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CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX AH: Marine Sediment Quality Baseline and Impact Assessment Technical Report (2017)

A part of BMT in Energy and Environment

BMT WBM

Marine Sediment Quality Baseline and Impact Assessment – Technical Report

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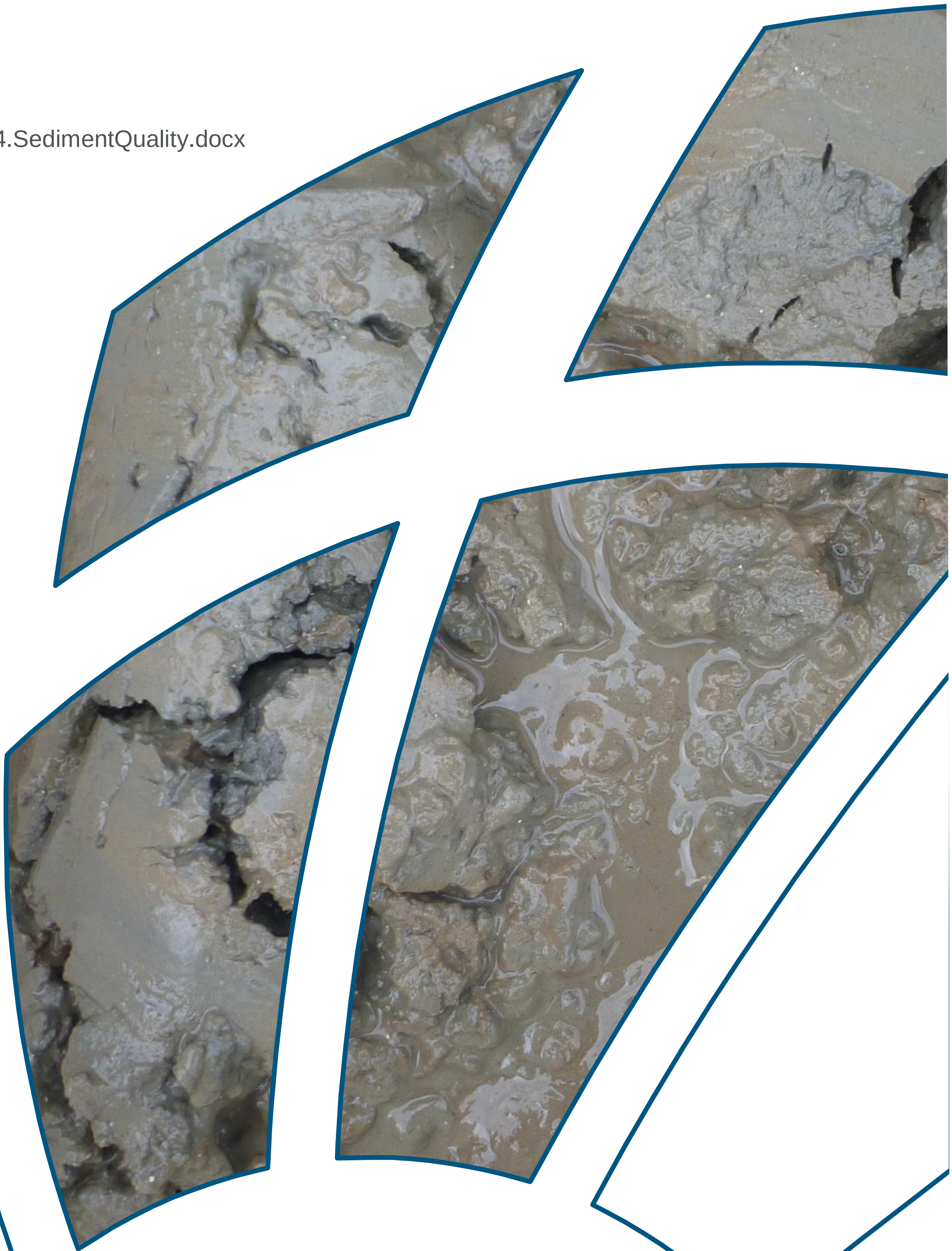

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Synopsis: This report presents the findings of an assessment of baseline marine sediment quality and impact assessment relevant to marine sediment quality due to the proposed Cairns Shipping Development Project

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Contents

List of Figures

List of Tables

Acronyms

DSD	Department of State Development
AHD	Australian Height Datum
ASS	Acid sulfate soils
BTEX	Benzene, toluene, ethylbenzene, xylene
CPM Act	Queensland *Coastal Protection and Management Act 1995*
DMPA	Dredge Material Placement Area
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
GBRMPA Act	Great Barrier Reef Marine Park Authority
LAT	Lowest astronomical tide
LTDSMP	Long-term Dredge Spoil Disposal Management Plan
NAGD	National Assessment Guidelines for Dredging
OCPs	Organochlorine pesticides
OPPs	Organophosphate pesticides
PAHs	Polycyclic aromatic hydrocarbons
PASS	Potential acid sulfate soil
PCBs	Polychlorinated biphenyls
PSD	Particle size distribution
SAP	Sampling and Analysis Plan
SD Act	Queensland *State Development Act 2009*
SDPWO Act	Queensland *State Development and Public Works Organisation Act 1971*
SP Act	Queensland *Sustainable Planning Act 2009*
TBT	tributyltin
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TPHs	Total petroleum hydrocarbons
TSHD	Trailer suction hopper dredge
UCL	Upper confidence limit
DSD	Department of State Development

1 Introduction

1.1 Overview

The Port of Cairns (hereafter 'the Port'), at the entrance to the Trinity Inlet, is fed by the Barron River and numerous freshwater creeks that drain from small catchments, including: Smiths Creek, Skeleton Creek and Redbank Creek. The catchments immediately adjacent to Trinity Inlet and the wider Cairns Harbour area are largely developed with the exception of broad mangrove areas on the eastern boundary. While mangroves within Trinity Inlet provide a substantial buffer between a mixed urban and agricultural land use to the south, the Port itself is multipurpose, dealing with bulk and general cargo, reef fleet tourism vessels, cruise ships, passenger ferries and a large fishing fleet. The Port also provides a number of slipways and dry-docking facilities for ship maintenance requirements.

Ports North is responsible for the development and management of port facilities in far north Queensland and in 2012 proposed an upgrade to the Port to secure Cairns' place as a premier cruise destination. The proposed Cairns Shipping Development Project (hereafter 'the Project') will accommodate larger cruise ships, upgrades to services and existing shipping wharves and future expansion of the HMAS Cairns Navy Base. The proposed Project will require capital dredging of up to 1 M m^3 and onshore placement of dredge material.

The Project was originally referred to the Queensland Department of State Development (DSD) under Section 26 of the Queensland *State Development Act 2009* (SD Act) and the *Environmental Protection Act 1994* (EP Act) in September 2012 (Ports North 2012) and assessed as a significant project requiring an Environmental Impact Statement (EIS). The Project was also declared a 'controlled action', requiring assessment under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), due to likely potential impacts on matters of national environmental and international significance.

The Draft EIS for this project was submitted in April 2015, and was based on offshore placement of approximately 4.4 M m^3 of dredge material. However, the project has now been revised with the following key changes:

- Significant reduction in capital dredge volume (from 4.4 M m^3 down to 1 M m^3) due to a refined channel design.
- Onshore placement of dredge material at the Northern Sands Dredge Material Placement Area (DMPA) for soft material and the Tingira Street DMPA for stiff clay.

Terms of reference (TOR) for the project have been set by the Queensland Government (2012) with provisions to address marine sediment quality, potential impacts, mitigation and monitoring in Section 5.3.3 of the TOR. Additionally, the EIS guidelines for the project have been set by the Australian Government (2012) with provisions to address the existing environment, potential impacts, mitigation and monitoring in Section 5.10.9 of the EIS guidelines.

This chapter provides:

- Baseline information on the key environmental values of marine sediments and sediment quality in areas of potential direct disturbance for the Project, with a focus on evaluating the portion of the sediment profile not previously dredged (i.e. capital dredging).
- An assessment of the potential for values to be affected by the Project, taking into account:
  - Construction phase dredging (capital dredging) and sediment disturbance in the dredging footprint.
  - Operational phase effects as a result of maintenance dredge material placement at sea.
- Measures proposed to manage and mitigate potential impacts to marine sediment quality, such that sediment quality is maintained to relevant quantitative standards in the Project Area and surrounds.

