CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX AO: Marine Ecology Impact Assessment Report (2017)

A part of BMT in Energy and Environment

Marine Ecology Impact Assessment - Technical Report

Reference: R.B22074.011.04.Marine Ecology Impact Assessment.docx
Date: July 2017
Confidential

Document Control Sheet

BMT WBM Pty Ltd
Level 8, 200 Creek Street
Brisbane Qld 4000
Australia
PO Box 203, Spring Hill 4004

Tel: +61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.bmtwbm.com.au

Document:	R.B22074.011.04.Marine Ecology Impact Assessment.docx
Title:	Marine Ecology Impact Assessment - Technical Report
Project Manager:	Brad Grant
Authors:	Conor Jones, Beth Toki, Darren Richardson
Client:	Flanagan Consulting Group / Ports North
Client Contact:	Pat Flanagan
Client Reference:	

Synopsis:

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by	Issued by
0	18th May 2017	GWF	BMG
1	24th May 2017	GWF	BMG
2	5th June 2017	GWF	BMG
3	15th June 2017	GWF	BMG
4	3rd July 2017	GWF	BMG

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Flanagan Consulting Group	PDF	PDF	PDF	PDF	PDF						
BMT WBM File	PDF	PDF	PDF	PDF	PDF						
BMT WBM Library	PDF		PDF	PDF	PDF						

Contents

List of Figures

List of Tables

1 Introduction

The Cairns Shipping Development (CSD) Project (the project) is a capital dredging project that aims to increase the capacity of the Port of Cairns for tourism and shipping. Up to 1 M m^3 of material is proposed to be dredged from Trinity Bay and Trinity Inlet and placed onshore. Most material would be placed at the Northern Sands Dredge Material Placement Area (DMPA), and stiff clays placed at Ports North land at Tingira Street. Dredged material will be pumped to the Northern Sands DMPA via a pipeline offshore from the Richters Creek mouth. Tailwater from the DMPA will be discharged into the Barron River.

This report presents the findings of the assessment of potential impacts to the marine environment associated with the construction and operation of the recalibrated CSD EIS, with particular focus on the following:

- Construction related – primarily capital dredging and placement activities, and also construction of wharf infrastructure.
- Operation of the port facilities, focusing on accommodating an increased number of larger cruise vessels at Trinity Inlet wharves, maintenance dredging of the entrance channel, and placement of maintenance dredge material at the approved marine Dredge Material Placement Area (DMPA).
- Options for managing and mitigating identified impacts.

The impact assessment addresses relevant to aquatic ecology as set out in:

- Queensland Government (2012) terms of reference (TOR) Section 5.4.3
- Australian Government (2012) Environmental Impact Statement (EIS) guidelines Sections 5.10, 5.10.7, 5.10.9, 5.10.10, 5.19 and 5.20 of the EIS guidelines.

Baseline marine water quality and marine ecology studies relevant to the project are reported separately in the EIS. The assessment of ecological impacts within this report associated with water quality changes is based on threshold values set out in the Marine Water Quality Chapter of the EIS.

2 Assessment of Potential Impacts

2.1 Overview

Components of the project with potential to impact the marine environment include:

- Dredging, involving:
  - Widening and deepening of the existing inner and outer shipping channels, and lengthening of the outer channel
  - Establishment of a new swing basin at Smiths Creek to enable future expansion of the HMAS Cairns Navy base and increasing the extent of the Crystal swing basin
- Structural upgrades to the existing cruise shipping wharves 1-5 to accommodate larger and heavier cruise ships
- Creation of a temporary steel pipeline from an offshore dredge pump-out location near Richters Creek to the Northern Sands DMPA, and associated dredge vessel movement between the loading sites and the pump-out location
- Tailwater discharges from the Northern Sands DMPA into the Barron River.

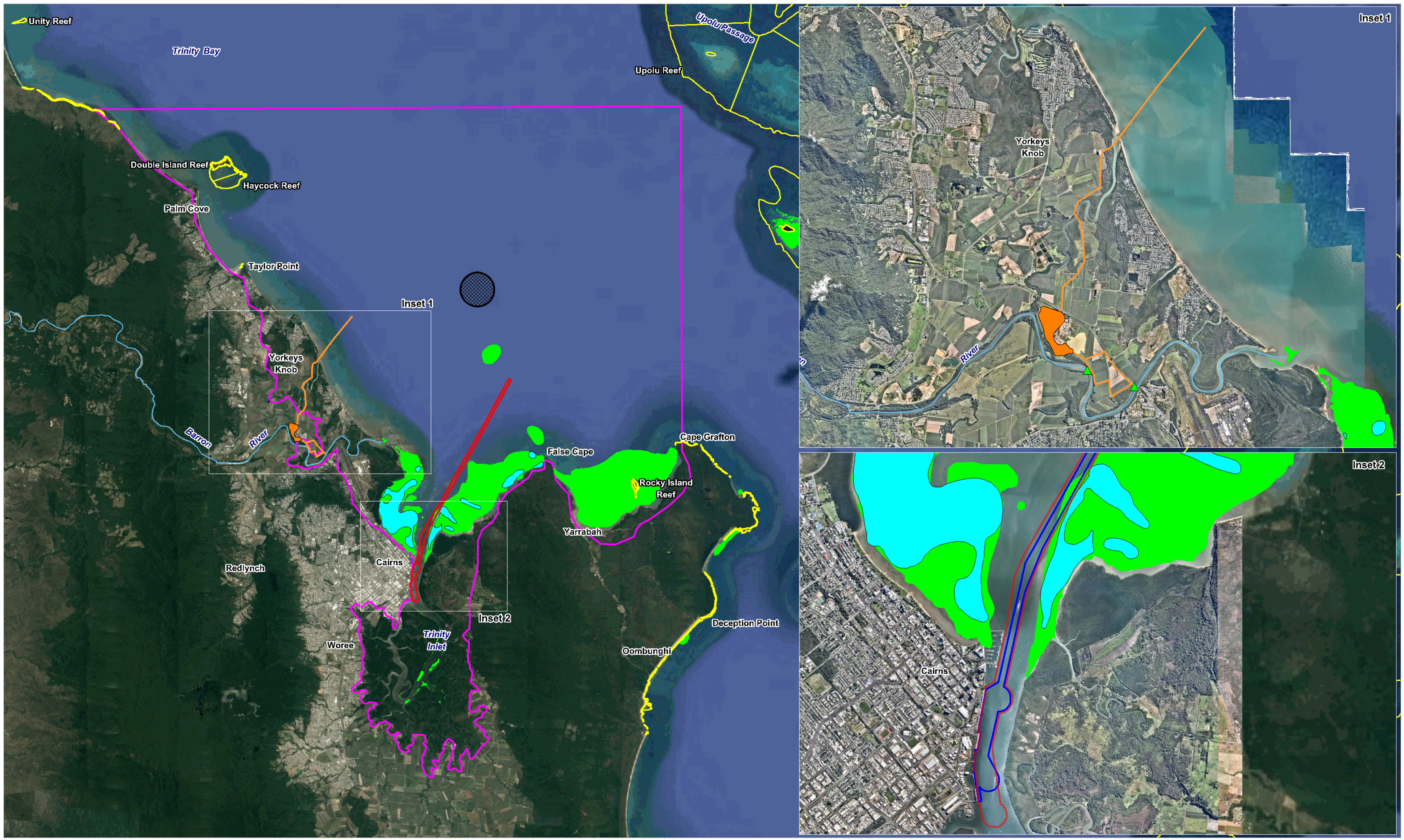
The harbour and channel development works will primarily involve capital dredging of up to 1 million m^3 (Mm^3) of material. The soft clay material will be pumped to the Northern Sands DMPA (DMPA) and de-watered into the Barron River. Stiff clays will be placed at the Tingira Street DMPA and will not require tailwater discharge. Potential impacts from placement at the Tingira Street DMPA will be managed on site in accordance with existing practices, and are not considered further in this assessment, as marine ecology impacts are not expected. Maintenance dredging of harbour and channel areas as well as placement at the existing and proposed DMPAs during the operational phase of the project are also considered.

Table 2-1 summarises the key processes for each project component that has the potential to affect ecological value of the marine environment, during either the construction and/or operational phases of the project. Figure 2-1 shows the direct disturbance footprint for the project and the location of key sensitive marine ecology receptors. Table 2-2 summarises the approximate area and type of each marine habitat affected by direct impacts at each location, as well as other anticipated direct habitat changes.

Table 2-1 Summary of impacting processes, primary impacts, secondary effects during construction (C) and operation (O) phases of the project

Phase	Impacting Process	Primary Impact	Secondary Effects	Section
C/O	Dredging and dredged material placement	Temporary loss or mobilisation of benthic fauna.	Change in prey availability for marine fauna.	2.3.1.3 2.3.1.4
C		Long term change in benthic habitat conditions and benthic fauna.	Change in prey availability for marine fauna.	2.3.1.3 2.3.1.4
C/O		Increased suspended solid concentrations and sedimentation.	Loss or degradation of seagrass and corals.	2.4
C/O		Acoustic effects to marine fauna.	Avoidance of area by marine fauna.	2.6.1.2 2.7
C/O		Direct effects of dredge plant on marine megafauna.	Injury or mortality to marine megafauna.	2.6.1.1
C	Tailwater Discharges from the Northern Sands DMPA	Increased suspended sediment concentrations and altered salinity	Loss or degradation of seagrass and riparian habitat	2.5.2 2.5.4
			Temporary mobilisation or loss of benthic fauna and fish	2.5.3
C/O	Wharf and pipeline infrastructure development and operation	Direct changes to marine habitat.	Change in prey availability for marine fauna.	2.4.1.1
		Acoustic effects to marine fauna (e.g. physiological damage, masking of important sounds) associated with construction (e.g. piling) and operational vessel noise and vibration.	Adverse marine fauna behavioural responses, temporary avoidance or displacement of affected area.	2.3.3 2.6.1.1 2.6.1.2 2.7
C/O	Increased vessel movements	Increase in boat strike (construction vessels and increased ship movements).	Injury or mortality to marine megafauna.	2.6.1.1
		Increase potential for marine pest introductions.	Out-competition of native species and loss of biodiversity values.	2.8.1.1
		Increase in vessel wash and disturbance of seabed habitats, flora and benthic fauna.	Change in prey availability for marine fauna.	2.8.1.1
C/O	Construction plant and operational lighting	Increased light spill into the marine environment.	Disorientation of marine fauna, particularly marine turtles.	2.6.1.2

Phase	Impacting Process	Primary Impact	Secondary Effects	Section
C/O	Increased potential for debris and spills to enter the marine environment	Ingestion of debris or entanglement of marine megafauna. Toxicity effects to marine biota	Loss of biodiversity values.	2.8.2



Legend

- Study Area
- Reefs
- Existing Maintenance Dredging DMPA
- Seagrass maxima (1983-2015)
- Seagrass 2015 (York et al. 2016)
- Pipelines (Spoil and tailwater)
- Existing Channel
- Proposed Channel Footprint
- Tailwater Output
- Northern Sands DMPA

Title:
Direct Disturbance Footprints and Sensitive Receptors

Figure: **2-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

Main Map
0 5 10km
Approx Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B22074.I.Cairns EIS Update\DRG\ECO_013_170509_Impacts_A3.wor

Table 2-2 Area of Disturbance within each impact location

Location Figure 2-1	Phase	Activity	Effect Type	Habitat Type	Area (ha) Affected
Direct Irreversible Losses and Gains at Wharf					
Wharf area on inset 2	C	Wharf dolphin structures, associated piles for wharf infrastructure.	Loss of soft sediment habitat.	Subtidal soft sediments	0.005 ha
			Habitat modification – hard substrate habitat associated with wharf upgrade works (84 piles)	Hard substrate	~0.005 ha (gain)
Direct Habitat Disturbance Associated with Dredging Activities					
Blue channel area on inset 2	C, O	Dredging and deepening of inner port (previously dredged areas).	Habitat modification: • Increase depth in capital dredging footprint • Disturbance by maintenance dredging at similar frequency as existing maintenance dredging)	Subtidal soft sediments	40.88 ha
Red channel area in inset 2	C, O	Dredging and deepening of inner port in previously un-dredged areas.	Habitat modification - increase in depth where capital dredging will occur; disturbance by maintenance dredging	Subtidal soft sediments	21.50 ha
Blue channel area	C, O	Deepening of the existing outer channel (previously dredged areas).	Habitat modification - increase in depth; disturbance by maintenance dredging (at similar frequency as existing maintenance dredging)	Subtidal soft sediments	99.23 ha
Red channel area	C, O	Channel widening in previously undredged areas.	Habitat modification - increase in depth; ongoing disturbance by maintenance dredging	Subtidal soft sediments	12.95 ha
Blue DMPA	C, O	Dredged material placement at the DMPA.	Direct habitat modification due to dredged material placement from maintenance dredging	Subtidal soft sediments	269 ha
Direct Habitat Disturbance Associated with Pipeline Alignment					
Orange pipeline	C	Trenching the pipeline at Richters Creek Crossing and shoreline modification	Habitat modification – disturbance to beaches and creek bank at pipeline crossing locations	Intertidal and subtidal soft sediments, river bank habitat	0.12 ha

2.2 Methodology

2.2.1 Assessment Approach

As outlined in Chapter A1, a risk-based approach has been used in the marine ecology impact assessment. This is based on the identification of potential impacting processes and characterising the likely level of impact to the existing environment. For the purposes of this Marine Ecology assessment, impacts levels and risks were defined on the basis of the following: and based on the consideration of the following:

- **Consequence of Impact** – made up of assessment of the intensity, scale (geographic extent), duration of impacts and sensitivity of environmental receptors to the impact. Impact consequence ratings take into account the conservation management objectives for protected and threatened species (as outlined in the relevant recovery plans for species listed in the Marine Ecology Chapter of the Draft EIS). (Table 2-3 is a summary of the categories used to define impact consequence.
- **Duration of Impact -** the duration of identified impacts is classified as per Table 2-4.
- **Likelihood of Impact** – which assesses the probability of the impact occurring. Table 2-5 is a summary of the categories used to define impact likelihood.
- **Risk rating** – which assesses the level of risk for key impacting processes. The risk table (Table 2-6) adopted is generated from the Consequence and Likelihood scores, based on the overall matrix presented in Part A.

To determine the most appropriate impact consequences, impact definitions were further defined using assessment methods from elsewhere in this EIS. This includes the ‘zones of impact’ assigned to processes associated with water quality and sediment deposition, which take into account the relevant project-specific ecological threshold values applied for this EIS.

The water quality impact predictions (zones of impact) have been derived using percentile exceedance plots. The zones of impact are generally based on dredging environmental assessment guidelines produced by the WA EPA (2016), and include the following:

- Zone of High Impact = water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months.
- Zone of Low to Moderate Impact = water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range).
- Zone of Influence = extent of potentially detectable[1] plume, but no predicted ecological impacts.

Full details on these zones, their determination, and criteria are provided in the EIS. Key assumptions and limitations of the impact assessment are outlined in the relevant sections.

[1] ‘Detectable’ plume in terms of detectable above background conditions by instrumentation deployed in the water column

Table 2-3 Impact Consequence Criteria (marine ecology)

Impact Consequence	Definition	How Defined
Very High	The impact is considered critical to the decision-making process as it would represent a major change to the ecological character of Cairns harbour and/or the immediate surrounds. This level of impact would be indicated by any of the following:	
	• Irreversible or long-term (i.e. greater than decades) loss of a unique/rare habitat or community type that is of regional importance	Direct loss of value in the project footprint that is absent elsewhere in the Cairns region
	• Irreversible or long-term (i.e. greater than decades) loss or diminishment of important habitats or communities that lead to major flow on effects to biodiversity values and ecosystem functioning at a regional (Cairns wide) scale	Direct loss of value in the project footprint that leads to regional flow-on impacts to the Cairns region
	• Severe impacts to populations of Commonwealth or State listed threatened species, such that their capacity to reproduce and recover is significantly affected.	Area supports 'important population' (as per MNES Guidelines 2013), and action is likely to cause impacts to overall population status of the species
High	The impact is considered important to the decision-making process as it would represent a detectable change to the values that underpin the ecological character of the study area (Cairns harbour and surrounds). This level of impact would be indicated by any of the following:	
	• >10%, long-term reduction in the total extent of existing seagrass meadows or potential seagrass habitat in the Cairns region	Direct loss of habitat in footprint
	• A detectable, medium term (>5 years) change to the structure (diversity, richness, composition, etc.) of high ecological value communities (i.e. reefs, seagrass, high value fisheries species) that lead to significant detectable flow on effects to biodiversity values and ecosystem functioning at a regional (Cairns wide) scale	Zone of High Impact: Deposition/turbidity (percentile + ecological thresholds
	• Mortality of a several individuals of internationally/nationally threatened species, but no detectable change to population status or the capacity of populations to recover.	Loss of individuals from study area (from mortality or permanent abandonment, etc.), but unlikely to result in impacts to population (as per MNES Guidelines).
Moderate	While important at a state, regional or local scale, these impacts are not likely to be critical decision making issues. This would be indicated by:	
	• Long-term loss or severe modification of important habitat type (particularly seagrass or reefs) including colonisation by invasive marine pests	Direct loss of habitat in project footprint

Impact Consequence	Definition	How Defined
	• A detectable significant change to the structure (diversity, richness, composition, etc.) of a high ecological value community structure (i.e. reef-associated benthos, seagrass, high value fisheries species), but recovery to a state resembling that prior to being impacted within a timeframe of five years or less	Zone of Low to Moderate Impact (seagrass, corals).
	• Loss of several individuals, or temporary loss of life history function for threatened species, or species of high fisheries or otherwise ecological value, but no detectable change in their population status at local (study area and surrounds) spatial scales (e.g. once off interruption of breeding or spawning, not necessarily affecting all of local population).	Loss of individuals from study area (from mortality, long-term or temporary abandonment etc.), but unlikely to result in impacts to any local population (as per MNES Guidelines).
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. This would be indicated by:	
	• Changes to sediment type and soft sediment benthic communities at local scale (measured at scale of 10s to 100s of metres)	Any change to soft sediment habitat that is well represented in the Cairns region
	• Short term (i.e. duration of dredge campaign, less than one year) changes to the distribution of threatened species or species of high fisheries significance (i.e. avoidance of areas), but no long-term effects to local population status.	No loss of individuals of any threatened species, but temporary avoidance of affected areas possible
Negligible	Minimal change to the existing situation. This could include, for example, impacts that are below levels of detection, impacts that are within the normal bounds of variation, or impacts that are within the margin of forecasting error.	Zone of Influence
Beneficial	Existing marine flora/fauna populations and/or habitat is improved in Trinity Inlet, Trinity Bay and surrounds.	

Table 2-4 Classifications of the duration of identified impacts

Relative duration of impacts	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent / Irreversible	In excess of 50 years

Table 2-5 Categories Used to Define Likelihood of Impact

Likelihood	Categories
Highly Unlikely/Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the project but probability well <50%; unlikely but not negligible
Possible	Less probability of occurrence than 'Likely' but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability >50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impact period

Table 2-6 Risk Matrix for Marine Ecology

Likelihood	Impact Consequence				
	Negligible	Minor	Moderate	High	Very High
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

Table 2-7 Risk Rating Legend

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact to marine ecology values
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact to marine ecology values
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

2.2.2 Dredging and Tailwater Scenarios

The total duration of the capital dredging campaign is expected to be approximately 12 weeks for the TSHD, with the BHD dredging component expected to take approximately 5-6 weeks within this dredging period. For assessments based on predictive model outputs of dredging scenarios, two scenarios were considered:

- **Scenario 1** - lower end of the expected total dredge material volume (710,000 m^3 of soft material from the channel and 100,000 m^3 of stiff clay material from the inner channel and harbour) and limited overflow from the TSHD (maximum 10 minutes of overflow).
- **Scenario 2** - upper end of the expected total dredge material volume (900,000 m^3 of soft material from the channel and 100,000 m^3 of stiff clay material from the inner channel and harbour) and less-restricted overflow from the TSHD (30 minutes of overflow per cycle).

For assessments of tailwater discharges into the Barron River, predictive modelling was used to assess two possible release locations, both consisting of seawater released at 100 mg/L (~60 NTU):

- Tailwater discharge point A – located just downstream from the Northern Sands DMPA
- Tailwater discharge point B – located at the Bruce Highway crossing of the Barron River

Modelling of both dredging and tailwater scenarios was undertaken over three different weather periods (representing a range of wind and wave conditions), with the best and worst of the modelling outputs representing the 'likely best case' and 'likely worst case' scenarios presented in this report. Each percentile plot is based around a 30 day modelling window. As such, these scenarios provide lower and upper bounds to expected impacts.

It should be noted that extreme climatic events are not included as part of the worst-case scenarios as dredging would be unlikely to be occurring during these periods.

2.3 Direct Modification of Benthic Habitats and Communities from Dredging, Dredged Material Placement, Wharf Upgrades and Pipeline Trenching

This section describes direct impacts to benthic habitats and communities due to dredging activities, dredged material placement, wharf upgrade works, and pipeline trenching at Richters Creek. Note that indirect impacts associated with water quality effects are considered in Section 2.4.

2.3.1 Dredging of the Channel, Inner Harbour and Swing Basins

2.3.1.1 Dredging Specifications

Figure 2-1 shows the proposed dredging footprint. For capital works, dredging of the outer channel will widen the existing channel from 90 m to 100 m and deepen the channel from -8.3 m LAT to -8.8 m LAT. Practically, the outer channel will be dredged wider to accommodate channel batters (typically one in four slope), and deeper in some areas to allow for siltation between maintenance dredging campaigns.

The inner channel extends for 2.4 km and has variable widths incorporating bends and swing basins. Capital dredging here will expand the existing Crystal Swing Basin for use by cruise ships, relocate the existing main swing basin further south (to be designated Smith's Creek Swing Basin), and increase the width and depth of the existing inner port channel along its full length.

