Initially a two-dimensional (depth averaged) hydrodynamic model was developed in the Delft3D-FLOW modelling package, with suspended sediments assessed using the ‘random walk’ particle tracking module, Delft3D-PART, but that has now been updated to a three dimensional model.

Several key sources of information were used in development of the model including:

- Site-specific bathymetric survey data;
- Site-specific current data (ADCP);
- Site specific sediment characterisation; and
- Historic water quality monitoring data from both previous campaigns at HMAS *Coonawarra* and the surrounding harbour area.

The model has undergone a process of calibration and validation against site-specific ADCP current data and available water level recordings at Darwin (Fort Hill) tide station. The dredging was assessed for a representative one-month period in order to capture two spring and neap tides within the period.

In the Referral, 12 scenarios were modelled, covering combinations of dredge type, source location and seasonal wind conditions as well as multiple sediment sources to simulate the dredging and disposal activities.

To support the SER process, the 3-dimensional model was used to reanalyse the 'tide only' scenario (i.e. no wind) during offshore discharge with the dredge vessels operating close to the entrance of the basin as this represents a conservative (high) scenario for dredge plume dispersion from within the basin. Wet and dry season results plots have been produced by adding the average background conditions (identified in Section 4.5) of 3 mg/L for the dry season and 5 mg/L for the wet season to the models 90th percentile results.

The full description of the model development and outputs is presented in the NCIS-5 HMAS *Coonawarra* Basin Referral (KBR,2021) and Supplementary Environmental Report (KBR, 2023).

5.3 MODELLING RESULTS

5.3.1 Discharge of dredged sediment

Suspended sediment concentration

The release of dredged sediment at the proposed discharge location will result in changes to the marine water quality due to the generation of a suspended sediment plume. It is predicted that sediment plumes generated at this location will typically follow the tidal regime with suspended sediment concentrations greatest close to the point of discharge. Fine sediment particles (the majority of the discharge) will disperse over a large area while heavier particles (e.g. gravels, clumps of clay) will settle on the bed in the vicinity of the discharge location.

The results of the suspended sediment modelling provide evidence of this as shown in Figures 5.1 to 5.4. These figures present snapshots of the suspended sediment concentrations predicted above background during different tidal phases.

Due to the large tidal range in this area of the harbour, plume behaviour varies significantly between the different tidal phases. As would be expected the plumes travel to the north during the ebb tide and south during the flood tide. During neap tide conditions, the plume tends to stay close to the discharge source whereas during spring tides plumes travel further from the source.

As outlined in the Referral, the 90^{th} percentile result was chosen for the purposes of impact assessment as it is representative of infrequently occurring (only 10%) suspended sediment concentrations at the higher end of the simulated range.

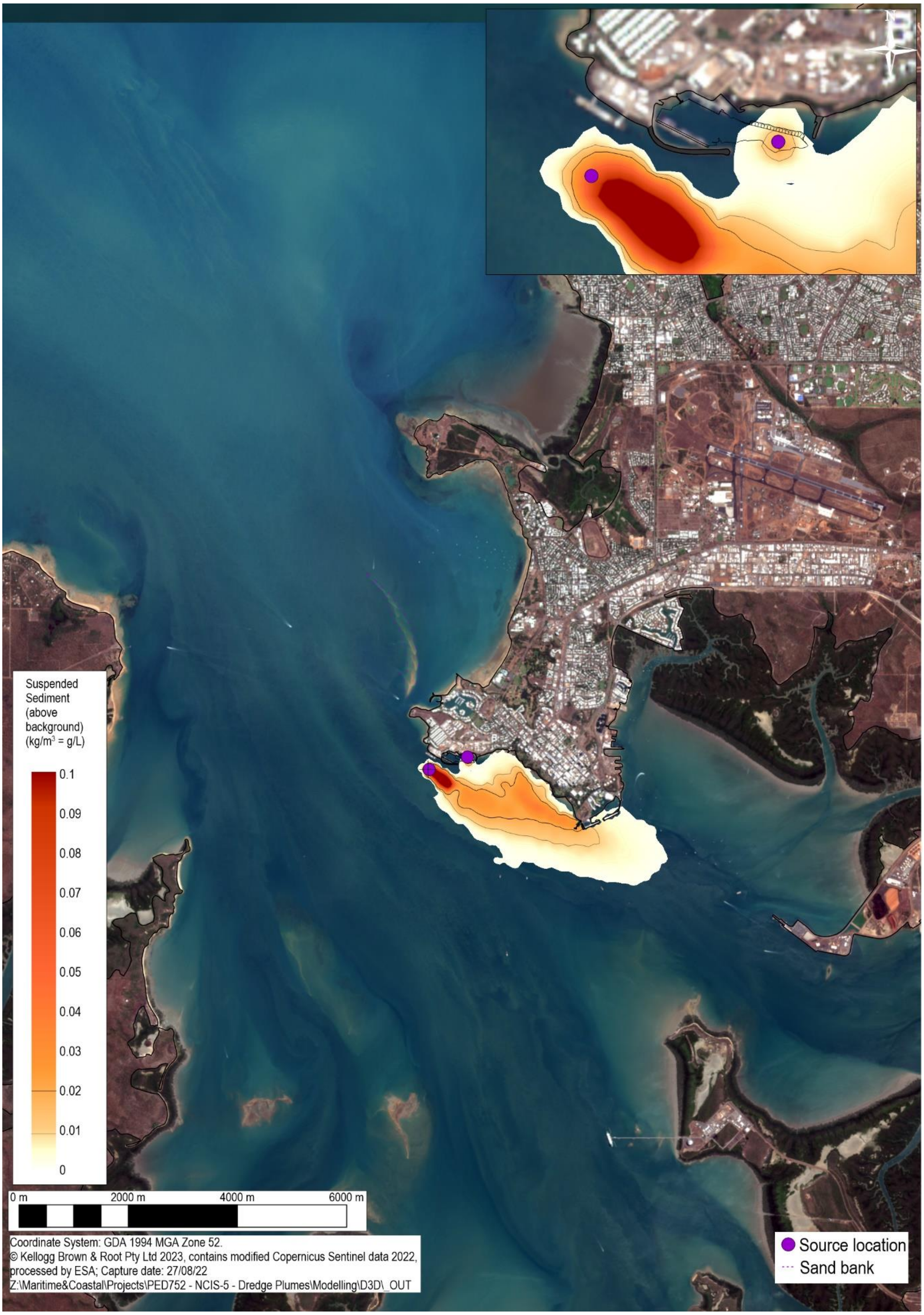

Figure 5.1 **Instantaneous suspended sediment concentrations above background - Snapshot at 12/11/2017 14:00 – Flood tide, neap condition – CSD dredging with nearshore discharge– NCIS-5 current works**

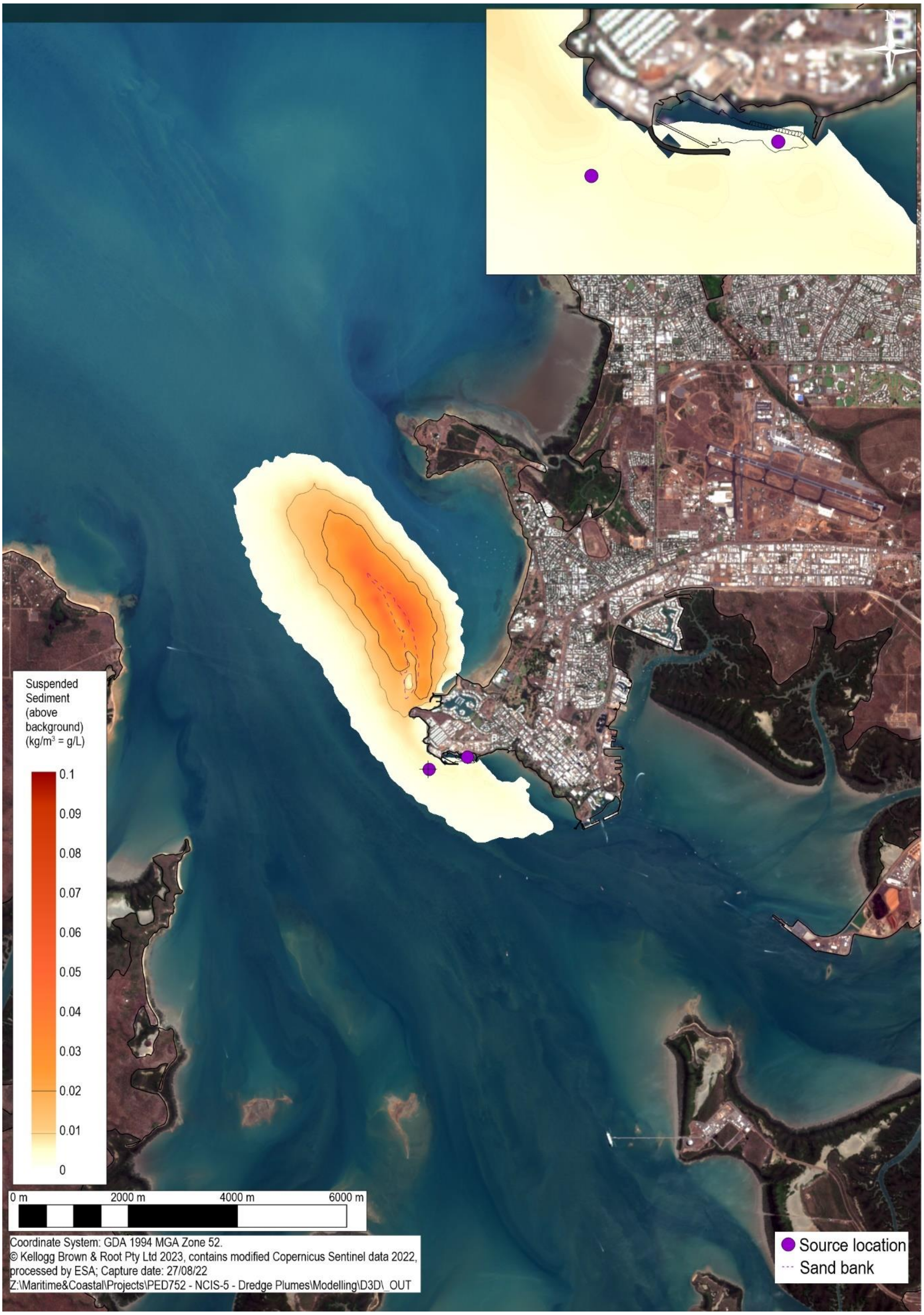

Figure 5.2 **Instantaneous suspended sediment concentrations above background - Snapshot at 12/11/2017 21:00 – Ebb tide, neap condition – CSD dredging with nearshore discharge– NCIS-5 current works**

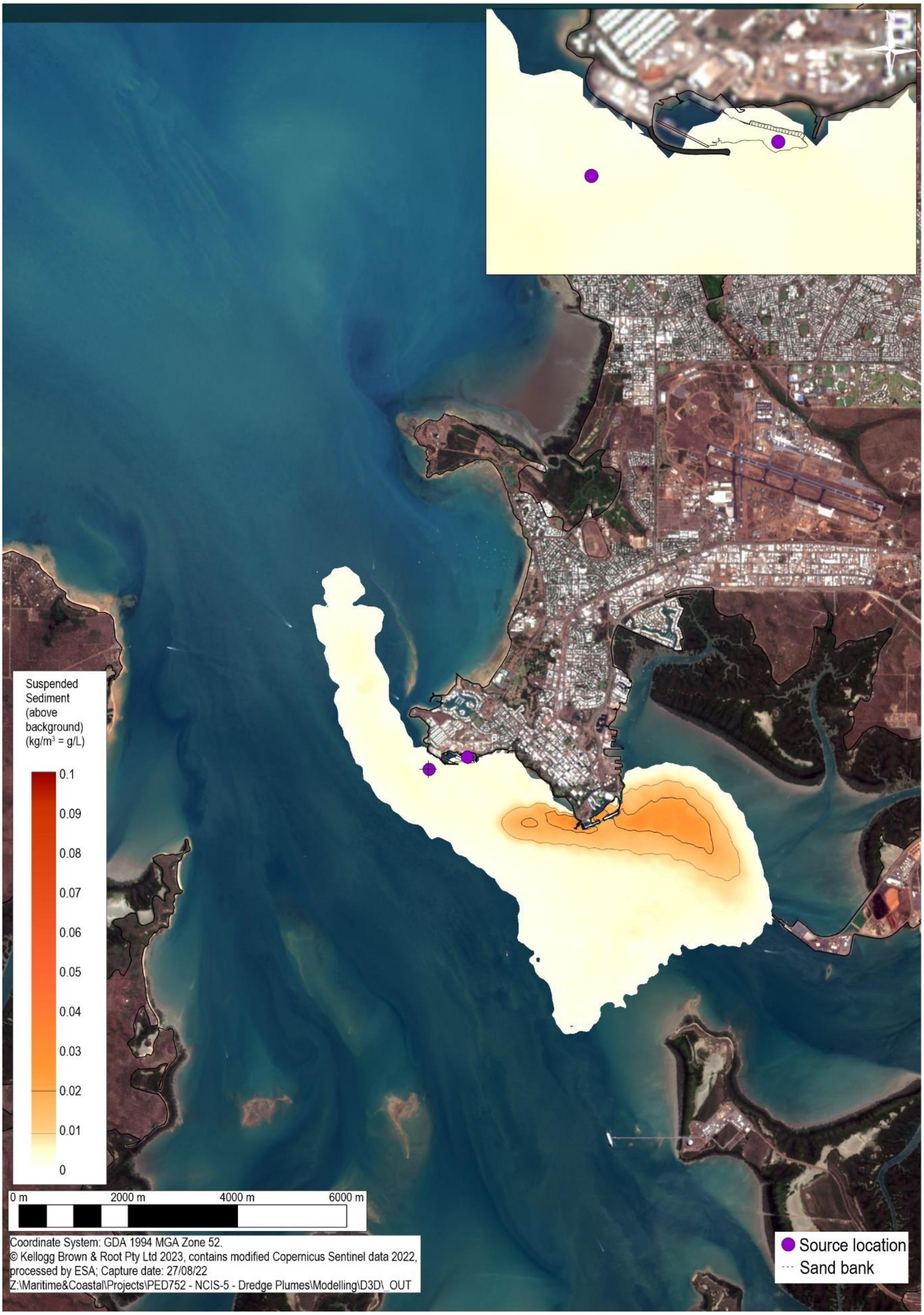

Figure 5.3 Instantaneous suspended sediment concentrations above background - Snapshot at 12/11/2017 21:00 – Flood tide, spring condition – CSD dredging with nearshore discharge– NCIS-5 current works

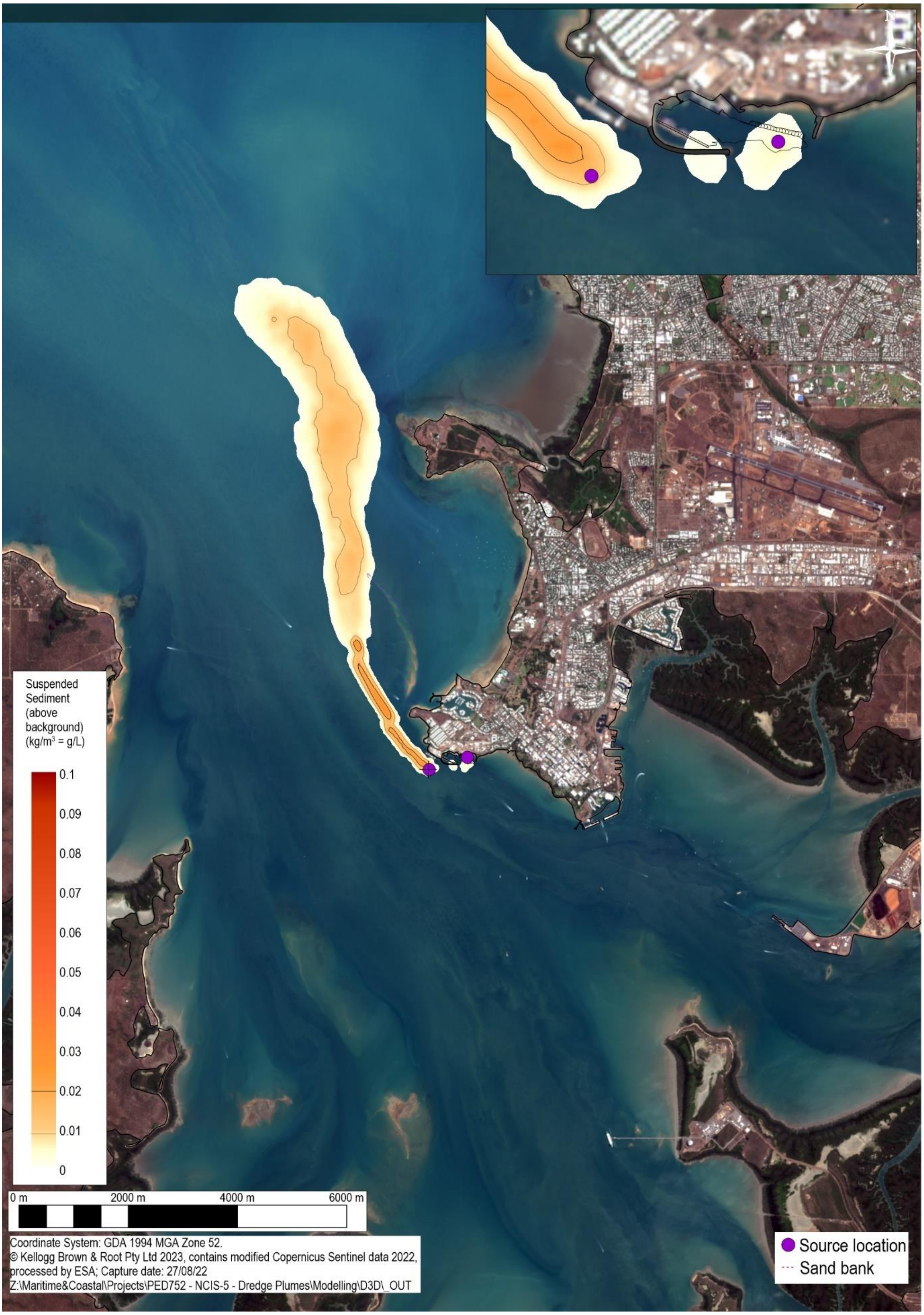

Figure 5.4 Instantaneous suspended sediment concentrations above background - Snapshot at 18/11/2017 13:00 – Ebb tide, spring condition – CSD dredging with nearshore discharge– NCIS-5 current works

The 3D modelled 90th percentile suspended sediment concentration for the dry season is shown in Figure 5.5. During the dry season, the plume extent is shown to extend approximately 9 km from the site to the north, and approximately 5 km from the site to the south. To assess the temporal variation of the sediment plumes, times series results from the full simulated period for the CSD and nearshore discharge has been extracted at six representative reporting locations. The reporting locations and dry season timeseries outputs are provided in Appendix A.

The wet season modelled 90th percentile suspended sediment concentration is similar in its extent and behaviour, with a minor increase in turbidity due to slightly higher baseline water conditions experienced during the monsoon season (Figure 5.6). The wet season timeseries outputs are provided in Appendix A.

The asymmetric extent of the dry and wet season plumes running to the north during the ebb tide and south during the spring tide, aligns with the hydrodynamics, a behaviour that is consistent with past measurements and previous modelling results.

Modelled results for each reporting location for both the dry and wet season are discussed further in Appendix A and are generally consistent with the results presented in the published Referral document. The supplementary modelling results again reiterate that elevated sediment plume concentrations are not predicted to encroach into Fannie Bay, where potential seagrass habitat has been reported.

The suspended sediment concentration predictions for all reporting locations are shown to be within the range of values known to occur naturally within the harbour. The timeseries data for both dry and wet season shows that peaks in suspended sediment concentration typically last 12 hours before returning to baseline conditions and no gradual increase in the underlying 'baseline' concentrations is observed at any site. The duration of 'high peak' periods are generally short and range between 2 to 4 hours. This indicates that once dredging ceases the system will quickly return to its pre dredging condition.

Consistent with the findings outlined in the published Referral, only a small area within the predicted plume may experience suspended sediment concentrations consistently above 20 mg/L with concentration spikes above this value all aligning with a specific tidal phase (i.e. the neap tide). The neap tide phase is when tidal movement and mixing is at its lowest however this phase tends to last only 3 to 4 days before an extended period of up to 9 days of more favourable mixing conditions and lower suspended sediment concentrations.

This modelled data assumes that dredging will occur 12 hours per day 7 days a week however in practice the dredge will not operate on Sundays and there will be frequent stoppages for maintenance, and to minimise disruptions to ongoing naval operations. These stoppages will result in additional recovery time and reduce the magnitude and duration of the daily plumes.

Overall 3D modelling of the spatial behaviour and concentration of the predicted sediment plumes during flood and ebb tides are generally consistent with the results of the previous 2D model.

Sediment deposition

Sediment plumes generated during discharge will follow the strong current vectors to the north and south-east of the discharge location. As described above, plumes generated during discharge generally extend over areas of highly mobile sediments with limited habitat values. Based on the hydrodynamic modelling, benthic habitat mapping and monitoring from previous similar campaigns, sediment plumes are not predicted to extend over areas which support benthic habitats which are sensitive to elevated suspended sediment concentrations.