Separate technical reports and chapters of the EIS will address the placement of dredge material within the onshore DMPAs.

1.2 Previous dredging at Port of Cairns

The Port of Cairns has required ongoing annual maintenance dredging since its development over 100 years ago. Maintenance dredging of the existing 11.2 km Outer Channel and the 2.4 km Inner Port shipping channel and swing basins has typically been completed using a trailing suction hopper dredge (TSHD; the *Brisbane* in recent years). A clam shell dredger is used in areas within the Inner Port that are inaccessible to the TSHD *Brisbane*.

Dredged material has been placed at different marine Dredge Material Placement Areas (DMPAs) in the past. A DMPA one nautical mile south-west of the current DMPA was used between 1978 and 1990, and prior to this a DMPA five nautical miles to the south-east of the existing DMPA was used. The current approved ~269 ha offshore DMPA is ~14 km north of the Cairns Port entrance and has been in use since 1991.

1.3 Proposed Project

1.3.1 Capital dredging

The existing Port and the proposed upgrade is presented in Figure 1-1. The Project will include capital dredging the channel to a design depth of -8.8 m lowest astronomical tide (LAT) from an existing declared depth of -8.3 m LAT). The existing Crystal swing basin adjacent to Wharves 1–3 will be expanded to 380 m to allow specific use by cruise ships. The main swing basin (the 'Smith's Creek swing basin') will be moved further south, adjacent to the Tropical Reef Shipyard, to provide a wider (310 m) and deeper inner channel for the full length of the inner port and also provide future capacity for HMAS Cairns to expand. Inner Port channel width will be ~110 m and taper to 90–100 m in the Outer Channel, allowing passage of larger cruise ships. The channel bend will be approximately 180 m wide.

Capital dredge volumes of up to 1 M m^3 of material are expected. The capital dredge material includes ~710,000 - 900,000 m^3 of soft clay (250,000 - 320,000 m^3 of Possible Acid Sulfate Soils and 460,000 – 580,000 m^3 of self-neutralising clay material) to be dredged by a Trailer Suction Hopper

Dredge (TSHD) with a 5,600 m^3 capacity. It is expected that there will be approximately 100,000 m^3 of stiff clay to be dredged by a backhoe dredge.

It is assumed that the dredging will be undertaken in one single campaign by a dredge of similar design or specification to that outlined in other Chapters for which inputs to the various models has been based, and it is envisaged that a maintenance campaign will be conducted prior to the capital works. The duration of the dredging program is expected to be approximately 12 weeks.

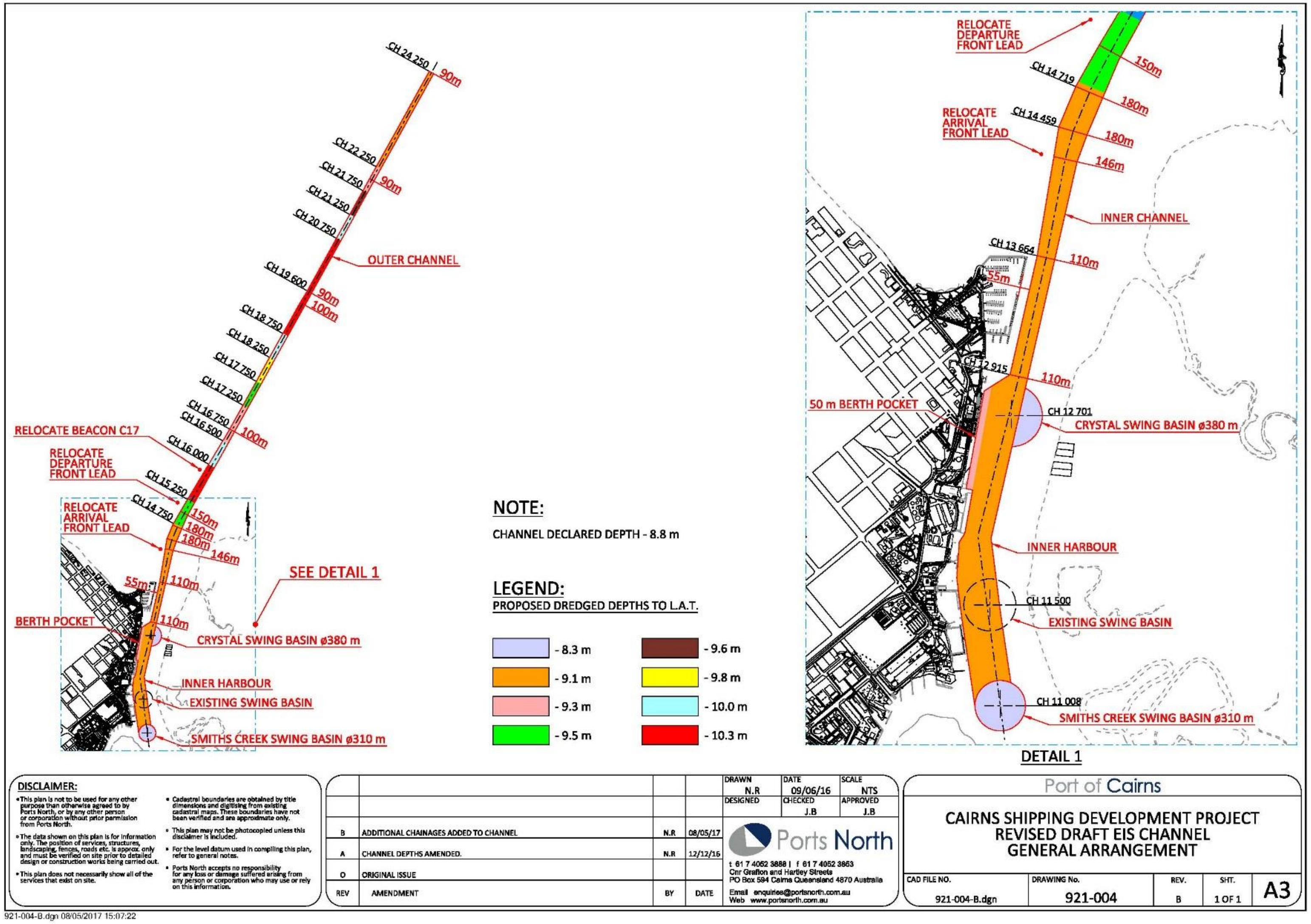

Figure 1-1 Proposed Cairns Shipping Development Project

1.3.2 Dredge Material Placement Areas

The ~710,000 - 900,000 m^3 of soft clay dredge material will be transported to an onshore DMPA at Northern Sands Pty Ltd (hereafter 'Northern Sands'; a sand extraction operation on the Barron Delta). Dredge material will be pumped from a dredge pump-out location offshore from the Cairns Northern Beaches and pumped via a submerged steel pipeline. The pipeline will make landfall near the Richters Creek mouth before traversing cane farm headlands and passing through culverts under the Captain Cook Highway. The length of the pipeline (approximately between 8.1 km and 9.1 km) requires up to three pipeline boosters, depending on the TSHD capacity.

The capacity of the Northern Sands DMPA is 2.4 M m^3 (to make allowance for the bulking factor of dredge material), and over time the material will consolidate to 1 M m^3 and settle at ~0.68 m Australian Height Datum (AHD). The Northern Sands DMPA will require temporary bunding with 100 year flood immunity and freeboard (7.5 m AHD), to minimise risk of sediment remobilisation during flooding, and a rock and clay wall at Reedy/Snake Island to separate the DMPA from the sand spit. Tailwater from the bunded area will be discharged into the Barron River adjacent to the site or pumped to an outfall at the Barron River highway bridge.

The ~100,000 m^3 of stiff clay will be placed at a land reclamation area previously used for placement of dredge material: Ports North land at Tingira Street. Stiff clay material will be dredged by a backhoe dredge, then barged and placed at the Tingira Street site using a land-based excavator and a small fleet of heavy haulage vehicles (e.g. Moxies). Due to the relatively dry placement of material, there will be no tailwater discharge from this site.