Based on the anticipated dredge volumes and materials, it is anticipated that the dredging program will take approximately 12 weeks. Future maintenance dredging requirements are expected to be increased by approximately 2-6%.

2.3.1.2 Benthic Habitat Modification

Dredging will result in the direct removal of soft sediment habitat and biota from within the dredge footprint areas of the existing assessed and approved channel structure. Capital dredging will involve the disturbance of approximately 174.5 ha of soft, unconsolidated sediment, of which 140 ha is already disturbed by the annual maintenance dredging program. Hence, it is proposed that the project will impact approximately 34.5 ha of seafloor that has not previously been dredged, namely the widening of portions of the channel and the small batter slope/ swing basin extensions within the inner port.

It is expected that dredging to widen the outer channel and inner port area will create benthic habitat conditions that are similar to those found within the existing outer channel and previously dredged areas of the inner port. Existing benthic habitats and macroinvertebrate assemblages within the outer channel are highly simplified and have low diversity compared to adjacent undredged areas. The existing outer channel and inner port are subject to ongoing disturbance as a result of maintenance dredging.

Water depth will also increase, typically by approximately 0.5 – 2.0 m throughout the existing dredge footprint. The increase in water depth will represent a permanent change in habitat conditions as these depths will be sustained by ongoing maintenance dredging campaigns throughout the operational phase. The following habitat responses are predicted:

- Given the increase in water depth, the seafloor within the dredge footprint is expected to receive slightly lower light levels than present due to light attenuation with depth.
- Localised changes to bed stability on the batter slopes of the dredge footprint.
- Highly localised and minor changes in the speed and direction of currents after development completion. For example, the highest magnitude changes in tidal current flow velocities are not large (generally ±0.1 m/s) and are unlikely to alter local scour or sediment accretion at rates that would affect seagrass or benthic communities.

2.3.1.3 Effects to Benthic Fauna Communities

Initially, dredging will cause a temporary loss of biota from within the dredge footprint, since benthic communities typically inhabit the surface sediments that will be extracted by dredging. Biota will soon recolonise the dredge footprint but will continue to be regularly subject to similar disturbance through boating propeller wash and the ongoing annual maintenance dredging regime.

While in this modified state, it would be expected that benthic communities within both the existing channel/harbour and proposed new dredge areas (i.e. channel widening/extension area and parts of the inner port that have not previously been dredged) will support similar benthic communities and ecological functions as that currently found in the existing channels.

Benthic fauna communities within the proposed dredge footprint are largely simplified, with a lower fauna abundance and diversity compared to soft sediment habitats elsewhere in the study area. This relates to both epifauna and infauna communities, and is largely associated with much of the dredge footprint having been exposed to past dredging effects, either directly, or by being located immediately adjacent to previously dredged areas. No reef communities or other features of high fauna biodiversity value occur in the proposed newly dredged areas.

In regards to the proposed dredge pump-out mooring point offshore from Richters Creek, studies undertaken in this area indicated that epibenthos densities varied from bare substrate to low-density benthic communities. Furthermore, habitats along the dredge pump-out alignment from the mooring point to the mouth of Richters Creek do not contain hard substrates or abundant epibenthic communities.

Recolonisation of benthic fauna to a dredged area may occur via several processes including:

- Passive recolonisation, involving the passive settlement of entrained or otherwise resuspended organisms (Morton 1977)
- Larval settlement by planktonic organisms (Skilleter 1998)
- Post-colonisation invasion of the dredged area by adult and juvenile fauna from neighbouring undisturbed areas (noting rates of colonisation dependent on the mobility of the animals present in adjacent areas).

Initial passive recolonisation of dredged areas may occur immediately after dredging, followed shortly by the commencement of recolonisation through larval dispersal or active invasion (within hours to days) (WBM 2004). While commencement of initial recolonisation will occur in a short time frame, 'recovery' (functional recovery in terms of a return to comparable numbers of species and total individuals) for areas that have not previously been dredged would be in the order of months to years but will ultimately be limited by the frequency and timing of maintenance dredging (i.e. maintenance dredging fosters a continuous cycle of disturbance and recovery, such that communities remain in a state of flux). However, such areas are subject to natural disturbances from cyclones and would have significant recovery potential. As such, areas of the dredge footprint that have not previously been dredged can be expected to undergo a shift in community composition, whereby for example, the more tolerant or opportunistic species would contribute proportionately more to total fauna abundances. On the whole, and throughout the longer term operational phase, benthic fauna communities across the dredge footprint will likely reflect those currently inhabiting the existing dredged areas.

2.3.1.4 Seagrass

The dredge footprint does not presently support seagrass meadows. Approximately 9 ha of the dredge footprint overlaps with seabed areas that have previously supported seagrass and as such, these areas represent potential habitat for seagrass. Of the 9 ha of historic seagrass within the new channel footprint, 6 ha of this falls within the existing footprint. Seagrass in the dredge footprint is ephemeral *Halodule uninervis*, with periodic detections during times of favourable conditions with detections in the mid 2000's and again most recently in 2016 (Ports North, *pers com*). The seagrass previously recorded here was dominated by *Halodule uninervis*, and at times was also comprised of *Cymodocea serrulata*, similar to other seagrass beds previously mapped on the eastern side of the existing channel (York et al. 2016). The total area of potential seagrass habitat in the footprint is ~ 1% of the cumulative historical extent of seagrass meadows in the Cairns region and ~2% of the meadow extent mapped in 2015.

2.3.1.5 Secondary (Indirect) Effects

The change in habitat conditions in the dredge channel is predicted to have highly localised secondary effects to marine flora and fauna. Alterations in the composition and abundance of benthic fauna assemblages can be expected within the dredged area immediately after dredging (i.e. prior to recolonisation), resulting in a temporary loss of prey items for fish and invertebrates in the dredge footprint.

Given much of the dredge footprint is already subject to ongoing maintenance dredging, this area does not contain large or dense seagrass areas. Hence, any seagrass present is unlikely to provide a critical foraging function for fish, green turtles, dugongs (or other seagrass dependent marine species) compared to the more extensive seagrass meadows normally occurring elsewhere in Cairns harbour (i.e. in the vicinity of Cairns Esplanade and Bessie Point).

Overall, modifications to benthic habitats and communities in the proposed channel expansion area are expected to initially result in highly localised reductions in benthic fauna richness and abundance. These communities will begin to recover (possibly commencing immediately after dredging) but will continue to fluctuate in response to maintenance dredging and natural ambient disturbances from extreme weather events, similar to the present situation in maintained dredged areas. Overall, these changes are not expected to cause detectable flow-on effects to other ecosystem components or functions throughout the study area, beyond the dredge footprint.

Note that for marine protected areas, dredging will encroach on the Trinity Inlet FHA and GBR Coast State Marine Park General Use Zone. These effects and corresponding mitigation measures are detailed in the EIS. No dredging will occur within the GBRMP.

2.3.2 Wharf Upgrade Works

Marine aspects of the wharf upgrade works focus on the installation of 21 independent dolphin structures between existing bents, together with a new fender system every five bents. Each dolphin has four steel piles (totalling 84 piles during construction), concrete pile caps and mooring bollards. Piles are 900 mm in diameter, and subject to detailed design, equalling a total base area of 53.76 m^2 for all piles combined.

This area (53.76 m^2) represents the area of marine habitat and associated benthic infauna communities that will be permanently displaced through the construction of the wharf upgrade works. All of this habitat will be subtidal soft sediment (mud) and represents a small proportion of available soft sediment habitat within the inner port local area (refer sediment class distribution map in the EIS). This area is already in a modified condition due to existing development, and is a highly mobile fine sediment environment not favourable to establishment of benthic flora or fauna. As such, this loss is not expected to result in detectable flow-on effects to other local fauna components (e.g. fish, large invertebrates) that rely on benthic infauna as a food resource. The loss of benthic habitat and associated assemblages within the wharf upgrade footprint is irreversible and therefore rated as a moderate impact.

The piles will provide additional artificial hard substrata (i.e. 84 piles in approximately 8 m water), which will gradually be colonised by sessile and encrusting biota over time (e.g. algae, attached bivalves, molluscs, bryozoans, etc.), resulting in a benefit in terms of habitat availability for these hard substrate associated communities. It is likely that species richness and biomass of benthic assemblages on the piles will be far greater than on the soft substrate that it replaced. While the piles will act as a fish aggregation device, they are unlikely to increase fisheries productivity except at localised spatial scales.

2.3.3 Richters Creek Pipeline Trenching

Approximately 0.12 ha of subtidal river bank will be temporarily modified at the pipeline crossing of Richters Creek. The pipeline will rest on the creek bed and will not restrict fish passage. The disturbance to soft sediment and bank communities is considered to be of minor impact consequence and low environmental risk given the very small scale of the disturbance, its temporary nature, and a lack of sensitive receptors.

Flow-on effects from the potential water quality impacts of this disturbance are considered to be of negligible consequence and mitigation measures are discussed in the EIS. Directs impacts to mangrove communities from this crossing and alignment are also discussed in the EIS.

2.3.4 Habitat Changes due to Altered Hydrodynamics

The project is predicted to result in minor, highly localised changes to hydrodynamics. Within and immediately adjacent to the dredging footprint, depth-averaged current speeds are predicted to increase/decrease (depending on location) within a range of ±0.1 m/s. Smaller magnitude reductions in peak current speeds (<10 percent) are predicted more broadly within Trinity Bay.

These minor changes in hydrodynamics would not be expected to result in detectable changes to marine habitats and biota.

2.3.5 Changes to Habitat and Prey Resources for Species of Economic Significance

Two critical considerations when considering the potential impacts of loss or disturbances to benthic assemblages on the foraging of fishery species are:

(1) The spatial scale of the impact relative to the total area of habitat available; and

(2) The degree of foraging specialisation exhibited by key fishery species.

With respect to loss or changes in prey resource availability, the level of impact will depend on the whether the animal has a highly specialised diet, and whether the area affected contain critical food resources.

The total area of soft sediment habitat loss proposed (as described above for dredging and piling) is relatively small compared to the total available soft sediment habitat resource in the harbour, Trinity Inlet and the wider study area. Based on habitat assessments and benthic macroinvertebrate community surveys, none of the potentially affected areas are known to support unique benthic macroinvertebrate or benthic habitats, nor are benthic macroinvertebrate communities within these areas considered to be particularly diverse or abundant compared to adjacent areas (consistent with much of the project footprint already having been subject to past/present disturbance).

Fish species occurring in unvegetated soft sediment habitats are generally recognised as being opportunistic benthic foragers (e.g. Hobday et al. 1999). This is demonstrated by how rapidly some fish species occurring in these habitats learn to consume introduced invertebrate species such as bivalves and polychaetes (Hobday et al. 1999). Similarly, prawns and crabs of economic significance also have a plastic (adaptable) diet (Dall 1992; Wassenberg and Hill, 1987).

Key commercial and recreational fisheries species potentially occurring at and adjacent to areas of disturbance can be broadly classified as broadly opportunistic species which feed on a wide variety of benthic invertebrates and pelagic fish (Table 2-8).

Table 2-8 Prey of key harvested species that may overlap spatially with the area of habitat impacts for the project

Species	Prey	Source
Eastern king prawn, Tiger prawn, Banana prawn	Benthic invertebrates – crustaceans and polychaetes.	Moriarty (1977)
Blue swimmer crab	Benthic invertebrates - crustaceans, molluscs, echinoderms, polychaetes.	Williams (1982), Wassenberg and Hill (1987)
Mud crab	Benthic invertebrates – molluscs, crustaceans, sedentary or moribund fish.	Williams (1997)
Barramundi	Fish and macrocrustaceans (prawns, crabs, etc.).	Davis (1987)
Threadfin salmon	Demersal and pelagic fish (e.g. ponyfish, flathead, scats, sardines) and macro-crustaceans.	Kailola et al. (1993)
Queenfish	A variety of pelagic fish species and cephalopods.	Kailola et al. (1993)
Sand whiting	Benthic invertebrates – crustaceans, molluscs, polychaetes.	McKay (1992)

Given the opportunistic behaviour of the benthic foragers listed above, together with the small proportion of habitat lost, it is not expected that permanent loss or modification of habitat would lead to a long-term reduction in populations of species of economic significance. However, it would be expected that demersal fish, crabs and prawns will avoid areas that have depauperate benthic macroinvertebrate assemblages as a result of dredging. This is expected to result in a redistribution of fauna, with animals foraging in other parts of the study area (e.g. adjacent to project footprint) until such times as benthic communities recolonise the disturbed area (i.e. recolonisation will commence immediately in dredged areas, but invertebrates communities in such areas will likely remain in a cyclical state of flux in response to ongoing maintenance disturbance).

Mud crabs, blue swimmer crabs and demersal fish utilise a range of soft sediment habitat types. There is no empirical evidence to suggest that these species have a strong association with a particular sediment type. Some correlative preferences for sediment type (i.e. grain size distributions) have been shown for commercial prawn species (e.g. Somers 1994). However, Somers (1994) suggested that variables other than sediment grain size may be more important, particularly factors such as the availability and extent of food and nursery habitats (e.g. seagrass, mangrove and benthic faunal communities). In the context of this project, this means that longer term changes in habitat conditions (e.g. sediment types, water depths) as a result of dredging, and associated changes to benthic macroinvertebrate communities, the risk of impact is considered to be low for species of economic significance. Further discussion on fisheries impacts specifically relating to the generation of turbid plumes is provided in Section 2.4.1.1.

2.4 Increased Suspended Sediment Concentrations and Sedimentation from Dredging

Dredging will generate turbid plumes that will extend over marine areas outside the project footprint. The two key effects of this for consideration in terms of potential impacts to marine ecology relate to:

- Water quality effects associated with temporary increases in suspended sediment concentrations (turbidity)
- Increased sediment deposition from suspended sediments settling out of the water column (deposition).

These two items are discussed separately below.

2.4.1 Increased Turbidity (Capital Works)

Predicted Turbidity

Turbid plumes generated by dredging will reduce light levels on the seabed, which could affect photosynthetic benthic species requiring light for energy production (e.g. seagrass, algae, and soft coral). The actual impact of turbid plumes on these benthic primary producers will depend on whether critical light requirements are met, and consideration of the magnitude, frequency and duration of low light events.

Numerical modelling of turbid plumes has been carried out for a range of scenarios. Ecological impact assessments in this section are primarily based on this modelling of the best and worst case scenarios, presented as zones of impact in Figure 2-5.

Note that both scenarios assume there is overflow from the TSHD and that stiff clays are removed by BHD. Both scenarios assume varying levels of overflow from the TSHD, depending on the type of bed materials encountered and during the worst 30 day period (i.e. taking into consideration both climatic and operational factors). In the context of these outputs, impacts to the 95th percentile turbidity represents the predicted acute water quality effects above background levels over a short-term period (36 hours); while impacts to the 50th percentile turbidity indicate more chronic cumulative water quality effects over a longer (15 day) duration. The extent, location and magnitude of turbidity plumes will ultimately depend on where a dredge vessel is operating at any given time, what type of dredger is operating, and the meteorological/sea conditions at the time of dredging and placement activities.

Ambient turbidity created by wind, waves, and river input is substantial within the study area. For context, percentile contour plots showing modelled ambient turbidity (without dredging) during 50th and 95th percentile conditions are provided in Figure 2-2. Further modelled ambient turbidity plots are included in BMT WBM (2017).

Based on the modelled worst case scenario presented here (Figure 2-3), it is predicted that median turbidity would increase slightly (in the order of 2-4 NTU) along the northern coastline from near the mouth of Barron River to Yorkeys Knob for portions of time during the dredging campaign (~15 days out of 30). The greatest increase to median turbidity would be near the channel dredging area which would increase to approximately 20 NTU above background. For the likely worst case scenario, under short-term acute (95^{th} percentile) conditions, turbidity is predicted to temporarily increase by approximately 10-20 NTU above background conditions outside of the channel regions, with turbidity approaching 100 NTU within channel in close proximity to the channel dredging area (Figure 2-4).

The likely worst case impact plot shows the Zone of Influence (detectable plumes but no ecological impacts) extending from Cape Grafton to beyond Double Island (Figure 2-5). The likely best-case scenario shows the zone of influence extending from the channel area to just beyond Double Island. No detectable ecological impact is expected in this zone.

The Zone of High Impact (severe impact, possible mortality) and Zone of Low to Moderate Impact (moderate to low impact, potential sub-lethal effects) represent areas where detectable ecological effects could occur. The Zone of Low to Moderate Impacts is absent in the likely best case scenario, whereas in the likely worst case scenario, it extends from the bend in the channel south into Trinity Inlet (Figure 2-5). The Zone of High Impact was restricted to the channel area in both scenarios.

Further details of the predicted turbidity changes at specific locations are provided in the EIS.

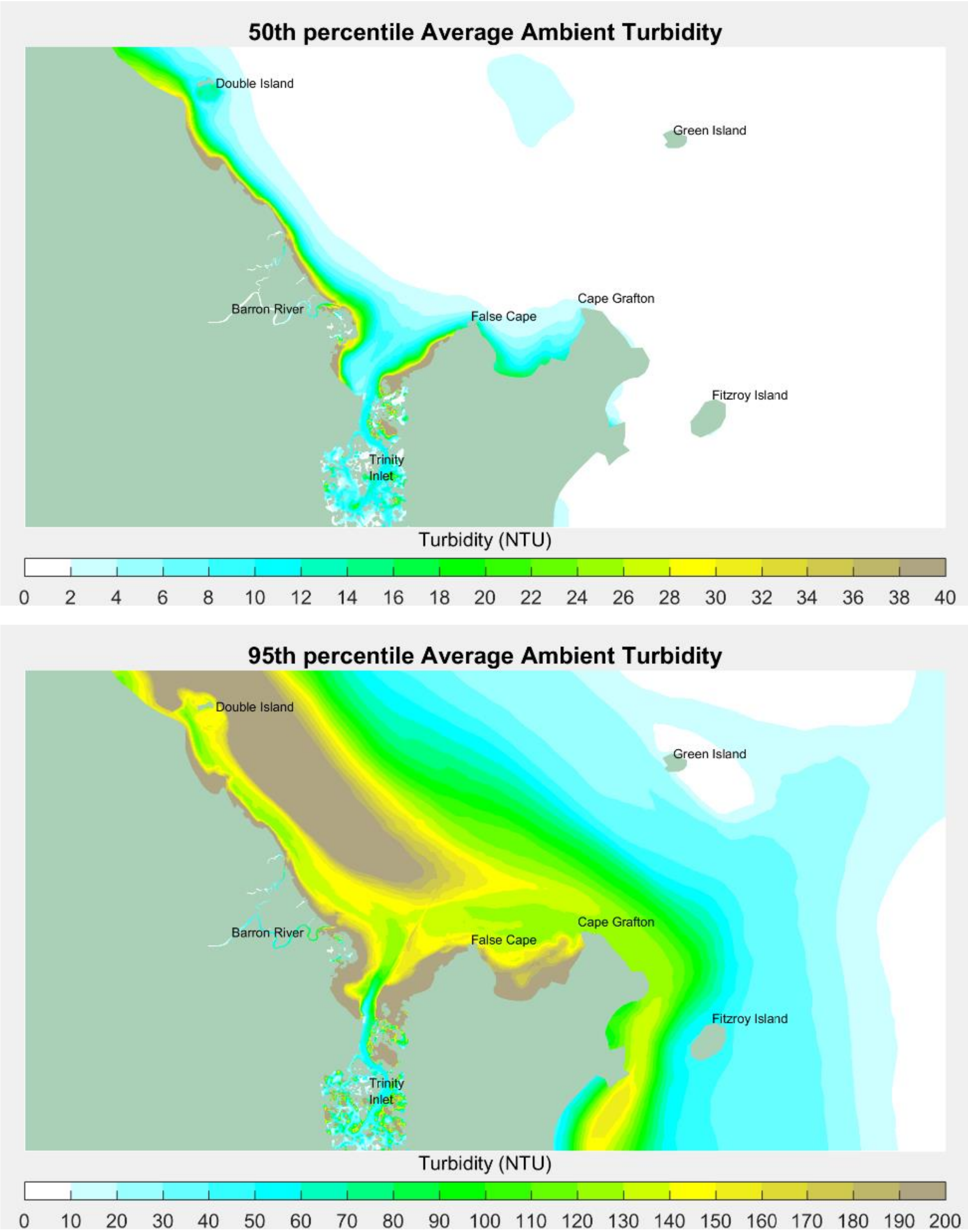


Figure 2-2 Modelled Ambient Turbidity (without dredging) – 50th percentile (top) and 95th percentile (bottom)