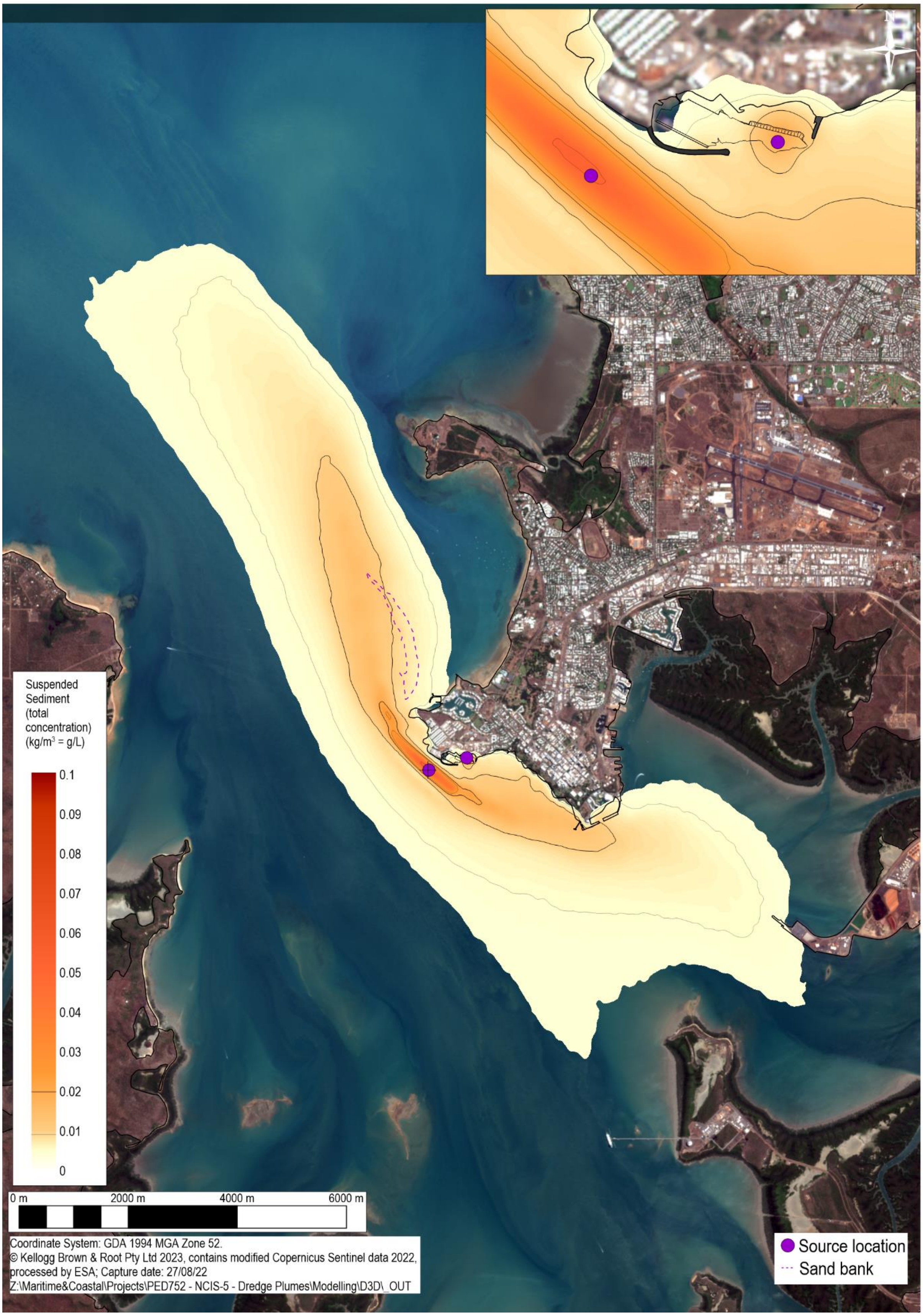

Figure 5.5 90th Percentile suspended sediment concentration from CSD with offshore discharge – Dry season (includes 3 mg/L background concentration)

Figure 5.6 **90th Percentile suspended sediment concentration from CSD with nearshore discharge – Wet season (includes 5 mg/L background concentration)**

The deposition of fine and coarse material was initially assessed and reported in the Referral. However, the sediment deposition and sediment transport model were expanded as part of the SER process to further define the magnitude and extent of sediment deposition, and the fate of deposited sediments associated with the proposed dredging and disposal activities.

Coarse sediment deposition

The majority of sediment to be dredged will consist of fine material which remains in suspension for an extended period (the main focus of the impact assessment), however there will also be a component of coarser heavy particles which settle very quickly. The deposition of this coarse material (which would include gravel, rock fragments, pieces of cohesive clay, and coarse and medium grained sands) was modelled to predict the extent of direct deposition in the immediate vicinity of the discharge location. The modelling work confirmed that coarse-grained sediments quickly settle out of suspension, falling to the seabed within a short distance of the release point.

The deposition area and thickness are presented in Figure 5.7, which captures the extent of sediment deposition for coarse gravel, and coarse and medium grained sands. This extent of coarse sediment deposition would be similar to what has occurred previously during past dredging campaigns.

The initial deposition of coarse material in the immediate vicinity of the discharge location will temporarily impact benthic habitat with some reduction of abundance, species diversity and productivity likely. Based on the results of the benthic habitat assessment, and as shown in Figure 5.8, bare substrate which supports sparse sponge dominated filter feeders is the only sensitive receptor within the predicted zone of high impact which constitutes the direct footprint of the modelled zone of heavy material deposition within the vicinity of the dredge and discharge locations.

The benthic habitat assessment also noted that the type and condition of benthic communities at the proposed discharge location remains similar to that of the surrounding project area, even after the completion of multiple dredging campaigns. It is likely that upon cessation of the discharge activities, the presence of some additional harder substrate material within what is deposited will provide opportunities for the regrowth of filter feeders.

Fine sediment fate

For fine sediment (the majority of what will be discharged), the model predicts the net thickness (in millimetres) of fine sediment deposited onto the seabed at the completion of the dredge campaign. The model was run over a one month period, representing a full dredging and dredge material discharge period (albeit conservatively). The simulated net thickness of sediment is a function of the estimated density of the material and the transport, deposition and erosion processes simulated by the model.

Figure 5.7 shows the predicted fine sediment deposition. The extent and thickness of fine sediment deposition is very low throughout the project area. The highest sedimentation predicted is within the HMAS *Coonawarra* basin, where the dredging is to be undertaken. The modelled thickness of fine material deposition within this portion of the dredge area is approximately 10 mm. Beyond the basin area, fine material deposition is lower with a nearshore area likely to receive up to approximately 5mm (and up to 8mm in a smaller area closer to the basin), with the remainder of the area to experience less than this.

These modelling outcomes confirm the initial predictions as presented in the Referral, which noted that it is unlikely that released fine sediments will remain close to the discharge location, given that the bed stresses in this area of the harbour are very high.

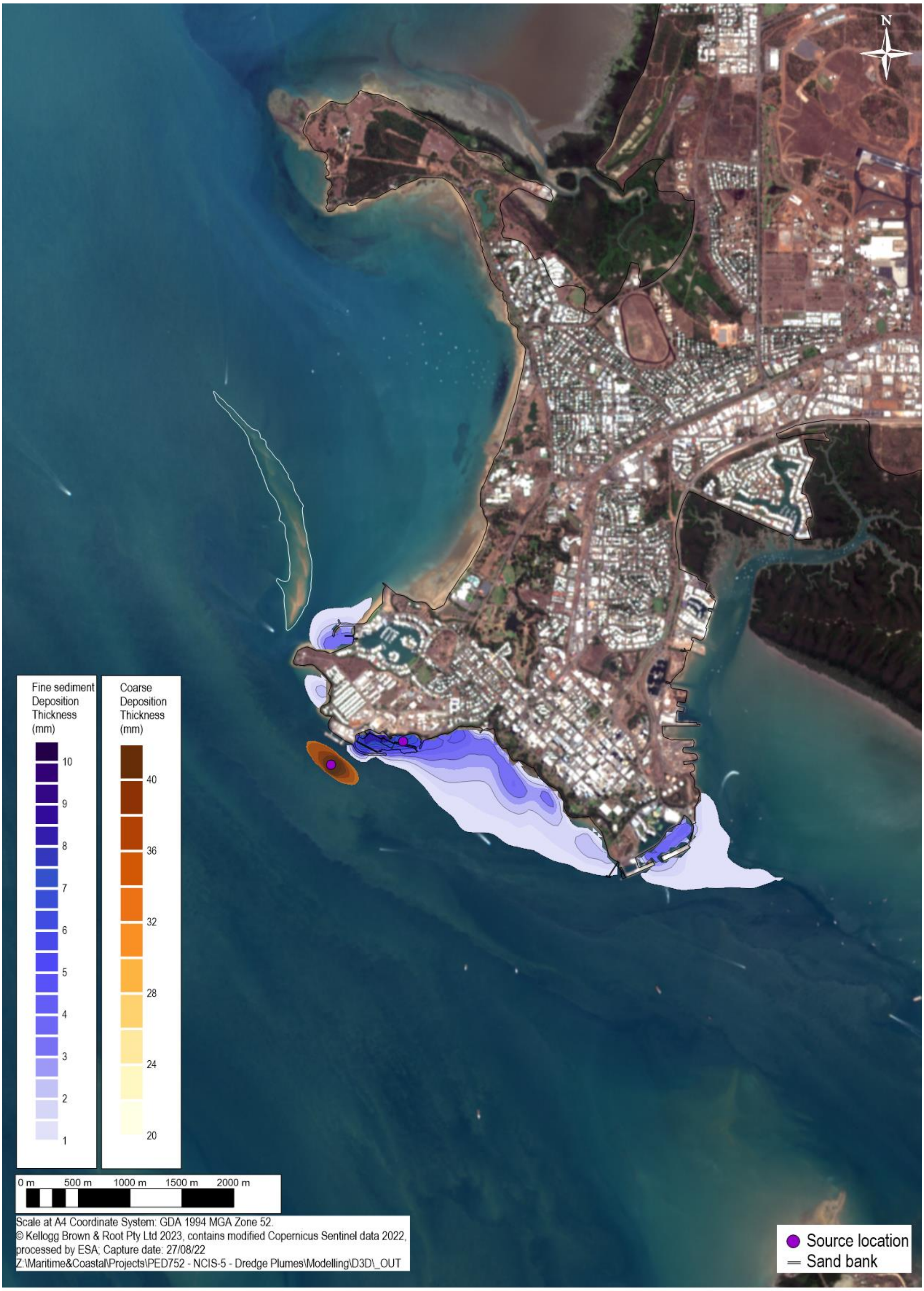

Figure 5.7 Fine and coarse sediment deposition thickness (mm) following the completion of dredging

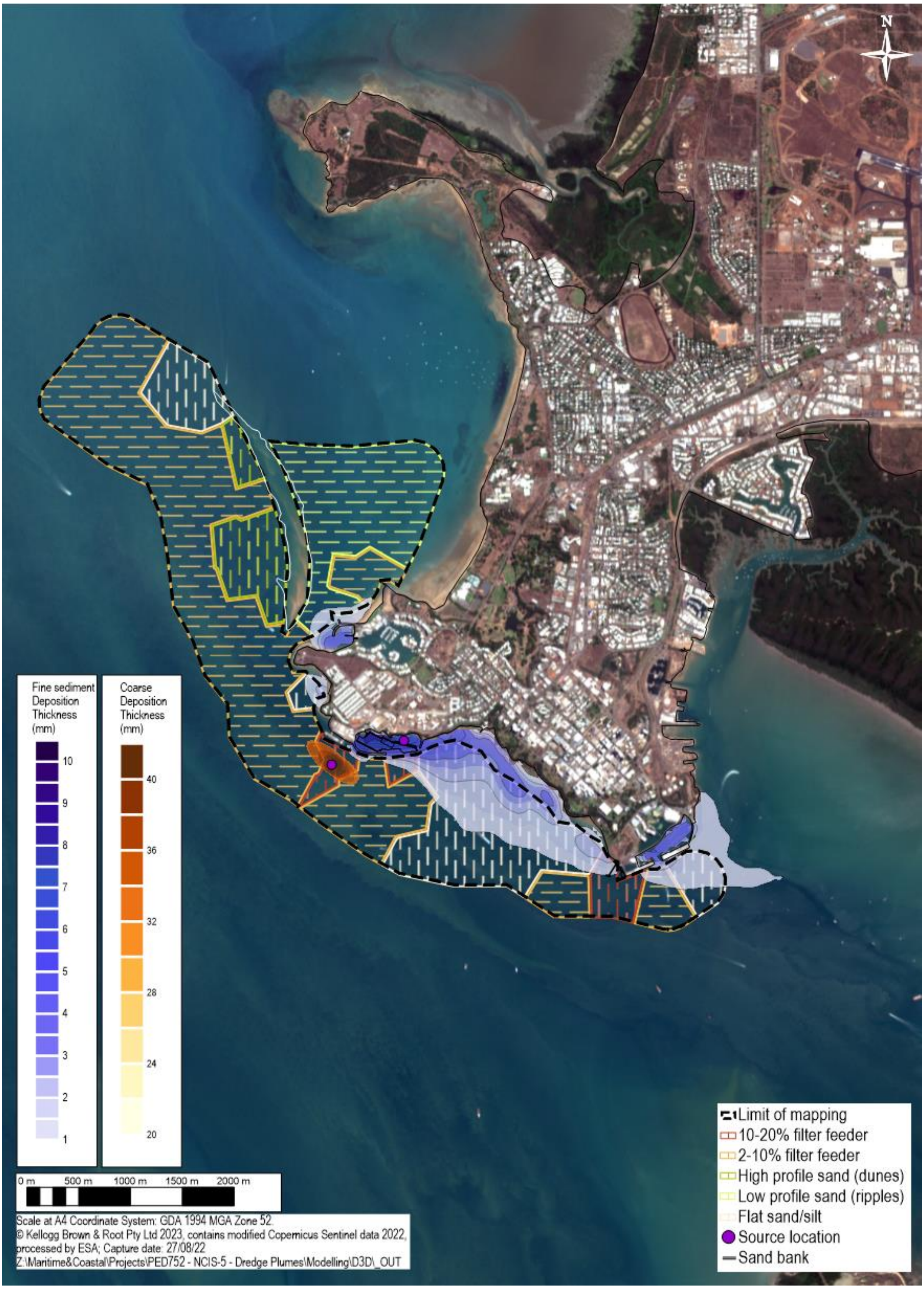

Figure 5.8 **Comparison of benthic habitats and sediment deposition thickness (mm) following the completion of dredging**

Some short-term temporary settling of fine material may occur within the extents of the plume, during low current periods (e.g. at turn of the tide), however, this would be resuspended and dispersed when currents increase. The erosion and sediment transport processes within the main plume area are consistently high, typically exceeding critical erosion stresses by orders of magnitude on a daily basis.

Fine materials fall out of suspension and remain on the bed where bed stresses are very low, particularly along the margins of the intertidal area around small foreshore areas, mangrove fringes and in enclosed basins. Modelling of the fate of material supports this finding (Figure 5.7), indicating settling in the low energy environment of Cullen Bay and in artificially deepened areas at Fort Hill (less than 3 mm). The deposition of fine marine sediments across these nearshore areas would be indiscernible from the distribution of natural sediments that continually circulate via the same resuspension and deposition processes.

The distribution of fine sediment deposition within the harbour has been compared with the benthic habitat mapping for the project area in Figure 5.8. The majority of fine sediment deposition will occur in areas which are characterised by bare substrate with sparse filter feeders. Modelling results also indicate that deposition of up to 2 mm of fine sediments in the vicinity of small patches of mangroves which occur along the rocky intertidal area following the Darwin esplanade shoreline. This is an order of magnitude less than the level of sediment deposition which may cause stress to mangroves (50 mm).

5.3.2 Backhoe dredging

Figures 5.9 and 5.10 present 90th percentile results associated with backhoe dredging during both the dry season and wet season, respectively. These figures show that the plumes as a result of dredging are largely contained within the HMAS *Coonawarra* basin with the maximum plume extent reaching approximately 1 km along the Larrakeyah coastline (south of Fannie Bay) at the northward extent, and approximately 600 m to the west, following the currents along the coastline. Outside of the basin these plumes are expected to rapidly reduce to less than 10 mg/L suspended sediment concentration. The insets on both figures show the plumes generated at the dredge source are small and are generally overwhelmed by the plumes generated by the discharge activities.

Based on these modelling results and the evidence from previous campaigns within the HMAS *Coonawarra* basin, impacts to marine water quality as a direct result of dredging are expected to be small with suspended sediment concentrations of less than 20 mg/L which are predicted to dissipate below 10 mg/L within 100 m of the dredge source.

5.4 ZONES OF IMPACT AND INFLUENCE

The proposed suspended sediment concentration trigger values outlined in the published Referral have been reviewed based on the outcomes of the benthic habitat assessment, further examination of available baseline water quality data, and review of available literature on the tolerance limits of those benthic habitats present within the zone of influence.

Given that quantitative data on tolerance thresholds for filter feeder species is limited, criteria which reflects a conservative approach and the impact mechanisms identified has been adopted.

It is proposed that suspended sediment concentration trigger levels of 10 mg/L and 23 mg/L be adopted to represent the Zone of Influence and Zone of Low to Medium Impact, respectively. These trigger values would be applied to both the dry and wet season and will be reviewed as further data is obtained (i.e. at this stage these trigger values are conservatively derived from published ‘effect based’ experiment results and are not derived from site specific suspended sediment data).

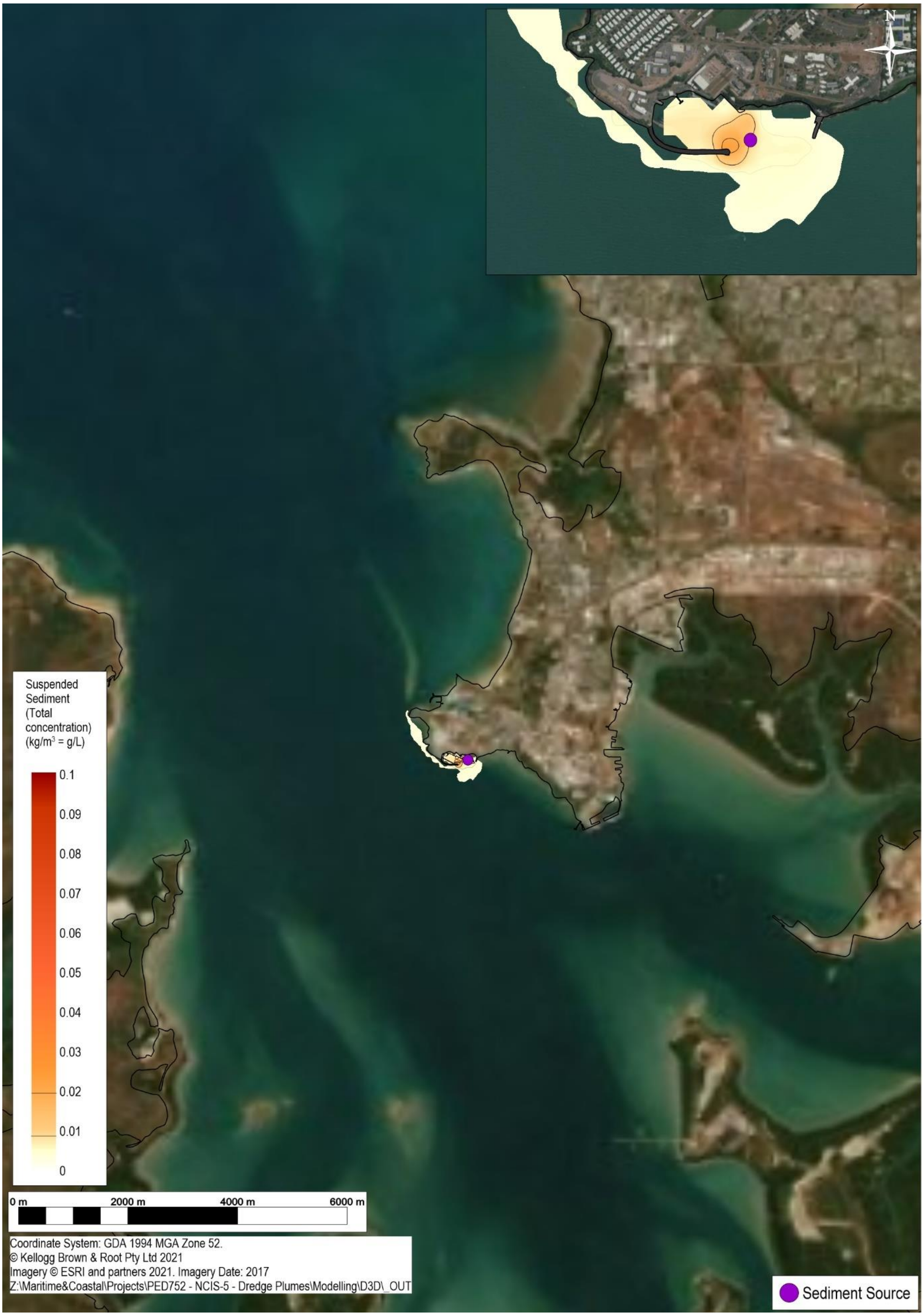

Figure 5.9 **90th Percentile suspended sediment concentration from backhoe dredge – dry season (includes 3 mg/L background concentration)**

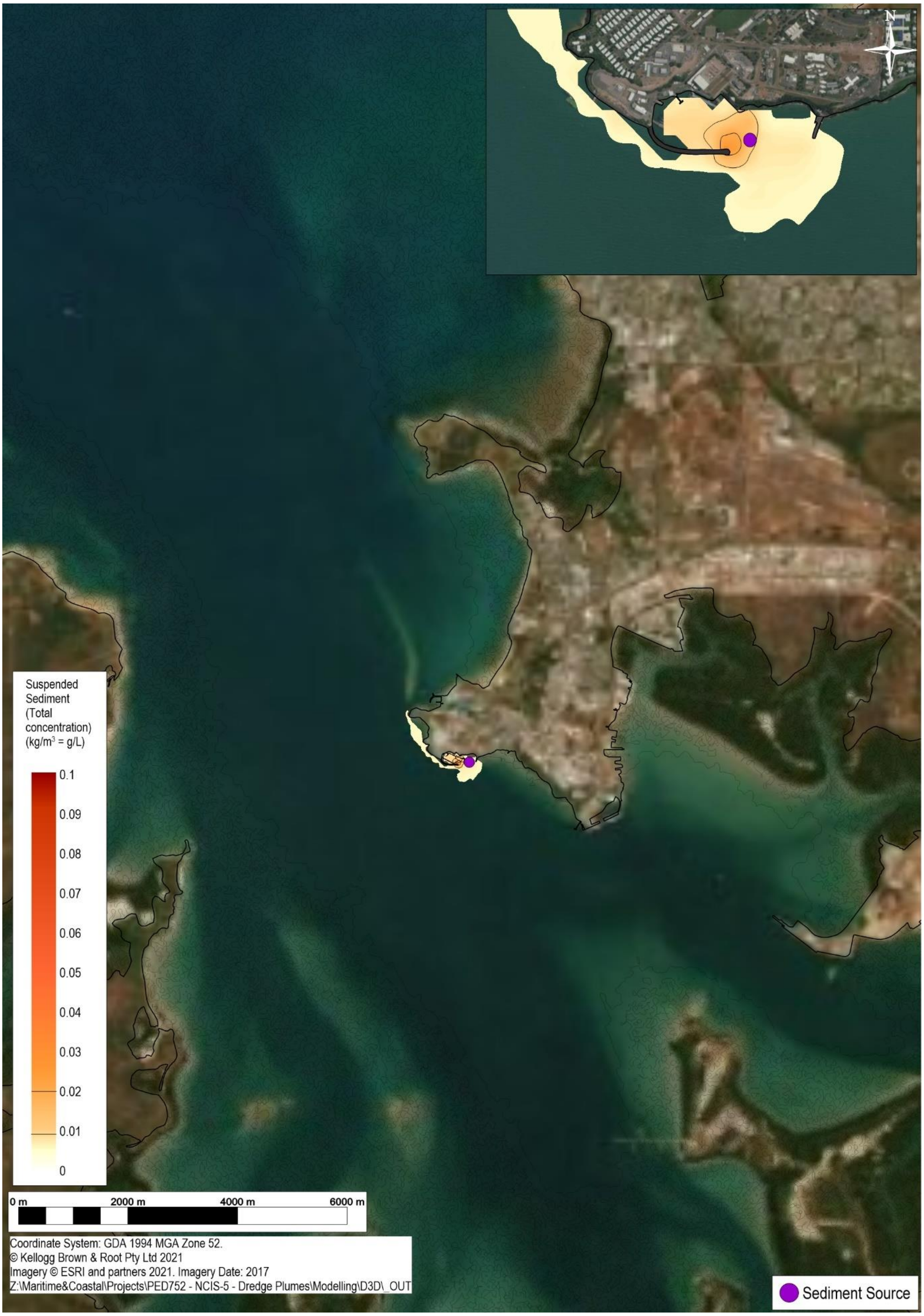

Figure 5.10 **90th percentile suspended sediment concentration from backhoe dredge – wet season (includes 5 mg/L background concentration)**

These values are considered to be conservative given that they are derived from observations of 28 days continuous exposure to elevated suspended sediment concentrations. During the proposed dredging, elevated concentrations of suspended sediment will not be constant given the strong bidirectional currents experienced within the project area and that dredging and discharge operations will not be continuous.