1.3.3 Maintenance Dredging

Once capital dredging has been undertaken, regular ongoing annual maintenance dredging will resume. Maintenance dredging would be managed through the routine annual maintenance SAP process under Ports North's existing permits. As discussed in Section 5.2, the Long Term Dredge Spoil Disposal Management Plan (LTDSDMP) will be updated to reflect the new channel design and potential slightly increased maintenance volume anticipated from the wider and deeper channel (refer Chapter C3 Coastal Processes).

2 Methodology

2.1 Applicable Legislation and Policies

The following policy and guidelines are relevant to the dredging and onshore placement of marine sediment associated with the Project.

- *Environment Protection (Sea Dumping) Act 1981* – The Sea Dumping Act provides the framework against which the Australian Government regulates the disposal of wastes and other materials at sea. It is through the Sea Dumping Act that Australia also implements its obligations and commitments under the international London Protocol. As this Act relates to placement of material at sea, the extent to which it applies to this project relates to obligations in regard to the ongoing maintenance dredging component of the project.
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) – The EPBC Act applies to projects which are likely to have a significant impact on a matter of national environmental significance. The Project has been referred to the Australian Department of Environment (DoE) due to the potential to have a significant impact on matters of national environmental significance: world heritage properties, national heritage places, wetlands of international importance, nationally listed threatened species and communities, migratory species, Commonwealth marine areas and the Great Barrier Reef Marine Park.
- *Environment Protection Act 1994* (EP Act) – The EP Act and associated policies and regulations provide for sustainable resource development, while protecting ecological processes, by regulating environmentally relevant activities (ERA), including dredging under ERA 16.
- *Sustainable Planning Act 2009* (SP Act) – The SP Act provides the framework against which the State Government regulates works undertaken in, on, over or through tidal waters, including dredging of material and the construction of a reclamation area and breakwater.
- *Coastal Protection and Management Act 1995* (CPM Act) – The CPM Act provides the framework against which the State Government regulates the dredging and placement of dredged material (i.e. allocation of quarry material and sea dumping in a coastal management district). Requirements for dredging and placement of dredged material at sea that relate to the CPM Act also appear in the State Development Assessment Provisions (2014) Module 10 – Coastal Protection.
- *Great Barrier Reef Marine Park Act* and *Regulation* - The Act and Regulation outline permitting and assessment process for construction and maintenance of structures within the marine Park and is supported further in respect of dredging and placement by way of the GBRMPA Dredging and Dredge Spoil Disposal Policy (GBRMPA, 2016). The intent of this policy is to provide a transparent, consistent and contemporary approach to management of the potential environmental impact of dredging and offshore placement in the Great Barrier Reef Marine Park.
- National Assessment Guidelines for Dredging (NAGD) (CA, 2009) – The NAGD provides a framework for the review and assessment of ocean placement of dredged material in support of the *Environment Protection (Sea Dumping) Act 1981* and the EPBC Act. Although ocean placement is no longer proposed for the Project, GBRMPA and the State Governments (as a

Terms of Reference requirement) are required to adhere to these guidelines when assessing applications under the legislation which references the NAGD, and the guidelines provide a useful reference for the assessment and management of dredging operations and have been used to inform the EIS. The NAGD framework for sediment sampling and assessing sediment quality evaluates alternatives to ocean placement, assesses feasibility of dredging and placement sites, assesses potential impacts on the marine environment and other users and determines management and monitoring requirements.

- Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1998 (Ahern et al. 1998) – These guidelines provide a state-wide standardised sampling and analysis regime for characterising acid sulfate soils. These guidelines are relevant to any proposal to place dredged material on land.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) – Contaminants may be released into the marine environment during dredging from the disturbance of sediment and release of interstitial (pore) water, and during placement and release of return water. The impact of these discharges is assessed by comparison of elutriate waters, derived from the proposed dredge material, with ANZECC and ARMCANZ (2000) trigger values for physical and chemical stressors.

Legislation applicable to the land placement of capital dredge material (such as *EP Act 1994 Environmental Protection (Waste Management) Regulations* and National Environmental Protection Measures) is covered in relevant chapters of the EIS which address the land based aspects of dredge material placement.

2.2 Assessment Approach

2.2.1 Assessment of Sediment Quality

NAGD (CA, 2009) sets out the approach to determine the suitability of dredge material for unconfined ocean placement. While all dredge material will be placed onshore, the NAGD guidelines are still applicable for the assessment of potential contamination of the marine environment from the capital dredging process.

NAGD provides a decision-tree approach for assessing potential contaminants, comprised of five phases as summarised in Figure 2-1.

This chapter includes an assessment of existing data which relate to overlying maintenance material in accordance with Phase I of the NAGD assessment framework. Furthermore, a Phase II assessment of the current contamination status of the Port of Cairns sediments that underlie the existing maintenance material (i.e. the capital material) was undertaken as part of the Draft EIS. The Phase II process includes:

- Preparation and submission of a Sampling and Analysis Plan (SAP) to the Determining Authority.

- Sampling and Analysis for Contaminants of Concern (COCs[1]) and Contaminants of Potential Concern (COPCs).
- Comparison of sediment data against screening levels and background levels.

The findings of this Phase II sediment testing are detailed in the sediment quality technical report (BMT WBM 2014) appended to the Draft EIS, and summarised in this report.

[1] In accordance with NAGD, COPCs are those contaminants that exceed the background concentrations and the Screening Level (or elevated concentrations of contaminants for which guidelines do not exist). COCs are those contaminants which exceed the background concentrations and the Screening Level and for which the bioavailability, bioaccumulation or toxicity assessments indicate that significant effects from the contaminants are likely. For COCs, definite actions are required. For COPCs, no immediate action may be required.