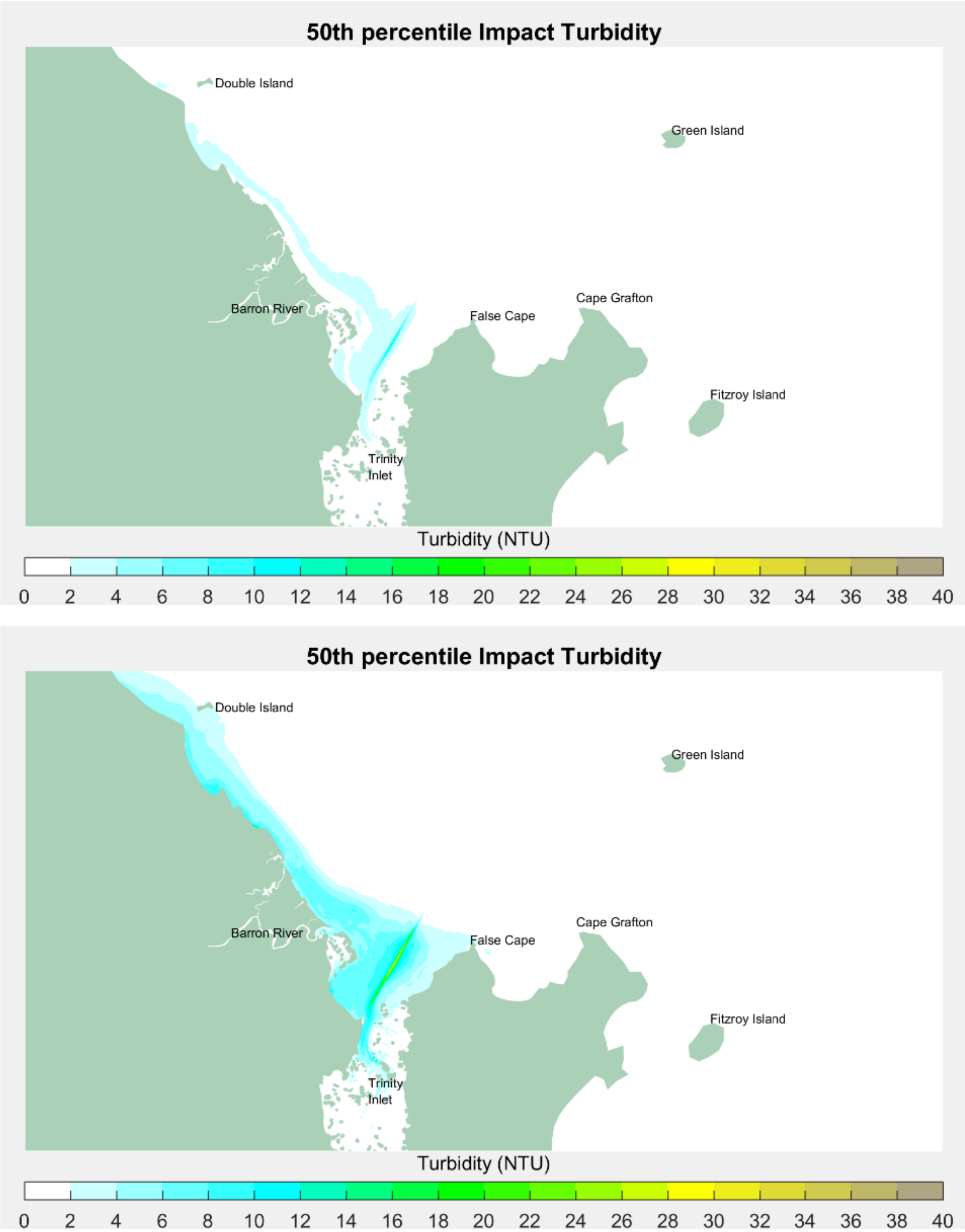
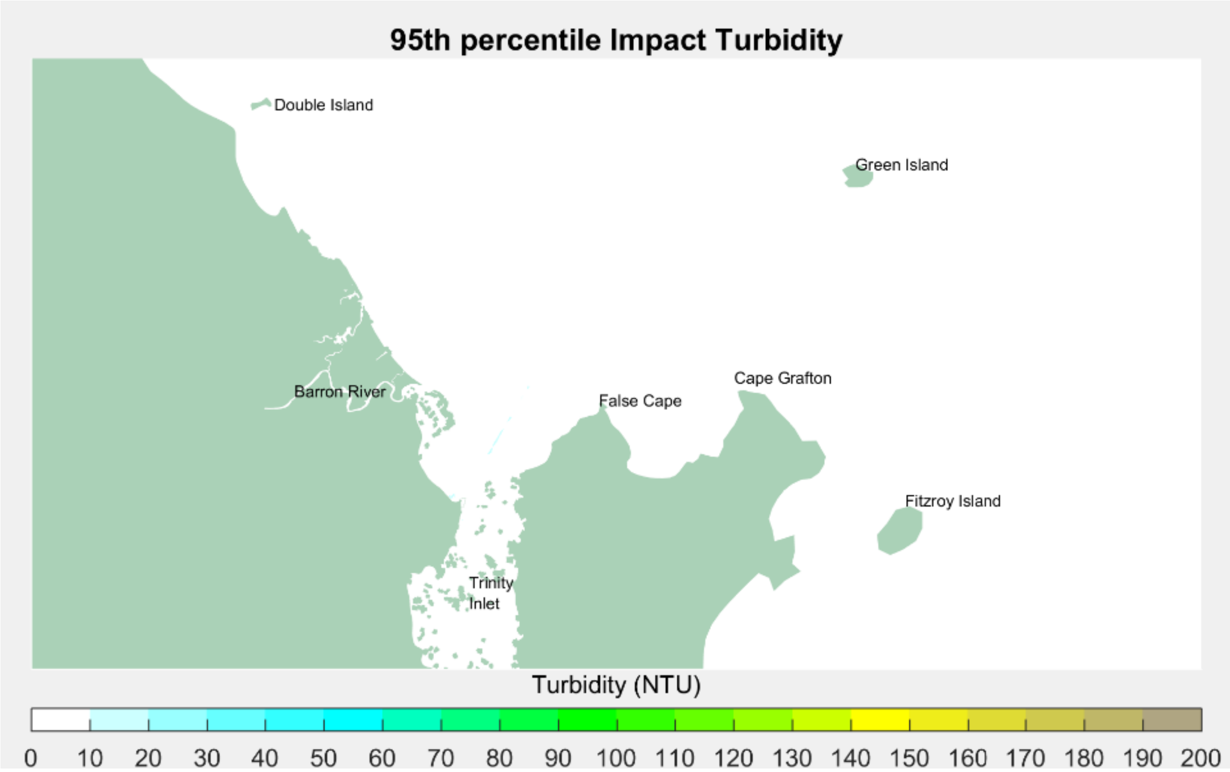


Figure 2-3 Impact of Dredging on 50th Percentile Turbidity under the likely best case scenario (above); and likely worst case scenario (below) (Scale: 2 to 40 NTU)



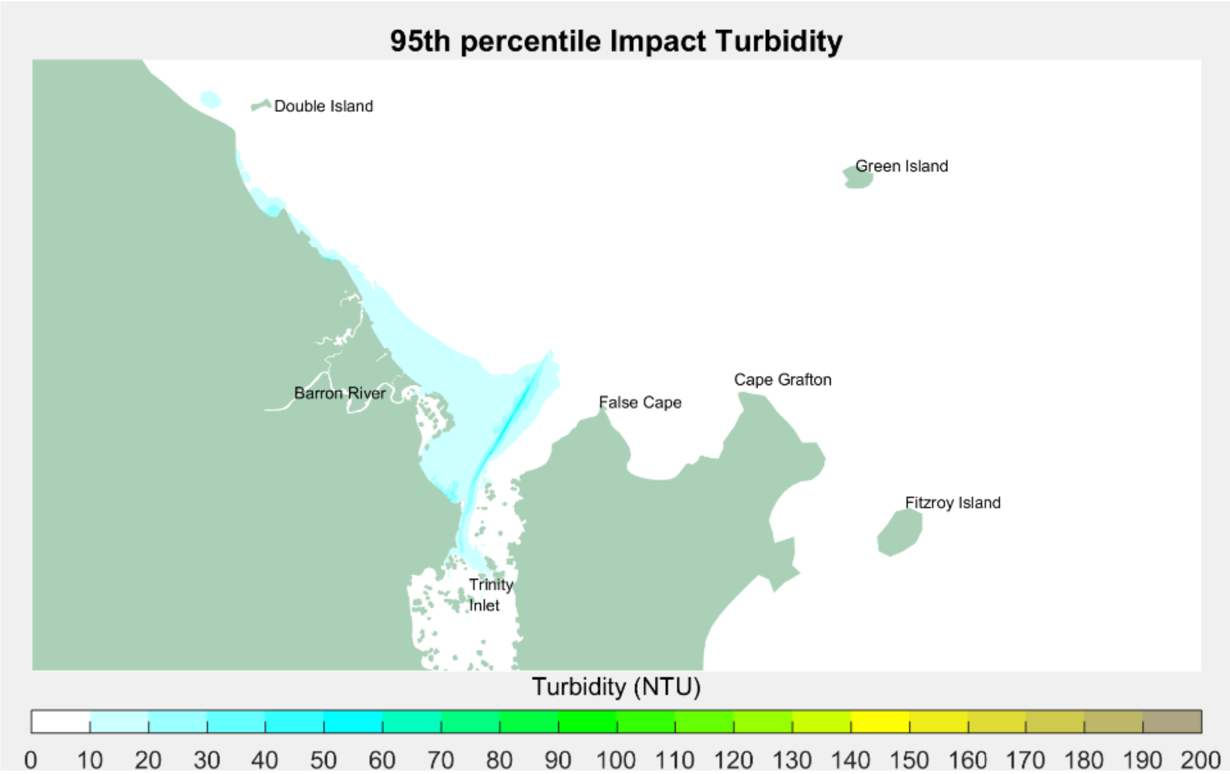
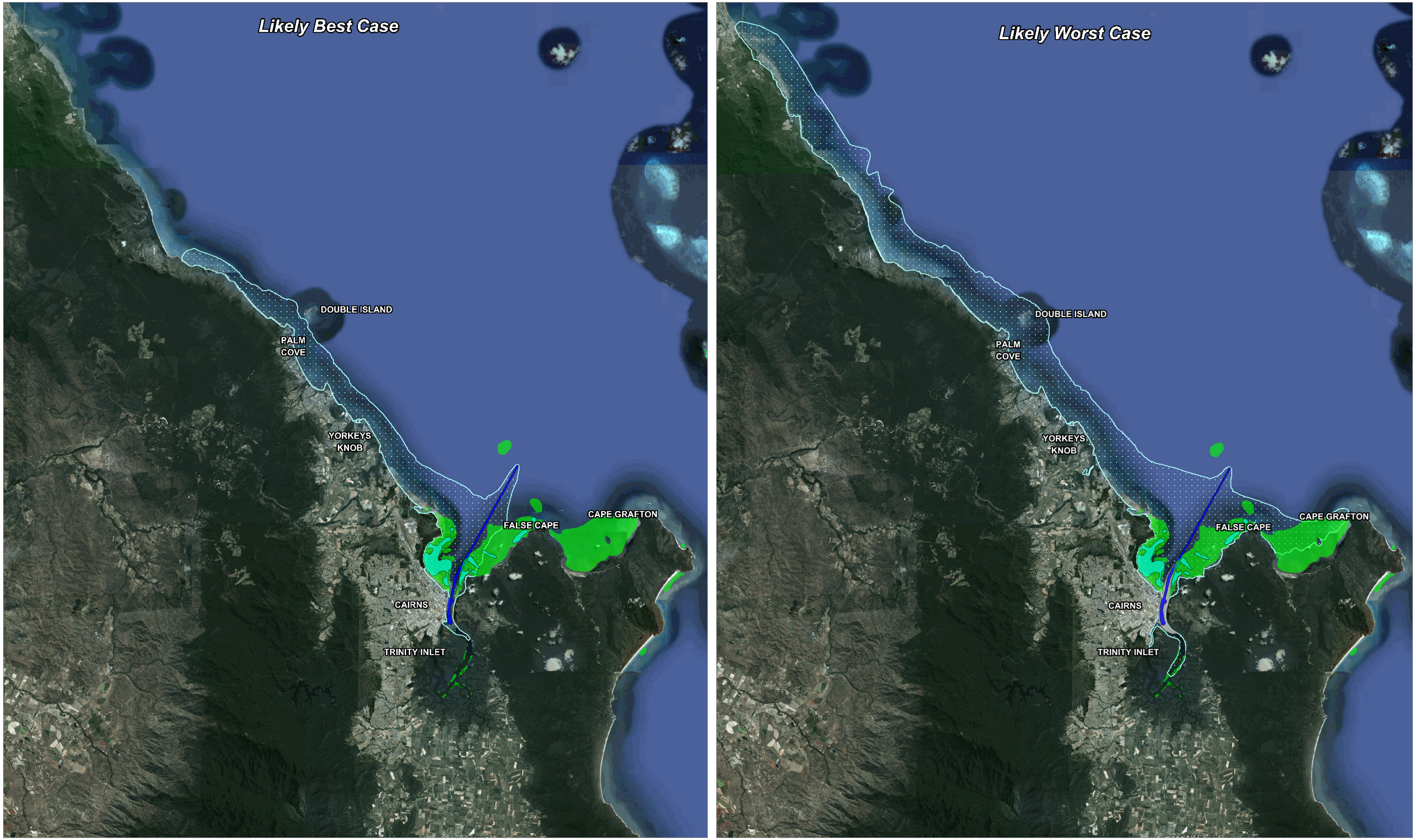
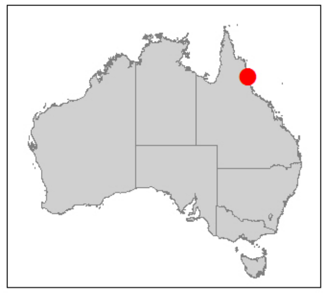


Figure 2-4 Impact of Dredging on 95th Percentile Turbidity under the likely best case scenario (above); and likely worst case scenario (below) (Scale: 10 to 200 NTU)





LEGEND

- Historic Seagrass Extent (1984 - 2015)
- 2015 Seagrass Extent

Zones of Impact

- Zone of Influence (no ecological impacts)
- Zone of Low to Moderate Impact
- Zone of High Impact

Title:

Zones of Impact - Turbidity - Capital Dredging
Likely Best Case (left) and Likely Worst Case (right)

Figure: **2-5**

Rev: **A**

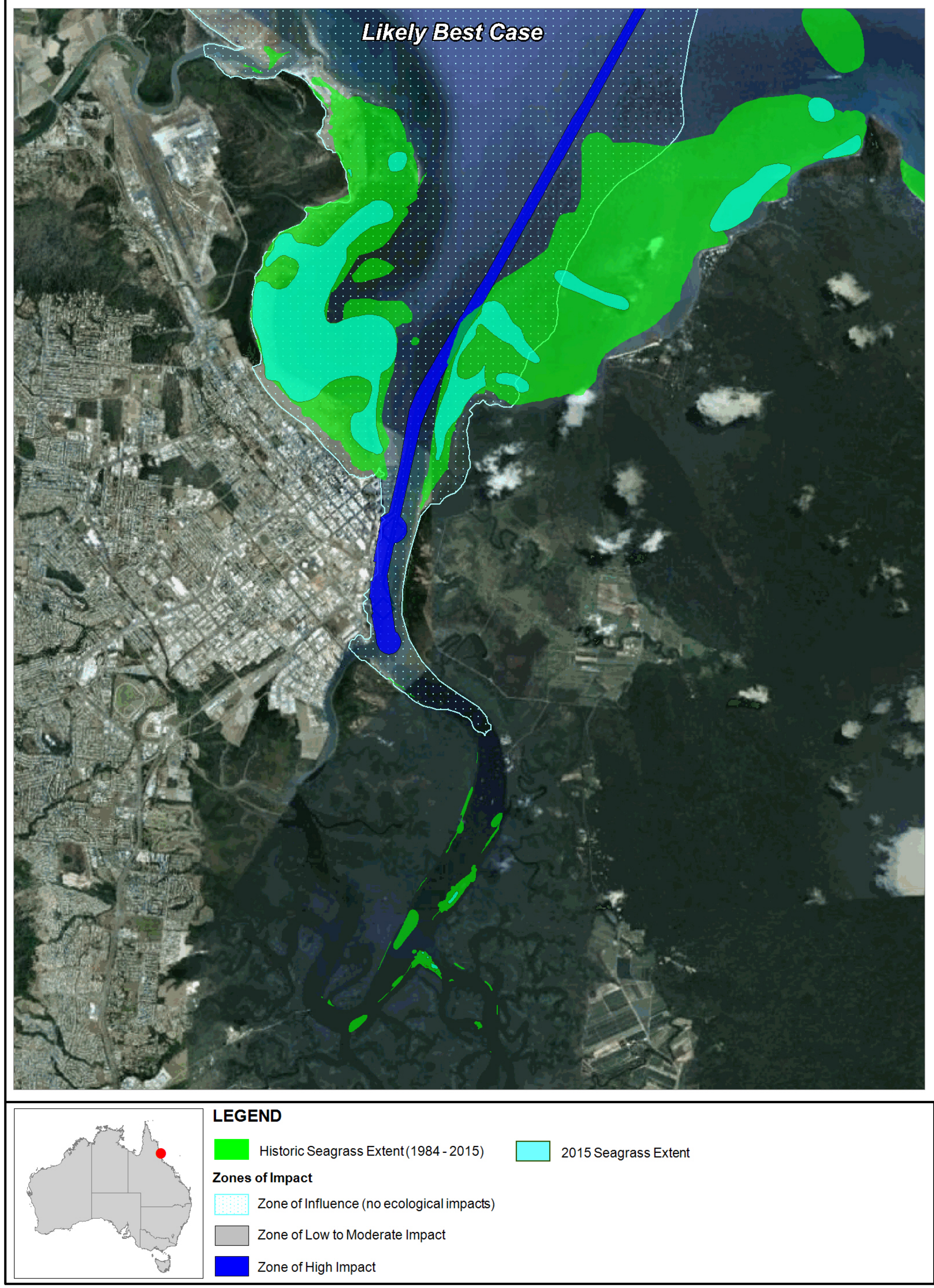
BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 5 10 km
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B22074.I.Cairns EIS Update\DRG\ECO_017_170516_ZOI_turb.wor



Title:

Zones of Impact - Turbidity - Capital Dredging (Trinity Inlet) Likely Best Case (left) and Likely Worst Case (right)

Figure: 2-6

Rev: A

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B22074.I.Cairns EIS Update\DRG\ECO_018_170516_ZOI_turb_Zoom.wor

2.4.1.1 Biotic Effects from Dredge Plumes

Seagrasses and hard corals, as well as other photosynthetic biota (e.g. algae, some soft coral), are considered the key sensitive receptors in terms of turbid plume effects.

The Zone of High Impact is located within the channel, and intersects with areas that have previously supported seagrass. This Zone of High Impact does not intersect areas presently supporting seagrass meadows.

The Zone of Low to Moderate Impact does not coincide with any past or present seagrass distributions, coral reefs or any known high density benthic fauna communities, in the best or worst case scenarios. Localised, temporary effects to soft sediment benthic communities in this zone could occur in this zone as discussed in Section 2.3.1.5.

The Zone of Influence (under any modelled dredge scenario) coincides with known (as mapped in 2015) seagrass meadows and coral reefs (e.g. Cairns Harbour, Double Island). By definition, the Zone of Influence includes areas where detectable turbidity changes could occur, but adverse ecological effects are not expected based on known tolerances of sensitive receptors. There are some uncertainties regarding the sensitivities of 'new growth' seagrass (i.e. seagrass that has not been mapped in 2015 but new shoots occur prior to the dredging campaign) and seagrass that is at or near the limits of its tolerance range, and implications are discussed further below.

Seagrass

Seagrass communities in the vicinity of Cairns harbour are usually dominated by *Halodule uninervis, Zostera muelleri*, and to a lesser extent *Halophila ovalis*. Presently the most extensive meadows are dominated by *H. uninervis* and *Cymodocea serrulata.* In the context of the tolerances of these species to increased turbidity and light attenuation, the following is noted:

- *Z. muelleri* can survive up to a month at low light levels (five percent surface irradiance) but requires 30 percent surface irradiance for long-term survival, as shown in studies undertaken further south at Cleveland Bay (Grice et al. 1996). Studies of seagrasses in tropical regions have shown that *Zostera* spp. have significantly greater light requirements (Grice et al. 1996, Bach et al. 1998, Collier et al. 2009) than other species occurring in the study area such as *Halodule uninervis* and *Halophila* spp. (Freeman et al. 2008).
- *C. serrulata* withstand (with some shoot loss) complete light deprivation for at least a 14 week period, making it one of the more tolerant species to light deprivation (Collier et al. 2016).
- *Halodule* spp. appear to be reasonably tolerant to light deprivation, with *Halodule pinifolia* surviving up to three to four months following complete light attenuation (Longstaff et al. 1999). In Townsville under warm conditions, *H. uninervis* appears also to be relatively tolerant of light deprivation, compared to *Z. muelleri* and *H. ovalis* (Collier et al. 2016).
- *Halophila ovalis* is among the most sensitive species to light attenuation (Longstaff et al. 1999). This species can show signs of stress after several days of complete light attenuation and mortality within 30 days of complete attenuation (Longstaff et al. 1999)
- Some seagrass species are able to tolerate episodic pulses of high turbidity over an extended period. For example, Chartrand *et al.* (2012) conducted shading experiments to determine the effects of short pulses of low light (shading) conditions over eight, 12 and 16 week periods on the

seagrass *Zostera mulleri*. Significant declines in seagrass were recorded under light deprivation between three and four weeks, however, cyclic shading (two weeks of shade followed by two weeks of light) resulted in no declines after eight weeks.

- Shading experiments in Townsville using *C. serrulata, H. uninervis, Z. muelleri,* and *H. ovalis* suggest that *Z. muelleri,* and *H. ovalis* have the highest light requirements and thresholds designed to protect these species will also protect the more tolerant *C. serrulata* and *H. uninervis* (Collier *et al.* 2016).

In consultation with JCU, seagrass tolerance values which may be relevant for Cairns were developed to test water quality thresholds in the EIS. These tolerance values included the following:

- **Zone of High Impact -** Total loss of seagrass would likely occur if the light requirement (LR) was not met for more than six weeks for *Zostera* (LR = 4.5-12 mol/m^2/day rolling two week average) and more than 21 days for *H. ovalis* (LR = 2.8-4.4 mol/m^2/day).
- **Zone of Low to Moderate Impact -** Declines in seagrass, with some recovery within a month, would likely occur if the LR was not met for one week (low impact) to six weeks (moderate impact) for *Zostera* during the growing season (July-Dec). For *H. ovalis* this equates to one week without the LR (low impact) to three weeks (moderate impact).
- **Zone of Influence -** No predicted impacts to seagrass if light does not fall below LR for *H. ovalis* and *Zostera* for more than seven consecutive days.