In addition, modelling indicates that elevated suspended sediment concentrations typically last 12 hrs before returning to baseline conditions, which is substantially less than the 28 days of continuous exposure which the trigger levels are based on. The duration of 'high peak' periods are shorter and range between 2 to 4 hours. Modelling also shows no gradual increase in the underlying 'baseline' concentrations which indicates that once dredging is complete the system will quickly return to its pre dredging condition.

The definitions for each zone of impact and zone of influence have been updated and are described below.

Zone of High Impact

This zone constitutes the area of the coarse heavy material deposition which is predicted to occur within the immediate vicinity of the dredge (within the basin) and discharge location and accounts for smothering/blanketing from coarse sediments discharged during dredging.

Based on the outcomes of the recent benthic habitat survey, the filter feeders present within the vicinity of the discharge location are evidence of recovery from similar effects during the previous dredging campaign.

Zone of Low to Medium Impact

Within this zone, some impact to benthic habitats and benthic biota may occur as a result of indirect impacts from increased fine suspended sediment which occur at times occur within this zone. While impacts within this zone are predicted to occur, there is a good likelihood that disturbed areas will recover after completion of the dredging and disposal operations.

It is expected that there will be no long-term modification of the sponge dominated filter feeder communities in this zone. The outer edge of the Zone of Low to Moderate Impact is delineated by the 90^{th} percentile 23 mg/L contour plot for suspended sediment concentration, as defined by dredge plume modelling. This delineates the areas within which the 90^{th} percentile concentration is predicted to be above the trigger value of 23 mg/L suspended sediment concentration.

Zone of Influence

This zone includes the areas in which, at some time during the dredging works, benthic communities may experience (detectable) changes in sediment-related environmental quality. However, the intensity, duration and frequency of these changes is such that any stress or impact to benthic habitats is likely to be reversable and no mortality of benthic biota is expected to occur.

The outer boundary of this zone is delineated by the 90^{th} percentile 10 mg/L contour plot for suspended sediment concentration as defined by dredge plume modelling. This reflects the area where, for 90% of the time, suspended sediment concentrations from dredging and discharge related activities will be above the tolerance limit of 10 mg/L for filters feeders but below 23 mg/L.

Figures 5.11 and 5.12 present the predicted zones of impact and influence during the dry and wet seasons respectively. Figures 5.13 and 5.14 represents those benthic habitat communities within the zones of impact and influence.

Based on the modelling results and the definitions of the zones of impact and influence, it is apparent that frequent high suspended sediment concentrations from dredging and discharge related activities are predicted to be limited to the vicinity of the dredge and discharge location.

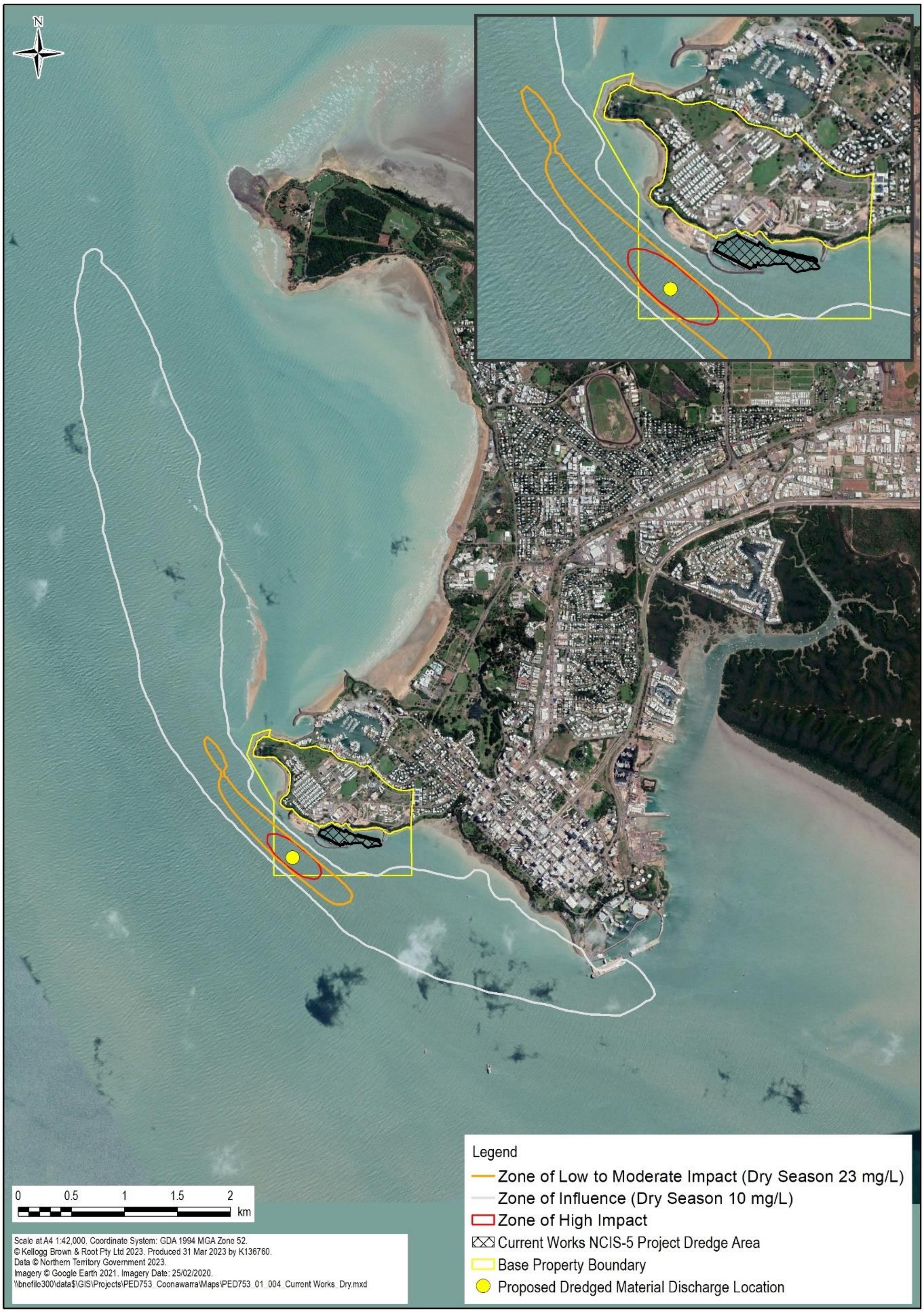

Figure 5.11 90th percentile current NCIS-5 project suspended sediment concentration zones of impact and influence (Dry Season - includes 3 mg/L background)

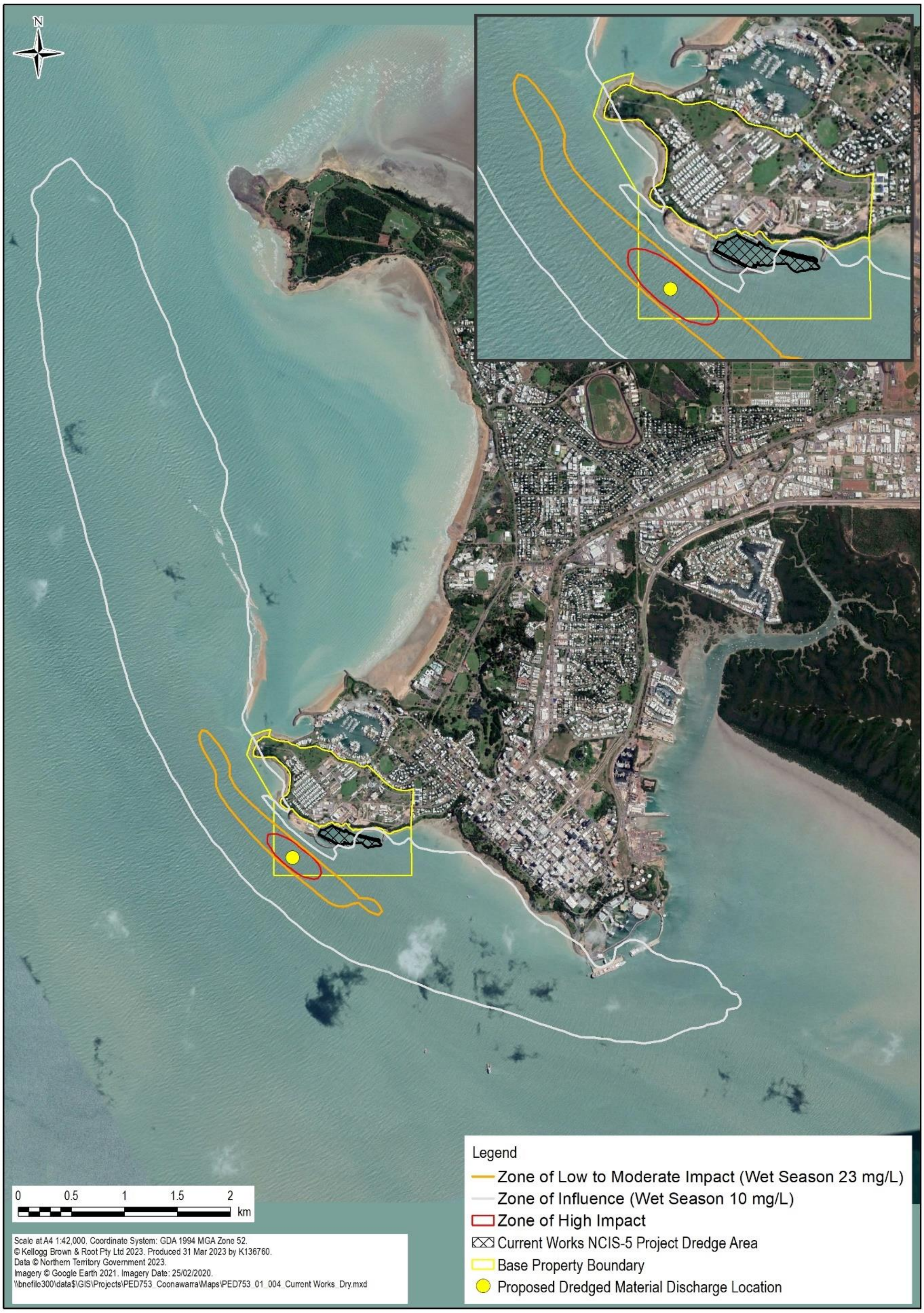

Figure 5.12 90th percentile current NCIS-5 project suspended sediment concentration zones of impact and influence (Wet Season - includes 5 mg/L background)

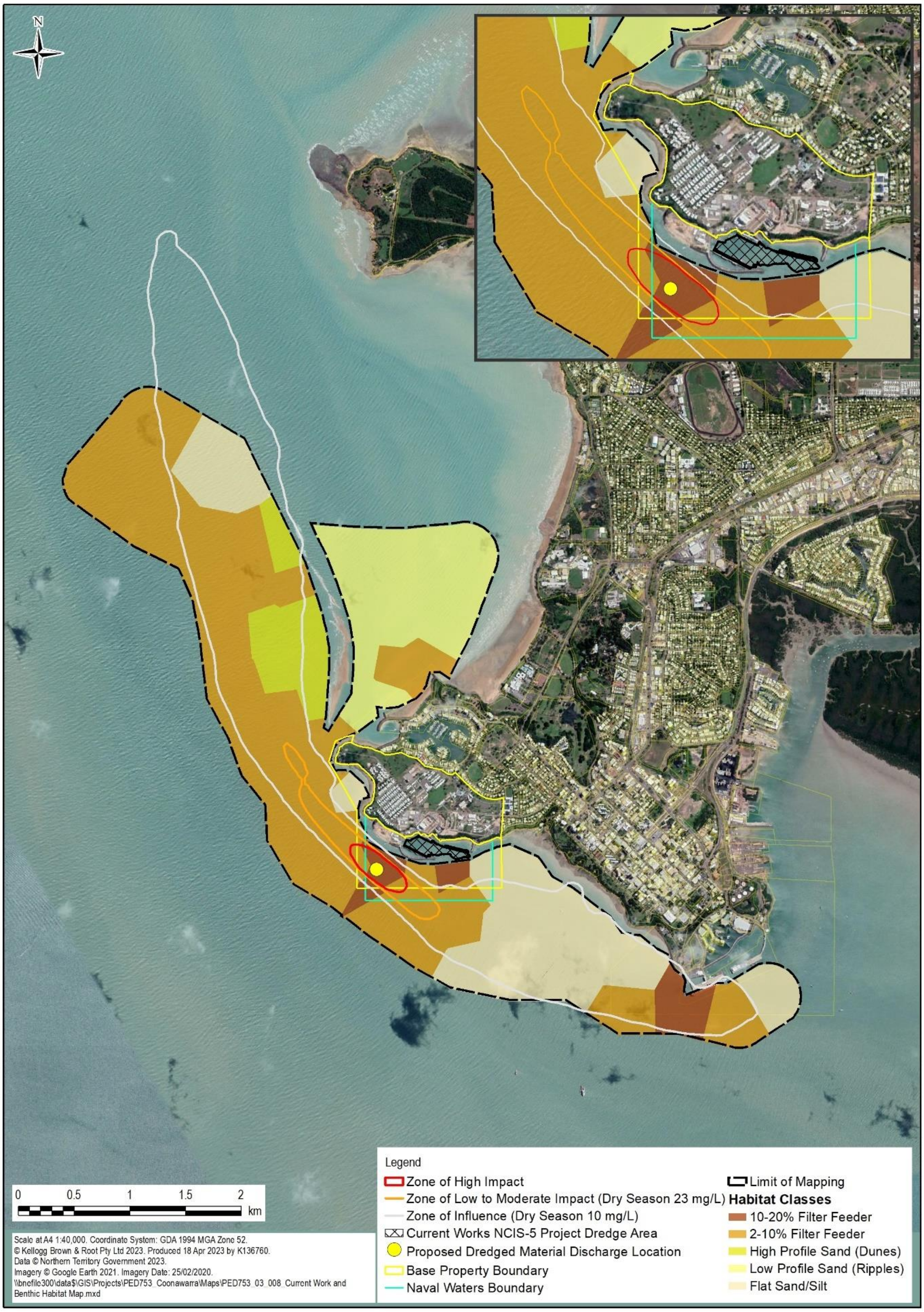

Figure 5.13 **Benthic habitats within the 90th percentile suspended sediment concentration zones of impact and influence (Includes 3 mg/L background – Dry Season)**

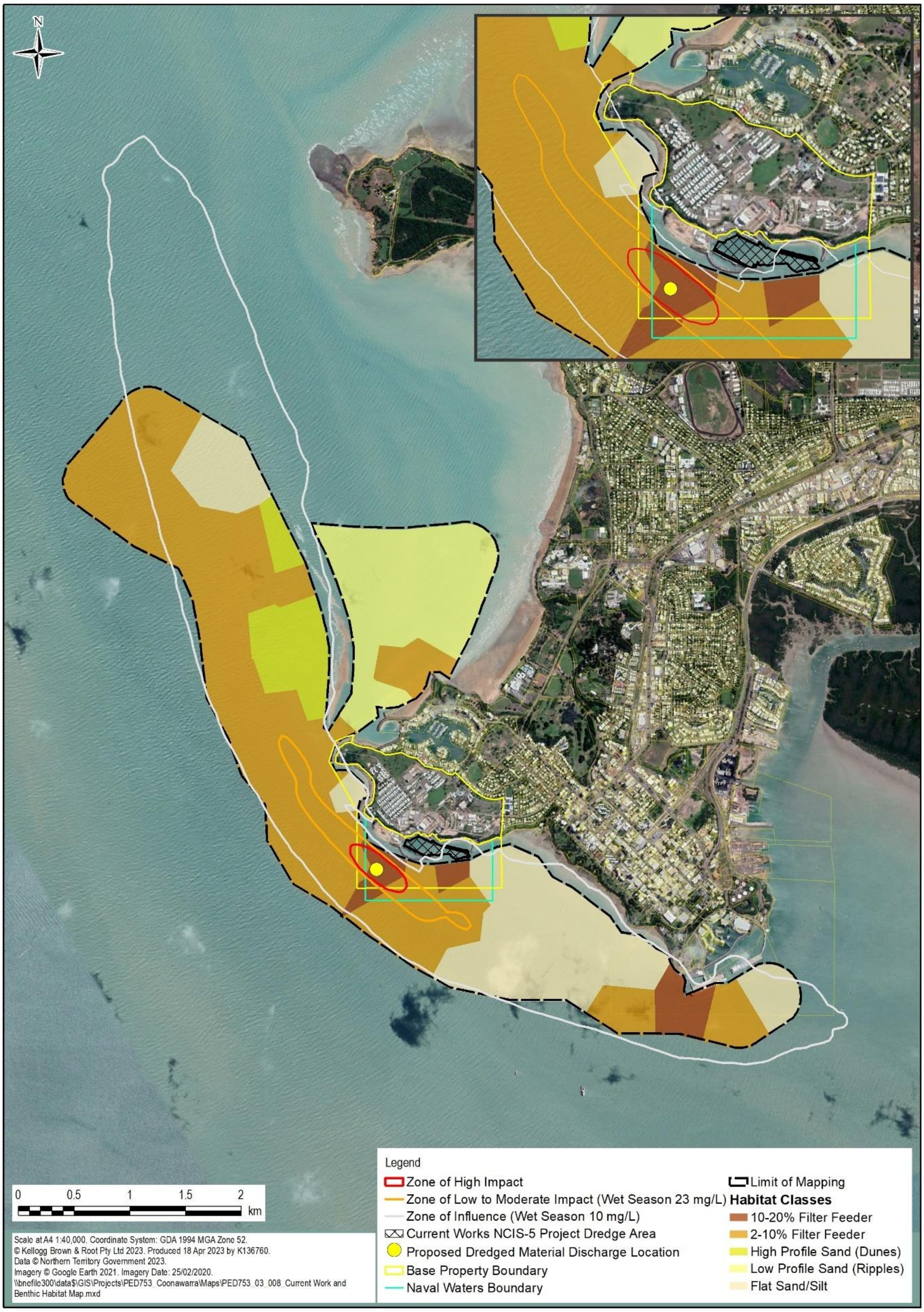

Figure 5.14 Benthic habitats within the 90th percentile suspended sediment concentration zones of impact and influence (Includes 5 mg/L background – Wet Season)

As previously noted, no benthic communities which are highly dependent on benthic light availability have been identified within the zones of impact and influence. The nearest area of benthic habitat which could at times be sensitive to changes in light penetration, is the potential seagrass habitat located to the north of the project (outside of the predicted zone of influence) within Fannie Bay. As shown in Figures 5.13 and 5.14 the zones of impact and influence are not anticipated to reach this area.

Given the low frequency of suspended sediment results predicted to occur above the trigger values, and the fact that suspended sediment concentrations consistent with the modelled predictions occur frequently as part of the natural variation of the harbour where these sparse filter feeders are present, it is unlikely that permanent impacts would occur.

Modelling shows that while elevated suspended sediment concentrations are predicted to occur throughout the dredging campaign, the duration of the 'high peak' periods is generally short and ranges between 2 to 4 hours. Based on the modelling predictions and the results of previous dredging campaigns at HMAS *Coonawarra,* once dredging is complete the system will quickly return (within 3 to 4 days) to its pre dredging water quality condition (i.e. near baseline marine water quality conditions).

6 Environmental risk assessment

6.1 PURPOSE

A systematic environmental risk assessment process has been applied to address the potential risks associated with dredging and dredged sediment disposal at HMAS *Coonawarra*.

The purpose of the risk assessment process was to identify the activities, and environmental aspects associated with those activities that have the potential to result in environmental impacts; and to guide the development of corresponding management measures and controls to avoid or reduce those potential impacts.

6.2 RISK METHODOLOGY

In order to assess and quantify the level of environmental risk associated with the proposed dredging and material disposal activities, a version of the Defence environmental risk tool has been used.

Risk level and score is calculated using the Defence standard risk matrix in Table 6.1. The definitions for the likelihood and consequence ratings are shown in Table 6.2 and Table 6.3, respectively.

Table 6.1 Risk assessment matrix

Likelihood rating	Consequence rating				
	Severe	Major	Moderate	Minor	Insignificant
Almost certain	Very high	Very high	High	Medium	Low
Likely	Very high	High	High	Medium	Low
Possible	High	High	Medium	Medium	Low
Unlikely	High	Medium	Medium	Low	Low
Rare	Medium	Medium	Low	Low	Low

Table 6.2 Likelihood definitions

Rating	Descriptors
Almost certain	Very high probability of the consequences occurring during the project timeframe.
Likely	High probability of the consequences occurring during the project timeframe.
Possible	Even probability of consequences occurring during the project timeframe.
Unlikely	Low probability of occurrence during the project timeframe but not negligible.
Rare	Very low probability of the consequences occurrence during the project timeframe but not impossible.