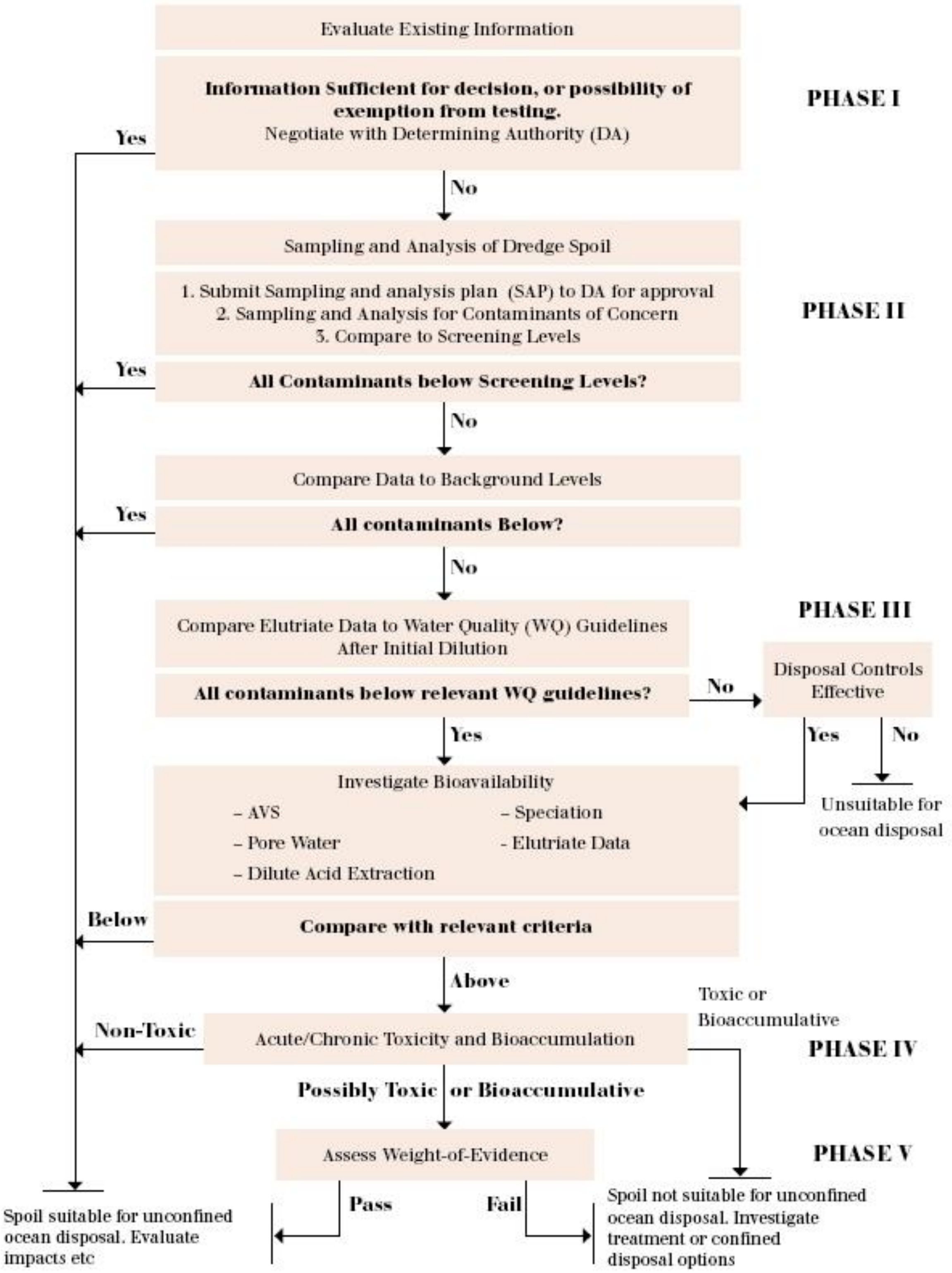

Figure 2-1 NAGD Tiered Assessment Approach

2.2.2 Sediment Quality Guidelines

Table 2-1 shows NAGD screening levels (CA, 2009) adopted in the present assessment. It is noted that a local screening level of 30 mg/kg for arsenic was agreed to by the Determining Authority in 2009 as part of developing the LTDSDMP and approval of the present Sea Dumping and Marine Park Permit. Given that NAGD does not specify a screening level for the herbicide diuron, a literature derived screening level of 2 µg/kg was adopted in 2008.

Table 2-1 NAGD Sediment Quality Screening Levels

Analyte	Screening Level (ISQG Trigger Value)	High Value (ISQG High)
Metals and Metalloids (mg/kg = ppm)		
Antimony	2	25
Arsenic	20 (30 local)	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1.0
Nickel	21	52
Silver	1.0	3.7
Zinc	200	410
Organics (µg/kg = ppb)		
Total PCBs	23	-
DDD	2	20
DDE	2.2	27
Total DDT	1.6	46
Dieldrin	280	270 e / 620
Chlordane	0.5	6
Lindane	0.32	1.0
Endrin	10	120 e / 220
Total PAHs	10,000	50,000
Total petroleum hydrocarbons	550 mg/kg	-
Tributyltin (as Sn)	9 µg Sn/kg	70
Herbicide Diuron	2 (literature derived)	-

2.3 Review of Existing Information

A review of relevant literature and existing data, together with targeted sampling of marine sediments, were undertaken in order to:

- Describe the physical properties of sediments in the Project's disturbance footprints.
- Characterise the chemical properties of sediments in the disturbance footprints, in terms of current and/or known recent concentrations of trace metals/metalloids, nutrients and other analytes relevant under the applicable legislation.
- Identify contaminants of potential concern (COPC) in the Project's disturbance footprints.

Key sediment quality information sources include:

- GHD (2000) HMAS Cairns – Report on Dredge Spoil Disposal Options. Report prepared for the Department of Defence.
- BMT WBM (2014) Cairns Shipping Development Project - Sediment Quality Report.
- Carter *et al* 2001 Sedimentology of Trinity Bay.
- Golder Associates (2012) Preliminary Investigation – Sediment Sampling and Analysis. Common User Barge Facility, Tingira Street Cairns. Report prepared for Ports North.
- Golder Associates (2016) Draft Values and Constraints Assessment – Dredge Material Properties - Cairns Shipping Development Project.
- Golder Associates (2017) Assessment of Materials Proposed for Dredging - Cairns Shipping Development Project.
- Worley Parsons (2010) Cairns Port Long Term Management Plan – Dredging and Dredge Spoil Management. Report prepared for Ports North.
- Worley Parsons (2010) Cairns Port 2010 Annual Sampling and Analysis Plan – Sediment Characterisation and Introduced Marine Pest Survey Report. Report prepared for Ports North.
- Worley Parsons (2011) Port of Cairns Maintenance Dredging: 2011 – Sediment Characterisation Report. Report prepared for Ports North.
- Worley Parsons (2012) Port of Cairns Maintenance Dredging: 2012 – Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.
- Worley Parsons (2013) Port of Cairns Maintenance Dredging: 2013 – Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.
- Worley Parsons (2014) Port of Cairns Maintenance Dredging: 2014– Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.
- Worley Parsons (2015) Port of Cairns Maintenance Dredging: 2015– Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.
- Worley Parsons (2016) Port of Cairns Maintenance Dredging: 2016– Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.

It is noted that Worley Parsons (2010) includes a comprehensive review of existing sediment quality data collected between 1995 and 2009, and that the status of the list of contaminants of concern for each annual SAP is informed by the findings of the prior year.

3 Existing Situation

This section presents sediment quality data in two sections, as follows:

(1) Historical data collected between 1995 and 2013.

(2) Recent sediment quality data collected specifically to inform the EIS, including the Draft EIS (2014) and the revised EIS (2016/2017).

3.1 Historical Sediment Quality Data

A number of previous studies were reviewed in order to provide an overview of the historical physical and chemical properties of the sediments within the Project's footprint and also to determine the potential contaminants of concern.

Detailed sediment quality studies of maintenance material and periodic capital works (i.e. Cityport North Marina) have been undertaken within the Port of Cairns since 1995. Worley Parsons (2010) provides a comprehensive review of all sediment data collected between 1995 and 2009. Sediment testing results are compiled for annual routine sediment monitoring due to requirements of the Sea Dumping Permit G10/33155.1 and the Cairns Port Long-term Dredge Spoil Disposal Management Plan (LTDSDMP; Worley Parsons, 2010) for maintenance dredging. These findings are summarised in the SAP Reports compiled by Worley Parsons for the period 2010 to 2016.

Previous sampling and analysis included the Outer Channel, Inner Port (wharf area), HMAS Navy Base, Marlin Marina and Commercial Fishing Bases 1 and 2 areas. Surface (top 5-10 cm) sediment samples were generally collected at Outer Channel sites using a grab sampler and sediment cores (up to 1.2 m in depth) were usually collected at Inner Port sites using a piston corer. The review of existing sediment quality results was restricted to the dredge areas relevant for the Project, i.e. Outer Channel, Inner Port and Navy Base.

It is noted that between 1995 and 2016, maintenance dredging material has been assessed by the Determining Authority as suitable for unconfined ocean placement as per NAGD (CA 2009).

Table 3-1 Summary of historical sediment analyses

Parameter	Study area	
	Inner Port, Navy Base	**Outer channel**
Particle size distribution	2008-2016	2008-2016
Inorganics		
Metals & metalloids	1995-2016	1995-2000, 2002-2016
Acid sulfate potential (Chromium Suite)	2000, 2012	2012, 2016
Cyanide	1998, 1999, 2006, 2007	1998,1999
Organics		
Organotins	1995–2016	1995–2000, 2002–2016
Diuron	2007–2016	2006–2008, 2010–2016

Parameter	Study area	
	Inner Port, Navy Base	Outer channel
Organophosphate and organochlorine pesticides (OPPs and OCPs)	2000, 2003–2007	2000, 2003, 2004
Polycyclic aromatic hydrocarbons (PAHs)	1995, 1996, 2000, 2003–2008, 2012, 2015	1995, 2000, 2003, 2004, 2008, 2012, 2015
Total petroleum hydrocarbons (TPHs)	1995–2009, 2012, 2015	1995–2001, 2003, 2004, 2008, 2012, 2015
Benzene, toluene, ethylbenzene, xylene (BTEX)	2000, 2003–2007	2000, 2003, 2004
Volatile chlorinated hydrocarbons	2006	–
Polychlorinated biphenyls (PCBs)	2000, 2003–2008	2000, 2003, 2004, 2008
Phenols	Not specified	Not specified
Perfluorinated compounds (PFCs)	2013	2013
Nutrients (organic and inorganic)	2007–2016	2007–2016

Source references: GHD (2000), Carter et al (2001), Golder Associates (2012), Worley Parsons (2010, 2011, 2012, 2013, 2014, 2015, 2016)

3.1.1 Particle size distribution

Results of particle size distribution analysis were relatively consistent across all studies and can be summarised as follows:

- All dredge areas were dominated by silt and clay fractions.
- Sands were in slightly higher proportions within Inner Port (wharf area) sediments.
- Outer channel and Inner Port sediments varied considerably in sand and gravel fractions between sampling locations. Sands and gravels were most prevalent at sites near the mouth of Trinity Inlet, but are not a dominant fraction of the sediments to be dredged.