As discussed above, the Zone of High Impact and Zone of Low to Moderate Impact do not coincide with existing seagrass meadows, indicating that it is unlikely that indirect impacts to existing seagrass would occur. The Zone of High Impact intersects with potential seagrass habitat (i.e. seagrass has been recorded previously) in the dredge channel, however any seagrass present here would be directly impacted (removed) by dredging.

Notwithstanding the above, it is important to note that there is little information on the tolerance of new seagrass growth during periods of recovery. While it is thought that new seagrass regrowth (e.g. new shoots, seedlings) would be less resilient to reduced light levels, there is uncertainty as to what appropriate thresholds would be. In general, (i) new seedlings/shoots have a low energy store so are more dependent on photosynthesis and would be less resilient to periods of low light; and (ii) new seedlings and shoots would have high energy requirements in order to sustain the high rate of growth required to become established (Jarvis *et al.* 2014; pers. comm. M. Rasheed, 2014). As such, this assessment has conservatively assumed that even minor turbidity increases could potentially affect new seagrass growth in recovering areas, particularly in areas directly adjacent to the channel where turbidity generated by dredging will be greatest. On this basis, there is the possibility that impacts to recovering seagrass areas could occur, particularly those directly adjacent to the channel.

Overall, given (i) the minor to moderate scale of predicted impacts; (ii) the current condition and extent of seagrasses; and (iii) the temporary nature of turbid plumes, water quality effects resulting from the project are unlikely to affect the longer-term recovery of seagrass (following large scale declines over the last few years in response to natural disturbance) at the broader Cairns harbour level. Nonetheless, seagrass monitoring will be critical to ensuring that no significant impacts will occur (as listed under mitigation in Section 3.3). Seagrass surveys will be undertaken before dredging works, in order to define where areas of active seagrass recovery (i.e. new shoots, seedlings) are located at the time of dredging works as well as to confirm any recovery of seagrass within the footprint or Zone of High Impact (although considered unlikely). Further, ongoing monitoring of seagrass condition at both established meadows and recovering areas will form a key component of the reactive monitoring program that will be undertaken during dredging.

In the unlikely event that seagrass mortality occurs as a result of increased turbidity, impacts would be temporary and recovery is expected to occur through a number of mechanisms. Seagrass species found in the study area have adaptations that can allow relatively rapid growth and recovery following disturbance (Duarte *et al.* 1997). Overall, the rate of recovery would depend on factors such as the location, magnitude and extent of disturbance, as well as the time of year and environmental conditions during the recovery period.

Fish and Invertebrates of Commercial Significance

Most fish expected to occur in the study area have a lateral line system, which assists fish to feed in highly turbid waters. Disturbance of the seafloor by dredging will result in mobilisation and entrainment of invertebrates in the water column. This increase in the availability of food resources is expected to lead to an increase in the abundance of fish that feed on invertebrates to the dredging and dredged material placement sites. The increase in small fish could have a localised cascading effect, with piscivorous fish and dolphins also attracted to the dredge sites. Therefore, this could result in localised changes to fish distribution and abundance, and potentially higher rates of predation.

Turbid plumes may also result in physiological effects to fish. Jenkins and McKinnon (2006) suggested that very high suspended solid concentrations (e.g. 4000 mg/L) could cause gill blockage and eventually mortality to fish. There are very few documented cases of fish kills resulting solely from turbid plumes, and in any case, such concentrations would only be expected occur only rarely and at highly localised spatial scale (within the immediate vicinity of the dredger). Blaber and Blaber (1980) also suggested that turbidity gradients may aid fish larvae in locating estuarine nursery grounds. Although empirical data are lacking, it is possible that the creation of a turbidity gradient during the recruitment period of key species may lead to larvae being attracted to a region where settlement and recruitment rates are normally low due to lack of suitable estuarine habitat.

Prawns and portunid (mud and sand) crabs represent key species of commercial significance, and utilise both near shore and offshore waters (including parts of the study area) for parts of their life cycle. These species primarily inhabit turbid water environments, and tolerate a wide range of turbidity conditions. Therefore, direct impacts to prawns as a result of high suspended sediment concentrations and sedimentation are not expected and considered to be a negligible impact.

Impacts to key recreational target species (such as mackerel, grunter etc.) are predicted to be low, with some localised short term-impacts predicted, dependant on the timing of dredging along the length of the channel relative to time of year and movement of schools within Trinity Bay.

Further, given photosynthetic epibiota (including seagrass) are sparse within the predicted zones of impact, the epibiota in these areas are not considered to represent a key food resource for species of fisheries significance. Therefore, flow-on effects to fisheries as a result of turbid plumes impacting fish food resources are not expected.

Marine Megafauna

Of the very few species of mega fauna recorded from the study area, dolphins are the most commonly occurring cetacean species occurring in the study area and are capable of successfully foraging in turbid waters. Dolphins often stir up bed sediments when foraging for benthic prey, resulting in limited to no visibility for prey detection. It is thought that dolphins detect prey using echolocation rather than visual cues (Mustoe 2006, 2008). Dugongs have poorly developed eyesight and rely on bristles on their upper lip, rather than visual cues, to detect seagrass food resources. Therefore, high suspended solid concentrations generated by dredging and dredged material placement are not expected to adversely affect foraging success for cetaceans or dugongs.

Sea turtles generally have good eyesight and rely on visual and olfactory cues to detect prey and other food resources (Swimmer et al. 2005). Flatback turtles are known to feed in turbid shallow waters (Robins 1995) and may not be directly affected by turbid plumes generated by dredging and placement. Other species such as green and hawksbill turtle, which feed on seagrass and/or in reef environments, may avoid areas affected by turbid plumes. It is noted, however, that key foraging habitats for these species (i.e. reefs, notable seagrass beds) generally do not coincide with the predicted extent of turbidity impact zones.

Other Receptors

The predicted plumes classified as potentially resulting in ecological effects (i.e. zones of low to moderate and high impacts) do not coincide with the known locations of other sensitive biotic receptors such as coral reef communities. Similarly, the modelled dredge plumes of a level that could cause ecological impacts are not predicted to extend to other habitat types present in the broader study area (i.e. occur in the vicinity of soft sediments or pelagic waters only).

Given the extent and location of potentially impacting plumes within the zones of low to moderate and high impacts, together with the sparseness of photosynthetic epibiota in these offshore areas, detectable flow-on effects to other fauna communities are not anticipated. The sparseness of sensitive receptors (e.g. seagrass, soft corals) suggests they would not be of critical importance as a food source to species of high conservation or fisheries value, and that flow-on effects to additional receptors will be negligible.

Noting that the current proposal does not propose placement of capital dredge material in the Great Barrier Reef Marine Park, significant impacts to marine protected areas are not predicted, refer to the EIS for further discussion. This includes the proposal to amend the boundary of the fish habitat area and State Marine Park to accommodate the changes to the channel geometry whilst ensuring no net loss in the area of these protected zones.

2.4.1.2 Biotic Effects - Increased Sedimentation (from Capital Works)

Changes in sediment deposition due to dredging (i.e. excess sediment) are discussed in BMT WBM (2017). Figure 2-7 (median, 50th percentile) and Figure 2-8 (95th percentile) show sediment deposition rates generated by dredging. The plots illustrate the simulated worst and best case 30 day periods during the capital dredging project.

Corals

Thresholds were developed to define the bounds of various impact zones, as described in the EIS. The impact zone thresholds were developed from case studies and guideline values based on the tolerances of hard corals to sediment deposition. The adopted thresholds were as follows:

- **Zone of High Impact** – Greater than 20 mg/cm^2/day in the 50th percentile case or more than 200 mg/cm^2/day in the 95th percentile case (over a 9-11 week period period).
- **Zone of Low to Moderate Impact** – Between 1.5 and 20 mg/cm^2/day in the 50th percentile case or between 15 and 200 mg/cm^2/day in the 95th percentile case (over a 9-11 week period).
- **Zone of Influence** – Between 0.5 and 1.5 mg/cm^2/day in the 50th percentile case or between 5 and 15 mg/cm^2/day in the 95th percentile case (over a 9-11 week period).

These values are considered conservative, given that the GBRMPA (2010) water quality guidelines establish the following trigger values: a maximum mean annual sedimentation rate of 3 mg/cm^2/day, and a daily maximum of 15 mg/cm^2/day, which approximate the impact zones described above.

Figure 2-9 shows the location of these zones and reef environments. The Zone of High Impact and Zone of Low to Moderate Impact does not intersect with any known reefs. On this basis, no impacts to reefs are expected.

Seagrass

Soft sediment habitats in the study area represent depositional environment and therefore biota here (i.e. seagrass, soft sediment benthic fauna) have adaptations that allow them to cope with sediment deposition. Erftemeijer *et al.* (2006) reviewed case-studies describing seagrass tolerances to sediment deposition and found the following critical thresholds for seagrass species and genera found in the study area:

- *Cymodocea serrulata* – 130 mm/year (Philippines)
- *Halophila ovalis* – 20 mm/year (Philippines)
- *Zostera noltii* - - 20 mm/year (Spain).

Notwithstanding the above, seagrass responses to sediment deposition are complex. For example, *Halophila ovalis* was found to show an opportunistic growth in plots receiving 40–80 mm of sediment, reaching shoot densities greater than control plots, i.e. increased growth with higher sedimentation (Duarte *et al.* 1997). Burial of *Cymodocea nodosa* with 50 mm of sediment resulted in 90% mortality after 35 days, although some individual shoots were able to survive burial as great as 60 mm (Marba and Duarte 1994 in Erftemeijer *et al.* (2006). Sediment type and ambient light conditions also strongly influence seagrass responses to sediment deposition (Erftemeijer *et al.* 2006).

There is also currently limited data available on sediment deposition thresholds for seagrasses found in turbid depositional environments along the tropical east coast of Australia. Literature values developed by DHI (in Chevron 2010) for a dredging project in north west Australia were considered in the context of sediment deposition results shown in Figure 2-7:

- Zone of High Impact: median (50th percentile) greater than 70 mg/cm^2/day (>25 mm/14 days)[2]

[2] 100 mg/cm^2 is approximately equivalent to 1-3 mm depth, depending on density of material

- Zone of Low to Moderate impact: median (50th percentile) 20 – 70 mg/cm^2/day (7-25 mm/14 days)

Sediment deposition rates shown in Figure 2-7 (median – 50th percentile) are well below the DHI (in Chevron 2010) Zone of High Impact threshold, except in the dredge channel, which does not presently support seagrass. It would be expected that any seagrass that establishes in dredge channel would be directly impacted (removed) by dredging. Seabed areas outside the dredge channel are predicted to have a 50th percentile sediment deposition value <10 mg/cm^2/day, which is less than the threshold for the Zone of Low to Moderate Impact in DHI (in Chevron 2010). Existing seagrass meadows areas outside the channel are predicted to occur within the Zone of Influence.

It should be noted that it is difficult to determine the degree to which sedimentation alone contributes to physiological stress in seagrass. Sedimentation often occurs in areas also (and simultaneously) impacted by elevated turbidity (Erftemeijer *et al.* 2006). This means that when combined with elevated turbidity levels, sediment deposition could result in cumulative stress to seagrasses, particularly during periods when seagrasses are less likely to adapt to sedimentation rates (e.g. autumn-winter). Similar to reduced light levels, this stress could result in localised effects to existing established seagrasses, or a range of other community changes symptomatic of stress (reduced shoot height, above ground biomass, etc.). On this basis, it has been conservatively assumed that localised, measurable effects could potentially occur to existing seagrass meadows close to the channel in response to higher turbidity and sediment deposition.

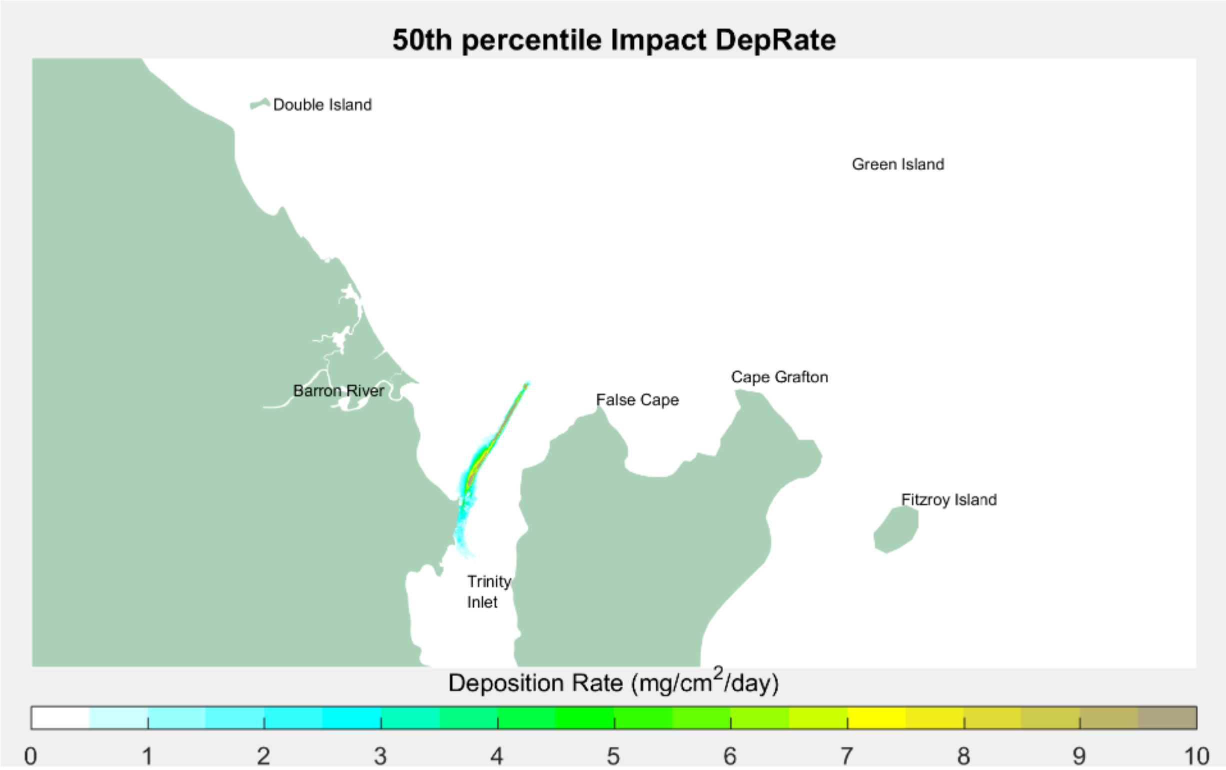
Soft Sediment Benthos

Much of the study area is largely a depositional environment. This is particularly true for Trinity Inlet which lacks major fluvial (riverine) flows to drive scour, and is somewhat protected from wave activity. Rather, near shore sediment transport processes throughout the broader study area are largely driven by inputs from the Barron River and associated interactions with wave action along the more exposed coastline to the north of Cairns harbour. Further offshore in the vicinity of the offshore DMPAs, marine beds are stable and exhibit little re-suspension. From an ecological perspective, this indicates that marine habitats are prone to sediment deposition near shore, while offshore sedimentary habitats are generally more stable.

Most benthic infauna species are capable of burrowing at least short distances through sediments, and therefore, have low sensitivity to low levels of sediment deposition. Some highly localised smothering of fauna with limited locomotory capacity could occur directly adjacent to the dredge site. However for most species, the rates of deposition would be minor compared to the ability of fauna to move through sediments, particularly when deposition is considered incrementally over the duration of the anticipated 10 week dredging program.

Low to medium density epifauna communities have been recorded on soft sediment habitats within the predicted moderate to high impact zones. These communities are comprised mainly of filter feeding fauna (e.g. sea pens, feather stars, sponges) and fauna that entrap their prey (some soft corals). At sub-lethal levels of suspended sediment concentrations, some filter-feeders may benefit from the larger amount of suspended organic matter (i.e. food resources) contained within the dredged material, or released from benthic substrates disturbed by the dredger. It is unlikely that suspended sediment concentrations will reach levels that lead to interference or blocking of the respiratory and feeding structures of these animals. For minor, sub-lethal rates of deposition, many filter feeding fauna are also able to actively self-clean parts of their body prone to trapping unwanted non-food particles. If individuals of these sessile epifauna are very small (recently settled juveniles less than the cumulative deposition depth for a given area, say 15 mm in the Zone of High Impact) they could be smothered, which could lead to stress or mortality. As much of the area within the predicted impact zones is considered to be representative of stable to depositional environments, it is expected that most benthic fauna would be well adapted for coping within the sedimentation rates predicted. The exception to this would be any very small bodied sessile fauna occurring within a Zone of High Impact, which corresponds mostly with the direct impact within the channel footprint.

Based on the predicted low to moderate sedimentation rates over the duration of the dredge program, together with the density and composition of existing benthic communities, sedimentation is expected to result in minor impacts to benthic communities. Most of this impact would be confined to locations within the Zone of High Impact and, to a lesser extent the Zone of Moderate Impact. Note that high sediment deposition is expected to occur in close proximity to areas that already undergo maintenance dredging (existing outer channel), where fauna are already exposed to comparable sedimentation rates from ambient hydrological, coastal process and periodic existing maintenance dredging works.



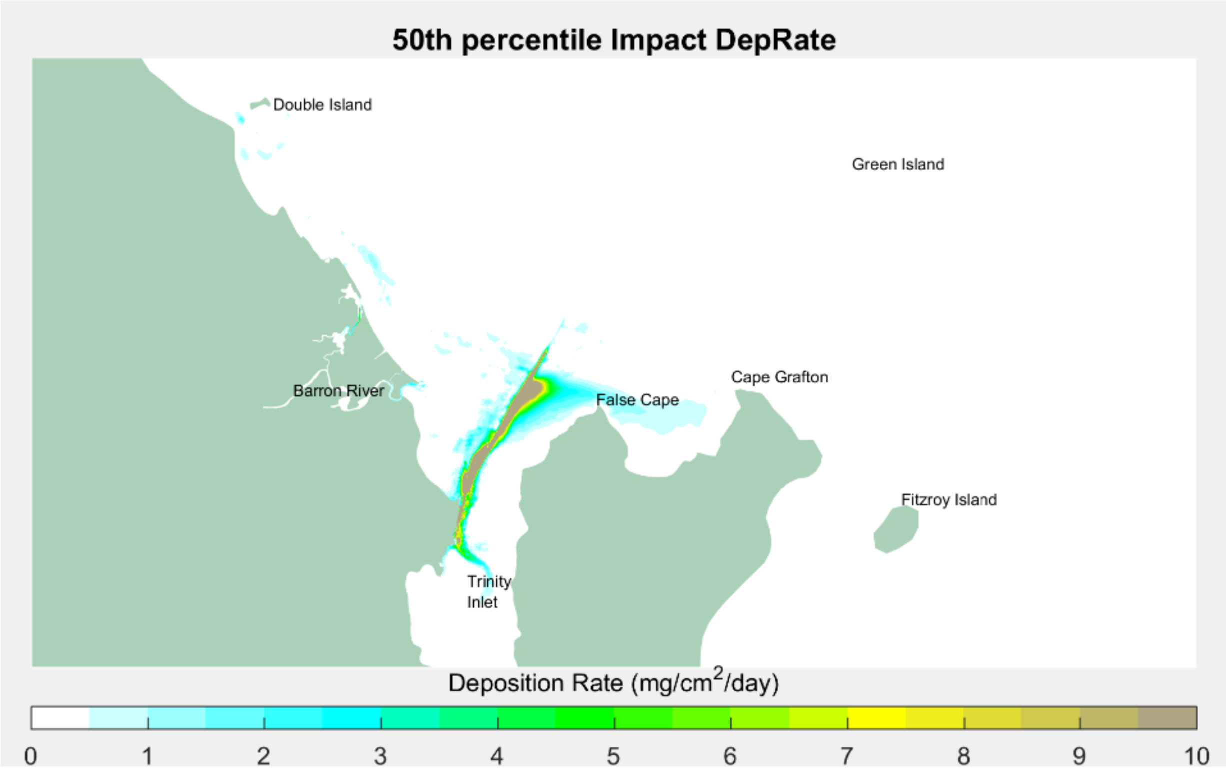
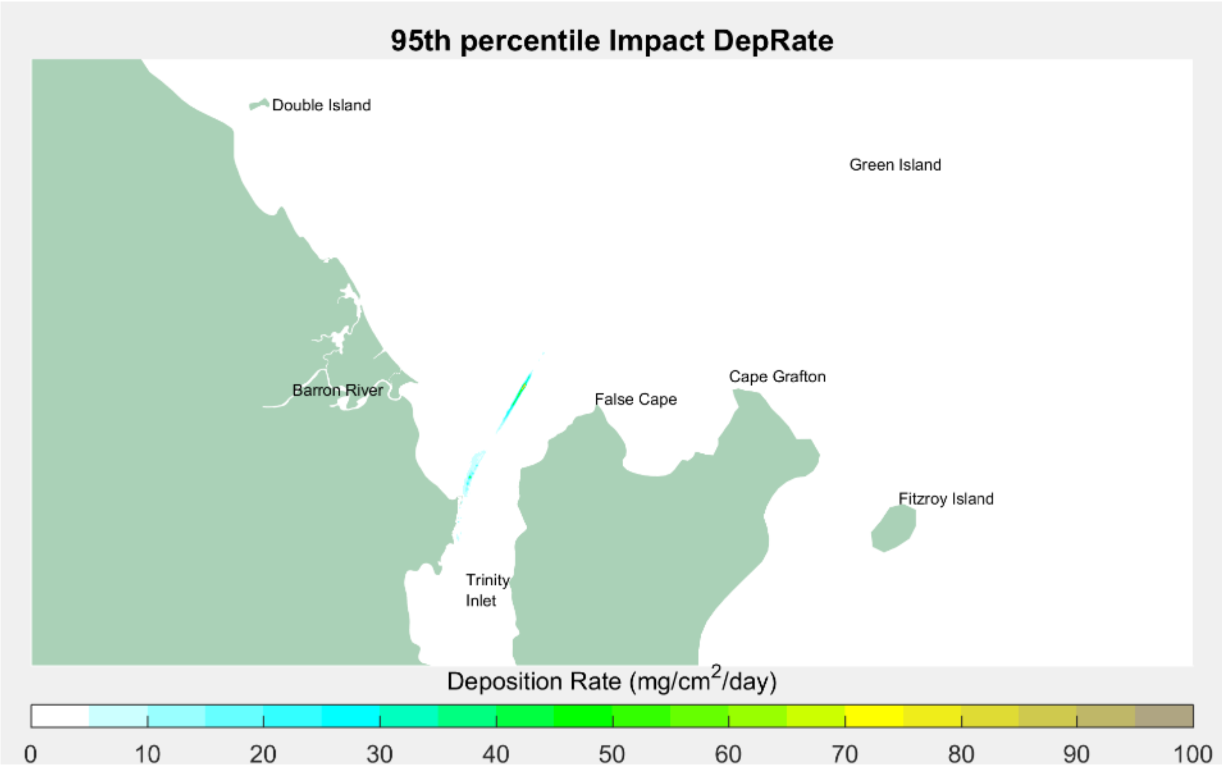