Table 6.3 Consequence definitions

Rating	Descriptors
Severe	Irreversible and extensive damage is caused to a State or Commonwealth listed matter (e.g. endangered species, Ramsar wetland, marine environment)
Major	Significant damage is caused to an environmentally significant area or asset from which it will take more than 10 years to recover.
Moderate	Moderate damage to the environment or a heritage listed asset or area, which is repairable. The value will take up to 10 years to recover.
Minor	Minor damage to the environment or heritage asset or area that is immediately contained on-site. It will take less than two years for the resource or asset to fully recover or it will only require minor repair. OR Disturbance to scarce or sensitive environmental or heritage resources.
Insignificant	Negligible damage that is contained on-site. AND The damage is fully recoverable with no permanent effect on the environment or the asset, it will take less than six months for the resource to fully recover.

6.3 RISK ASSESSMENT

Potential impacts associated with the proposed dredging and disposal activities and an overview of the associated risks are summarised in Table 6.4. The risks have been reviewed as part the assessment of potential environmental associated with the dredging and dredged material disposal activities. The risk evaluation comprised a desktop evaluation and the outcome of site specific investigations undertaken to date. The residual risk considered the proposed mitigation presented within the table.

Table 6.4 Risk assessment outcomes

Activity	Potential Impact	Proposed mitigation	Likelihood	Consequence	Residual risk
Coastal Processes					
Dredging (removed sediment from dredge area)	Change in bathymetry may alter the wave climate, tidal currents, or natural sediment transport processes.	• Hydrodynamic modelling completed during the design development process, with modelling outcomes used as inputs into the design. • Monitoring during dredging and dredged material disposal activities to ensure the works are undertaken in accordance with the design.	Rare	Minor	Low
Discharge of dredged sediments.	Deposition of discharge sediment may alter the bathymetry or natural sediment transport processes.	• Sediment plume behaviour and deposition modelling completed during the design development process, with modelling outcomes used as inputs into the design. Further assessment completed for Referral and SER. • Monitoring during dredging and dredged material disposal activities to ensure that the works are undertaken in accordance with the design and outcomes are as predicted.	Rare	Minor	Low
Water Quality					
Dredging of sediment	The suspension of fine sediment in the water column due to dredging.	• Undertake Water Quality Monitoring as per Section 7.2.2. • Ensure all dredging remains within the defined dredge area. • Perform pre-mobilisation checks of dredge vessel and undertake performance check during dredging. • All equipment should be maintained and operated in an efficient manner, and in accordance with manufacturer's specifications. • Assessment of suspended sediment plume generation during design and for Referral and SER.	Likely	Insignificant	Low
	The release of contaminants from disturbed sediment.	• Assessed during design and approval process. • Sampling and analysis of sediment completed in accordance with the NAGD to confirm suitable for proposed dredging /disposal.	Unlikely	Minor	Low
	The release of nutrients (nitrogen, phosphorous and/or ammonia) from disturbed sediment.	• Assessed during design and approval process. • Sampling and analysis of sediment completed in accordance with the NAGD to confirm suitable for proposed dredging /disposal.	Unlikely	Minor	Low

Activity	Potential Impact	Proposed mitigation	Likelihood	Consequence	Residual risk
Discharge of dredge sediments at nearshore location	The suspension of fine sediment in the water column due to discharge.	• Detailed modelling and assessment during design and for Referral and SER. • Undertake Water Quality Monitoring as per Section 7.2.2. • Ensure sediment discharge is at approved location. • Maintain dredged sediment delivery pipeline to ensure no leaks.	Likely	Insignificant	Low
	The release of contaminants from disturbed sediment	• Sampling and analysis of sediment completed in accordance with the NAGD to confirm suitable for proposed dredging /disposal.	Unlikely	Minor	Low
	The release of nutrients (nitrogen, phosphorous and/or ammonia) from disturbed sediment.	• Sampling and analysis sediment completed in accordance with the NAGD to confirm suitable for proposed dredging /disposal.	Unlikely	Minor	Low
Transport of dredge sediment via barge	The suspension of fine sediment in the water column due to vessel movement. (prop wash resuspension) or losses from overflow or deck washdown.	• Assessed during design and approval process. • Vessels/barges should take the shortest safe navigable route possible to and from the Port and limiting transport to within safe operating conditions. • Barge decks should be washed down to remove sediment using seawater. This is to only be done within the dredge area. • Overflow of water from barge hopper only to occur within dredge area.	Unlikely	Insignificant	Low
Spills, leaks and refuelling	Risk of hazardous materials could enter the marine environment and reduce water quality as a result of spills, leaks and refuelling.	• Implement adequate spill and leak prevention and control techniques for over water activities. • Ensure vessels have appropriate spill kits and provide training on kit use. • Ensure safe and effective fuel, oil/chemical storage and handling. • For marine based plant, ensure that any refuelling conducted over water occurs without any spills into the marine environment and is undertaken in accordance with industry standards and is suitable for the marine environment. Ensure refuelling facilities are fitted with an ‘auto shut-off’ valve. • Contain any fuel, oil or chemical spills and clean up immediately.	Unlikely	Minor	Low
Marine flora and fauna					
Dredging	Removal of benthic communities within the HMAS *Coonawarra* Basin.	• Ensure all dredging remains within the defined dredge area.	Likely	Insignificant	Low

Activity	Potential Impact	Proposed mitigation	Likelihood	Consequence	Residual risk
Dredging (continued)	Increased suspended sediment concentration impacting on benthic communities.	• Assessed and modelled in detail during design and for Referral and SER. • Implement planned management measures and monitor effectiveness. • All equipment maintained and operated in an efficient manner, and in accordance with manufacturer's specifications. • Undertake Water Quality Monitoring as per Section 7.2.2.	Likely	Insignificant	Low
	Vessel interaction with marine fauna species.	• Visually monitor and record the sightings of marine mammals and turtle species. • Apply observation zone and response zone. • Ensure dredging operations remain within the boundaries of the defined dredge area. • Speed limits within the immediate dredge area. • All vessels and barges are to adhere to the speed limits within Darwin Harbour. • All project vessels are to keep careful forward lookout for turtles and marine mammals that may be in the path to minimise risk of collision. • Provide operator awareness training.	Rare	Minor	Low
	Underwater noise resulting in the temporary displacement of marine fauna species.	• Visually monitor and record the sightings of marine mammals and turtle species. • Apply observation zone and response zone. • Ensure dredging operations remain within the boundaries of the defined dredge area.	Unlikely	Minor	Low
	Blanketing/smothering intertidal benthic habitats and communities.	• Assessed during design and for Referral and SER. • Undertake Water Quality Monitoring as per Section 7.2.2. • Implement planned management measures and monitor effectiveness. • Ensure dredging operations remain within the boundaries of the defined dredge area. • All equipment should be maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Likely	Insignificant	Low

Activity	Potential Impact	Proposed mitigation	Likelihood	Consequence	Residual risk
Discharge of suspended sediment	Increased suspended sediment concentration impacting on benthic communities.	• Assessed and modelled in detail during design and for Referral and SER. • Undertake Water Quality Monitoring as per Section 7.2.2. • Implement planned management measures and monitor effectiveness. • Inspection on dredging days to ensure dredge material discharge point is in the correct location and there are no leaks or breakages in the pipeline.	Likely	Minor	Medium
	Blanketing/smothering intertidal benthic habitats and communities.	• Assessed and modelled in detail during design and for Referral and SER. • Undertake Water Quality Monitoring as per Section 7.3.2. • Implement planned management measures and monitor effectiveness. • Inspection on dredging days to ensure dredge material discharge point is in the correct location and there are no leaks or breakages in the pipeline.	Likely	Minor	Medium
Support vessels and transportation of dredge material via barge	Vessel interaction with marine fauna species.	• Visually monitor and record the sightings of marine mammals and turtle species. • Impose speed limits within the dredge area. • All vessels and barges are to adhere to the speed limits within Darwin Harbour. • Provide operator awareness training.	Unlikely	Minor	Low
	Underwater noise resulting in the displacement of marine fauna species.	• Visually monitor and record the sightings of marine mammals and turtle species and provide operator awareness training.	Unlikely	Minor	Low
Noise					
Noise	Dredging operations may result in noise disturbance to nearby sensitive receptors.	• Ensure all works are undertaken within planned work hours. • All equipment should be maintained and operated in an efficient manner, and in accordance with manufacturer's specifications. • Set up feedback/reporting mechanism residents to report noise nuisance.	Unlikely	Minor	Low
Waste					
Waste	Waste generated during dredging may enter the marine environment resulting in the disturbance and potential injury to marine life.	• Ensure appropriate storage of waste materials aboard vessels. • Ensure all loads of waste materials transported and/or stored at the site are covered. • Store potentially hazardous chemicals in accordance with the manufacturer's specifications. • Contain all spills and clean up immediately.	Unlikely	Minor	Low

7 Environmental Management and Monitoring

7.1 OVERVIEW

The environmental management and monitoring program to be implemented as part of this DDMP includes the following aspects:

- Changes to coastal processes within the HMAS *Coonawarra* basin (Section 7.2);
- Water quality surrounding the dredge and dredge material discharge location (Section 7.3);
- Presence of marine fauna species within the vicinity of the dredging operations (Section 7.4);
- Noise attributable to the dredge operations (Section 7.5); and
- Waste attributable to the dredge operations (Section 7.6).

Environmental monitoring will be implemented as part of the overall environmental management system for the dredging of HMAS *Coonawarra*. Key risks associated with the dredging and dredged material disposal campaign have been identified and discussed in Section 6, and through the management framework described below, appropriate environmental protection measures have been established.

7.2 COASTAL PROCESSES

7.2.1 Potential impacts

Changes in bathymetry within the basin or direct deposition area as a result of dredging may alter the wave climate, tidal currents, or natural sediment transport processes.

7.2.2 Management measures

Management measures outlined in Table 7.1 are to be implemented for the duration of the works.

Table 7.1 Coastal processes management measures

Activity	Management measures	Responsibility
CSD and backhoe Dredging	• Undertake pre and post dredging bathymetric survey to ensure dredging is as per the design. • Undertake pre and post dredging bathymetric survey in the immediate area of the discharge location (the coarse/heavy material deposition zone) (Figure 7.1)	Dredging Contractor

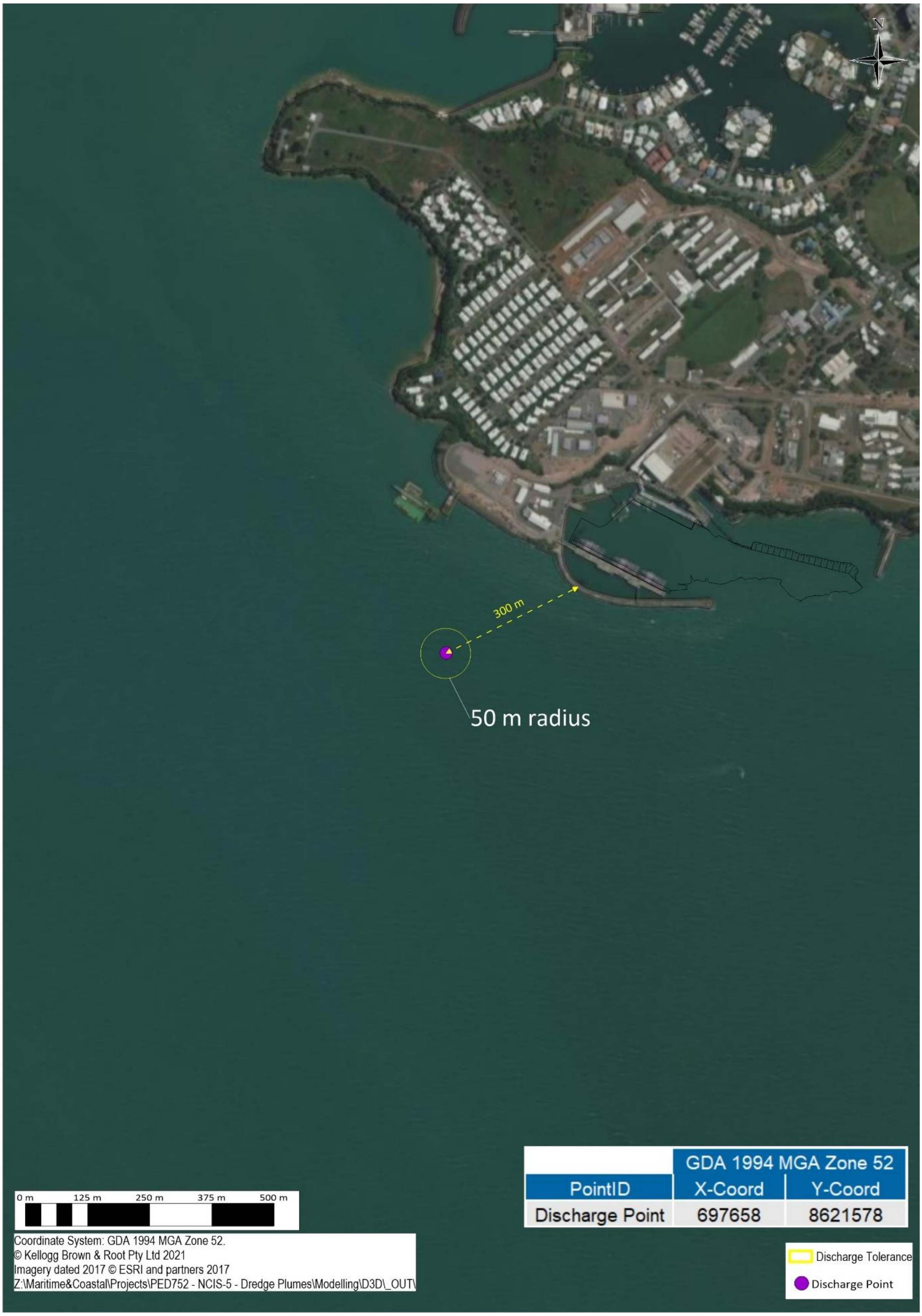

Figure 7.1 Dredged material discharge location (dredge pipe outlet position can vary within 50 m of discharge location)

7.2.3 Monitoring program

Performance criteria

- Dredge area design depth achieved.
- No significant change to bathymetry in vicinity of discharge location.

Monitoring plan

- Undertake pre and post dredging bathymetric survey to ensure dredge area design depth is achieved and no shoals or high points remain.
- Undertake pre and post bathymetric survey in the immediate area of the discharge location.

7.3 WATER QUALITY

7.3.1 Potential impacts

Dredging and dredged material discharge have the potential to impact marine water quality at the dredge area and the area affected by the dredge material discharge.

Mechanisms with the potential to effect water quality:

- The suspension of fine sediment in the water column as a result of dredging and dredged material discharge. This can result in the formation of a suspended sediment plume and reduce sunlight penetration of the water column;
- The release of contaminants from disturbed sediment;
- The release of nutrients (nitrogen, phosphorous and/or ammonia) from disturbed sediment in a form which is readily available for photosynthesis; and
- Risk of spills and leaks (e.g. fuel, oil, chemicals).

7.3.2 Management measures

The following water quality management measures outlined in Table 7.2 are to be implemented for the duration of the works.

Table 7.2 Water quality management measures

Activity	Management measures	Responsibility
CSD Dredging	• Perform pre-mobilisation checks of dredge vessel and undertake performance checks during dredging; • The dredge contractor shall operate the dredge efficiently and in a manner which minimises the extent of turbidity plumes as far as practicable; • Ensure dredging is limited to within the defined dredge area; • Confirm appropriate locations for moorings and for barge anchor lines; • All equipment should be maintained and operated in an efficient manner, and in accordance with manufacturer's specifications; and • When outside the dredge area, navigate all vessels in a manner which minimises sediment re-suspension.	Dredging Contractor
Nearshore Dredge Discharge	• Daily inspection on dredging days to ensure dredge material discharge point is in the correct location and depth; and • Maintain dredged sediment delivery pipeline to ensure no leaks.	Dredging Contractor

Activity	Management measures	Responsibility
Backhoe Dredging	• Perform pre-mobilisation checks of dredge vessel and all barge hopper seals and undertake performance check during dredging; • The dredge contractor shall operate the dredge efficiently and in a manner which minimises the extent of turbidity plumes as far as practicable; • Ensure dredging is limited to within the defined dredge area; • Confirm appropriate locations for moorings and for barge anchor lines; • All equipment should be maintained and operated in an efficient manner, and in accordance with manufacturer's specifications; and • When outside the dredge area, navigate all vessels in a manner which minimises sediment re-suspension.	Dredging Contractor
Transportation of material via barge	• Barge decks should be washed down to remove sediment using seawater before departing basin for transit. This is to only be done within the dredge area; • Water overflow from barge filling only to occur within dredge area; and • Vessels/barges should take the shortest safe navigable route possible to and from the Port and avoid spillage by not overloading and limiting transport to within safe operating conditions.	Dredging Contractor
Spills, leaks and refuelling	• Implement adequate spill and leak prevention and control techniques for over water activities; • Ensure vessels have appropriate spill kits and provide training on kit use; • Ensure safe and effective fuel, oil/chemical storage and handling; • For marine based plant, ensure that any refuelling conducted over water occurs without any spills into the marine environment and is undertaken in accordance with industry standards and is suitable for the marine environment. Ensure refuelling facilities are fitted with an 'auto shut-off' valve; and • Contain any fuel, oil or chemical spills and clean up immediately.	Dredging Contractor

7.3.3 Water quality monitoring program

Due to the substantial difference in the extent of marine water quality impacts predicted for the two dredges (i.e. CSD with nearshore discharge vs backhoe dredging with land-based disposal), a different monitoring program has been developed for each.

Cutter Suction Dredging and Nearshore Discharge

Performance criteria

- Suspended sediment plume behaviour and extent consistent with modelled predictions;
- No dredging outside approved areas;
- Pipeline discharge at approved location and depth range;
- No leaks or breaks in the pipeline.

Monitoring locations

The water quality monitoring locations, which are the same as those monitored during the baseline water quality monitoring program, are shown in Figure 7.2.

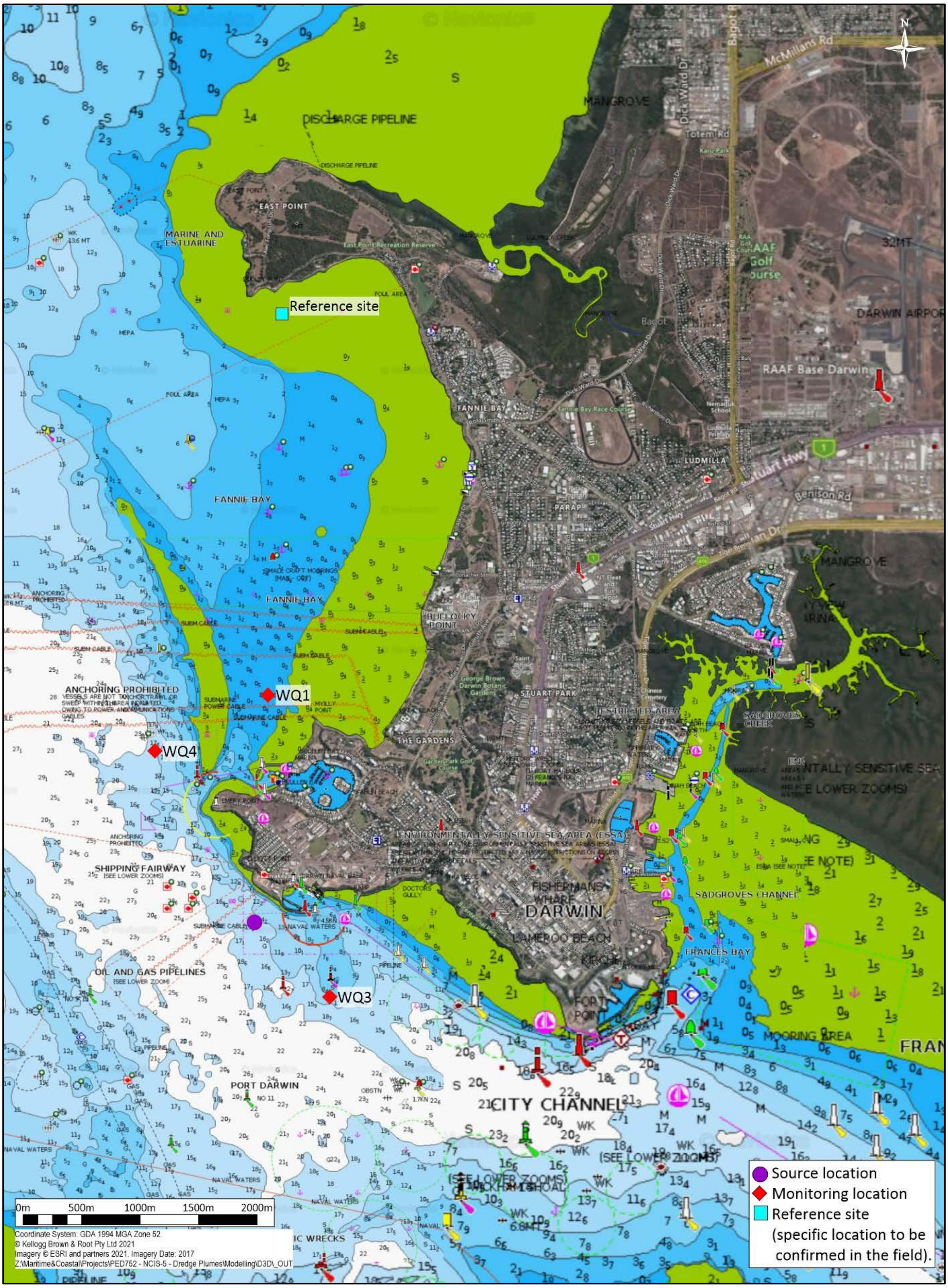

Figure 7.2 **Water quality monitoring locations during dredging**

Site WQ1 is proposed to be located outside the predicted zones of impact and influence and has been positioned to provide warning of the potential for sediment plumes to approach the area where potential seagrass habitat has previously been reported within Fannie Bay.

Monitoring locations WQ3 and WQ4 will be positioned within the main sediment plume area to the north and south of HMAS *Coonawarra*. These locations will capture data on characteristics of the sediment plumes generated by discharge during the ebb and flood tide. Monitoring location WQ3 near Bennett Shoal will capture sediment plumes on the flood tide while monitoring location WQ4 will be located to the west of the offshore sand bank in the area influenced on ebb tides.

A ‘reference’ site is also shown on Figure 7.2. The intent of the ‘reference’ site is to use this site to assist in the interpretation of elevated results from routine monitoring locations. The specific location of the ‘reference’ site will be confirmed in the field to ensure it is representative of water quality conditions which have not been influenced by the dredging and discharge activities.

Trigger levels

Water quality monitoring data will be collected at locations WQ3 and WQ4 during dredging. These locations are not response based locations, rather data from these sites will be used to confirm the understanding of sediment plumes generated during dredging and discharge and improve the modelling and assessment for future campaigns.