The particle size distribution of sediments within the Inner Port and Outer Channel were dominated by silts and clays (~80–99%), and this was generally consistent across all studies between 1995 and 2013 (Table 3-1). The highest proportions of silt and clay were recorded in 2012, ranging from 97–99% across all Inner Port and Outer Channel sites (Worley Parsons 2012). Sediments were also characterised by small proportions of sand which varied between the Inner Port and Outer Channel. Generally higher proportions of sand were measured within the Inner Port compared to the Outer Channel (~10% and ~20%, respectively; Worley Parsons 2010 to 2016). Gravel fractions were uncommon in in the results between 2010 and 2013. However, between 1995 and 2009 small proportions of gravel were found across all sites, with slightly higher sand and gravel fractions within sediments collected near the mouth of the Trinity Inlet which generally had higher proportions of sand and gravel fractions (Worley Parsons 2010).

3.1.2 Metals and Metalloids

Historic sediment quality data was available between 1995 and 2016 as part of the Port of Cairns routine monitoring program.

Being part of the annual routine sediment testing, metals and metalloids generally showed the highest degree of variation of all contaminants, largely attributable to local geology, catchment land use, industries and port operations (CPA 2007). However, metal and metalloid contaminants were typically below NAGD screening levels (or screening levels in National Ocean Disposal Guidelines for Dredged Material – NODGDM prior to 2009).

An exception to this was arsenic. It is recognised that arsenic is naturally elevated in the Cairns region due to the presence of natural mineralisation in metamorphic rocks of catchments discharging to Trinity Inlet (NAGD 2009, Preda & Cox 2002, Munksgaard & Parry 2002). Arsenic has consistently exceeded the screening level at the 95% Upper Confidence Limit (95% UCL) in most dredge areas. Exceedances tended to be marginally over the 20 mg/kg screening level with a maximum 95% UCL of 31.8 mg/kg. Additional elutriate and dilute acid extraction (DAE) analyses were undertaken in past SAP processes to assess bioavailability of arsenic and potential impacts on water quality during dredging and dredged material placement.

DAE analyses indicated a low level of bioavailability of arsenic with concentrations consistently below the 20 mg/kg screening level (maximum recorded DAE concentration was 12.9 mg/kg or 44% of total arsenic).

Elutriate testing undertaken with a 1:4 ratio of sediment to seawater returned a maximum concentration of 71.9 µg/L, which exceeded the low-reliability ANZECC/ARMCANZ (2000) limits of 2.3 µg/L for As(III) and 4.5 µg/L for As(V). However, with allowable dilution of at least 100 times at the DMPA, arsenic concentrations were found to be acceptable and unconfined placement was permitted as an outcome of the 2009 review of Sediment Analysis Plan implementations to inform the 2010-2020 LTDSDMP. Given that arsenic analysis results demonstrated an overall low risk to water quality and benthic communities, an increase of the local screening level within the Cairns Port dredge management areas to 30 mg/kg was agreed and approved by the Determining Authority. Whilst the 95% UCL for arsenic sometimes exceeded the NAGD screening level (up to 25 mg/kg) in recent years, it remained below the agreed local screening level of 30 mg/kg.

Cadmium and silver concentrations were mostly below detection limits across all dredge areas. However, the 95% UCL for silver exceeded the NAGD screening level of 1 mg/kg with a concentration of 3.37 mg/kg in 2011. Nevertheless, elutriate and DAE results for silver were below the laboratory limit of reporting (LOR) in all analysed samples. Cadmium exceeded the screening level in one sample in 2007. Given that the 95% UCL remained below screening level, no further testing was required.

For all studies undertaken between 1995 and 2016, concentrations of all metals/metalloids and their 95% UCL were below the NAGD or agreed local screening level. Therefore, metals and metalloids were classified as suitable for unconfined marine placement.

Furthermore, Carter et al. (2002) noted that there is no evidence for pollution in offshore Trinity Bay. Enhanced spot values of some metal pollutants do occur within Trinity Inlet in the vicinity of Smiths Creek and the Port. Unusually, the high metal values do not correlate well with the fine sediment fraction, and it seems likely that the pollutants lie in the silt-sand grain sizes which are regularly flushed out of the Port area, and diluted in the natural background sediment, by ebb-dominated tidal currents.

3.1.3 Acid Sulfate Soil (ASS)

Assessments of ASSs were undertaken in the late-1990s as part of sediment quality assessments for maintenance dredging within the Inner Port and Outer Channel areas. Potential acid sulfate soils (PASS) with levels above the Action Criteria set out by the Queensland Acid Sulfate Soil Investigation Team (action criteria 0.03%S; Ahern et al 1998) were recorded for sediments adjacent to the Navy Base (GHD 2000) and in Smiths Creek (Golder Associates 2012).

3.1.4 Cyanide

Sediments were analysed for cyanide in 1998 and 1999 (Inner Port and Outer Channel; Worley Parsons 2010), and 2006 and 2007 (Inner Port and Navy Base; Worley Parsons 2008). Concentrations of cyanide were below LoR at all sites on all sampling occasions.

3.1.5 Organotins

Organotin compounds (including TBT) are derivatives of antifouling paints and have been routinely detected in the marina areas, Navy Base, Inner Port and Outer Channel dredge area at or above screening guideline levels for individual samples. However, it is noted that exceedances of the screening level at the 95% UCL for TBT has, in the past, only occurred for some of the Inner Port dredge areas, whereas the 95% UCL for the Outer Channel has been consistently below the screening level.

In terms of spatial distribution of TBT detections in the Inner Port area, the Navy Base and wharf areas typically have had the highest concentrations of TBT. Given the exceedances of the TBT screening level within the Inner Port area, further testing was required with elutriate testing undertaken prior to 2008 and porewater analysis for some years since then. Of the more than 70 elutriate samples analysed for TBT since 2005, none have returned levels above 2 ngSn/L, which is below the 6 ngSn/L ANZECC/ARMCANZ trigger level (95% species protection level). While the 2008 porewater testing failed to meet the required laboratory limit of reporting (LOR), the 2009 porewater analyses returned no detections above the required LOR, even when total TBT concentrations were up to 92 µgSn/kg, i.e. more than 10 times the NAGD screening level.

In 2011, a 95% UCL for TBT of 26.5 µgSn/kg was recorded for the Inner Port dredge area, exceeding the NAGD screening level of 9 µgSn/kg. Despite this relatively high exceedance, further elutriate and porewater analysis resulted in TBT concentrations below the LOR.

Organotin concentrations were below the LOR in all samples of the Outer Channel, Inner Port and Navy Base in 2012.

On the basis of elutriate and porewater testing for TBT it has been consistently concluded that annual maintenance material has been suitable for unconfined marine placement as per NAGD.

Observation of trends in the data collected for the annual SAP for Cairns identifies a trend of a continual declining trend in the number of detections and actual concentrations in the port, and this is believed to be as a result of the International Maritime Organization (IMO) ban on TBT application to vessels, natural degradation of TBT, as well as significantly improved site management at the slipway facilities along Smiths Creek.

3.1.6 Herbicides and Pesticides

Diuron

The Determining Authority requested the herbicide diuron be included in the annual Port sediment monitoring from 2007 onwards. Diuron is a broad-spectrum herbicide, primarily used in agriculture but also as an active ingredient in some antifouling paints. Diuron has the potential to adversely affect benthic primary producers or mangrove habitat by inhibiting photosynthesis, though it is unlikely to cause any human health issues. This herbicide has been reviewed by the Australian Pesticides and Veterinary Medicine Authority and some restrictions on its use have been applied depending on the type of crop, application and seasonal considerations.