Figure 2-7 Impact of Dredging on 50th percentile deposition rate under the likely best case scenario (above); and likely worst case scenario (below) (Scale: 2 to 10 mg/cm^2/day)



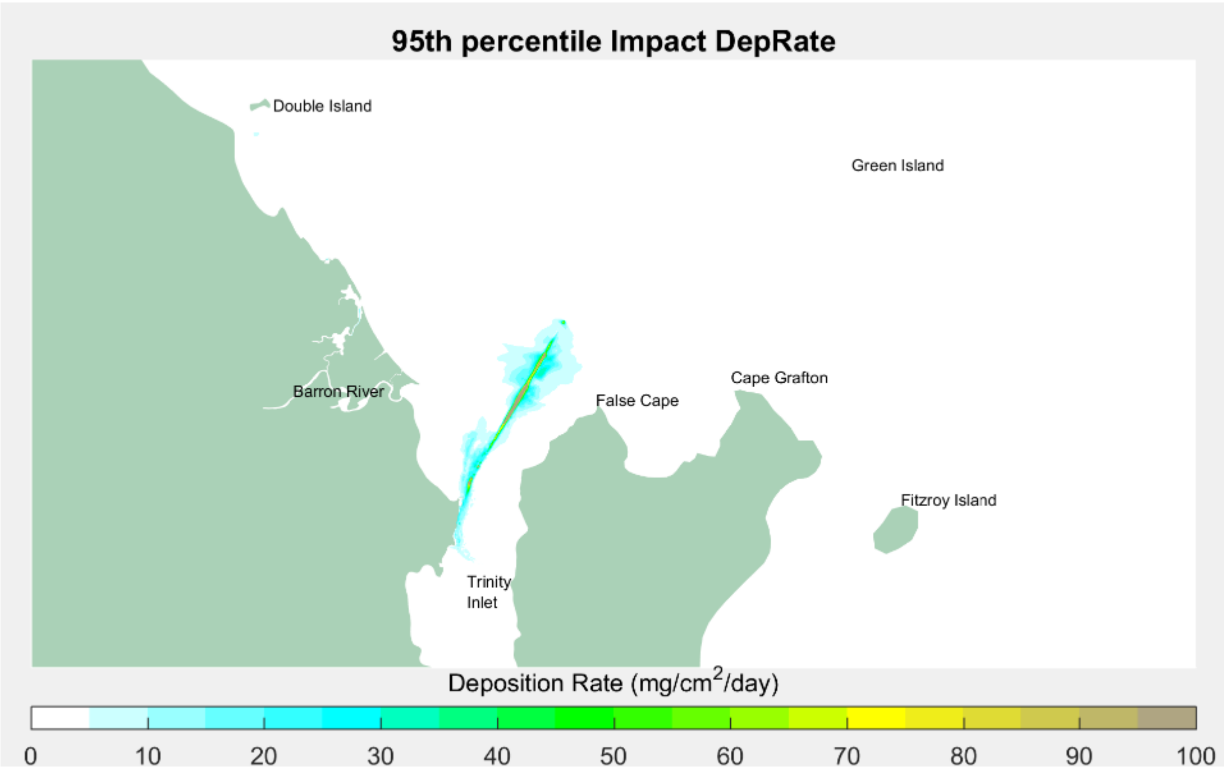
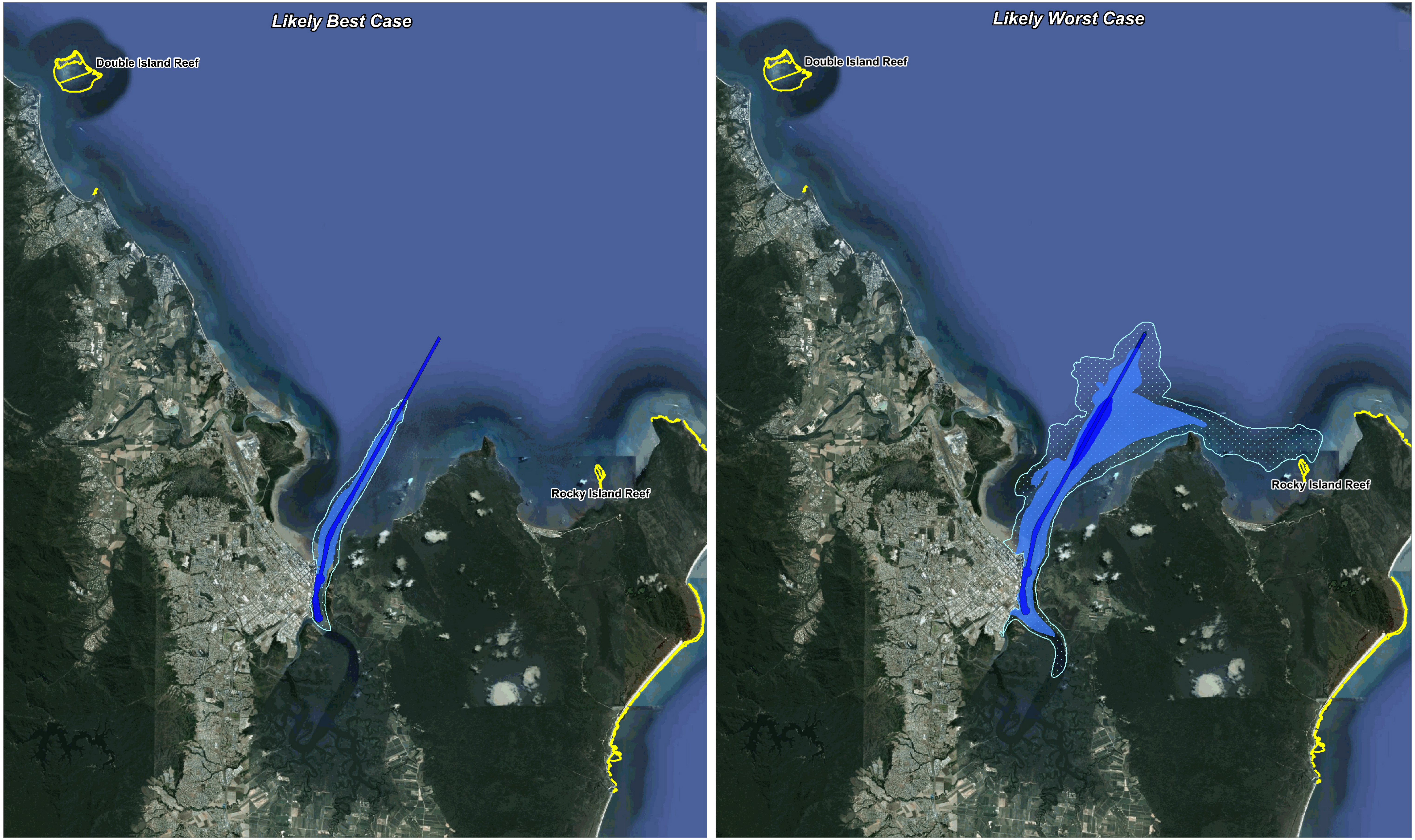


Figure 2-8 Impact of Dredging on 95th percentile deposition rate under the likely best case scenario (above); and likely worst case scenario (below) (Scale: 2 to 10 mg/cm^2/day)



LEGEND

Coral Reefs

Zones of Impact

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Title:

Zones of Impact (Corals) - Sediment Deposition Likely Best Case (left) and Likely Worst Case (right)

Figure: 2-9

Rev: A

N

0 km 5 10

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath: I:\B22074.I.Cairns EIS Update\DRG\WQU_011a_170523_Sediment Deposition_corals.wor

2.4.2 Maintenance Dredging

Future maintenance dredging will be required to ensure that the dredge footprint remains at the required depths for safe navigation of ships. Compared to capital dredging, much smaller volumes of material are involved in maintenance dredging and the timeframes over which dredging will occur will be shorter. At the outer channel an increase in annual maintenance dredging volume in the order of 2-6% per year is expected, while the existing annual maintenance dredging volume for the inner port is not likely to change significantly. Current channel maintenance dredging campaigns typically occur during the months of July to October and generally take about three-four weeks to complete. In some cases following large wet seasons split campaigns are undertaken with an earlier one-two weeks dredging in May-June. The additional volume associated with the expanded channel will likely extend these campaigns to a period of four-five weeks.

The frequency and duration of turbidity impacts from future maintenance are likely to be similar in nature to those presented above for capital dredging; albeit occurring over a much smaller duration each year, which limits the amount of material available for re-suspension. The Marine Water Quality Chapter of the EIS details potential impacts to water quality from maintenance dredging, utilising actual water quality monitoring data collected over a 12-month period for this EIS (including during annual maintenance dredging in 2013).

Impacts from maintenance dredging are considered to be localised and relatively short term with limited increases in turbidity adjacent to sensitive environments. Furthermore, impacts on sensitive receptors from maintenance dredging has been assessed previously (Environment North, 2005 and Worley Parsons, 2010) and considered acceptable to regulatory agencies (as outlined in the Ports North 10 year maintenance dredging permit and LTMP).

Based on the assessment presented in the Marine Water Quality Chapter of the EIS, turbid plumes from future maintenance dredging are considered to pose a minor impact to marine water quality. Flow on effects to flora, fauna and other marine ecology values, as a result of both water quality and sediment deposition effects, are likewise considered to minor.

Similar to the assessment presented above for capital dredging impacts on benthic habitats in Section 2.3.1.3, marine ecology impacts associated with dredged material placement at the offshore DMPA will cause a temporary loss of biota from surficial sediments, since benthic communities typically inhabit the top 30 cm of the seabed. However, biota will soon recolonise the dredge footprint (Neil *et al.* 2003, Worley Parsons, 2009) and will continue to be regularly subject to similar disturbance through the ongoing annual maintenance placement regime.

2.5 Tailwater Release from Northern Sands DMPA

2.5.1 Physico-chemical Changes

This section examines the potential effects of tailwater release on marine fauna and flora in the Barron River and Richters /Thomatis Creek (henceforth referred to as Richters Creek). The tailwater release simulation consisted of a constant release of turbid seawater (100 mg/L TSS or 60 NTU, at 35 PSU [3]) over 8 weeks of dewatering at 1 m^3 per second. While sedimentation impacts are not

[3] PSU = Practical Salinity Units which is the same as parts per thousand (ppt)

expected given these proposed release parameters, the discharge of this water and subsequent changes in water quality have the potential to impact:

- Benthic invertebrates and fish communities though turbidity and salinity impacts;
- Seagrasses through changes in turbidity; and
- Riparian vegetation through increases in salinity.

The water quality regime of the Barron River was examined over the 12 month instrument deployment period. Water quality data from this deployment shows that the lower Barron River can fluctuate from a fully saline system approaching 36 PSU to being completely fresh after heavy rainfall and associated flood event. The salinity regime is affected mostly by tides and rainfall with large high tides and low rainfall resulting in the highest salinity, and heavy rainfall induced flood event and neap tides resulting in the lowest salinities. Moderate rainfall conditions result in a freshwater upper layer, undermined by a salt wedge, which exists beneath the fresher upper layers due to the salt water being heavier (denser). During very high flow conditions, this stratification in salinity breaks down and fresh water occurs through the entire water column. The modelled peak (99^{th} percentile) ambient salinity and the median salinity for the Barron River and Richters Creek are shown in Figure 2-10. These plots show that the downstream reach becomes equivalent to seawater for brief periods throughout the year, while most of the time there is a salinity gradient where the upstream model extent is 0 PSU, grading to 6-10 PSU by the Richters Creek confluence, reaching 25 PSU at the highway crossing and increasing to seawater salinities (35 PSU) at the Barron River mouth.

Ambient turbidity is also relatively high within the Barron River and Richters Creek. The respective measured median turbidity for the Barron River and Richters Creek was 18.2 and 19.2 NTU, 80^{th} percentile turbidity was 74.4 and 29.8NTU, and maximum recorded turbidity was 508.9 and 346.2 NTU. The modelled peak (99^{th} percentile) ambient turbidity and median turbidity for the Barron River and Richters Creek are shown in Figure 2-11. These plots show that the downstream reach is moderately turbid for most of the year and turbidity can reach 50 NTU during major wave-driven resuspension conditions.

The modelled increases in median (50^{th} percentile) salinity from tailwater releases show that the upstream release point (discharge A) results in up to 3 PSU difference in median surface salinity within 400 m of the release point, and a change of 2 PSU within 2 km upstream of the release point, with very little difference in salinity observed beyond these distances (<1 PSU) (Figure 2-12). The tailwater release point on the Bruce Highway (discharge B) results in up to 2 PSU difference within a kilometre of the release point. The change in salinity appears smaller at the downstream release point because the ambient environment is naturally more saline, being further downstream. The relative changes in percentile salinity are very similar in the 99^{th} percentile case; however, the majority of the changes occur farther upstream (Figure 2-13).

Modelled increases in median turbidity and show that both release points alter ambient turbidity by approximately 5 NTU at the release point, grading down to 2 NTU within several hundred meters of the release point, to decreasing to 0 NTU within a kilometre. The downstream release point TW2 has a greater impact on downstream turbidity, while the upstream TW1 release point shows a greater increase in upstream turbidity. Turbidity plumes from either release point do not reach the mouth of the Barron.

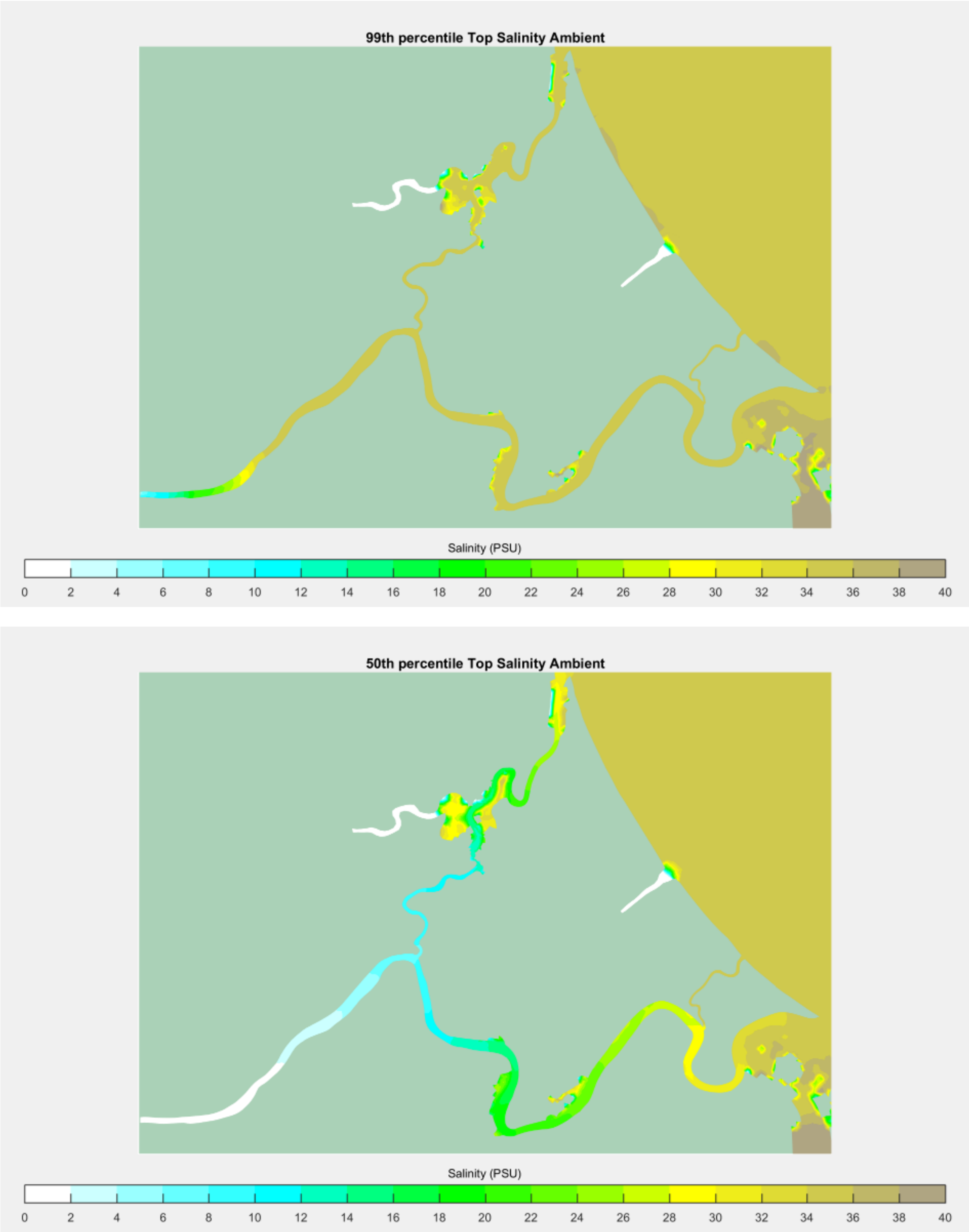


Figure 2-10 99th percentile of modelled ambient salinity (without tailwater discharge) (above); and 50th percentile modelled ambient salinity (without tailwater discharge) (below)