Telemetry based water quality monitoring will be undertaken at WQ1. Data at this location will provide an early warning of dredged related suspended sediments entering Fannie Bay. An impact based trigger is not needed at this location, instead an early warning plume detection level of 30 NTU (based on the 6 hourly average turbidity) will be used to detect whether sediment plume effects from dredging approach Fannie Bay.

Table 7.3 outlines the trigger values applicable to the telemetry based water quality monitoring surface buoy located at WQ1, Zone of low to moderate impact and Zone of influence. The trigger values for each zone are based on published data from the Western Australian Marine Science Institution (WAMSI) guidelines. The trigger value for WQ1 is a reactive value which triggers further investigation and management should it be exceeded.

Table 7.3 Trigger values for Zones of Impact and Influence and turbidity triggers for WQ1

Monitoring location^	Season	Trigger values >intensity value and >duration or >frequency		
		Intensity	Duration	Frequency
WQ1 Fannie Bay* Telemetry Surface Buoy	Wet and dry season	30 NTU (6-hourly average)	12 hours	12 hours
Zone of low to moderate impact*		70 ≥ 23 NTU (90th%ile)	N/A	N/A
Zone of influence*		10 ≤ 23 NTU (90th%ile)	N/A	N/A

** Only applicable where volume of material to be dredged is more than 20,000* m^3
^ WQ1 trigger values are reactive. Zone triggers are informative only.
Note - Refer to Figure 7.3 for application of trigger values.

TSS and NTU relationship

As suspended sediment concentration cannot be monitored directly in the environment (it is a laboratory determined parameter), turbidity (in NTU) is used for field measurements. To date, a relationship of 1:1 between NTU and suspended sediment concentration has been adopted. This is based on the harbour-wide NTU/TSS relationship of 1:1 which was derived during the INPEX capital dredging program undertaken in 2013 (Cardno 2013) and which has again been applied to the 2023 – 2027 Ichthys LNG Maintenance Dredging Program (INPEX, 2022).

The baseline water quality monitoring program completed in April/May 2023, was undertaken during a period where sea conditions were very benign (flat seas, low wind speeds) and there was no rainfall runoff entering the harbour. Consequently it was only possible to collect samples with turbidity and suspended solids concentration within a low value range. Therefore there is not yet sufficient data across a broad range of turbidity conditions to confirm the relationship between TSS and NTU.

Therefore, more site specific water quality data (turbidity and suspended solids determined on a series of samples across a range of water quality conditions) will be collected and analysed prior to and during dredging to further understand and validate the relationship between TSS and NTU, and support future dredging campaigns.

Monitoring Plan

The water quality monitoring plan is comprised of the following:

- Pre-dredging environmental monitoring
- Plume prediction validation monitoring
- Routine monitoring

Monitoring tasks to be undertaken prior to and during dredging are summarised below and are further described in the following sections.

- **Unattended monitoring (Bed frames)** – Deployment of three bed frames at WQ1, WQ3, and WQ4 with water quality monitoring instruments which will continuously monitor turbidity and PAR at approximately 15 minute intervals. An 'on land' reference PAR sensor station will also be deployed at Cullen Bay Marina, adjacent to the lock. This station will be deployed in a secure location free of shade and will record on land PAR data.
- **Unattended monitoring (Surface buoy)** – Deployment of one surface buoy at WQ1 with telemetry capability to continuously measure and transmit NTU data at 15 minute intervals.
- **Plume prediction validation monitoring** – The data for CSD discharge plume prediction validation will need to capture representative dredge/discharge operations and a selection of both spring and neap tides during the initial period of CSD dredging. It may not be possible to capture this data on consecutive days, for example, because of dredge stoppages, unsuitable weather conditions, or atypical dredge operation (e.g. encountering hard material with very low production and atypical (low) discharge). To address this, the plan is to collect data from at least seven (7) days with representative tide and discharge conditions during the first 4 weeks of CSD dredging. Vertical profiling at targeted locations and/or on transects within the visible extent of the dredge plume will be undertaken to define the extent and characteristics of the plume.
- **Infield water quality monitoring** – Water quality depth profiles to be undertaken daily on two days prior to the commencement of dredging, on the same days as plume validation monitoring and then monthly thereafter. Water samples will also be collected and analysed from a series of locations where turbidity is measured at the same time and location, sufficient to capture a range of suspended sediment concentrations.

- **Seagrass spot checks (Fannie Bay)** – Spot checks will be undertaken on two days prior to the commencement of dredging to determine the presence of seagrass within the area of Fannie Bay in the vicinity of WQ1 via direct inspection/drop camera and grab sampling.
- **Satellite imagery analysis** – To support the plume prediction validation monitoring task, published satellite data will be interpreted and compared with model predictions and field measurements.
- **Visual monitoring** – The Contractor will be responsible for undertaking daily visual monitoring during dredging (CSD and Backhoe) and dredge material discharge.

Pre-dredging environmental monitoring

At locations WQ1, WQ3 and WQ4 bottom frames with water quality monitoring instruments will be deployed prior to the commencement of CSD dredging. The bed frame mounted monitoring instruments will be installed at a depth of approximately 0.5 m above the seafloor. Instruments will monitor turbidity and PAR during the dredging program. Monitoring frequency can be adjusted but would be every 15 minutes. Location WQ1 will also have a surface buoy (sensors at approximately 0.7m depth) to measure turbidity, which will be telemetry enabled. These monitoring locations replicate those from the baseline monitoring program and their installation will be subject to the approval of the Darwin Harbour Master.

Pre-dredging environmental monitoring will be undertaken on two days prior to the beginning of CSD dredging and will include daily infield water quality monitoring and seagrass spot checks as summarised in Table 7.4. This data will complement the water quality data obtained from the project specific baseline monitoring program.

Table 7.4 Pre-dredging environmental monitoring tasks to be undertaken

Monitoring task	Monitoring approach
Unattended monitoring (bed frames and surface buoy)	• Deployment of bed frames and monitoring instruments at WQ1, WQ3 and WQ4 at least one week prior to the commencement of dredging. • Deployment of surface buoy and telemetry system at WQ1 at least one week prior to the commencement of dredging. • Continuous monitoring at all locations, with telemetered turbidity data from the surface buoy at WQ1.
Infield water quality monitoring	• Depth profiles measured at all water quality monitoring locations (Figure 7.2). • Measurements to be taken at approximately 1 m interval's from surface to bottom. • Parameters to be measured include depth, temperature, turbidity, and conductivity. • Water samples will also be collected and analysed in a laboratory from a series of locations where turbidity is measured at the same time and location, sufficient to capture a range of suspended sediment concentrations. Samples would be analysed for dissolved oxygen, TSS, nutrients and metalloids.
Fannie Bay - Seagrass spot checks	• Spot checks to determine the presence of seagrass within the vicinity of WQ1 in Fannie Bay undertaken via direct inspection/drop camera, grab sampling.

Plume prediction validation monitoring

The plume prediction validation will be done on at least seven (7) days with representative tide and dredging conditions during the first 4 weeks of CSD dredging operations. The monitoring tasks to be undertaken during this period are outlined in Table 7.5.

Table 7.5 Plume prediction validation tasks to be undertaken during dredging

Monitoring task	Monitoring approach
Plume prediction validation monitoring	• Vertical profiling at targeted locations and/or on transects within the visible extent of the dredge plume to define the extent and characteristics of the plume. • The location of the plume profiling transects will vary between monitoring periods as the plume shifts. • Monitoring at the vertical profiling sites will be undertaken at approximately 1.0 m intervals from surface to bottom. • Parameters measured include depth, temperature, turbidity and conductivity. • The observable extent of the plume will be marked using a GPS with a focus on the area where the above observations are made.
Satellite imagery analysis	• To support the plume prediction validation monitoring task, published satellite data will be interpreted and compared with model predictions and field measurements twice during this period.
Infield water quality monitoring	On the plume investigation days, infield monitoring will also occur at each of the water quality monitoring locations (Figure 7.2) and will consist of: • Water quality depth profiles measured at approximately 1.0 m intervals from surface to bottom. • Parameters measured include depth, temperature, turbidity, and conductivity. • Water samples will also be collected and analysed in a laboratory from a series of locations where turbidity is measured at the same time and location, sufficient to capture a range of suspended sediment concentrations. Samples will be analysed for dissolved oxygen, TSS, nutrients and metalloids.
Daily visual monitoring (to be undertaken by the Contractor)	The Contractor will be responsible for undertaking daily visual monitoring during CSD dredging, and will include the following tasks: • Visual monitoring of nearfield sediment plumes from the dredge conducted from a safe, elevated position. • Visual inspection and GPS check to ensure the dredge material discharge point is in the correct location and depth. • Visual inspection to ensure dredge material discharge pipeline is not leaking. • Visual inspection of nearfield discharge plume (e.g. within 100 m of source). • The extent, direction (bearing) and distance of any visible plumes extending from the dredge activity and the disposal location is to be described, for example, by sketching it on a proforma, along with details of the dredge location, tidal phase, wind and weather conditions.

The data from the plume prediction validation period will be analysed and compared with model predictions for equivalent conditions and dredge operation scenarios. The purpose will be to determine whether the model predictions are sufficiently representative, whether refinement of the model may be warranted, or whether the data indicates new or substantially different sediment related behaviours from those assessed. In addition to this initial data collection phase, this process will be ongoing based on the results of routine monitoring tasks.

Routine monitoring

Routine monitoring will commence after the plume predication validation phase of monitoring and will incorporate telemetry monitoring, fortnightly satellite data captures, monthly infield turbidity monitoring and daily routine visual monitoring, as described in Table 7.6.

Table 7.6 Routine monitoring tasks to be undertaken during dredging

Monitoring task	Monitoring approach
Unattended monitoring - Surface buoy	• Ongoing telemetry enabled turbidity monitoring at site WQ1. • Instrument data download, maintenance, calibration and redeployment will occur during each of the monthly water quality checks specified below.
Infield water quality monitoring	Infield water quality monitoring will occur at each of the water quality monitoring locations (Figure 7.2) and will consist of: • Water quality depth profiles measured at approximately 1.0 m intervals from surface to bottom. • Parameters measured include depth, temperature, turbidity, and conductivity. • Water samples will also be collected and analysed in a laboratory from a series of locations where turbidity is measured at the same time and location, sufficient to capture a range of suspended sediment concentrations. Samples would be analysed for dissolved oxygen, TSS, nutrients and metalloids.
Satellite imagery analysis	• Published satellite imagery will be reviewed fortnightly during this period and will be compared with modelled predictions and field monitoring results to assess plume behaviour.
Daily visual monitoring (to be undertaken by the Contractor)	The Contractor will be responsible for undertaking daily visual monitoring during CSD dredging, and will include the following tasks: • Visual monitoring of nearfield sediment plumes from the dredge conducted from a safe, elevated position. • Visual inspection and GPS check to ensure the dredge material discharge point is in the correct location and depth. • Visual inspection to ensure dredge material discharge pipeline is not leaking. • Visual inspection of nearfield discharge plume (e.g. within 100 m of source). • The extent, direction (bearing) and distance of any visible plumes extending from the dredge activity and the disposal location is to be described, for example, by sketching it on a proforma, along with details of the dredge location, tidal phase, wind and weather conditions.

An overview of the water quality monitoring plan is provided in Table 7.7.

Table 7.7 Summary of water quality monitoring plan during CSD dredging

Monitoring task	Frequency	Parameters	Monitoring Locations
Pre-dredging environmental monitoring			
Unattended monitoring – Bed frames	• Deployment of three bed frames prior to commencement of CSD dredging • Continuous monitoring at 15 minute intervals prior to and during CSD dredging	• Turbidity (NTU) • PAR • Depth	WQ1, WQ3, WQ4
Unattended monitoring – Surface buoy with telemetry	• Deployment of surface buoy prior to commencement of CSD dredging • Continuous monitoring with telemetered data at 15 minute intervals prior to and during CSD dredging	• Turbidity	WQ1
Infield water quality monitoring	• On two (2) days prior to commencement of CSD dredging	• Depth/Temperature • Turbidity (NTU) & TSS • Conductivity • Dissolved Oxygen • Nutrients and metals	WQ1, WQ3, WQ4
Fannie Bay - Seagrass spot checks	• On two (2) days prior to commencement of CSD dredging	• Presence/absence	Multiple locations in the vicinity of WQ1
During CSD Dredging			
Plume predication validation monitoring			
Plume prediction validation monitoring	• On at least seven (7) days with representative conditions during the first four (4) weeks of dredging operations.	• Depth/Temperature • Turbidity (NTU) • Conductivity	Plume profiling transects will vary due to tidal variation.
Satellite imagery analysis	• Twice during plume validation period. • Fortnightly following the plume validation period.	• Analysis of satellite imagery	Dredge area and Zone of Influence
Infield water quality monitoring	• On plume validation monitoring days.	• Depth/Temperature • Turbidity (NTU) & TSS • Conductivity • Dissolved Oxygen • Nutrients and metals	WQ1, WQ3, WQ4 Plus additional locations to capture variable readings.
Bed frames and Surface buoy	• Continuous unattended monitoring at all locations, with telemetered monitoring data from WQ1 surface buoy.	• Turbidity (NTU) • PAR • Depth	WQ1, WQ3, WQ4
Daily visual monitoring (to be undertaken by the Contractor)	• Daily visual monitoring during CSD dredging discharge	• Visual plume	Visual monitoring from dredge conducted from a safe, elevated position.
Routine monitoring			
Infield water quality monitoring	• Monthly following plume validation period.	• Depth/Temperature • Turbidity (NTU) & TSS • Conductivity • Dissolved Oxygen • Nutrients and metals	WQ1, WQ3, WQ4
Satellite imagery analysis	• Fortnightly following the plume validation period.	• Analysis of satellite imagery	Dredge area and Zone of Influence
Bed frames and Surface buoy	• Continuous unattended monitoring at all locations, with telemetered monitoring data from WQ1 surface buoy.	• Turbidity (NTU) • PAR • Depth	WQ1, WQ3, WQ4
Daily visual monitoring (to be undertaken by the Contractor)	• Daily visual monitoring during CSD dredging and discharge	• Visual plume	Visual monitoring from dredge conducted from a safe, elevated position.

Response to Exceedance

The following sections describe the adaptive management process that will be implemented to manage potential sediment-related effects associated with the dredging and discharge of sediment. The flow diagram provided as Figure 7.3 shows the required responses linked to turbidity data from monitoring.

The objective of the adaptive management response is to utilise turbidity data (supplemented by other forms of data) to identify circumstances which require further investigation, identify whether the observed values are associated with the dredging operation or other factors, if so to confirm whether the operation is complying with the relevant parts of the DDMP and, if necessary, amend the dredging and discharge operations to manage potential sediment-related effects.

Establish whether exceedance is attributable to dredging and discharge activities

If during monitoring elevated turbidity levels are detected above the WQ1 trigger level, further investigation will be undertaken to determine whether the exceedance is associated with the dredge and discharge operation. To determine whether the exceedance is attributable to the works, the following steps would be undertaken:

- Obtain and review dredging operations data
- Review weather conditions
- Review plume observations and/or compare available data with other relevant monitoring data
- Review and assess whether the dredge and discharge works are being conducted in accordance with the DDMP.

The PMCA will be notified of this level of exceedance, and the outcome of the review.

Responsive management measures

Responsive management measures will be implemented where the exceedance is attributed to dredging operations and persists for more than 3 days. These would include measures as appropriate from the following:

- Contact dredging contractor and dredging supervisor, obtain dredge operation data
- Assess whether dredge and discharge are operating in accordance with the DDMP
- Review and assess dredge records and weather conditions
- Where required, amend dredging and discharge activities to comply with the DDMP
- Conduct field monitoring to make additional observations and measurements including at reference site. Use reference site data to review and analyse monitoring location data
- Review dredging schedule, optimise planned down time such as dredge moves, maintenance, progress surveys
- Adjust depth/orientation of outfall.

This level of response will also be triggered if plume prediction validation outcomes indicate substantially different sediment behaviours or impact mechanisms not already assessed.

The PMCA will be notified if this response is triggered, and will be involved in the investigation and response.

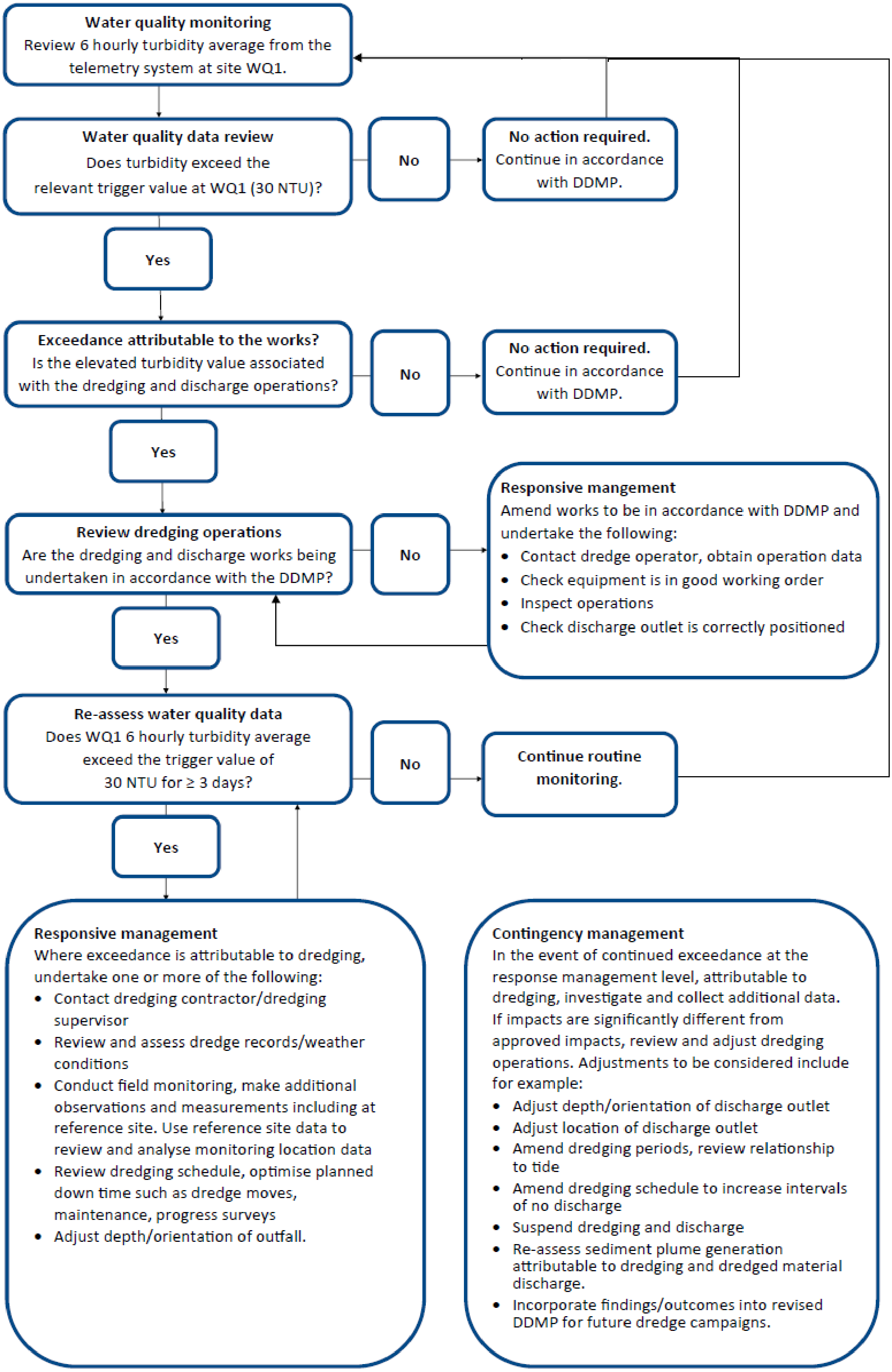

Figure 7.3 Water quality monitoring response flow diagram

Contingency management measures

Contingency management measures will be applied in the event that turbidity does not return to below the WQ1 trigger level following the implementation of responsive management measures and the exceedance scenario which triggered response measures is recurring.

The PMCA and the NT EPA would be notified if this level of management response is triggered.

The cause and issues associated with the exceedance would be investigated and additional data collected to establish whether there is a risk to sensitive receptors in the area of interest (i.e. impact on benthic habitat) which has not already been addressed in the assessment process. The data obtained will also be used to re-examine the model predictions and the predicted zones of impact.

If this indicates a significant difference from the approved impacts, dredging and discharge operations will be reviewed to identify adjustments to reduce the generation of turbidity plumes. Examples of adjustments to be considered include:

- Adjust depth/orientation of discharge outlet
- Adjust location of discharge outlet
- Amend dredging periods, review relationship to tide
- Amend dredging schedule to increase intervals of no discharge
- Suspend dredging and discharge

The additional data obtained, and any lessons learned would also be used to refine dredge plume predictions and the approach for assessment/mangement for future dredging campaigns. The outcome of this would be captured in a further revision of the DDMP.

Backhoe dredging with land disposal

Monitoring locations

Given the limited predicted plume extent during backhoe dredging, field deployed instrumented monitoring locations are not proposed. Monitoring will focus on validating the predicted plume extents during the initial days of backhoe dredging.

Trigger levels

As sediment plumes will predominantly be contained within the basin no quantitative turbidity trigger levels are proposed.

Monitoring plan

The water quality monitoring plan is comprised of the following:

- Plume prediction validation monitoring
- Routine monitoring

Details of the monitoring tasks to be undertaken prior to and during backhoe dredging are described in the following sections.

Plume prediction validation

The plume prediction validation will be done on at least two (2) days with representative tide and dredging conditions during the first eight (8) days of backhoe dredging operations. The monitoring tasks to be undertaken during this period are described in Table 7.8.

Table 7.8 Monitoring tasks during backhoe dredging

Monitoring task	Monitoring approach
Plume prediction validation monitoring	• Vertical profiling at targeted locations and/or on transects within the visible extent of the dredge plume to define the extent and characteristics of the plume. • The location of the plume profiling transects will vary between monitoring periods as the plume shifts. • Monitoring at the vertical profiling sites will be undertaken at approximately 1m intervals surface to bottom. • Parameters measured will include depth, temperature, turbidity and conductivity. • The observable extent of the plume is to be marked using a GPS with a focus of up to 500m from the source.
Satellite imagery analysis	• The plume prediction validation monitoring will include the use of published satellite data which will be interpreted and compared with model predictions and field measurements twice during this period.
Daily visual monitoring (to be undertaken by the Contractor)	The Contractor will be responsible for undertaking daily visual monitoring during backhoe dredging, and will include the following tasks: • Visual monitoring of nearfield sediment plumes from the dredge conducted from a safe, elevated position. • The extent, direction (bearing) and distance of any visible plumes extending from the dredge activity and the disposal location is to be described, for example, by sketching it on a proforma, along with details of the dredge location, tidal phase, wind and weather conditions.