The 95% UCL and individual normalised concentrations of diuron were below the literature derived screening level of 2 µg/kg at all Outer Harbour sites between 2008 and 2013. In 2008, diuron was found to be above the literature derived screening level of 2 µg/kg in sediments at sites within the Inner Port. Subsequent elutriate and porewater analyses of these samples resulted in elutriate concentrations less than the literature derived guideline level of 1 µg/L and porewater concentrations less than the laboratory LoR, even when tested at ultra-trace levels of 0.005 µg/L. Between 2009 and 2016, 95% UCL and individual normalised concentrations of diuron were below the literature derived screening level of 2 µg/kg for all Inner Port and Navy Base monitoring sites.

Organophosphate and organochlorine pesticides

Concentrations of OCPs and OPPs were below the laboratory LoR and relevant NAGD screening levels at all sampling sites between 2000 and 2007, and was not required to be analysed in subsequent sediment surveys.

3.1.6.1 Hydrocarbons

Polycyclic aromatic hydrocarbons

PAHs were below laboratory LoR at all Outer Channel sites undertaken between 2000 and 2012 (Worley Parsons 2010, 2011, 2012). Concentrations of PAHs were detected in samples collected adjacent to the Inner Port and Navy Base since 2004, with naphthalene exceeding the screening level in one sample in 2008. The total PAH concentration remained well below the NAGD screening level at all sites between 2000 and 2012 (Worley Parsons 2010, 2011, 2012).

Total petroleum hydrocarbons

TPH concentrations were detected in the Inner Port and Outer Channel dredge areas in concentrations well below NAGD screening levels.

Benzene, toluene, ethylbenzene and xylene

Concentrations of BTEX were below the laboratory LoR and relevant NAGD screening levels at all sampling sites between 2000 and 2007, and was not required to be analysed in subsequent sediment surveys.

Volatile chlorinated hydrocarbons and phenols

No volatile chlorinated hydrocarbons or phenol were noted within the Port of Cairns area (Worley Parsons, 2010).

3.1.6.2 Polychlorinated biphenyls

Concentrations of PCBs were below the laboratory LoR and relevant NAGD screening levels at all sampling sites between 1995 and 2007, and was not required to be analysed in subsequent sediment surveys.

3.1.7 Nutrients

Nutrients were tested between 2007 and 2016 as part of the Port's annual routine sediment monitoring (Worley Parsons 2010 to 2016). Results generally showed consistent trends between years. Total Nitrogen (TN) and Total Kjeldahl Nitrogen (TKN) concentrations generally increased from the Outer Channel towards the Inner Port area including the Navy Base. TN mostly consisted of TKN, indicating a high proportion of organically bound nitrogen.

Highest ammonia concentrations were recorded in the Navy Base dredge area with concentrations up to four times higher compared to the Inner Port and Outer Channel dredge areas. Oxidised nitrogen concentrations (nitrite and nitrate) were mostly below the LOR or measured at very low concentrations. Total Phosphorus concentrations did not show a clear concentration gradient and concentrations were similar across all dredge areas.

It is noted that NAGD does not specify screening levels for sediment nutrients. Table 3-2 provides a summary of nutrient concentrations measured between 2010 and 2016 at the Outer Channel, Inner Port and Navy Base dredge areas.

Table 3-2 Nutrient concentration ranges between 2010 and 2016

Parameter (mg/kg)	Outer Channel	Inner Port	Navy Base
Total nitrogen/ total Kjeldahl nitrogen	410–1500	1100–2230	1400–4000
Total phosphorus	286–548	328–478	408–784
Ammonia	2–18	6–65	16–223
Nitrate + nitrite	<0.1–0.2	<0.1–0.3	<0.1–0.1

Source references: Worley Parsons 2010, 2011, 2012, 2013, 2014, 2015, 2016

3.1.8 Perfluorinated Compounds (PFCs)

Perfluorinated compounds (PFCs) are chemical compounds often used as a component of aqueous film-forming foams (AFFFs) used for firefighting. These compounds are characterised as persistent in the environment with the potential to bio-accumulate or biomagnify. A spill of AFFFs (Tridol S3) occurred on 28 January 2013 from the BP Australia Pty Ltd depot on Draper Street in Cairns resulting in diluted foam being potentially discharged to Trinity Inlet.

Monitoring was undertaken by QLD DEHP, and PFCs were detected at the discharge site just after the event. Subsequent modelling and validation sampling in April 2013 recorded PFCs at low levels, although it was noted that some of the PFCs could have originated from other sources (such as the sewage treatment plant). Based on this monitoring, it was concluded that PFCs occurred at levels that represented a low risk to human health and recreational fishing, but had the potential for low level bioaccumulation and biomagnification.

Ports North undertook testing for PFCs on 39 sediment samples collected during the annual SAP implementation in April 2013. PFC residues were only detected in two samples at the shoreline near Wharf 10, potentially caused by historical contamination sources. The initial advice from the Department of Environment and Heritage Protection indicated that the spill presented a low risk to the Ports North maintenance dredging areas, and this sampling confirmed a low probability of a broad scale contamination issue with regards to PFCs and approval of the maintenance dredging for 2013 was granted. As a precautionary measure, analysis for PFCs was proposed to be included in subsequent SAP implementations, at a selection of sampling locations. Sampling for PFC's was also included in the SAP for the Maritime Safety Queensland dredge area at Smiths Creek, with results of sampling in July 2013 not detecting any PFC residues.

3.2 Recent Sediment Quality Data (2014 and 2017) – Capital Dredge Material

This section summarises data that was collected from studies that targeted the underlying capital dredge material. Assessment of the overlying maintenance material has been subject to the annual SAP process in 2013-16 as discussed in previous sections.

As part of the Draft EIS (Ports North 2015), a Sediment Sampling and Analysis Plan (SAP) and Implementation Report was prepared, in-line with sampling requirements for the previously proposed offshore placement of dredged material. While the project design has changed since the Draft EIS (reduced channel width and onshore placement – refer to Section 1.3), the results of the sediment sampling completed in 2014 for the Draft EIS (BMT WBM 2014) represents the most recent sediment quality data for the proposed capital material dredging areas. Therefore, this section provides an overview of those sediment monitoring results in reference to NAGD guidelines relevant to dredging and onshore placement.

It should be noted that contaminant sources in the study area have not changed since 2014, and considering the historical sediment quality results (i.e. clean material), it is reasonable to assume the 2014 data are relevant at the time of writing in 2017.

Additional 2016/2017 geotechnical data (Golder Associates, 2017) have been included in response to the change from offshore to onshore placement of dredge material.

The material to be dredged was analysed for the potential contaminants of concern in Table 3-3. Given the Cairns Port is located in a heavily urbanised catchment, the system is exposed to a range of contaminants associated with adjacent and upstream agricultural, residential, commercial and industrial land uses. However, historical monitoring indicates that that the Port area is well flushed and based on the review of existing data, a risk-based approach to monitoring meant that hydrocarbons, herbicides, pesticides, PCBs and nutrients were only monitored every three years and in a reduced number of samples – generally adjacent to the Inner Port (Table 3-3).

During implementation of the SAP process for the Draft EIS (BMT, 2014), it was noted that target core depths were not achieved at all monitoring sites due to a layer of consolidated clay material, forming ‘clay plugs’ at the end of the cores, and attaining a point of refusal in previously undisturbed seabed material. Clay plugs were collected at Inner Port sites (two samples) and Outer Channel sites (four samples) were analysed for potential contaminants. Concentrations of all chemical parameters were below relevant NAGD screening levels or the laboratory LORs in all clay plug samples. The results of the clay plug analysis indicated that deeper sediment layers, which could not be sampled due to core refusal, are unlikely to be contaminated.