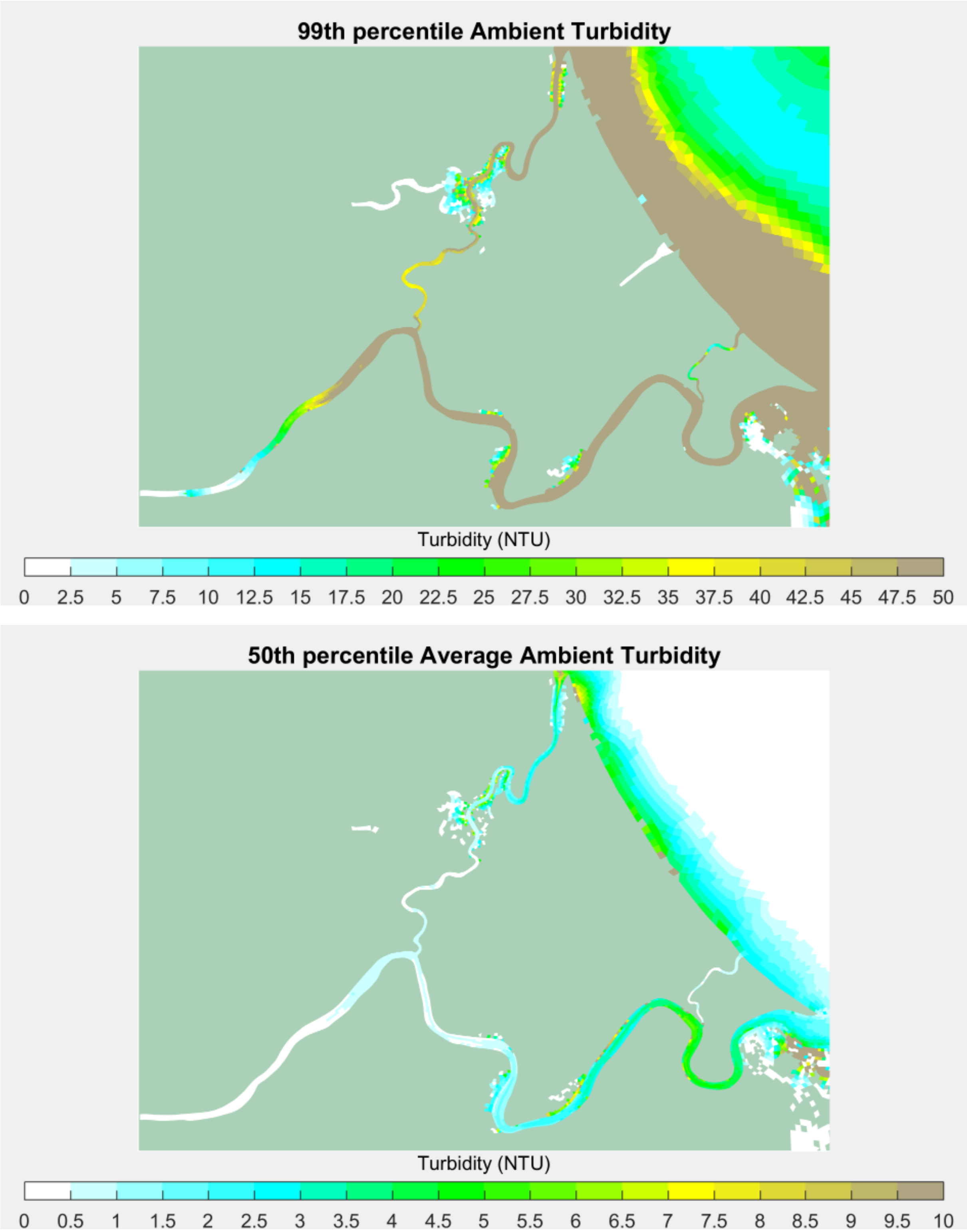
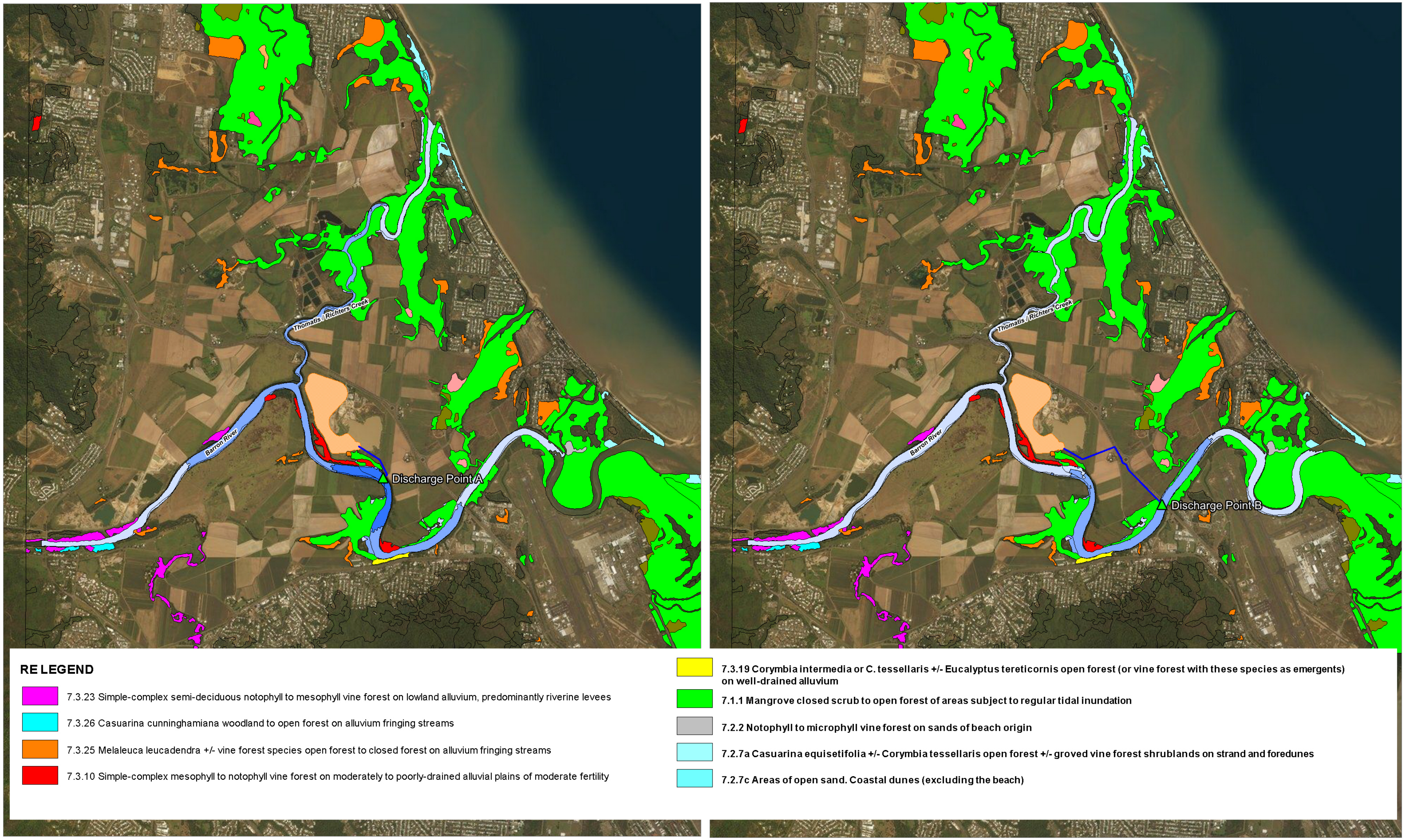


Figure 2-11 99th percentile of modelled ambient turbidity (without tailwater discharge) (above); and 50th percentile modelled turbidity (without tailwater discharge) (below)



LEGEND

Northern Sands DMPA

Tailwater Discharge Point

Change to 50%ile Ambient Salinity (ppt)

- 0 to 1
- 1 to 2
- 2 to 3
- 3 to 4

Title:
Tailwater Discharge - Salinity Impacts - 50%ile Discharge Point A (left) and Discharge Point B (right)

Figure: **2-12**

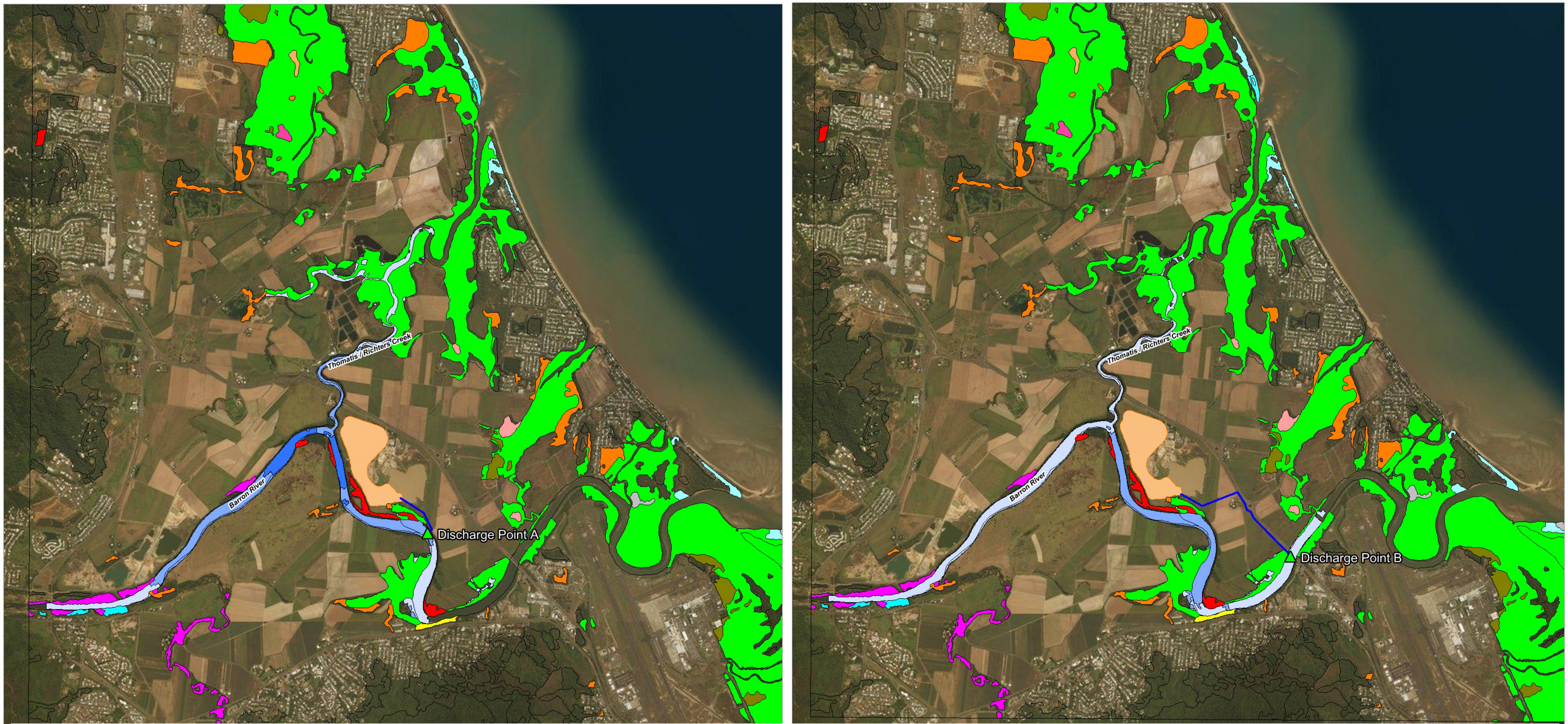
Rev: **A**

N

0 450 900m
Approx.Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B22074.I.Cairns EIS Update\DRG\ECO_014_170516_Riparian_50pc_Salinity.wor



RE LEGEND

- 7.3.23 Simple-complex semi-deciduous notophyll to mesophyll vine forest on lowland alluvium, predominantly riverine levees
- 7.3.26 Casuarina cunninghamiana woodland to open forest on alluvium fringing streams
- 7.3.25 Melaleuca leucadendra +/- vine forest species open forest to closed forest on alluvium fringing streams
- 7.3.10 Simple-complex mesophyll to notophyll vine forest on moderately to poorly-drained alluvial plains of moderate fertility
- 7.3.19 Corymbia intermedia or C. tessellaris +/- Eucalyptus tereticornis open forest (or vine forest with these species as emergents) on well-drained alluvium
- **7.1.1 Mangrove closed scrub to open forest of areas subject to regular tidal inundation**
- **7.2.2 Notophyll to microphyll vine forest on sands of beach origin**
- **7.2.7a Casuarina equisetifolia +/- Corymbia tessellaris open forest +/- groved vine forest shrublands on strand and foredunes**
- **7.2.7c Areas of open sand. Coastal dunes (excluding the beach)**

LEGEND

- Northern Sands DMPA
- Tailwater Discharge Point

Change to 99%ile Ambient Salinity (ppt)

- 0 to 1
- 1 to 2
- 2 to 3
- 3 to 4

Title:

Tailwater Discharge - Salinity Impacts - 99%ile Discharge Point A (left) and Discharge Point B (right)

Figure: **2-13**

Rev: **A**

N

0 450 900m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

Filepath: I:\B22074.I.Cairns EIS Update\DRG\ECO_015_170516_Riparian_99pc_Salinity.wor

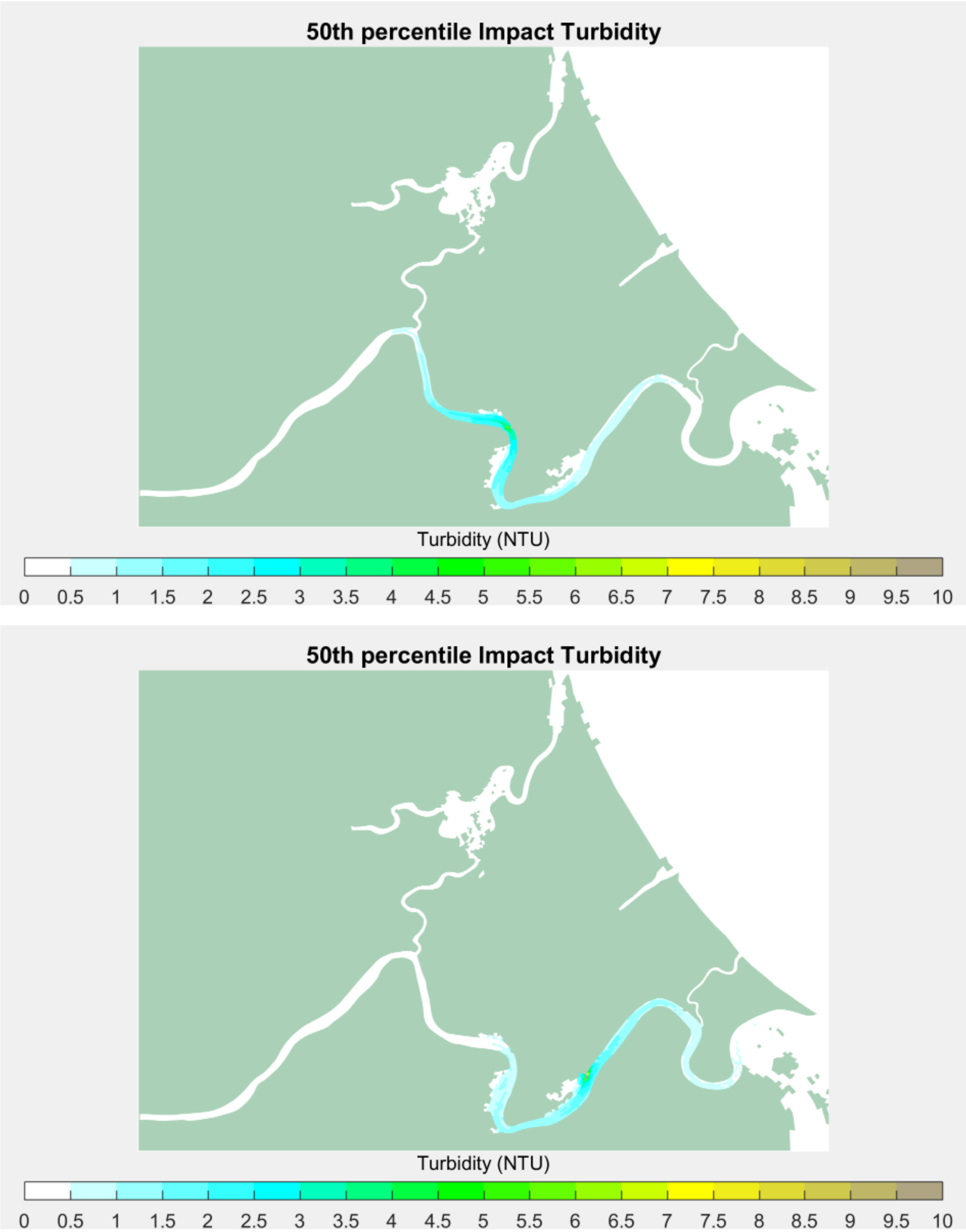


Figure 2-14 50th percentile increase in turbidity at discharge point A (above) and at discharge point B (below)

2.5.2 Turbidity Effects to Biota

As discussed in Section 2.4.1.1, high concentrations of suspended solids can impact the physiology of fish and invertebrates, and alter the behaviour of many species. The turbidity impact predicted here are well within the range of natural variation observed in the 12 month data set collected for the EIS. If conducted in the dry season, the impacts of either tailwater discharge point are not expected to push concentrations beyond the Water Quality Objective value of 10 NTU to protect slightly-moderately disturbed ecosystems. The dry season median for the Barron River / Richters Creek confluence was 4.8 NTU and additional median turbidity impacts are less than 5 NTU for the all of the Barron except within the immediate vicinity of the discharge. On this basis, significant impacts to benthic marine invertebrates or species of commercial fisheries significance are not expected.

2.5.3 Effects of Salinity

Alterations in salinity from tailwater discharges pose a potential threat to riparian communities. This assessment was based on the 2015 Remnant Regional Ecosystem (RE) Mapping (V10) and the information presented in the EIS. RE types that form part of the riparian fringe over these creeks include:

- 7.3.23 Simple-complex semi-deciduous notophyll to mesophyll vine forest on lowland alluvium, predominantly riverine levees (Endangered under the VM Act)
- 7.3.26 *Casuarina cunninghamiana* woodland to open forest on alluvium fringing streams (Endangered under the VM Act)
- 7.3.25 *Melaleuca leucadendra* +/- vine forest species open forest to closed forest on alluvium fringing streams (Of Concern under the VM Act)
- 7.3.10 Simple-complex mesophyll to notophyll vine forest on moderately to poorly-drained alluvial plains of moderate fertility (Of Concern under the VM Act)
- 7.3.19 *Corymbia intermedia* or *C. tessellaris* +/- *Eucalyptus tereticornis* open forest (or vine forest with these species as emergents) on well-drained alluvium (Of Concern under the VM Act)
- 7.1.1 Mangrove closed scrub to open forest of areas subject to regular tidal inundation (Least concern under the VM Act)
- 7.2.2 Notophyll to microphyll vine forest on sands of beach origin (Endangered under the VM Act / Listed as Critically Endangered Littoral rainforest and coastal vine thickets of eastern Australia under the EPBC Act)
- 7.2.7a *Casuarina equisetifolia* +/- *Corymbia tessellaris* open forest +/- groved vine forest shrublands on strand and foredunes (Endangered under the VM Act)
- 7.2.7c Areas of open sand. Coastal dunes (excluding the beach) (Endangered under the VM Act).

RE 7.1.1 (mangroves) is marine adapted vegetation and regularly experiences salinities beyond the likely change resulting from tailwater discharge and is not considered further.

RE’s 7.2.2, and 7.2.7a, occur on beach ridges and sand dunes and depend on fresh groundwater which will not be impacted by increased salinities in the Barron River and Richters Creek. The ecological values of non-vegetated coastal sand dunes (RE7.2.7c) will not be impacted by salinity levels in these waterways.

The remaining RE's occur on the alluvial floodplain and may be sensitive to elevated salinity in available water sources. However, salinity increase within the waterways is not expected to impact these riparian communities which would depend on fresh groundwater and overland flow. The current salinity regime of the water column in the vicinity of these riparian communities approaches seawater (35 PSU) during very dry periods. The expected increase in salinity, in the chronic and the acute cases, will not expose the water column, or riparian communities, to higher salinities than what already occurs. Although the changes in water column salinity associated with tailwater release occur in the vicinity of these remnant patches (Figure 2-12 and Figure 2-13) salinity elevations are minor with a change of only 1-2 PSU expected in the 99th percentile case for the discharge A site, and a change of 0-1 PSU expected from discharge site B, and will not impact on these riparian communities.

In the median (50th percentile) case, a similar magnitude of salinity change is expected with 1-2 PSU expected for the discharge A site around the Richters Creek confluence, and a change of 0-1 PSU expected surrounding discharge site B.

The highest increase in surface salinity concentrations occurs around the confluence with Richters Creek. However, very little of this water enters the Richters Creek system and salinity impacts in this reach are not expected in either scenario. In the 99th percentile case, increasing the salinity of the Barron in the vicinity of the Richters Creek entrance from 33 to 35 PSU is not expected to affect riparian communities.

Based on the existing salinity regime and likely changes to surface salinity, impacts are not expected to riparian communities from saline tailwater discharge. Increases in salinity are not expected to impact benthic fauna communities as they regularly experience full seawater salinity conditions, and increasing richness and abundance with salinity has been observed previously.

Furthermore, as dredging and tailwater discharges are proposed to occur during the dry season when there are less freshwater flows, ambient salinity would be expected to be higher. Tailwater salinity would therefore be likely to have less impact during this period.

The effects of groundwater salinity on vegetation surrounding the Northern Sands DMPA are considered in the EIS.

2.5.4 Effects on Seagrasses

There are currently no seagrass meadows present at the mouth of the Barron River, but meadows have been found there historically (Figure 2-1). Neither of simulated release points result in turbid plumes that reach the historical boundary of this seagrass layer. Therefore, impacts to seagrass (which have not been mapped recently but could be in an early colonising state) are not expected.

2.6 Interactions between Marine Fauna and Vessels

This section examines the potential for interactions between marine fauna and vessels including dredge plant, and associated ecological effects. While invertebrates and fish are mentioned, discussion focuses on marine megafauna species, particularly threatened or otherwise listed species of conservation significance (MNES).

For capital dredging, it is anticipated that the following dredge plant will be required:

- At least one medium-sized trailing suction hopper dredge (TSHD)
- Backhoe dredger (BHD) and bed leveller
- Work boats/survey boat (discussed below in next section).

Interactions between such vessels and marine fauna may arise during capital dredging or maintenance dredging by way of one or more of the following mechanisms:

- Direct contact or obstruction of fauna passage
- Emissions of artificial noise from the dredger
- Entrainment of fauna at the dredge head
- Emissions of artificial light during night dredging works and from navigation lighting on the dredge pump-out.

The ongoing operation of the wharf will facilitate an increase in the size and frequency of ship traffic to the CCLT, which will increase the underwater noise and artificial lighting sourced from such vessels, and the potential for direct interactions with marine fauna. Note that such vessels frequent the broader study area but that some of the larger cruise ships are unable to approach the existing port facilities. Rather, large cruise ships currently moor off Yorkeys Knob and ferry passengers by tender to the mainland. This means that impacts relating to interactions between these vessels and marine fauna, essentially relate to a shift in the location of such interactions (i.e. from Yorkeys Knob to the outer channel and inner port), as well as any anticipated increase in cruise ship movements.

Cruise ships (because of their large size and slow speeds) do not present a high risk to marine fauna, except for whales in open sea areas. There will be an increase in cruise ship movements irrespective of the project (noting the new infrastructure only relates to an additional 30 or so ship calls under the high growth scenario). Broader shipping movement in and out of the Reef area is currently being managed under the North-East Shipping Management Plan (AMSA). It is noted that an increase in cruise ships berthing at Trinity Wharves (as opposed to Yorkeys) could increase the risk of interaction with marine fauna, however the shipping channel and inner port are not important habitat for turtles, dolphins and dugong and these large vessels present a low risk to these species.

2.6.1.1 Direct Interactions between Marine Fauna and Vessels or Dredge Plant

When operating any kind of vessel in marine waters, there is a potential risk of fauna vessel strike, primarily for mobile megafauna that swim near the surface and/or frequent the surface to breath, such as whales, dolphins, dugongs and turtles. Interactions may also occur if the presence of a vessel obstructs fauna passage, which may occur if the presence of a vessel deters an animal from continuing along an intended path of passage, or is inclined to detour significantly around a vessel to reach an intended destination (i.e. avoidance behaviour – discussed further below with respect to potential noise effects).

Large vessels currently operate within the study area, including, the TSHD dredger for annual maintenance dredging and large cruise vessels which moor approximately 4 km offshore from Yorkeys Knob. Smaller vessel movements (commercial charters, recreational, small cruise vessels) regularly occur throughout the study area. The large vessels specifically associated with this project would represent a small proportion of the total number of boat movements expected to occur over the duration of capital or operational works. However, while large vessels are slow-moving and provide marine fauna time to evade the approaching vessel, they also typically have large powerful propellers and a lower draft. This means that if an animal does not move out of the vessel path, there is a greater risk of severe injury or mortality. In the event that such interactions occur, they would generally occur at locations within the footprint and associated vessel movement paths.

Given marine megafauna prone to vessel strike (turtles, dugongs, cetaceans) occur within the study area, and that these fauna are afforded a high conservation value (MNES), mitigation measures are proposed in Section 3.5 to reduce the risk of impacts to marine megafauna.