Routine monitoring

Routine monitoring will commence after the plume predication validation phase and will incorporate the following visual monitoring tasks as outlined in Table 7.9.

Table 7.9 Routine monitoring tasks to be undertaken during dredging

Monitoring task	Monitoring approach
Daily visual monitoring (to be undertaken by the Contractor)	The Contractor will be responsible for undertaking daily visual monitoring during dredging, and will include the following tasks: • Visual monitoring of nearfield sediment plumes from the dredge conducted from a safe, elevated position. • The extent, direction (bearing) and distance of any visible plumes extending from the dredge activity and the disposal location is to be described, for example, by sketching it on a proforma, along with details of the dredge location, tidal phase, wind and weather conditions.

An overview of the water quality monitoring plan to be implemented during backhoe dredging is provided in Table 7.10.

Table 7.10 Overview of water quality monitoring plan during backhoe dredging

Monitoring task	Frequency	Parameters	Monitoring Locations
Plume predication validation			
Plume prediction validation monitoring	• On at least two (2) days with representative conditions during the first eight (8) days of dredging operations.	• Depth • Temperature • Turbidity (NTU) • Conductivity	Plume profiling and/or transects will vary due to tidal variation.

Monitoring task	Frequency	Parameters	Monitoring Locations
Satellite imagery analysis	• Twice during backhoe dredging	• Analysis of satellite imagery	Dredge area
Daily visual monitoring (to be undertaken by the Contractor)	• Daily visual monitoring during backhoe dredging	• Plume does not visually extend more than 500 m outside of basin entrance.	Visual monitoring from the dredge conducted from a safe, elevated position.
Routine monitoring			
Daily visual monitoring (to be undertaken by the Contractor)	• Daily visual monitoring during backhoe dredging	• Plume does not visually extend more than 500 m outside of basin entrance.	Visual monitoring from the dredge conducted from a safe, elevated position.

7.3.4 Reporting

Water quality monitoring reporting requirements are outlined in Table 7.11.

Table 7.11 Reporting requirements

Report	Description	Responsibility
Initial Pre-start and Plume investigation report	A report will be provided which details the results of monitoring undertaken during the pre-start and plume investigation phase.	DSC
Monthly Water Quality Progress Reports	Monthly reports will be provided detailing field activities and any observations made.	DSC
Weekly Visual Observation Reports	Weekly reports will be provided which present the results of the daily visual monitoring undertaken by the Contractor.	Contractor
Final Water Quality Monitoring Compliance Report	A final report will be provided which will report monitoring results from pre-dredging, during dredging and post dredging, and review compliance with the criteria.	DSC

7.4 MARINE FAUNA

7.4.1 Potential impacts

Vessel traffic

There is already regular vessel traffic in and around the HMAS *Coonawarra* basin, and this has been the case since it was constructed in the 1980s.

When considering the potential for interaction, and potentially collision, between vessels and marine animals such as turtles, dugongs and dolphins, it is principally fast-moving vessels which represent a higher risk. This is also linked to the number of animals present in the area of operation, and the awareness and vigilance of the personnel operating the vessel.

In the case of the proposed dredging campaign, although turtles and dolphins are likely to occasionally visit the project area, it does not support habitat which is attractive or frequently utilised by these animals. Consequently the number of these animals which occur in the area and the frequency of occurrence is expected to be low. In the case of dugong the likelihood of occurrence may potentially be even lower as there is no grazing habitat in the area where dredge vessels would operate.

Underwater noise

Increased human activity during construction, including changes in underwater noise levels, may affect the behaviour of marine fauna. Sources of underwater noise will principally include:

- Dredging;
- Movement of barges
- Movement of smaller support vessels.

In general underwater noise assessments indicate that activities which are continuous in time such as vessel movements and dredging are typically quieter (and therefore, lower risk) when compared to impulsive noise sources such as pile driving, air guns, and explosives. While these continuous activities may cause a temporary behavioural shift, the overall risk from these activities is low.

While dredging activities are may cause a temporary behavioural shift for those fauna species within the vicinity of HMAS *Coonawarra* (i.e. dolphins, turtles, dugong, and fish), the majority of noise generating activities will be confined to basin where there is a low probability of marine fauna being present. Additionally, while barges and support vessels may generate underwater noise outside of the basin these vessels will be operating within areas that are already subject to vessel related underwater noise.

7.4.2 Management measures

In addition to the monitoring regime to be implemented during dredging, the following management measures outlined in Table 7.12 will be implemented for the duration of works.

Table 7.12 Marine fauna management measures

Activity	Management measures	Responsibility
Vessel and marine fauna interactions	• Visually monitor and record the sightings of marine mammals and turtle species; • Apply observation and response zones; • Ensure dredging operations remain within the boundaries of the defined dredge area; • Enforce speed limits within the immediate dredge area; • All vessels and barges are to adhere to the speed limits within Darwin Harbour; • All project vessels are to keep careful forward lookout for turtles and marine mammals that may be in the path to minimise risk of collision; • Provide operator awareness training; and • When a CSD is in operation, rotation of the dredge cutter head will only start when it is positioned near the seabed, and rotation will be ceased before the cutter is raised through the water column.	Dredging Contractor
Underwater noise	• All equipment should be maintained and operated in an efficient manner, and in accordance with manufacturer’s specifications.	Dredging Contractor
Introduction of marine pests	• Ensure that all vessels and floating plant arrive with non-fouled hulls and have undertaken management and mitigation measures in accordance with the Commonwealth *Biosecurity Act* 2015. • Ensure ballast and bilge water is disposed of in accordance with relevant guidelines and legislation.	Dredging Contractor

7.4.3 Marine fauna monitoring program

Performance criteria

- No injuries or deaths of marine megafauna associated with dredging works.

Monitoring plan

The marine fauna monitoring plan and responses to any sightings of marine megafauna within close proximity to the dredge operation are outlined in Table 7.13.

During active dredging approach distances (trigger values) for marine megafauna are:

- Observation Zone - < 100 m from dredge; and
- Response Zone < 50 m from dredge.

Table 7.13 Marine fauna monitoring and management response

Monitoring Regime	Monitoring plan and response
Marine fauna observations (to be undertaken by the Contractor)	• Marine fauna observations will be conducted by a specifically nominated crew member from the dredging team during operational dredging hours; • If marine megafauna are identified within the observation zone (100 m of the dredge), the dredge or vessel operator is to be informed; and • If the observed marine megafauna continues to proceed closer and is observed within the response zone (less than 50 m from the dredging), dredging is to temporarily cease until the observed marine megafauna is greater than 100 m from the dredge activity.

Reporting

Marine fauna monitoring reporting requirements are outlined in Table 7.14.

Table 7.14 Reporting requirements

Report	Description	Responsibility
Weekly Progress Reports	Weekly reports will be provided detailing field activities and any observations made.	Contractor
Incident Reports	Any vessel interaction incidents and protected species injury or mortality will be reported to the NT EPA within 24 hours of the incident occurring.	Contractor
Final Monitoring Compliance Report	A final report will be provided summarising marine mammal observations and associated management measures taken.	Contractor

7.5 NOISE

7.5.1 Potential impacts

The proposed dredging and dredged material management activities will generate noise.
The nearest noise sensitive receptors are the residences on Steele Street (within the Larrakeyah Barracks) which are located approximately 190 m from the nearest point of the works with most of the dredging works in excess of 500 m from these residences. The nearest noise sensitive receptors external to the base are located on Larrakeyah Terrace and are approximately 350 m away from the nearest point of the works with the majority of dredging occurring in excess of 500 m from these receptors.

Noise generating activities are expected to include CSD operation, attendant work boats, the backhoe dredge and barge movement.

CSD operations are proposed to occur during daylight hours six days a week, apart from normal stoppages for repositioning equipment and maintenance. The contractor will also need to make provision for navy vessels to enter and leave the basin and manoeuvre on and off wharves which will require periods of no dredging.

Noise from the continuous operation of the CSD is not likely to be loud enough to cause nuisance at noise sensitive locations. This is based experience from previous dredge campaigns, during which there was no reported noise nuisance, and the fact that the operation of the CSD and support vessels will generate noise similar to existing shipping and vessels movements conducted within and surrounding HMAS *Coonawarra* and will be limited to normal work hours. In addition, there is an escarpment approximately 10-15 m high which separates both the base residents and non-base residents from the basin and the location of dredging noise sources. This will contribute to noise attenuation and reduce the potential for noise nuisance.

Backhoe dredging of hard material and the subsequent filling of barges is expected to be a louder process but also unlikely to result in noise nuisance.

Noise emissions will vary in volume and duration and may overlap with different sources resulting in a cumulative impact depending on the location of the receptor (e.g. residences), prevailing weather conditions (i.e. higher during calm conditions and timing). There is some potential for base residents and site users to be affected by noise during dredging activities, and the potential for nuisance associated with these temporary impacts will be managed via the implementation of this DDMP.

7.5.2 Management measures

Performance criteria

No noise complaints associated with the dredging activities.

Management measures

Noise management measures will be implemented for the duration of dredging operations as outlined in Table 7.15.

Table 7.15 Noise management measures

Activity	Management measures	Responsibility
Dredging	• Inform the community of date and duration of dredging works; • Limit works to nominated work hours; • Ensure all machinery is well maintained and effectively muffled as per the manufacturer’s specification; • Provide mechanism for feedback/complaint. Details to be recorded shall include date, time and duration of noise nuisance; and • Should a noise complaint be received, the source of the noise should be identified, and maintenance records checked to ensure that all machinery has been maintained. Any equipment found to be noncompliant with noise standards should be fitted with improved noise attenuation (or other appropriate maintenance works) and should not be used on site until compliance is achieved.	Dredge Contractor

7.6 WASTE

7.6.1 Potential impacts

A variety of wastes will be generated during dredging and dredged material disposal. General rubbish (refuse generated from the crew), sewage waste (including both black and grey waters) and hazardous wastes including diesel fuel, hydraulic oils, engine oils, greases and lubricants will be generated during dredging and dredged material disposal operations.

Potential mechanisms of release of waste materials which may pose a potential risk to the marine environment include:

- Incorrect storage and handling of waste materials;
- Loss of waste materials to the waters of Darwin Harbour;
- Diesel spills during refuelling;
- Hydraulic oil spills during equipment failure (e.g. burst hydraulic hose);
- Release of oily bilge waters; and
- Contaminated deck wash.

As per current practices at the base, there will be no discharge or pump out from dredging vessels to the marine environment.

7.6.2 Management measures

Performance criteria

- No litter present within the vicinity of the dredge area; and
- No loss of waste or stored hazardous chemicals/fuel or similar products to the marine environment.

Management measures

Waste management measures will be implemented for the duration of dredging operations as outlined in Table 7.16.

Table 7.16 Waste management measures

Activity	Management measures	Responsibility
Waste generated during dredging and the potential for spills/leaks	• Ensure all loads of waste materials transported and/or stored at the site are covered; • Place all domestic garbage and construction waste in lidded bins. No open or ground garbage mounds are permitted; • Collect garbage regularly and transport it from the site for disposal at an approved location; • Collect any waste oil from machinery maintenance and transport it to a designated disposal or recycling site; • Ensure all oils, fuels and chemicals for use at the site are located within bunded areas with a storage capacity 110% of the storage vessel; • Store potentially hazardous chemicals in accordance with the manufacturer's specifications; • Contain all spills and clean up immediately; and • Keep a spill containment kit on site at all times and ensure site staff are appropriately trained to use it.	Dredging Contractor

7.7 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMS

Details of the monitoring requirements, including frequency, trigger values, response to exceedance or non-compliances and responsibility, are provided in Table 7.17. All instruments, equipment and measuring devices used for measuring or monitoring must be calibrated, and appropriately operated and maintained.

Table 7.17 Monitoring requirements

Issue	Monitoring	Frequency/Timing	Performance criteria	Response to non-compliance	Responsibility
Pre-dredging environmental monitoring					
Water quality	Infield water quality monitoring (in accordance with Section 7.3.3).	Refer Table 7.7.	Not Applicable.	Not Applicable.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
Benthic Habitat (Fannie Bay)	Spot checks to determine the presence of seagrass undertaken via direct observation/drop camera/grab sampling.	Refer Table 7.7.	Not Applicable.	Not Applicable.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
Plume prediction validation monitoring					
Water quality	Plume characterisation/validation monitoring.	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	Plume behaviour and extent consistent with plume model predictions.	Review to determine if measured verse modelled plume represents any change to environmental risk and whether any adjustments to monitoring regime are required. Utilise data in assessment of future campaigns.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
	Infield water quality monitoring (in accordance with Section 7.3.3).	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	6 hourly average turbidity results reported for WQ1 is at or below 30 NTU.	As per Figure 7.2.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
	Collection of water samples for laboratory analysis of suspended sediment samples to confirm the relationship with field turbidity.	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	Not Applicable.	Not Applicable.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
	Telemetry water quality monitoring.	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	The 6 hourly average turbidity at WQ 1 is at or below 30 NTU during both the dry and wet season dredging.	As per Figure 7.2.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.

Issue	Monitoring	Frequency/Timing	Performance criteria	Response to non-compliance	Responsibility
Water Quality (continued)	Satellite imagery analysis	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	Modelled predictions and field monitoring results are comparable with satellite imagery analysis.	Compare with other monitoring data sources, review dredging operational data, review weather and metocean data, review model for equivalent scenario, investigate on next scheduled field monitoring visit.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
	Visual monitoring of dredge plant.	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	Dredge plant is maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Identify issue and repair accordingly.	Dredging Contractor.
	Visual monitoring of dredge location.	Refer Table 7.7 (CSD) and Table 7.10 (Backhoe).	All dredging remains within the defined dredge area.	Cease dredging and return to dredge area.	Dredging Contractor.
	Visual monitoring of discharge pipeline.	Refer Table 7.7.	Discharge point is at or within 50 m of the specified location and depth.	Cease dredging and move pipeline to correct location.	Dredging Contractor.
		Refer Table 7.7.	No leaks or breakages.	Cease dredging and repair pipeline.	Dredging Contractor.
	Visual monitoring of CSD dredge plume (in accordance with Section 7.3.3).	Refer Table 7.7.	Plume does not visually extend more than 500 m outside of basin entrance.	Notify PMCA. Confirm dredge is operating in accordance with the DDMP and that dredge plant is maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Dredging Contractor.
	Visual monitoring of Backhoe dredge plume.	Refer Table 7.10.	Plume does not visually extend more than 500 m outside of basin entrance.	Notify PMCA. Confirm dredge is operating in accordance with the DDMP and that dredge plant is maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Dredging Contractor.

Issue	Monitoring	Frequency/Timing	Performance criteria	Response to non-compliance	Responsibility
Routine Monitoring					
Water Quality	Infield water quality monitoring (in accordance with Section 7.3.3).	Refer Table 7.7.	Turbidity results reported for WQ1 are at or below 30 NTU.	As per Figure 7.2.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
	Telemetry water quality monitoring.	Refer Table 7.7.	The 6 hourly average turbidity at WQ 1 is at or below 30 NTU.	As per Figure 7.2.	DSC – Environmental Monitoring Specialist/ Environmental Advisor.
	Visual monitoring of dredge plant.	Refer Table 7.7.	Dredge plant is maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Identify issue and repair accordingly.	Dredging Contractor.
	Visual monitoring of dredge location.	Refer Table 7.7.	All dredging remains within the defined dredge area.	Cease dredging and return to dredge area.	Dredging Contractor.
	Visual monitoring of discharge pipeline.	Refer Table 7.7.	Discharge point is at or within 50 m of the specified location.	Cease dredging and move pipeline to correct location.	Dredging Contractor.
		Refer Table 7.7.	No leaks or breakages.	Cease dredging and repair pipeline.	Dredging Contractor.
	Visual monitoring of CSD dredge plume (in accordance with Section 7.3.3).	Refer Table 7.7.	Plume does not visually extend more than 500 m outside of basin entrance.	Notify PMCA. Confirm dredge is operating in accordance with the DDMP and that dredge plant is maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Dredging Contractor.
	Visual monitoring of Backhoe dredge plume.	Refer Table 7.10.	Plume does not visually extend more than 500 m outside of basin entrance.	Notify PMCA. Confirm dredge is operating in accordance with the DDMP and that dredge plant is maintained and operated in an efficient manner, and in accordance with manufacturer's specifications.	Dredging Contractor.

Issue	Monitoring	Frequency/Timing	Performance criteria	Response to non-compliance	Responsibility
For Duration of Dredging					
Marine Fauna	Specific checks by nominated crew member and all crew members keep watch.	Daily.	No dredging conducted while marine megafauna species are observed to be within the response zone (50 m of the dredge operation).	Cease dredging if marine megafauna sighted within 50 m of dredge. Re-start dredging once megafauna has moved over 100 m from dredge (outside of the observation zone).	Dredging Contractor.
	Monitor any injuries or deaths to marine fauna as a result of the dredging operations.	Weekly reporting (with incidents reported within 24 hours of occurrence).	No injuries or deaths of marine megafauna species at the site attributable to the dredge operation.	Report incident and review operation to ensure vessels are operating in accordance with the DDMP.	Dredging Contractor.
Noise management	Monitor number of complaints. If necessary, noise monitored to determine the level of impact.	Throughout dredging.	No noise complaints.	Should a noise complaint be received, the source of the noise should be identified, and maintenance records checked to ensure that all machinery has been maintained.	Dredging Contractor.
Waste management	Visual inspection of vessel checks and work location for litter, debris or wastes not properly handled.	Weekly.	No litter and no wastes uncontained.	Remove litter and waste from marine and environment and ensure waste is stored appropriately.	Dredging Contractor.
	Visual checks by all crew members to ensure all hazardous waste is stored correctly and no spills have occurred.	Daily during all dredging.	No inappropriate storage or disposal of hazardous wastes.	Store and dispose of hazardous waste appropriately.	Dredging Contractor.
	Visual inspections of fuel dispensing equipment and surrounding waters (where applicable).	During and after fuel transfer.	No spills or leaks during fuel transfer.	Contain all spills and clean up immediately.	Dredging Contractor.

8 Reporting

8.1 ROUTINE REPORTING

8.1.1 Daily reporting

Brief daily reports will be provided by the Contractor to the PMCA and will include:

- A summary of the dredging completed on that day and status of dredging operations;
- Information relating to any exceedances detected through monitoring;
- Proposed schedule for dealing with exceedances reported and next steps to be followed;
- Records of sightings of protected marine species; and
- Daily dredge logs.

8.1.2 Weekly monitoring report

Each week during dredging and disposal activities, a weekly summary report of monitoring data will be submitted by the Contractor to the PMCA. The report will include:

- Summary of daily data reports;
- Discussion of any trigger level exceedances;
- Corrective actions taken to address exceedances;
- Details of any injuries to, or mortalities of, turtles, dugongs or dolphins as a result of dredging activities; and
- A summary of environmentally significant equipment failures or events and an outline of corrective actions taken, or proposed, to reduce environmental harm.

8.1.3 Dredge operation records and reporting

The Contractor will maintain daily records of areas dredged and the volumes of material disposed, and GPS track logs of dredge and barge locations/works.

These records will be provided to the PMCA weekly, and the findings from hydrographic surveys confirming dredge volumes and locations will be included in the Contractor report to the PMCA on completion of dredging and disposal activities.

Copies of daily environmental inspection checklists and other relevant environmental records will be provided by the Contractor to the PMCA. All records will be provided in a format that allows auditing by environmental regulators if required.

8.1.4 End of dredge phase reporting

Within one month of the conclusion of dredging and disposal activities, the Contractor will submit a monitoring report to the PMCA which includes the outcomes of all their monitoring activities, exceedances, management actions and any relevant trend analysis and interpretation of analytical data collected in accordance with environmental conditions.

8.1.5 Compliance reporting

Defence hold the necessary approvals for the dredging and disposal activities. As the approval holder, the PMCA, on behalf of Defence, will submit any reports, data and information in accordance with the timeframes required under Environmental Approval EP2022/015-001 to the NT EPA.

During dredging, the PMCA will notify NT EPA of any non-compliance with approval conditions.

8.2 ENVIRONMENTAL INCIDENT NOTIFICATION AND REPORTING

In the event of the following environmental incidents, the NT EPA will be notified within 24 hours of the incident occurring. Examples of incidents to be reported include vessel interactions with protected marine species, and spills of hazardous substances such as fuels, oils or hydraulic fluid.

If the incident is a notifiable incident under the *Waste Management and Pollution Control Act*, then NT EPA will also be notified within 24 hours.

All incidents will be investigated and recorded on a Contractor 'Incident Form', 'Environmental Incident Details Dorm' or similar in accordance with the Contractor's accident investigation and reporting procedures. Preventative and corrective actions will be established, and these will be recorded on the Contractor's 'Non-conformance and Corrective Action Register', and the progress tracked for completion.

8.3 COMPLAINTS REPORTING

In the event of a complaint received as a result of dredging and dredge material disposal activities, they will be entered and tracked using the Contractor's incident management system. Details to be recorded include:

- Date, time and method of complaint;
- Description of complaint;
- Complainant details;
- Details of person who received the complaint; and
- Corrective action taken to prevent a recurrence.

Corrective action in response to valid complaints is to occur within 48 hours following receipt of the complaint. Records will be made available to relevant parties and authorities upon request, taking into account any privacy issues of the complainant as appropriate.

8.4 EMERGENCY RESPONSE PLAN

The contractor will be responsible for preparing an emergency response plan for all dredging works. This procedure will take into account operational requirements of the Base and will be reviewed by Defence to ensure consistency with internal procedures and protocols for emergency response planning.

Site specific inductions and training will be undertaken by the dredging contractor. Following an emergency incident, an investigation will be conducted, and corrective actions identified and addressed in accordance with the procedures outlined in this DDMP.

9 References

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Appendix A:
Dredge Plume Modelling Results

Dredge Plume Modelling Results

TIMESERIES OUTPUTS FOR REPRESENTATIVE REPORTING LOCATIONS

Suspended sediment concentration – Dry and Wet Season

To assess the temporal variation of the sediment plumes, times series results from the full simulated period for the CSD and nearshore discharge has been extracted at six representative reporting locations as shown in Figure A1. The dry season timeseries outputs shown in Figures A2 to A7 represent the tide only scenario including a representative dry season background (3 mg/L).