Table 3-3 Potential contaminants of concern and 2014 sampling frequency (BMT WBM 2014 / Golder Associates 2017)

Parameter	Inner Port	Outer Channel
Particle size distribution	All surface samples, 10 samples per sediment class	All surface samples, 10 samples per sediment class
Inorganics		
Metals & metalloids	All samples	All samples
Acid sulfate potential (Chromium Suite)	All samples – including Golder Associates (2016, 2017) results	All samples – including Golder Associates (2016, 2017) results
Cyanide	Not analysed[1]	Not analysed[1]
Organics		
Organotins	All samples	All samples
Diuron	20% of samples initially, plus supplementary samples (BMT WBM 2014)	Not analysed initially but analysed during supplementary sampling (BMT WBM 2014)
Organophosphate and organochlorine pesticides (OPPs and OCPs)	20% of samples	Not analysed
Polycyclic aromatic hydrocarbons (PAHs)	20% of samples	Not analysed
Total petroleum hydrocarbons (TPHs)	20% of samples	Not analysed
Benzene, toluene, ethylbenzene, xylene (BTEX)	20% of samples	Not analysed
Volatile chlorinated hydrocarbons	Not analysed	Not analysed
Polychlorinated biphenyls (PCBs)	Not analysed	
Phenols	Not analysed	Not analysed
Perfluorinated compounds (PFCs)	All samples	Not analysed
Nutrients (organic and inorganic)	20% of samples	20% of samples

Notes:
[1] As per the approved SAP, cyanide was not included in the Phase II assessment of sediments given they were not detected in previous sampling events

3.2.1 Particle size distribution

The particle size distribution (PSD) of sediments within the Inner Port and Outer Channel were dominated by silts (~47–55%) and clays (~37–34%) (Table 3-4). Small proportions of sand (~14–10%) and gravel (~2.5–1%) were also recorded across Inner Port and Outer Channel sites (Table 3-4). The data indicated that the sand fractions were predominantly fine grained sand, with a lower proportion of medium and course grained sand (SAP implementation).

This data supports historical PSD results, indicating that silt and clay material is generally confined to the existing channel areas, with only low proportions of sand and gravel.

Table 3-4 Mean particle size distributions for each dredge area

Dredge area	Clay (<2 µm)	Silt (2–60 µm)	Sand (0.06–2.00 mm)	Gravel (>2 mm)
Inner Port	36.9	46.8	13.8	2.5
Outer Channel	33.9	54.8	10.1	1.3

Note: Values represent percent (%) of sediment (by dry weight) retained within each particle interval

3.2.2 Metals and metalloids

For the Inner Port dredge area, the 95% UCL of the mean concentrations for most metals and metalloids were below their respective NAGD or local screening levels. The only exception was mercury with a 95% UCL concentration of 0.196 mg/kg which marginally exceeded the NAGD screening level of 0.15 mg/kg. While mercury concentrations were well below the screening level for most locations in the Inner Port, high concentrations of 1.2 mg/kg and 0.62 mg/kg were measured in two samples.

For the Outer Channel, the 95% UCL of the mean concentrations for all metals and metalloids were below their respective NAGD or local screening levels. One elevated mercury concentration was measured in the surface sediment at one location (0.29 mg/kg). Nevertheless, the 95% UCL concentration of mercury (0.033 mg/kg) remained well below the NAGD screening level of 0.15 mg/kg for the Outer Channel.

Based on the elevated mercury levels in two samples in the Inner Port and one sample in the Outer Channel, additional elutriate and bioavailability testing (using dilute acid extraction) was undertaken to further investigate potential mercury contamination. Furthermore, re-analysis in triplicate of mercury concentrations in the three samples with elevated concentrations was undertaken.

Elutriate test results were below the LOR for all samples and therefore below the ANZECC trigger level of 0.1 µg/L. Dilute acid extraction results were below the LOR for all samples and therefore below the NAGD screening level of 0.15 mg/kg. The results of elutriate and bioavailability analyses demonstrate that no elevated mercury concentrations are expected during dredging. Bioavailability of mercury appears to be very low and marine organisms are not expected to be impacted after dredging. Furthermore, the triplicate re-analysis of the three samples with elevated mercury concentrations could not confirm the initial results. Therefore, it appears to be likely that the initial elevated mercury results were erroneous.

Arsenic concentrations were mostly well below the local screening level of 30 mg/kg in the Inner Port and Outer Channel areas. The only exception was one location in the Inner Port where an arsenic concentration of 33.3 mg/kg was recorded. However, the 95% UCL concentration for arsenic in the Inner Port was 20.38 mg/kg which remained well below the local screening level.

Three marginal exceedances of the nickel screening level of 21 mg/kg were recorded at two Inner Port locations. Nevertheless, the 95% UCL concentrations in the Inner Port and Outer Channel remained below the NAGD screening level with 16.21 mg/kg and 16.29 mg/kg respectively.

Antimony and cadmium were not detected in any of the Inner Port or Outer Channel samples.

As coring could not penetrate the underlying consolidated clay material, clay plugs (obtained from the end of the core) were sampled for the Inner Port (two samples) and the Outer Channel (four samples) and analysed for potential contaminants. Concentrations of all chemical parameters were below their respective screening levels or below the LOR in all clay samples. The results of the clay plug analysis indicated that deeper sediment layers, which could not be sampled due to core refusal, are unlikely to be contaminated.

3.2.3 Acid Sulfate Soil (ASS)

BMT WBM provided an ASS assessment in the 2014 SAP Implementation report (BMT WBM, 2014). However, these results were limited to surface sediments and not necessarily representative of the full depth of proposed capital dredging works. Acid sulfate soil (ASS) characteristics of proposed dredge material within the Inner Port and Outer Channel areas were again investigated by Golder Associates in 2016 (Golder Associates 2016, 2017). The results of the Golder Associates (2016, 2017) and BMT WBM (2014) are summarised as follows:

- Actual acidity was below the laboratory LoR at all sites and sampling depths for BMT WBM (2014) sampling, indicated surface sediments in the proposed dredge area are not Actual Acid Sulfate Soils. However, core refusal was relatively shallow (<2 m) and no definite conclusions can be made regarding the acid sulfate potential of deeper sediment layers that will be dredged as part of the Project.
- PASS is expected to be present in the very soft to soft clay and silt materials, which represent ~250,000 - 320,000 m^3 of the proposed dredge volume (Golder Associates 2017). The areas where PASS materials (without sufficient neutralising capacity[2]) have been identified are summarised in Table 3-5 (lower volume of 710,000 m^3) and Table 3-6 (upper volume of 900,000 m^3).
- The remaining material (~460,000 – 580,000 m^3) is expected to be self-neutralising clay material.
- Stiff clays, which represent approximately 80,000 m^3 of the total proposed dredge volume have been confirmed as non-ASS (Golder Associates 2017).

[2] i.e. calcium carbonate from crushed shell fragments.

Table 3-5 Volumes of PASS in each Dredge Area (Lower Volume Estimate of 710,000 m³)

Dredge		Chainage (m)		Soft Material Volume (insitu m³)		
Area	Location	Start	End	PASS	SNP^	Total
1	Outer Channel 1	22,500	24,500	-	6,857	6,857
2	Outer Channel 2	20,500	22,500	-	42,246	42,246
3	Outer Channel 3	18,500	20,500	-	203,333	203,333
4	Outer Channel 4	16,500	18,500	74,962	154,614	229,576
5	Outer Channel 5	14,500	16,500	124,722	13,131	137,853
6	Inner Channel	12,500	14,500	8,592	37,045	45,637
7	Inner Harbour	11,000	12,500	43,604	894	44,498
All				251,880	458,120	710,000

Notes:
^ Self-Neutralising PASS

Table 3-6 Volumes of PASS in each Dredge Area (Upper Volume Estimate of 900,000 m³)

Dredge		Chainage (m)		Soft Material Volume (insitu m³)		
Area	Location	Start	End	PASS	SNP^	Total
1	Outer Channel 1	22,500	24,500	-	8,691	8,691
2	Outer Channel 2	20,500	22,500	-	53,551	53,551
3	Outer Channel 3	18,500	20,500	-	257,746	257,746
4	Outer Channel 4	16,500	18,500	95,022	195,989	291,011
5	Outer Channel 5	14,500	16,500	158,099	16,645	174,744
6	Inner Channel	12,500	14,500	10,891	46,958	57,849
7	Inner Harbour	11,000	12,500	55,275	1,133	56,408
All				319,287	580,713	900,000

Notes:
^ Self-Neutralising PASS

3.2.4 Organotins

BMT WBM (2014) data indicated that the 95% UCL concentration for the organotin Tributyltin (TBT) was 0.7 µgSn/kg for the Inner Port and therefore well below the NAGD screening level of 9 µgSn/kg. Organotins were below the LOR in most samples and, where detected, only measured at low concentrations.

For the Outer Channel, the 95% UCL concentration for TBT was 0.4 µgSn/kg and therefore well below the NAGD screening level. Similar to the Inner Port, organotin concentrations were mostly below the LOR or measured at low concentrations in the Outer Channel.