In terms of entrainment, it is possible for the suction at the dredge head to entrain fauna, potentially resulting in fauna injury or mortality. Of the marine megafauna, turtles are the group most likely to be affected by this process. Turtles are highly mobile and will tend to avoid the dredger, typically returning to the surface to breathe every few minutes.

However, they can remain underwater for as long as two hours without breathing when they are resting. Dr Col Limpus suggests that sea turtles can use shipping channels as resting or shelter areas, and that there are recorded incidences of turtles being injured by trailer suction hopper type dredgers. GHD (2005), citing personal communication from Dr Limpus, suggest that the numbers of turtles captured during dredging across all Queensland Ports is decreasing, with an average of 1.7 loggerhead turtles per year. Furthermore, it was suggested that current research indicates the impact of dredging on the overall viability of turtle populations is very low compared to the numbers killed by vessel strikes, trawling, fishing, ingestion of marine debris and indigenous hunting. No incidents between dredgers and turtles have been reported in Cairns for the past 10 years, and the potential for such is considered very low. Maintenance dredging with the TSHD Brisbane over this period has incorporated turtle deflection devices and the exclusion practices noted below.

Given the relatively low numbers of turtles impacted by dredgers compared to other activities, and the use of effective management and operational practices to reduce the potential for turtle capture, it is considered that the proposed dredging will have a negligible consequence on turtle populations in the study area. Other megafauna species (e.g. cetaceans, whales and dugong, etc.) are not considered to be prone to dredge entrainment and will not be impacted by such interactions. Best practice dredging equipment, techniques and management will be used to further reduce risks to turtles (see below).

2.6.1.2 Indirect Interactions between Marine Fauna and Vessels

Lighting

When vessels or navigation lights are operated at night, their on-board lighting systems will generate light emissions to the marine environment. Marine turtles are particularly sensitive to artificial lighting as they may become disorientated during nesting and hatching (Witherington 1992). However, no turtle nesting areas exist in close proximity to the dredge operations or at the inner port, and there is a low incidence of turtle nesting elsewhere in the harbour (i.e. in sight of the outer channel). Further, in the unlikely event that light from project-related vessels or dredge pump-out facilities can be detected by emerging hatchlings during either project construction or operation, the seaward position of such lighting at all times does not pose a risk for guiding hatchlings landward. In this respect, land-derived lighting such as those at the port or throughout Cairns City presents a significantly greater lighting attraction risk for marine fauna. Artificial light is not known to have a major effect on foraging patterns of turtles, dolphins or dugongs.

Mitigation strategies will be implemented to further reduce potential impacts (see below).

Noise

The production and reception of particular sounds are important to many marine fauna species, particularly marine mammals. Both natural and anthropogenic sounds have the potential to interfere with various biological functions. During construction, noise generated by dredging has the potential to adversely affect megafauna as it will form a persistent source of underwater noise that will continue (intermittently) for the duration of dredging works. Such noise may be generated by mechanical means (vessels engines, dredge gear, propellers and other machinery), or by water movements on the vessel hull. While dredger generated noise is normally unlikely to occur at levels that could cause acute hearing damage to marine fauna, it may cause subtle but possibly more widespread increases to ambient noise levels. This may include for example, masking of biologically important sounds (e.g. vocalisations), interfere with dolphin sonar signals or alter fauna behaviour (i.e. noise avoidance). Similar such effects can be expected during the operational phase of the project when large cruise vessels are approaching or docking at port, or during maintenance dredging campaigns.

Additionally, the floating marine booster pump proposed to be located between the offshore dredge pump-out mooring point and the mouth of Richters Creek will potentially produce noise impacts to marine fauna species. Noise from this marine booster pump is expected to be approximately 115 dBA LAeq (15 minute) for approximately 6 hours per day (6 dredge cycles of 1 hour pumping per cycle) while the dredge is moored and pumping material to shore.

In general, the most likely impact of underwater noise from project-associated vessels for marine megafauna is the temporary avoidance of the offending vessels, marine booster pump and their immediate surrounds. The inner port is known to support inshore dolphin species, while the wider harbour area supports sea turtles, dolphins, whales, dugongs and other threatened and/or migratory marine species at various times; depending on temporal factors such as migration seasons, availability of food resources, etc. The likelihood of acoustic impacts to marine fauna occurring would depend on whether these fauna are present at the time of vessel operation, the number of animals present and their proximity to the underwater noise source.

If present in or near the dredge footprint during dredge or cruise vessel operation, turtles may exhibit a different response to noise than marine mammals. Turtles often remain stationary for long periods, feeding and resting. GHD (2011) observed turtles exhibiting negligible response in close proximity to marine piling operations and, based on this observation, suggested that it cannot be assumed that turtles will voluntarily move away from adverse vessel/dredge noise effects.

The Noise and Vibration Chapter of the EIS details the ambient underwater noise conditions of the study area and associated impacts predicted to result from construction and operations during the life of the project. While information on the effects of noise on marine fauna in an Australian context is extremely limited, dredging is predicted to have negligible impact on marine mammals and dugongs, primarily restricted to localised behavioural changes within ~100-200 m of the dredge. Hearing damage would only be expected if animals remain in the vicinity (~10 m of the dredge) for prolonged periods, which is considered extremely unlikely to occur. For underwater noise associated with shipping, effects to marine fauna are expected to be negligible since similar noise sources currently occur in the study area and localised behavioural changes (avoidance) are considered the most likely effect.

As discussed below, mitigation measures will be implemented to further reduce the risk of vessel related noise effects.

2.7 Acoustic Effects to Marine Fauna from Wharf Upgrade Works

2.7.1.1 Underwater Noise during Wharf Upgrade

The Noise and Vibration Chapter of the EIS describes noise and vibration impacts on fish and marine mammals.

For the wharf upgrade works, underwater noise will result from multiple sources, of which the most chronic will be repeated pulsed inputs from driving the 84 racking steel piles during construction. Noise will also be generated directly from general wharf construction work, as well as through the operation of construction vessels. It is envisaged that the piles will be driven from a barge, by a piling rig with crane and hammer.

Section 2.6.1.2 (above) describes the general impacts that could occur from interactions between marine fauna and anthropogenic underwater noise. Fish deaths have also occasionally been reported in close proximity to piling as physical damage can occur to non-auditory tissue (e.g. vascular tissue) or air-filled cavities such as swim bladders.

As described Chapter B10, Noise and Vibration, piling activities during the wharf upgrade works are predicted to result in localised fish mortality within the immediate vicinity (~one-three metres) of the piling rig and behavioural changes (avoidance) expected at distances within one km of the piling rig.

Piling noise is expected to potentially result in hearing damage to marine mammals in the immediate vicinity of the piling rig (up to ~10 m). Although behavioural changes (avoidance) are expected, these are predicted to be limited to within up to ~500 m of the piling rig. Overall, any piling related noise effects to marine megafauna are considered to be temporary (for the duration of construction works) and minimal in the context of the existing noise regime of the area.

2.8 Other Indirect Interactions between Vessels and Marine Receptors

2.8.1.1 Potential for Marine Pest Introductions

There is a risk that dredging plant (construction stage) and other vessels (operational stage) could translocate introduced marine pests from the port of origin to the Port of Cairns. Few marine pest outbreaks (and eradication operations) have occurred at the Port of Cairns in recent years. While marine pests, if present, could be transported from the dredge or cruise vessels to the local marine environment, the project is not considered to pose a notable risk in terms of the potential of introducing marine pests to the Cairns harbour and surrounds if appropriate biosecurity inspections and management are employed. This is based on the following:

- The study area is not currently known to support populations of marine pests of concern that could be dispersed by the vessels to waters elsewhere.
- The dredge vessel remaining in the study area for the duration of the dredging campaign.
- As part of the Dredge Management Plan, appropriate measures will be in place during construction to reduce the potential for introducing marine pests from the dredger (e.g. compliance with antifouling, hull cleaning and ballast treatment requirements).

- The study area is already regularly visited by dredge plant and international cruise ships, in addition to other international vessel traffic.
- Cairns is a tropical port and tropical ports are generally less prone to marine pest invasion in comparison to ports in the southern temperate waters of Australia (Hilliard and Raaymakers 1997; Hilliard 1999; Hutchings et al. 2002). This is because I) tropical species often have a widespread equatorial distribution, resulting in a higher probability that Cairns is within their natural geographic range; and ii) foreign temperate species used to cooler waters are less likely to survive and establish in warmer tropical waters.

Notwithstanding this, translocation of exotic marine pests into a new environment is potentially an important issue for the Port of Cairns. The environmental and economic impacts due to the introduction of exotic marine pests can be significant. Marine pests, once established, can be difficult to eradicate and can have serious and permanent consequences for the marine environment, marine productivity and public health. While unlikely, the introduction and subsequent establishment of marine pests would be present a moderate consequence from a marine ecology perspective. Marine pest risks will be managed in accordance with standard mitigation procedures discussed in Section (3.6.1).

2.8.2 Exposure of Marine Flora and Fauna to Debris, Spills and Dredging-Borne Contaminants

2.8.2.1 Marine Debris

Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. Construction and operational works will generate large quantities of rubbish which could pose a risk to the marine fauna of the study area if not appropriately managed. In particular, plastic bags and packaging could pose a risk to local marine turtles, whales and fish populations.

A variety of waste management strategies will be employed as part of the environmental management plans developed for this project, to reduce waste generation and the quantity of plastic wastes entering the marine environment.

2.8.2.2 Potential Spills

It is possible that chemical spills would occur on, or from the dredger or other vessels such as cruise vessels, creating the potential for dredge-derived potential contaminants to be introduced to the marine environment. These could include, for example, hydrocarbons or other potential toxicants stored on board. Spills could occur either in the vicinity of the dredge footprint, or while vessels are in port or underway outside the project footprint. In the event that a spill occurs, it may present a toxicity risk to marine flora and fauna. The significance of such an impact is highly variable, depending on factors such as:

- The type of material spilt and its chemical constituents
- The volume and/or load concentration of potential toxicants of concern entering the marine environment
- Climate and tidal conditions at the time of event

- The location and timing of a spill, which can dictate the mixing potential (i.e. concentration reduction), extent of water quality effects, and the likelihood of sensitive receptors occurring in the affected area.

Spills of this nature are considered to be unlikely, and no more likely than typical for other large vessels using the wider study area at any given point in time under existing conditions. Given their localised extent or potentially undetectable effects in the event that they do occur, are considered to represent a low level of impact. Mitigation measures outlined in the Marine Water Quality Chapter B5, in combination with mitigation measures listed in Section 3.6.4, will further reduce the likelihood of such occurrences.

2.8.2.3 Potential Toxicants Mobilised by Dredging and Construction

As discussed in the EIS, marine sediments in the proposed dredging and pile driving areas contain potential contaminants at concentrations (95 percent UCL) that are below NAGD screening levels, and therefore do not pose a toxicity threat. As such, impacts to marine biota from mobilisation of contaminants from the dredging process are expected to be negligible.

Potential acid sulfate soils (PASS) will be managed in the Northern Sands DMPA such that tailwater discharges into the Barron River are at a neutral pH with negligible impacts. Further details on how the PASS will be managed in the Northern Sands DMPA is discussed in the EIS. With appropriate site management, PASS disturbance risk is considered to be negligible.

2.8.3 Summary of Impacts to Marine Fauna

2.8.3.1 Key Impacting Processes Considered for Marine Megafauna

As described in the above sections, the main processes with the potential to impact marine megafauna communities within the study area are:

- Modifications to benthic habitats and associated benthic communities as a i) direct result of dredging in the dredge footprint (Section 2.3), or ii) through water quality and sedimentation effects resulting from turbid plumes (Section 2.4)
- Direct interactions between megafauna and vessels or dredge plant (i.e. entrainment or vessel strike) (Section 2.6.1.1)
- Indirect interactions between megafauna and vessels or pile driving works (i.e. artificial lighting and noise) (Sections 2.6.1.2and 2.7.1.1)
- Potential exposure of megafauna to marine debris (Section 2.8.2).
- In general, the following conclusions are drawn with respect to marine megafauna impacts:
  - Turbid plumes generated by either capital or maintenance dredging and dredged material placement are not expected to result in direct effects to marine megafauna. Some species such as green and hawksbill turtle, which feed on seagrass and/or in reef environments, may avoid areas affected by turbid plumes which will vary in the area affected depending upon dredge operational strategy and climatic conditions. However, it is noted that key foraging habitats for these species (i.e. reefs, notable seagrass beds) do not coincide with the predicted extent of turbidity impact zones.

  - Significant flow-on effects resulting from direct loss or disturbance of benthic habitats are considered unlikely, since benthic habitats within the dredge footprint or pile driving footprint are unlikely to provide critical foraging or other habitat functions for green turtles and dugongs (particularly since seagrass in these areas is absent or sparse, relative to elsewhere in the study area). Impacts to other megafauna are likewise considered unlikely as soft sediment habitats, similar to those in the immediate footprint, are widespread throughout the remainder of the study area.

- Vessel fauna strike, or entrainment (at the dredge head) may occur, but this is considered a very low probability and is dependent on highly variable factors such as the species present, the number of individuals present and their condition, at the time of such works/operations. Numerous mitigation measures will be implemented to reduce this risk:
  - Lighting effects to marine megafauna are considered to be negligible, especially near shore in the context of land derived light sources
  - Potential noise effects may be caused by pulsed pile driving works, the more persistent (albeit temporary) dredge and vessel sources, or the marine booster pump. For these noise sources, the most likely effect is expected to be temporary megafauna behavioural changes, by way of avoidance of the noise source and its immediate surrounds. Hearing damage would only be expected if animals remain in close range to the noise source for prolonged periods. This is considered unlikely for most marine megafauna.

3 Recommended Mitigation Measures

3.1 Direct Impacts to Soft Sediment Areas

Habitat removal and physical habitat alteration within the project footprint is an inherent impact of any project that incorporates a marine dredging component. For the project, considerable effort during the design and EIS phases went to the identification and selection of both a dredge footprint and Northern Sands DMPA site that would minimise new direct ecological effects to marine environmental values. The dredge footprint largely aligns with that of the existing outer channel (albeit wider in places) and other areas that are already regularly dredged or influenced by dredging under existing conditions. The re-calibrated footprint is designed to minimise the capital dredge footprint as far as practical and reduces the extent of dredging required in greenfield areas.

The Dredge Management Plan provides guidance on (i) the mitigation measures that will be adopted to minimise direct impacts to marine flora and fauna; and (ii) monitoring that will be undertaken to validate impact predictions outlined in the EIS. This includes the following relevant strategies and components:

- Seagrass will be surveyed within the channel footprint to determine whether there are any potential direct impacts
- A bathymetry survey of the channel and surrounds will be undertaken progressively and upon completion to minimise over-dredging and confirm final depths at the completion of the capital dredging campaigns

For marine protected areas, note that offsets are proposed to compensate for dredging activities encroaching on these areas (e.g. Trinity Inlet FHA).

The location and extent of physical habitat alteration and disturbance during construction phase dredging is unlikely to affect high value marine fauna, but the channel footprint coincides with a small area of potential seagrass habitat. Therefore, changes in habitat due to direct modifications are considered to represent an irreversible long-term **Low** risk, and cannot be practically mitigated (Table 4-1).

3.2 Impacts to Commercial Fisheries Species

The residual risk of habitat modification (i.e. expanded channel) on the commercial catch of economically significant species is considered to be long-term and **Low** (Table 4-1). Further discussion on fisheries impacts specifically relating to the generation of turbid plumes is provided in Section 2.4.1.1.

3.3 Dredge Plume and Sedimentation Impacts

The project design and Dredge Management Plan incorporate numerous mitigation measures that will be adopted to reduce the extent and magnitude of turbid plumes in order to minimise impacts to marine flora and fauna. Modelled dredge scenarios included either 10 or 30 minutes of overflow. Limiting overflow is likely to reduce the potential sedimentation impacts predicted for seagrasses in the worst case scenario. Specific relevant strategies and components of the DMP include:

- Capital dredging will not be carried out in late spring and summer (November to February). This coincides, in part, with when seagrasses and other benthic biota may be most likely to be undertaking important life history functions (e.g. seagrass growth, coral spawning, spawning on many commercially significant fisheries species) or coping with seasonal environmental stress (e.g. flood-related effects)
- An environmental valve ("green valve") will be used in overflow pipes of the TSHD to reduce the dispersion of sediments from dredging
- Overflow levels will be raised to the highest allowable point during sailing from the dredge area to the dredge pump-out location to ensure spillage of sediment is minimised
- Sailing routes will be optimised to minimise the generation of propeller wash (noting that propeller wash from the dredger has been taken into account in the modelling as a contributor to sedimentation impacts)
- A reactive water quality monitoring program will be developed and implemented. Dredging activities will be modified or suspended in the event that monitoring detects exceedance/s of trigger values, which will illicit various management responses. Water quality baseline data collected for this project, together with local photosynthetic active radiation (PAR) data collected by James Cook University, will be used as the basis for establishing these trigger values
- A seagrass monitoring program (and soft sediment benthos monitoring) will be developed and implemented to identify any changes to communities as a result of the dredging program. This will include sampling at multiple times before and dredging at putative impact sites located adjacent to the near shore project footprint, and at suitable control sites.

Reactive water quality and seagrass monitoring, in combination with active management of overflow (informed by the reactive monitoring program), would reduce the risk of impact to a short-term **Low** risk activity (for turbidity and sediment deposition), in terms of residual risk (Table 4-1).

3.4 Impacts of Tailwater Releases on Flora and Fauna

The simulated releases of 1 m^3 of water per second at 35 PSU and 100 mg/L TSS (~60 NTU) into the Barron River are not likely to result in any observable impacts to benthic invertebrates, commercially significant fisheries species, seagrasses or riparian communities, given the wide range in salinity and turbidity conditions that these communities are regularly exposed to.

Tailwater will need to be managed to ensure that it complies with the release criteria set by the regulator. Other properties of the tailwater, notably dissolved oxygen and pH, will require management to ensure compliance with release criteria. The residual risk rating is short-term and **Low** (Table 4-1).

3.5 Impacts to Megafauna

3.5.1 Direct Impacts

Management strategies primarily focus on dredge vessels and dredge plant, and will be implemented throughout the course of the proposed capital and operational dredging works to minimise the risk of interactions with vessels. These management strategies are set out in the Dredge Management Plan and will include:

- Implementation of marine megafauna management strategies
- Implementation of megafauna exclusion zones (maintaining a given buffer distance between the dredge vessels and megafauna) and associated reactive megafauna monitoring program (regular visual inspections of dredge footprint area and dredge path)
- If visual monitoring for megafauna from the dredge vessels detects megafauna within or headed towards exclusion zones, execute strategies to avoid interactions as required stopping work if megafauna, especially whales, are within or near exclusion zones; halt dredge vessel transit if there is a likelihood the vessel would encroach on observed whales or their anticipated path
- Operational procedures to minimise the risk of capture of turtles lying on the seabed, especially utilising fauna exclusion devices on the dredge head to reduce fauna entrainment and prevent fauna injury and mortality
- Ensure dredge suction is not started until the dredge head is lowered and in contact with the seafloor, and stops before lifting the dredge head from the seabed
- Where it does not conflict with security and safety requirements, lighting on the dredge vessel will aim for low wattage and/or directional light fixtures.

Together, these mitigation strategies will reduce the likelihood of interactions between the dredge vessels and marine megafauna, such that the overall residual impacts to marine megafauna are considered highly unlikely for all related mechanisms (i.e. vessel strike, noise, entrainment and light). The residual risk rating following mitigation is short-term and **Low** (Table 4-1).

In terms of operational phase impacts from increased shipping in Trinity Inlet and Trinity Bay, the potential risk to marine fauna from vessel strike has been assessed as Low (Table 4-1) due to the large size and slow speeds of cruise ships. Broader shipping movement in and out of the Reef area is currently being managed under the North-East Shipping Management Plan (AMSA), and is not a port issue. As there are no mitigation measures identified for the operational phase, the residual risk rating is **Low** (Table 4-1).

3.5.2 Acoustic Impacts

Recommended mitigation measures to specific to construction phase piling works are covered in Chapter B10 Underwater Noise. These mitigation measures include:

- Resilient pad (dolly) used where feasible between the pile and hammer head.
- A megafauna observation zone of one km, and exclusion zone of 100 m will be adopted, with piling operation shut down if marine megafauna species are observed within or approaching the exclusion zone.
- A ‘soft-start’/‘ramp-up’ regime will be adopted at each day’s commencement of piling works.
- Underwater noise monitoring conducted at the onset of piling to confirm/calibrate the noise predictions, and noise management adapted appropriately.

The residual risk rating following mitigation is short-term and **Low** (Table 4-1).

3.5.3 Megafauna Impact Mitigation Summary

Key mitigation strategies specific to minimising potential harm to marine megafauna as a result of the project are primarily focused on reducing interactions (direct or indirect) between megafauna and vessels, dredge plant and pile driving. These include management strategies set out in the Dredge Management Plan, and management strategies to be implemented during pile driving works as listed in Section 4. These measures were developed in line with current best industry practice, and also consider general management strategies outlined in species recovery plans (including the 2003 Recovery Plan for Marine Turtles in Australia).

Mitigation measures focusing on protecting megafauna habitats (e.g. seagrass) are provided elsewhere, in the previous sections of this impact assessment.

Overall, implementation of these mitigation strategies, together with best practice construction and waste management methodologies, are expected to result in minor residual impacts for marine megafauna. The residual risk rating following mitigation is short-term and **Low** (Table 4-1).

3.6 Other Marine Vessel Impacts

3.6.1 Marine Pests

International and domestic vessels involved in either the construction or operational phases of the project will be required to comply with national and state biofouling and ballast water management guidelines, and other requirements to minimise the risk of introductions of marine pest species. The residual risk rating following mitigation is long-term and **Low** (Table 4-1).