The wet season timeseries outputs shown in Figures A8 to A13 represent the tide only scenario including a representative wet season background (5 mg/L).

Discussion of timeseries outputs

Reporting locations TS01 and TS02 to the north of the discharge location are directly influenced by the predicted sediment plumes. The model predictions at TS01, show short term elevated suspended sediment concentrations of up to 90 mg/L with the highest concentrations all predicted within the neap tidal phase where tidal movement is at its lowest (Figure A2). As expected, the concentrations predicated at the TS02 site are less than at TS01 as a result of increasing plume dispersion with distance from the discharge location.

Sediment concentrations at both TS01 and TS02 are predicted to be less than 20 mg/L for approximately 90% of the time. Due to tidal reversal, and the daily shutdown period of the dredge, recovery to baseline is shown to occur within almost every 24 hour period regardless of the concentrations experienced during that day. At TS01, where the highest concentrations are predicted, the elevated suspended sediment is only predicted to be above 10 mg/L for 12 hrs before returning to near baseline conditions. The duration of 'high peak' periods are typically short and range between 2 to 4 hours.

The supplementary modelling results again reiterate that elevated sediment plume concentrations are not predicted to encroach into Fannie Bay, where potential seagrass habitat has been reported. The very low suspended sediment time series results for reporting locations TS03 and TS04 within Fannie Bay support this (Figures A4 and A5).

The results from TS03 show that the dredging and discharge related activities have very little effect on suspended sediment concentrations at this location, with less than approximately 7 mg/L (dry season) predicted throughout the dredging campaign with recovery to baseline occurring every 24 hours (in a number of instances during daylight hours).The highest concentrations again occur within the neap tidal phases where mixing and water movement is at its lowest. Location TS04 which is located in the northern section of Fannie Bay is outside the 90th percentile predicted plume area with no elevated turbidity levels as a result of dredging predicted (Figure A5).

Time series reporting locations TS05 and TS06 are located within the predicted plume to the south of the discharge location. As with the reporting locations to the north, both TS05 and TS06 show elevated suspended sediment concentrations (Figures A6, A7, A12 and A13). Turbidity concentrations between 10 mg/L and 20 mg/L commonly occur at TS5 with the highest concentrations at this location ranging between 30 mg/L and 40 mg/L. Concentrations at TS6 are slightly higher than those reported at TS05 and more commonly range between 20 mg/L and 40 mg/L. Peak concentrations at TS05 are predicted to occur within the neap tidal phase where tidal movement is at its lowest, while predicted concentrations at TS06 tend to follow the tidal cycle and are more pronounced during spring tides.

The difference in predictions between TS05 and TS06 is a result of the more complex current patterns in this area (e.g. a local gyre forms on the flood tide). As TS05 is located slightly further inshore than TS6 it experiences different current and tidal movements.

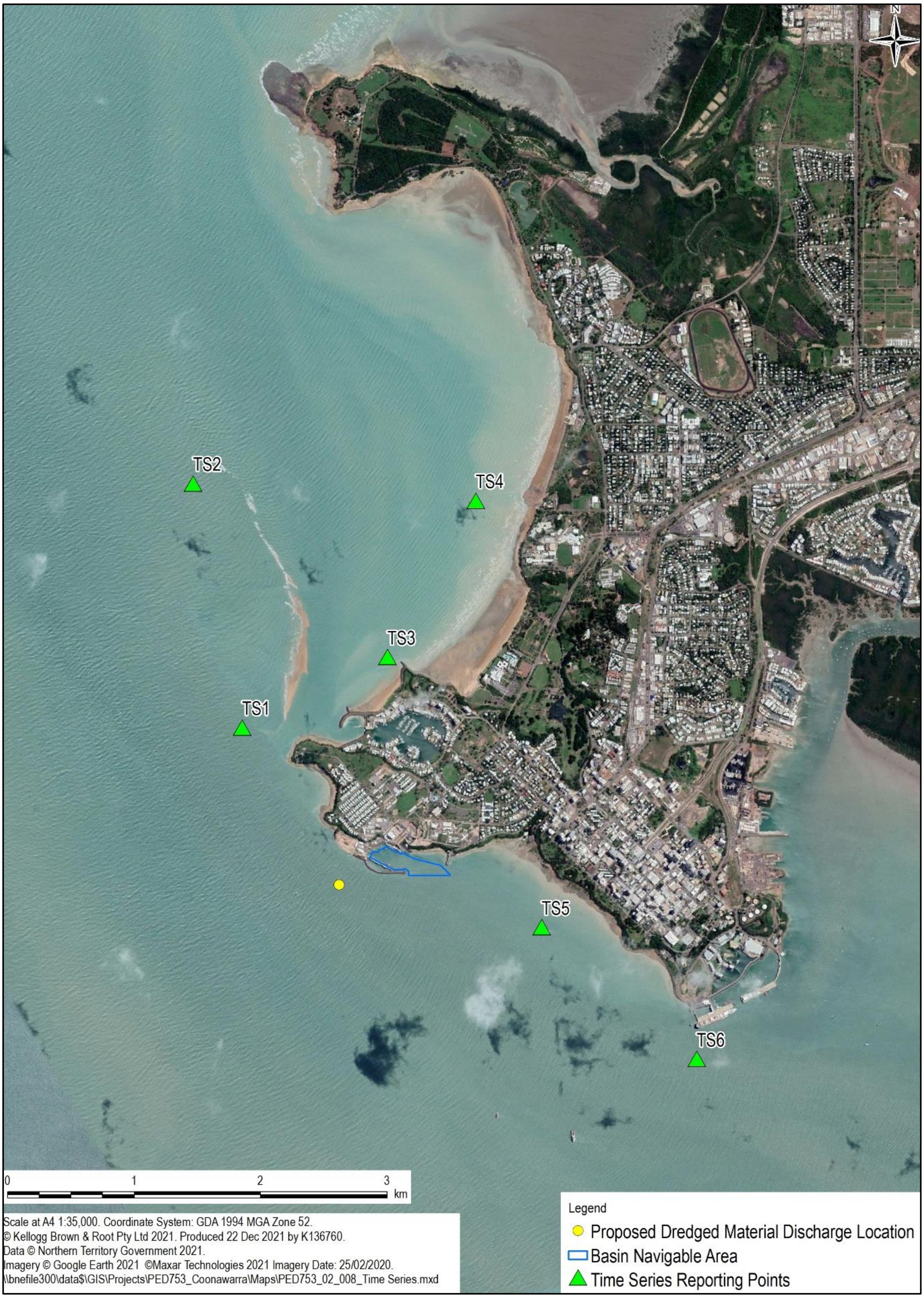

Figure A1 **Time series modelled data reporting locations**

DRY SEASON TIMESERIES OUTPUTS

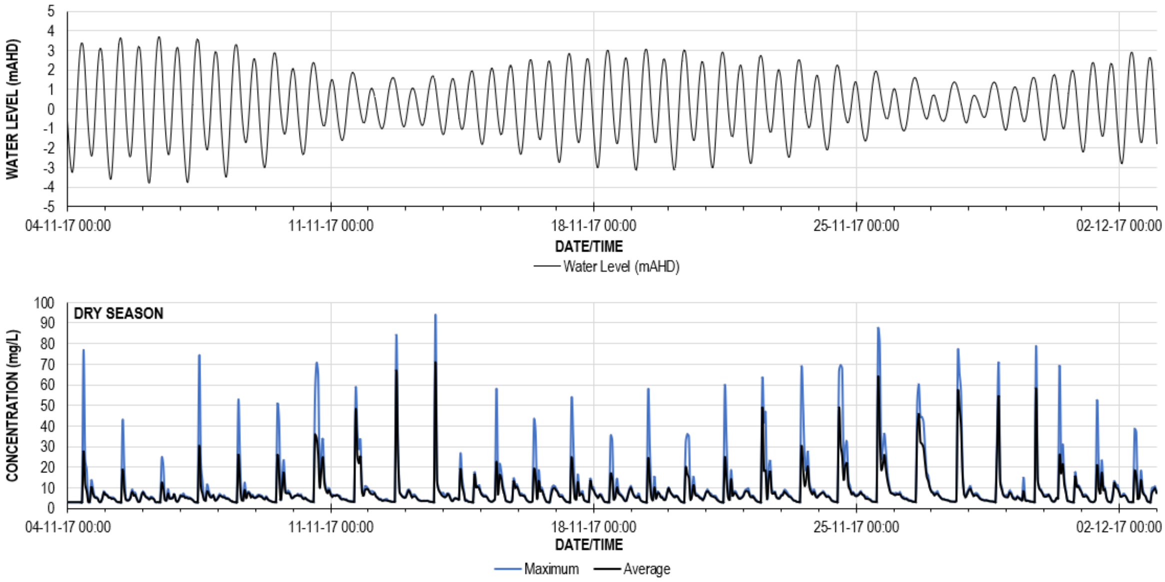

Figure A2 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS01**

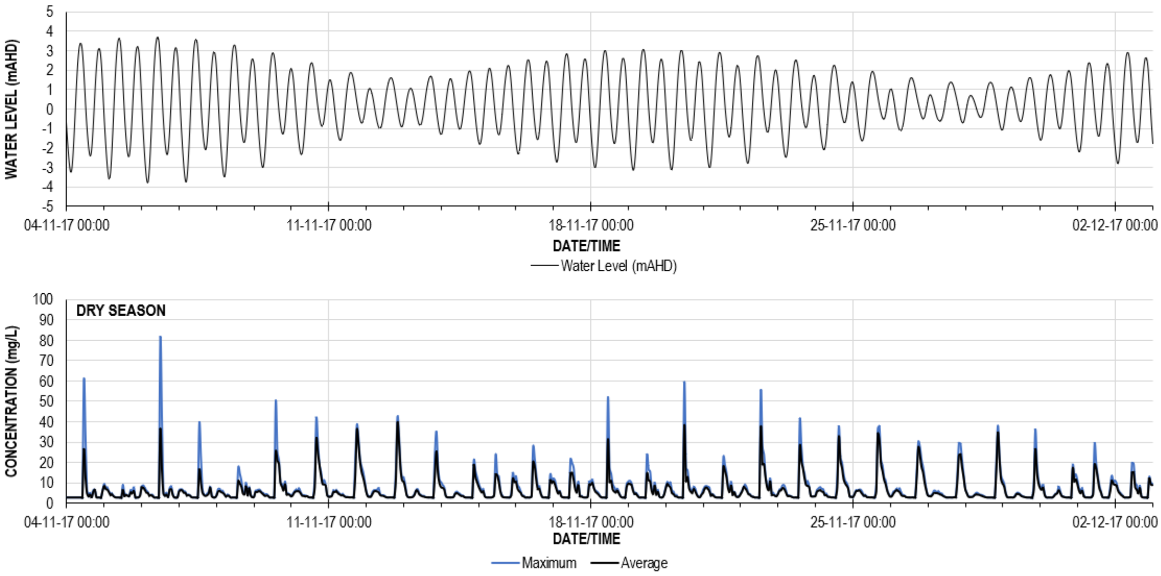

Figure A3 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS02**

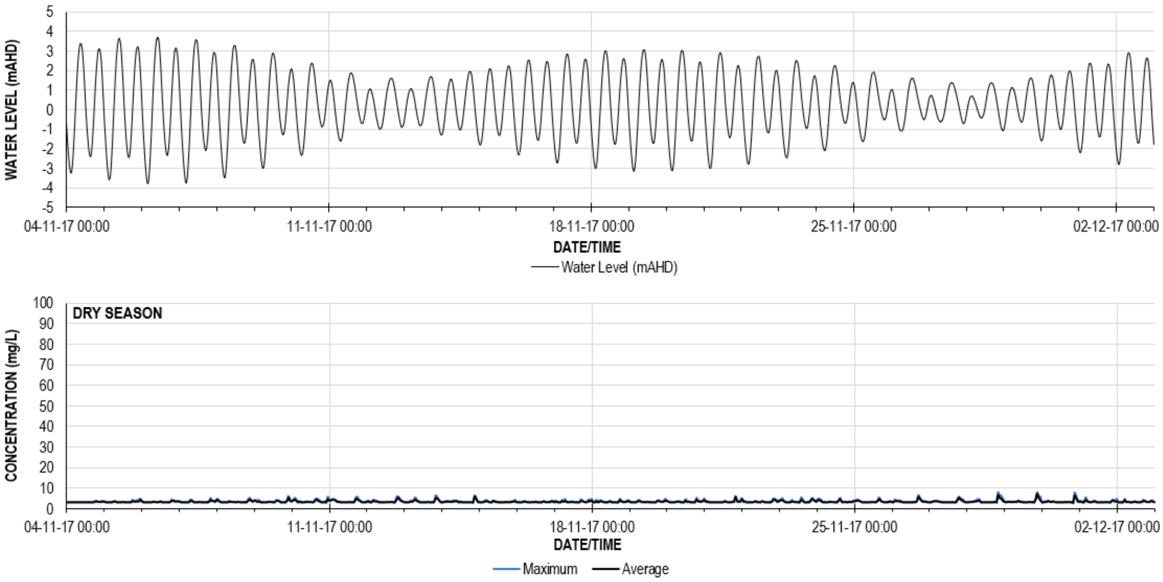

Figure A4 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS03**

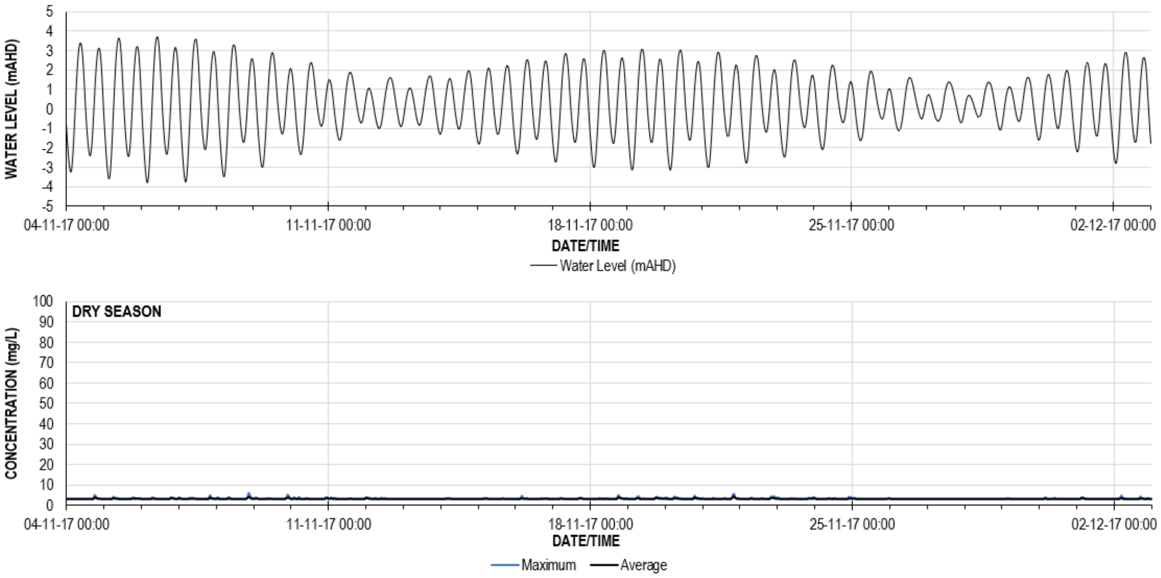

Figure A5 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS04**

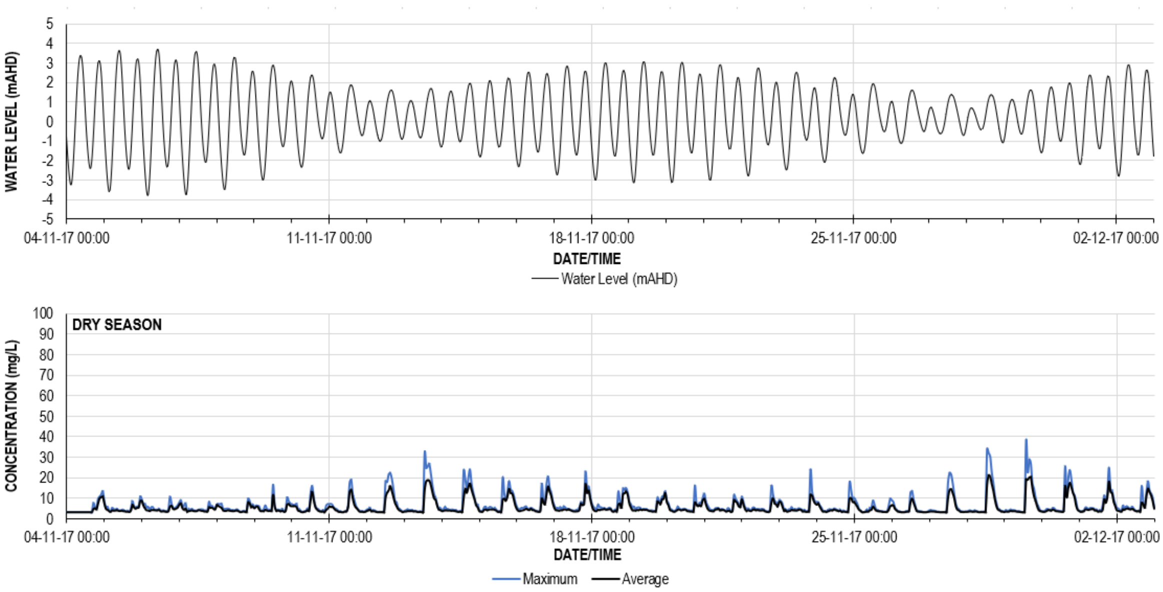

Figure A6 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS05**

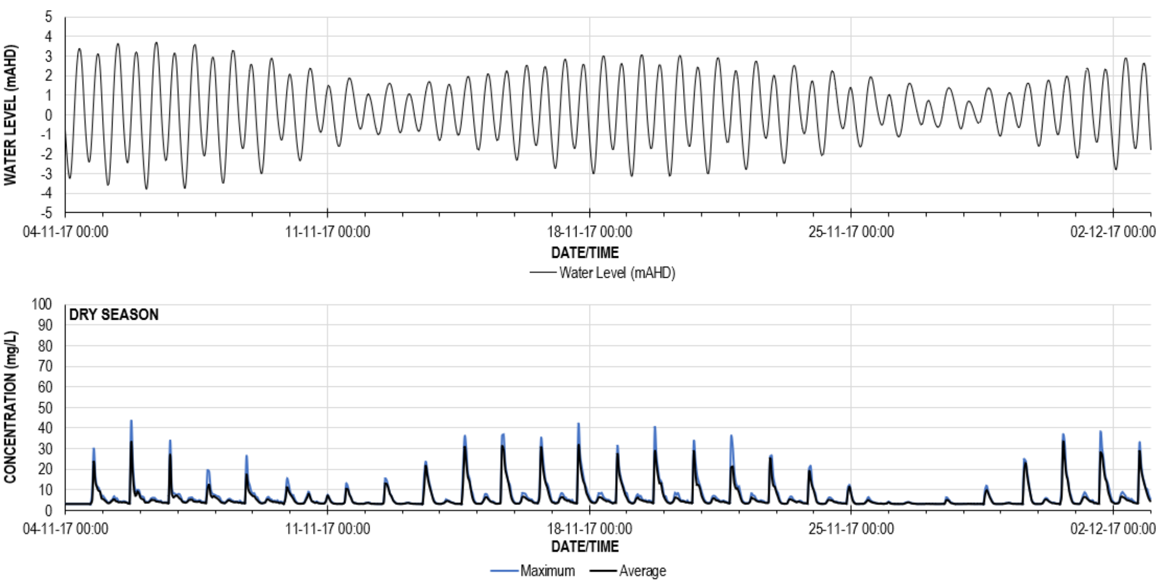

Figure A7 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location TS06**

WET SEASON TIMESERIES OUTPUTS

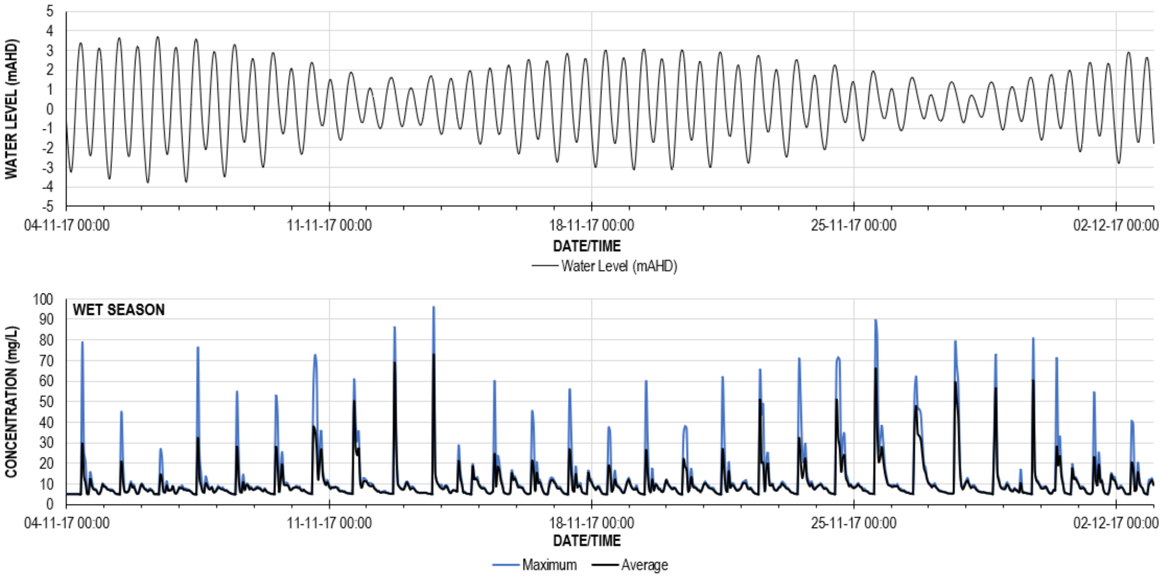

Figure A8 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS01

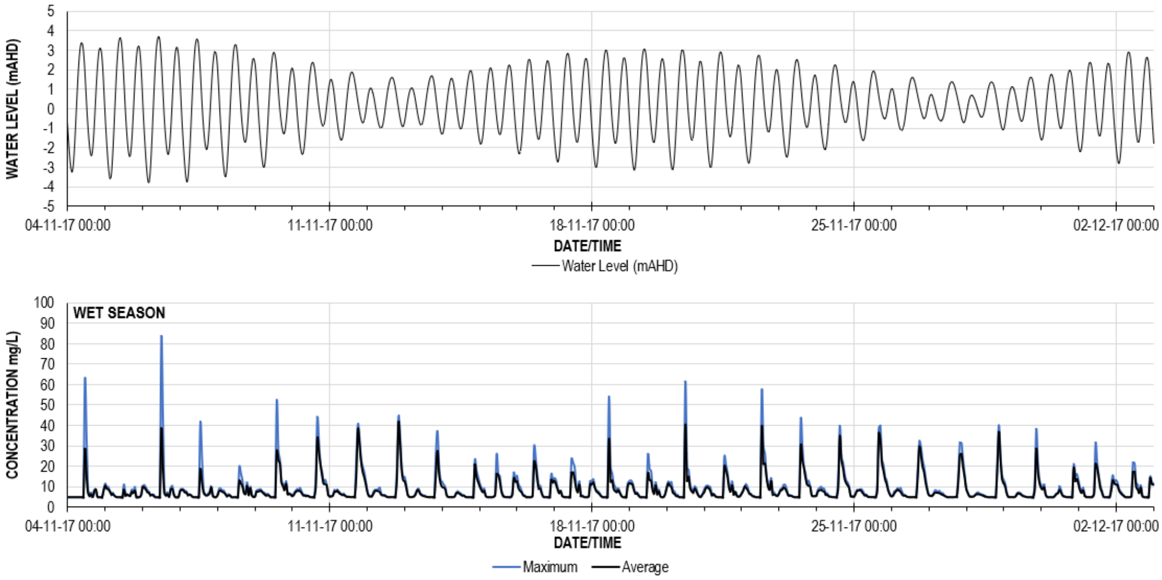

Figure A9 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS02

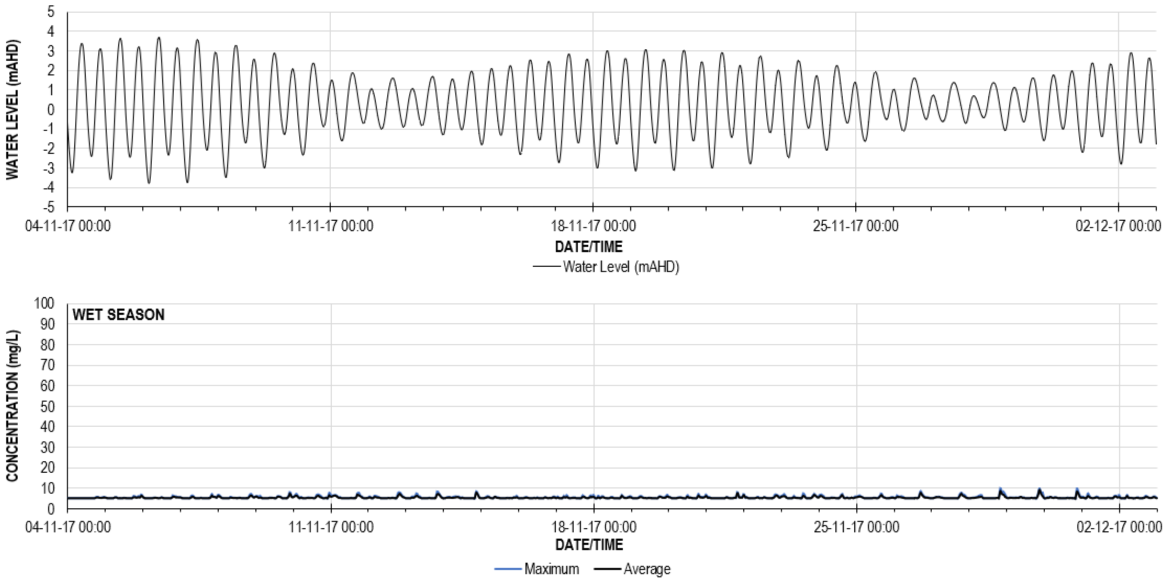

Figure A10 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS03

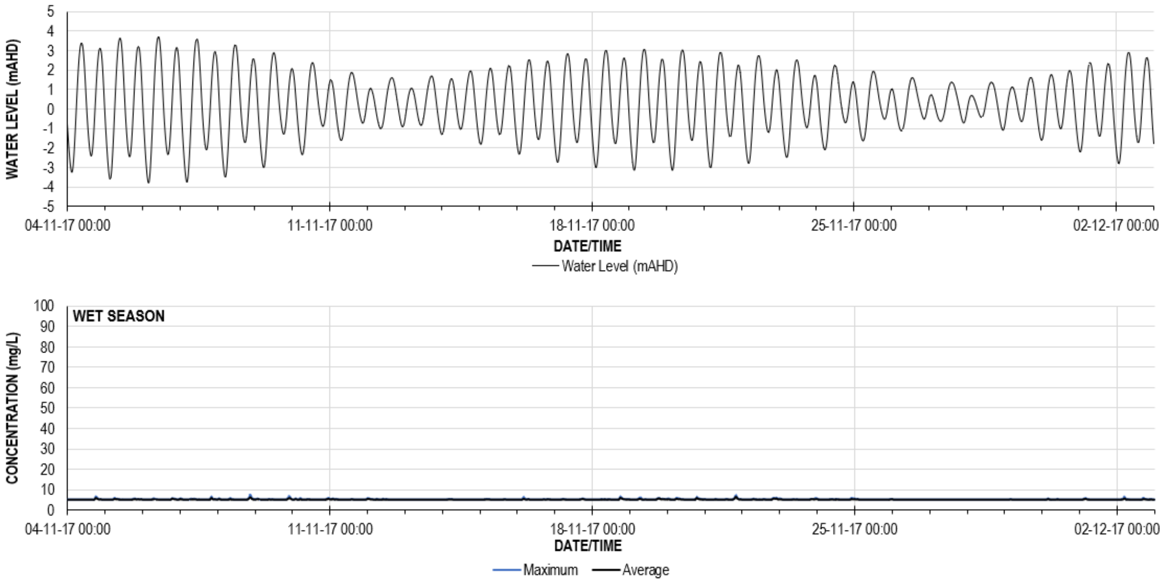

Figure A11 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS04

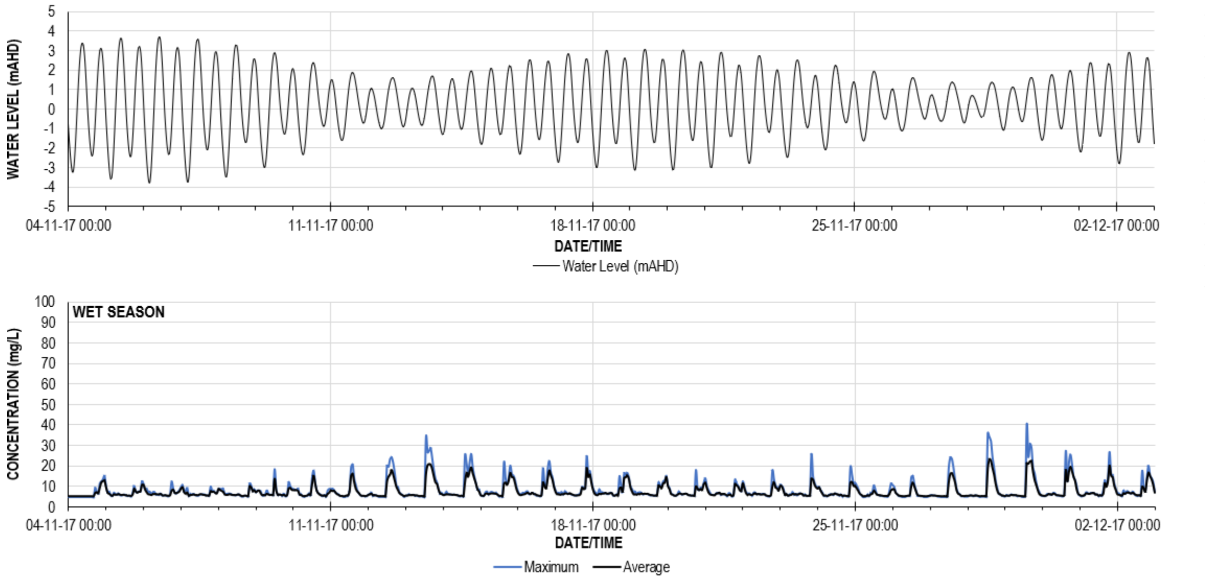

Figure A12 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS05

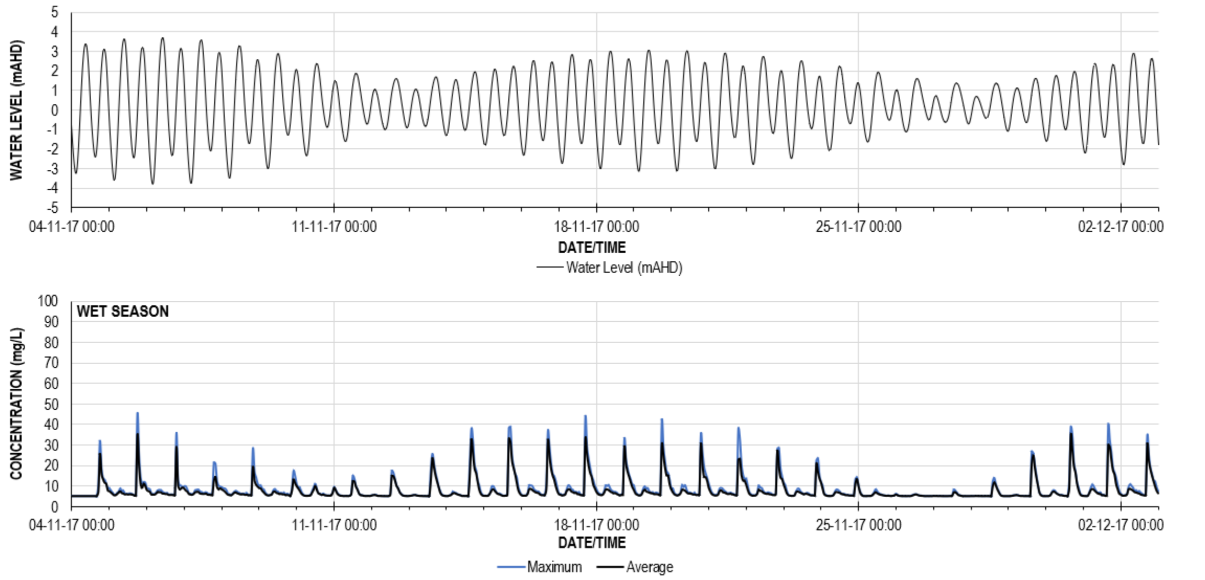

Figure A13 Wet season CSD dredging with nearshore discharge – suspended sediment concentrations including background (5mg/L) Timeseries output location TS06

TIMESERIES OUTPUTS FOR MONITORING LOCATIONS WQ1, WQ3 AND WQ4

Additional timeseries outputs for monitoring locations WQ1, WQ3 and WQ4, were also reviewed to understand sediment concentrations within the vicinity of Bennett Shoal, to the west of the offshore sand bank and in the entrance to Fannie Bay (Figure A14). The dry season timeseries outputs shown in Figures A15 to A17 represent the tide only scenario plus dry season background (3 mg/L).

The time series results for WQ1 are consistent with those predicted for TS03. Very low suspended sediment concentrations are predicted to occur (predominantly less than approximately 5 mg/L) because the plume is not anticipated to encroach into Fannie Bay (Figure A15).

WQ4 is within close proximity to TS01 and shows similar elevated suspended sediment concentrations with peaks of up to 90 mg/L, although the magnitude of concentrations predicted is somewhat less pronounced than those reported at TS01 (Figure A16). The highest concentrations are more closely related to the neap tidal phase where tidal movement is at its lowest than those predicted for TS01.

WQ3 is associated with Bennett Shoal (Figure A17). Time series data at this locations shows elevated suspended sediment concentrations which typically occur during neap tide. Concentrations typically range between 10 mg/L and 20 mg/L with individual short term peak concentrations ranging between 60 mg/L and 160 mg/L.

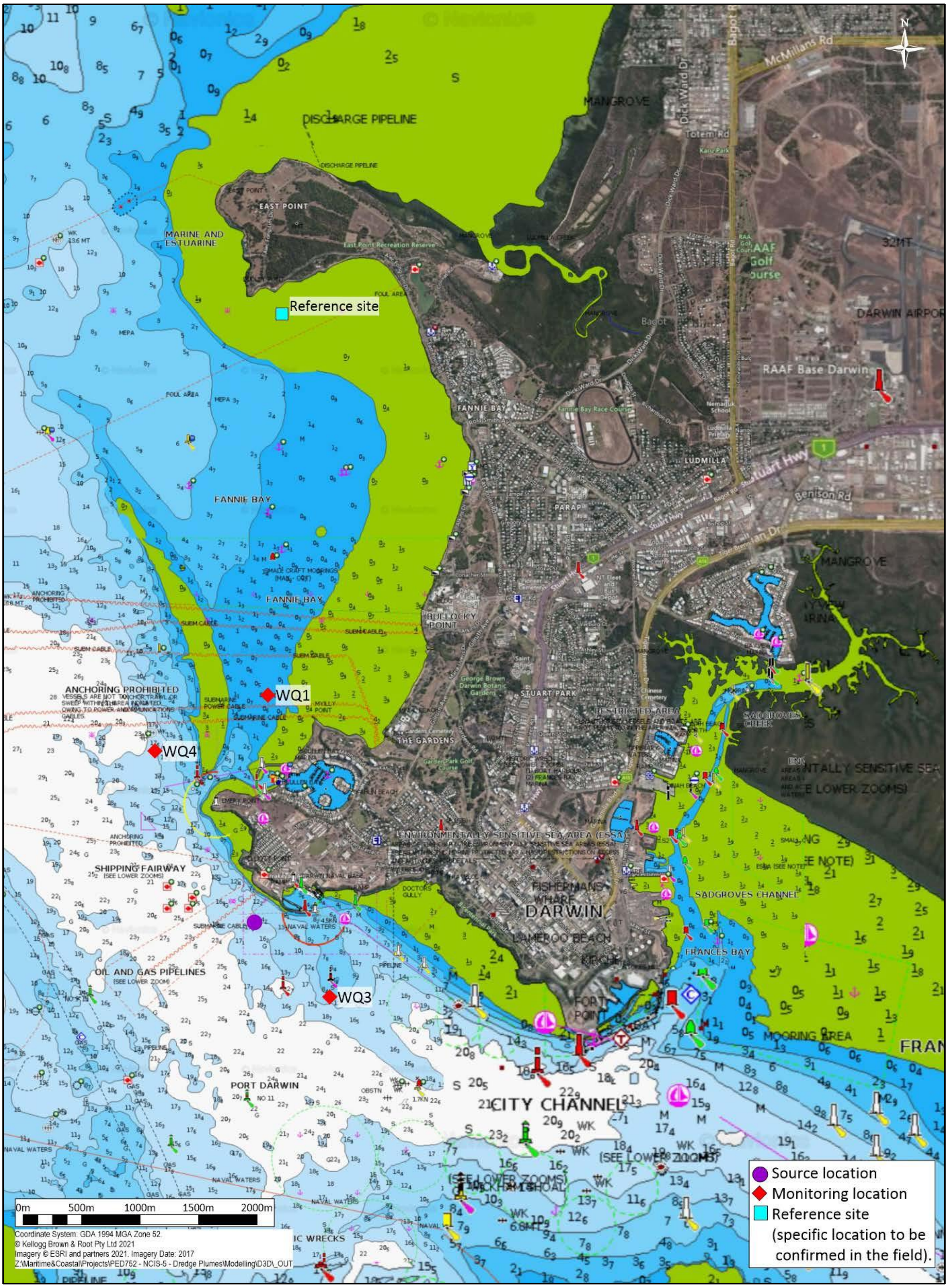

Figure A14 Water quality monitoring locations during dredging (WQ1, WQ3 and WQ4)

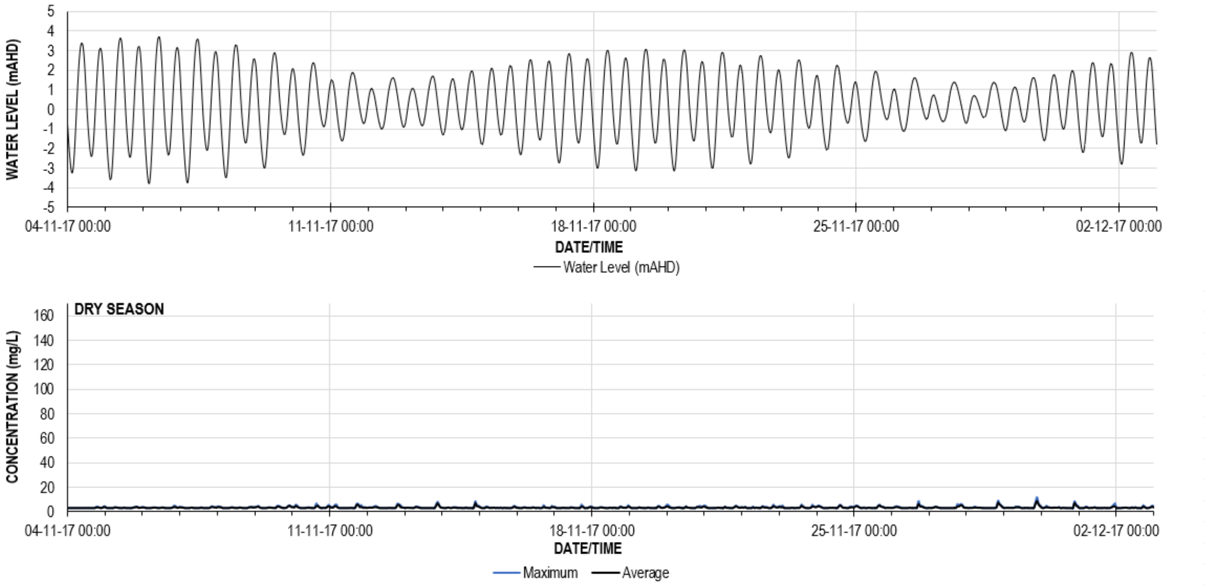

Figure A15 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location WQ1**

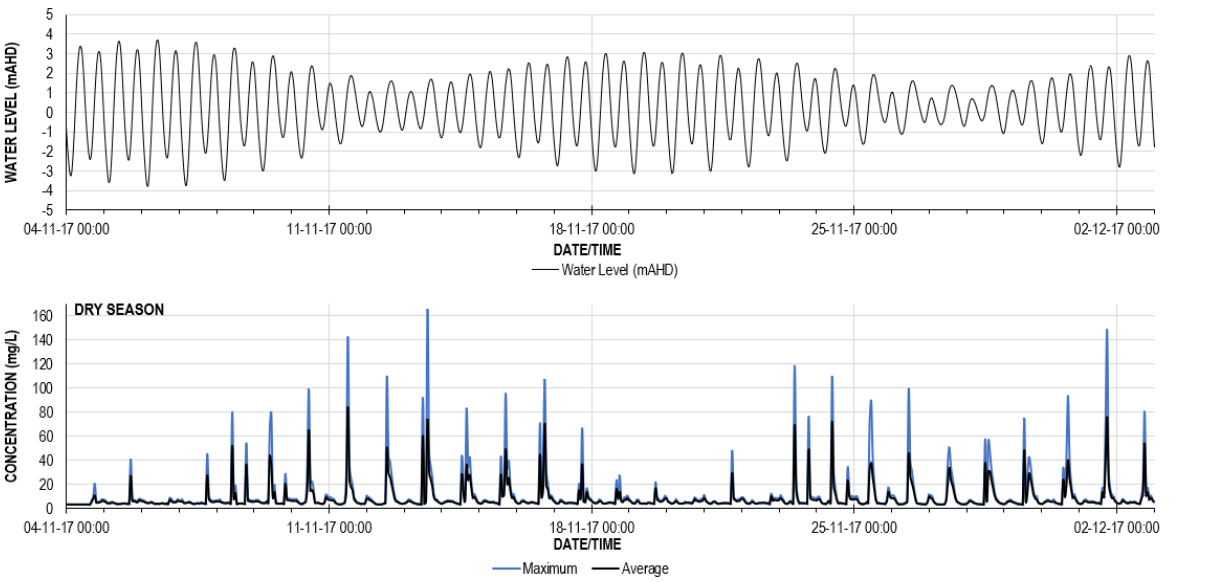

Figure A16 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location WQ3**

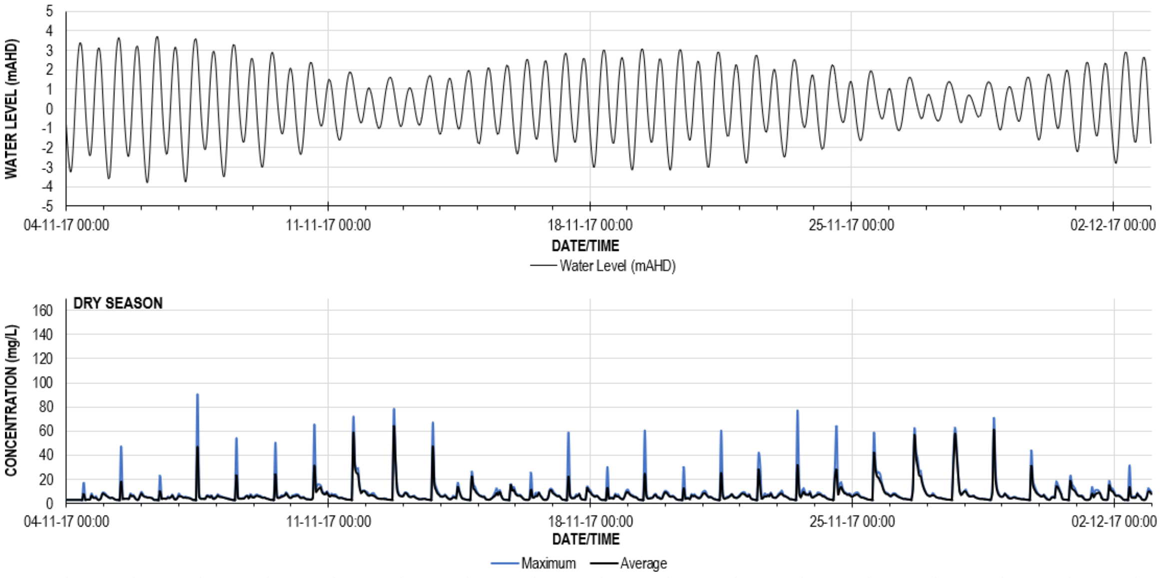

Figure A17 **Dry season CSD dredging with nearshore discharge – suspended sediment concentrations including background (3mg/L) Timeseries output location WQ4**