3.6.2 Marine Debris

Throughout both the construction and operational phases of the project, ships, dredgers and other vessels associated with the project will need to ensure waste materials are properly managed in accordance with standard protocols and waste management strategies in the respective Management Plans. The Port of Cairns will provide appropriate waste reception facilities for accommodating this, in line with best practice (e.g. Best Practice Guidelines for waste Reception Facilities at Ports, Marinas and Boat Harbours in Australia and New Zealand, IMO Guide to Best Practice for Port Reception Facility Providers and Users). The residual risk rating following mitigation is long-term and **Low** (Table 4-1).

3.6.3 Potential Toxicants Mobilised by Dredging or Construction:

It is assumed that the following standard mitigation measures will be employed to ensure associated impacts are negligible:

- Dredging will be undertaken in a manner consistent with the requirements of the NAGD
- A Dredge Management Plan has been developed for the project, which will be implemented throughout the duration of the works. A key component of this plan is a water quality monitoring program that will enable reactive and adaptive management of dredging operations in order to minimise water quality effects and, thus, effects to marine flora and fauna
- Dredge material should remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidisation

- Future maintenance dredging during the operational phase of the project is undertaken consistent with the LTDSDMP and in accordance with NAGD or future versions of these guidelines.

The residual risk rating following mitigation is short-term and **Negligible** (Table 4-1).

3.6.4 Spills

The following additional mitigation is proposed to reduce the potential impacts associated with spills during project construction and operation:

- Hazardous material handling procedures have been developed for the project as part of the Dredge Management Plan
- Emergency spill response procedures will be implemented if/when required
- Relevant staff will be trained to ensure they have an appropriate level of competency for executing the above spills procedures
- Revise fuel handling and spill response procedures in the port's operational procedures to minimise the potential future risk to sediment quality from refuelling activities associated with the provision of IFO at the port.

With the implementation of the above measures, it is considered highly unlikely that spills, if they occur, will cause adverse impacts to the marine environment. Note that spill and emergency response procedures will be outlined as part of the Dredge Management Plan.

Overall, through the implementation of the above strategies, the residual impact to marine ecological values is considered to be long-term and **Low** (Table 4-1).

4 Residual Impacts and Assessment Summary

In accordance with the methodology described in Section 2.2, Table 4-1 summarises the marine ecology issues identified by the impact assessment in the previous sections. This assessment table also includes the significance of each of the identified impacting processes, the likelihood of the impact occurring, and the resulting risk rating.

Most potential impact processes are rated as having a negligible to low risk to marine ecology. The standard and additional mitigation measures discussed in previous sections are also summarised in Table 4-1, with a risk rating indicated for the residual impacts after mitigation. As indicated in this assessment table, all residual impacts are rated as between a low and medium risk.

Construction phase residual impacts would be short-term (up to one year) in duration, while operational phase residual impacts (including permanent benthic habitat modification, which are irreversible impacts) would be long-term in duration extending over the life of the project.

Table 4-1 Assessment Summary Table – Marine Ecology

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Primary impacting processes	**Statutory mitigation measures required**	**Consequence of impact**	**Likelihood of impact**	**Risk rating**	**Additional mitigation measures proposed**	**Consequence of impact**	**Likelihood of impact**	**Residual Risk rating**
Construction Phase								
Direct modification of benthic habitats (subtidal soft sediment habitats, potential seagrass habitat) from capital dredging, and wharf upgrade works. (Seagrass is not currently in the direct impact footprint but may be present at the time of dredging)	Project design minimises area of marine habitat directly lost/ affected by proposal.	Minor	Possible	Low	None Seagrass surveys to confirm presence of unpredicted seagrass. If detected, seagrass impacts will be offset in accordance with Environmental Offsets Act	Minor	Possible	Low
Impacts to commercial fisheries from habitat modification (i.e. expanded channel)	Nil	Minor	Unlikely	Low	Nil	Minor	Unlikely	Low

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Increased suspended sediment concentrations from capital dredging (resultant water quality effects) resulting in localised but short-term impacts to seagrass or corals	• Project design minimises the extent (volume) of dredging • Ensure TSHD dredge operates within the approved dredge footprint at all times • Overflow dredging by the TSHD is undertaken in accordance with the overflow regime in the Dredge Management Plan. • Dredge hopper compartment is to be kept water tight during all dredging activities. • Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle • No high pressure jets to be used on drag heads outside of dredge footprint Dredge to be fitted with a 'green valve'.	Moderate	Possible	Medium	• Implementation of DMP, including: ○ avoidance of summer months for dredging ○ sailing routes optimised to minimise propeller wash ○ implementation of reactive water quality monitoring program ○ implementation of soft sediment benthos and seagrass monitoring program.	Moderate	Unlikely	Low

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Increased sediment deposition from capital dredging resulting in localised but short-term impacts to seagrass or corals	• Project design minimises the extent (volume) of dredging • Ensure TSHD dredge operates within the approved dredge footprint at all times • Overflow dredging by the TSHD is undertaken in accordance with the overflow regime in the Dredge Management Plan. • Dredge hopper compartment is to be kept water tight during all dredging activities. • Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle • No high pressure jets to be used on drag heads outside of dredge footprint Dredge to be fitted with a 'green valve'.	Moderate	Unlikely	Low	• Implementation of DMP, including: ○ avoidance of summer months for dredging ○ sailing routes optimised to minimise propeller wash ○ implementation of reactive water quality monitoring program ○ implementation of soft sediment benthos and seagrass monitoring program.	Moderate	Highly Unlikely	Low
Generation of turbid plumes and increased salinity from tailwater discharges from the Northern Sands DMPA	Tailwater discharges from the Northern Sands DMPA do not exceed specified water quality criteria.	Minor	Possible	Low	Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Interactions between marine fauna and vessels or dredge plant (i.e. fauna vessel strike, entrainment, indirect artificial noise and lighting effects)	None identified	Moderate	Highly Unlikely	Low	• Implementation of DMP, including: ○ implementation of marine megafauna management strategies ○ implementation of megafauna exclusions zones ○ visual monitoring and implementation of reactive strategies ○ utilisation of fauna exclusion device(s) to reduced entrainment risk ○ cease dredge suction prior to lifting dredge head from seabed ○ minimise lighting utilisation as practicable.	Moderate	Highly Unlikely	Low
Acoustic effects to marine fauna from wharf upgrade works (especially pile driving)	None identified	Minor	Likely	Medium	• Resilient pad (dolly) used where feasible between the pile and hammer head • A megafauna observation zone of one km, and exclusion zone of 100 m will be adopted, with piling operation shut down if marine megafauna species are observed within or approaching the exclusion zone • A ‘soft-start’/‘ramp-up’ regime will be adopted at each day’s commencement of piling works • Underwater noise monitoring conducted at the onset of piling to confirm/calibrate the noise predictions, and noise management adapted appropriately.	Minor	Possible	Low

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Other indirect interactions from vessels: marine pest introductions	Vessel compliance with national and state biofouling and ballast water management procedures.	Moderate	Unlikely	Low	None identified	Moderate	Unlikely	Low
Introduction of marine debris leading to marine megafauna impacts	• Port of Cairns to provide appropriate waste reception facilities, in line with best practice • All vessels to comply with standard waste management protocols.	Moderate	Unlikely	Low	Implementation of waste management strategies in construction EMP to reduce waste generation and the quantity of plastics entering the marine environment.	Moderate	Highly unlikely	Low
Risk of toxic spills from vessels	None identified	Moderate	Unlikely	Low	• Implement hazardous material handling procedures • Implement emergency spill response procedures as required • Ensure relevant staff trained in above procedures to ensure competency • Revise port fuel handling and emergency response procedures.	Moderate	Highly unlikely	Low
Potential contaminants mobilised by dredging	Completion of sediment sampling and analysis program (SAP) in line with NAGD guidelines to characterise sediments	Minor	Unlikely	Low	• Implementation of DMP, including reactive water quality monitoring program and relevant adaptive management strategies • Dredged material to remain waterlogged and not to remain in TSHD hopper or dump barge for periods exceeding 24 hours.	Minor	Highly Unlikely	Negligible

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Operational Phase								
Future maintenance dredging – mobilisation of contaminants into water column, turbid plumes and sediment deposition	Existing maintenance dredging operations occur in accordance with an approved LTDSDMP which contains management measures to reduce impacts on water quality from dredging and placement	Minor	Possible	Low	Update the LTDSDMP to address the additional volumes and duration of maintenance dredging required by the wider channel	Minor	Possible	Low
Interactions between marine fauna and operational vessels/ship (i.e. fauna vessel strike, entrainment, indirect artificial noise and lighting effects	None identified	Moderate	Highly Unlikely	Low	None identified	Moderate	Highly unlikely	Low
Other indirect interactions from vessels: marine pest introductions	Vessel compliance with national and state biofouling and ballast water management procedures.	Moderate	Unlikely	Low	None identified	Moderate	Unlikely	Low
Introduction of marine debris	• Port of Cairns to provide appropriate waste reception facilities, in line with best practice • All vessels to comply with standard waste management protocols	Moderate	Highly unlikely	Low	Implementation of waste management strategies in operational EMP to reduce waste generation and the quantity of plastics entering the marine environment.	Moderate	Highly Unlikely	Low

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Risk of toxic spills from vessels	None identified	Moderate	Unlikely	Low	• Implement hazardous material handling procedures • Implement emergency spill response procedures as required • Ensure relevant staff trained in above procedures to ensure competency • Revise port fuel handling and emergency response procedures.	Moderate	Highly Unlikely	Low

5 References

Bach, S., Borum, J., Fortes, M., & Duarte, C. (1998). Species composition and plant performance of mixed seagrass beds along a siltation gradient at Cape Bolinao, The Philippines. Marine Ecology Progress Series 174, 247-256.

BMT WBM (2017). Cairns Shipping Development Project Hydrodynamic Modelling Report. Prepared for Flanagan Consulting Group and Ports North.

Blaber, S.J.M. and Blaber, T. G. (1980) Factors affecting the distribution of juvenile estuarine and inshore fish. Journal of Fish Biology. 17: 143-162.

Campbell, S.J. and McKenzie, L.J. (2004) Flood related loss and recovery of intertidal seagrass meadows in southern Queensland. Australia Estuarine, Coastal and Shelf Science 60: 477-490.

Carter, R.M., Larcombe, P., Liu, K., Dickens, J., Heron, M.L., Prytz, A., Purdon, R. and Ridd, P. (2002) The Environmental Sedimentology of Trinity Bay, Far North Queensland. June 2002.

Chartrand KM, R. P. (2012). Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program. Cairns: State of Queensland (Department of Agriculture, Forestry and Fisheries).

Coles, R., McKenzie, L. and Campbell, S. (2003) The seagrasses of Eastern Australia, in Green, E.P. and Frederick, T.S. (eds), World Atlas of Seagrasses, UNEP World Conservation Monitoring Centre, Cambridge.

Collier, C., Lavery, P., Ralph, P., & Masini, R. (2009). Shade-induced response and recovery of the seagrass Posidonia sinuosa. Journal of Experimental Marine Biology and Ecology 370, 89-103.

Collier, C.J., Adams, M.P., Langlois, L., Waycott, M., O'Brien, K.R., Maxwell, P.S., McKenzie, L. (2016) Thresholds for morphological response to light reduction in four tropical seagrass species. Ecological Indicators 67 (2016) 358-366.

Connolly, R., G. Jenkins, Loneregan, N. (1999). Seagrass dynamics and fisheries sustainability. Seagrass in Australia - Strategic Review and Development of an R & D Plan. A. J. Butler and P. Jernaakoff. Collingwood, CSIRO Publishing: 25-64.

Dall, W., Hill, B., Rothlisberg, P., & Staples, D. (1991). Biology of the Penaeidae; Advances in Marine Biology Series, Vol. 27. London: Academic press.

Davis, T. (1987). Biology of wildstock Lates calcarifer in northern Australia, in Copland, J.W. and Grey, D.L. Management of Wild and Cultured Sea Bass/Barramundi (*Lates calcarifer*). Canberra: ACIAR Proceedings 20.

DHI in Chevron (2010). Appendix N3 – Tolerance Limits Report for the Draft Environmental Impact Statement for the Proposed Wheatstone Project.

DSEWPAC/GBRMPA (2013) Guidelines for an Environmental Impact statement for the Cairns Shipping Development (Trinity Inlet) Project, in Port of Cairns and Great Barrier Reef Marine Park, Queensland – March 2013. Jointly prepared by the Australian Government Department of

Sustainability, Environment, Water, Population and Communities and the Great Barrier Reef Park Marine Authority.

Duarte, C., Terrados, J., Agawin, N., Fortes, M., Bach, S., & Kenworthy, W. (1997). Response of a mixed Philippine seagrass meadow to experimental burial. Marine Ecology Progress Series. 147, 285-294.

Ellison, J. (1998). Impacts of sediment burial on mangroves. Marine Pollution Bulletin 37, 420–426.

Environment North (2005) Cairns Harbour Dredging and Long Term Dredge Spoil Disposal Management Plan. Prepared for Cairns Port Authority by Environment North, in association with Hydrobiology and NIWA Australia, Cairns.

Erftemeijer, P.L.A., Lewis, R.R.R. (2006) Environmental Impacts of dredging on seagrasses: a review. Marine Pollution Bulletin 52: 1553-1572.

GHD. (2005). Port of Hay Point Apron Area and Departure Path Capital Dredging Draft Environmental Impact Statement. Prepared for Ports Corporation of Queensland.

GHD. (2011). Port of Townsville Limited Report for Port Expansion - Marine Megafauna. Townsville: GHD, for Port of Townsville Limited.

Grice, A., Loneragan, N., & Dennison, W. (1996). Light intensity and the interactions between physiology, morphology and stable isotope ratios in five species of seagrass. Experimental Marine Biology and Ecology. 195, 91–110.

Hillard, R., Raaymakers, S. (1997) Ballast water risk assessment for 12 Queensland ports, Stage 5: Executive Summary and Synthesis of Results. EcoPorts Monograph Series. No.14.

Hilliard, R. (1999) Marine pest invasion risks – warm versus cool-water ports. EcoPorts Monograph Series No.19: 65-70.

Hobday, D., Officer, R., & Parry, G. (1999). Changes to demersal fish communities in Port Phillip Bay, Australia, over two decades, 1970-91. Marine and Freshwater Research. 50, 397-407.

Hutchings, P. A. and P. Saenger (1987). Ecology of Mangroves. St Lucia, University of Queensland Press.

Jarvis, J.C., Rasheed, M.A., McKenna, S.A. and Sankey, T. (2014). Seagrass Habitat of Cairns Harbour and Trinity Inlet: Annual and Quarterly Monitoring Report 2013. JCU Publication, Centre for Tropical Water and Aquatic Ecosystem Research, Cairns.

Jenkins, G., & McKinnon, L. (2006). Channel Deepening Supplementary Environment Effects Statement – Aquaculture and Fisheries. Internal Report No. 77. Queenscliff: Primary Industries Research Victoria.

Kailola, P. J., Williams, M. J., Stewart, P. C., Reichelt, R. E., McNee, A., and Grieve, C. (1993). Australian Fisheries Resources. Canberra: Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation.

Kenworthy, W. J. (2000). The role of sexual reproduction in maintaining populations of Halophila decipiens: implications for the biodiversity and conservation of tropical seagrass ecosystems. Pacific Conservation Biology, 5, 260-268.

Longstaff, B., Loneragan, N., O'Donohue, M., & Dennison, W. C. (1999). Effects of light deprivation on the survival and recovery of the seagrass *Halophila ovalis* (R.Br.) Hook. Journal of Experimental Marine Biology and Ecology 234, 1-27.

McKay, R. (1992). FAO Species Catalogue, Vol 14, Sillaginid fishes of the world (Sillaginidae). An annotated and illustrated catalogue of the Sillago, smelt or Indo-Pacific whiting species known to date. n.s: FAO Fish Synopses 125.

McKenzie, L. (1994) Seasonal changes in biomass and shoot characteristics of a Zostera capricorni Aschers. Dominant meadow in Cairns Harbour, Northern Queensland. Aust. Journal of Marine and Freshwater Research, 45: 1337-52.

Moriarty, D. (1977). Quantification of carbon, nitrogen and bacterial biomass in the food of some penaeid prawns. Australian Journal of Marine and Freshwater Research 28, 113-118.

Mustoe, S. (2006). Penguins and marine mammals: final report. Melbourne: AES Applied Ecology Solutions Pty Ltd (through Maunsell Australia Pty Ltd), for the Port of Melbourne Corporation.

Mustoe, S. (2008). Townsville Ocean Terminal: dolphins, dugongs and marine turtles report Ecological impact assessment report. Melbourne: AES Applied Ecological Solutions Pty Ltd, for City Pacific Limited.

Orth, R. J., Harwell, M. C., Inglis, G. J. (2006). Ecology of seagrass seeds and seagrass dispersal processes, in Larkum, A.W. D. Orth, R. J. and Duarte, C. M. (eds). Springer, Netherlands. Seagrasses: Biology, Ecology, and Conservation.

Queensland Government 2012. Cairns Shipping Development Project, Terms of reference for an environmental impact statement. November 2012.

Rasheed M.A., McKenna S.A., Tol, S. (2013). Seagrass habitat of Cairns Harbour and Trinity Inlet: Annual Monitoring and updated Baseline Survey – 2012. JCU Publication, Centre for Tropical Water and Aquatic Ecosystem Research, Cairns.

Rasheed, M. (1999) Recovery of experimentally created gaps within a tropical Zostera capricorni Aschers.) Seagrass meadow, Queensland Australia. Journal of Experimental Marine Biology and Ecology, 235:183-200.

Robin, J. (1995). Estimated catch and mortality of sea turtles from the East Coast Otter Trawl Fishery of Queensland, Australia. Biological Convention, 74, 157-167.

Somers, I. (1994). Species composition and distribution of commercial Penaeid prawn catches in the Gulf of Carpentaria, Australia, in relation to depth and sediment type. Australian Journal of Marine and Freshwater Research, 45, 317-315.

Swimmer, Y., Arauz, R., Higgins, B., McNaughton, L., McCraken, M., Ballestero, J., *et al*. (2005). Food color and marine turtle feeding behavior: Can blue bait reduce turtle bycatch in commercial fisheries? Marine Ecology Progress Series, 295, 273-278.

Unsworth R.K.F., Taylor H.A., Rasheed M.A. (2009) Port of Townsville long-term seagrass monitoring: October 2008 QPI&F Publication PR09-4330 (QPI&F, Cairns), 30 pp.

Wassenberg, T., & Hill, B. (1987). Natural diet of the Tiger Prawns *Penaeus esculentus* and *P. semisulcatus*. Australian Journal of Marine and Freshwater Research, 38, 169-182.

Waycott, M., Longstaff, B.J., Mellors, J. (2005) Seagrass population dynamics and water quality in the Great Barrier Reef region: A review and future research directions. Marine Pollution Bulletin, 51: 343–350.

Western Australia Environmental Protection Authority (WA EPA) 2016. Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals.

Williams, M. (1982). Natural food and feeding in the commercial sand crab *Portunus pelagicus*. Journal of Experimental Marine Biology and Ecology. 59, 165-176.

Witherington, B. E. (1992). Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48, 31–39.

Worley Parsons (2009) Cairns Port Ocean Disposal Site: Benthic Macro-Invertebrate Infauna and Introduced Marine Pest Monitoring Survey 2009. Report prepared for Far North Queensland Ports Corporation by Worley parsons Services Pty Ltd. August 2009.

Worley Parsons (2010). Cairns Port Long Term Management Plan – Dredging and Dredge Spoil Management Report prepared for Ports North

York, P., Reason, C., Scott, E., Sankey, T., Rasheed MA (2016) Seagrass habitat of Cairns Harbour and Trinity Inlet: Annual Monitoring Report 2015. JCU Publication, Centre for Tropical Water & Aquatic Ecosystem Research Publication 16/13, Cairns, 53 pp.

BMT WBM Bangalow
6/20 Byron Street, Bangalow 2479
Tel +61 2 6687 0466 Fax +61 2 66870422
Email bmtwbm@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Brisbane
Level 8, 200 Creek Street, Brisbane 4000
PO Box 203, Spring Hill QLD 4004
Tel +61 7 3831 6744 Fax +61 7 3832 3627
Email bmtwbm@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Denver
8200 S. Akron Street, #B120
Centennial, Denver Colorado 80112 USA
Tel +1 303 792 9814 Fax +1 303 792 9742
Email denver@bmtwbm.com
Web www.bmtwbm.com

BMT WBM London
International House, 1st Floor
St Katharine's Way, London E1W 1AY
Email london@bmtwbm.co.uk
Web www.bmtwbm.com

BMT WBM Mackay
PO Box 4447, Mackay QLD 4740
Tel +61 7 4953 5144 Fax +61 7 4953 5132
Email mackay@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Melbourne
Level 5, 99 King Street, Melbourne 3000
PO Box 604, Collins Street West VIC 8007
Tel +61 3 8620 6100 Fax +61 3 8620 6105
Email melbourne@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Newcastle
126 Belford Street, Broadmeadow 2292
PO Box 266, Broadmeadow NSW 2292
Tel +61 2 4940 8882 Fax +61 2 4940 8887
Email newcastle@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Perth
Level 3, 20 Parkland Road, Osborne, WA 6017
PO Box 1027, Innaloo WA 6918
Tel +61 8 9328 2029 Fax +61 8 9486 7588
Email perth@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Sydney
Level 1, 256-258 Norton Street, Leichhardt 2040
PO Box 194, Leichhardt NSW 2040
Tel +61 2 8987 2900 Fax +61 2 8987 2999
Email sydney@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Vancouver
Suite 401, 611 Alexander Street
Vancouver British Columbia V6A 1E1 Canada
Tel +1 604 683 5777 Fax +1 604 608 3232
Email vancouver@bmtwbm.com
Web www.bmtwbm.com