3.2.5 Herbicides and pesticides

Diuron

During initial core sampling reported in BMT WBM (2014), diuron was detected in six of 16 samples within the Inner Port dredge area. Normalised concentrations ranged between 0.58 µg/kg and 3.84 µg/kg.

The detection of diuron triggered the need for further testing in accordance with the approved SAP. The additional testing involved re-sampling of the untested locations in the Inner Port and 20% of Outer Channel locations using a grab sampler. Following detection of diuron in two Outer Channel samples (located close to the Inner Port area), further sampling using a corer and grab sampler was undertaken at the remaining Outer Channel locations and some locations in the Inner Port in accordance with an approved Supplementary SAP (BMT WBM 2013).

Table 3-7 shows the summary statistics for all diuron data including the initial sampling, additional grab sampling and Supplementary SAP sampling.

Table 3-7 Diuron 95% UCL for Various Sampling Events

	Inner Port				Outer Channel	
	Initial sampling (µg/kg)	Initial sampling + additional grabs (µg/kg)	Supplementary SAP (µg/kg)	All samples combined (µg/kg)	Supplementary SAP (µg/kg)	All samples combined (µg/kg)
95% UCL	1.33	1.55	0.63	1.24	-	0.52

Whilst diuron was detected at some locations within the Inner Port dredge area, the 95% UCL of 1.24 µg/kg for all sampling data combined (initial sampling and additional grabs, plus Supplementary SAP samples) was below the literature derived screening level of 2 µg/kg.

Diuron was detected at normalised concentrations of 0.57 µg/kg to 0.95 µg/kg (below the screening level of 2 µg/kg) at two locations in the Outer Channel as part of additional grab sampling. Diuron was not detected in any of the remaining sampling locations of the Outer Channel for both grab sampling and Supplementary SAP sampling. The 95% UCL diuron concentration for all combined Outer Channel samples was 0.52 µg/kg and therefore well below the literature derived screening level of 2 µg/kg.

Diuron concentrations in the additional clay plugs analysed from the Inner Port were below the LOR in all clay samples indicating that the underlying clay layers are unlikely to be contaminated with diuron.

Organophosphate and organochlorine pesticides

Concentrations of OCPs and OPPs were below the LoR in all samples from the Inner Port. OCPs and OPPs were not analysed in sediments collected at Outer Channel sites.

3.2.6 Hydrocarbons

BMT WBM (2014) reported that Outer Channel sites were not analysed for PAH, TPH or BETEX as the review of the historical sediment sampling results indicated a low risk of this contaminant being present in the Outer Channel area.

Polycyclic aromatic hydrocarbons

The 95% UCL of normalised total PAHs concentrations was 35.3 µg/kg for the Inner Port sites, and well below 10% of the NAGD screening level (10,000 µg/kg) so no further testing was required as per the approved SAP (BMT WBM 2013).

Total petroleum hydrocarbons

TPHs were detected in low concentrations at Inner Port sites, with a maximum total normalised concentration of 54.2 mg/kg at one site. Therefore, the 95% UCL for total normalised TPH concentrations for Inner Port sites (32.2 mg/kg) was well below 10% of the NAGD screening level (550 mg/kg) so no further testing was required as per the approved SAP (BMT WBM 2013).

Benzene, toluene, ethylbenzene and xylene

Concentrations of BTEX were below the laboratory LoR within sediments sampled from the Inner Port.

3.2.7 Nutrients

Data reported in BMT WBM (2014) indicated that:

- Total Nitrogen concentrations ranged between 140 mg/kg and 1,540 mg/kg in the Inner Port, and between 150 mg/kg and 1,860 mg/kg in the Outer Channel.
- Total Phosphorus concentrations ranged between 139 mg/kg and 581 mg/kg for the Inner Port, and between 126 mg/kg and 1,770 mg/kg for the Outer Channel.
- Ammonia concentrations were below the LOR in about half of the Inner Port samples. Where detected, ammonia concentrations ranged between 1 mg/kg and 94 mg/kg. For the Outer Channel, ammonia concentrations were either below the LOR or ranged between 18 mg/kg and 124 mg/kg.
- Oxidised nitrogen (NOx) concentrations were mostly below the LOR with a maximum concentration of 0.2 mg/kg in the Inner Port. NOx concentrations were below the LOR in all Outer Channel samples.

No screening levels exist in NAGD for nutrients in sediments. However, nutrient levels in the Inner Port were consistent with previous testing from the Inner Port and Navy Base area (Table 3-2; Section 3.1.7). While nutrient concentrations in Outer Channel sediments were higher than previously recorded (Table 3-2Table 3-8; Section 3.1.7), it is noted that previous sediment sampling only included the surface sediments (using a grab sampler), and the higher nutrient concentrations detected in 2014 were measured in deeper sediment layers using coring methods. Nevertheless, the 95% UCL concentrations for nutrients in the Outer Channel (Table 3-8) appear to be consistent with previous test results.

Table 3-8 Ranges and 95% UCL of Inner Port and Outer Channel nutrients concentrations (BMT WBM 2014)

Parameter (mg/kg)	Outer Channel	Inner Port
Total nitrogen	150–1860 (1041)	140–1540 (1169)
Total phosphorus	126–1770 (535)	139–581 (393)
Ammonia	18–124 (52)	1–94 (35)
Nitrate + nitrite	<0.1	<0.1–0.2 (0.1)

Note: Parentheses = 95% upper confidence limit (UCL) of the mean

3.2.8 Perfluorinated Compounds (PFCs)

BMT WBM (2014) reported that concentrations of PFCs were below the LOR in most Inner Port samples. Individual PFC compounds were detected at very low concentrations close to LOR in two samples. One sample recorded a normalised concentration of 0.0026 mg/kg of the compound 6:2

Fluorotelomer sulfonate (6:2 FtS). The other sample had a normalised concentration of 0.00009 mg/kg of the compound PFNA.

As per the SAP, and on the basis of evaluation of probability, no testing for PFCs was undertaken for the Outer Channel dredge area.

4 Assessment of Potential Impacts

4.1 Overview

Construction works will involve the capital dredging and the placement of the dredged material at an onshore DMPA. Ongoing maintenance dredging and dredged material placement will also be required throughout the ongoing operation of the new channel infrastructure arising from this project. Dredging and other disturbances to marine sediments can alter the physical and/or chemical characteristics of the existing marine sediment environment, potentially resulting in adverse effects to marine ecological values.

In this section, potential impacts are discussed in terms of the construction and operational stages, as follows:

- Construction stage – primarily focusing on capital dredging and placement activities
- Operational stage - operation of the port facilities, maintenance dredging of the inner port and entrance channel, and placement of maintenance dredge material.

A risk-based approach has been used to assess sediment quality impacts, and is based on the consideration of the following:

- Consequence of Impact – made up of assessment of the intensity, scale (geographic extent), duration of sediment quality impacts and sensitivity of environmental receptors to the impact. Table 4-1 is a summary of the categories used to define impact significance.
- Duration of impact - the duration of identified impacts is classified as per Table 4-2.
- Likelihood of Impact – which assesses the probability of the impact occurring. Table 4-3 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 4-4) adopted is generated from the Consequence and Likelihood scores, based on the overall matrix presented in Part A.

Table 4-1 Categories Used to Define Consequence of Impact (Sediment Quality)

Impact Consequence	Description for Water Quality (includes magnitude, duration, and sensitivity of receiving values)
Very High	The impact is considered critical to the decision-making process due to its significance/importance at a national or international scale. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large-scale areas.
High	The effects of the impact are likely to be important to decision-making due to its state significance/importance. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large or medium scale areas.
Moderate	While important at a regional or local scale, these impacts are not likely to be key decision making issues. Impacts tend to be medium or short term and/or occur over a medium to small (local) scale.
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

Impact Consequence	Description for Water Quality (includes magnitude, duration, and sensitivity of receiving values)
	the consideration of standard mitigation measures. Impacts tend to be short term or temporary and/or occur at local scale.
Negligible	Minimal change to the existing situation. This could include for example impacts which are beneath levels of detection, impacts that are within the normal bounds of variation or impacts that are within the margin of forecasting error.
Beneficial	Any beneficial impacts as a result of the Project such as for example, the improvement of habitat.

Table 4-2 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 4-3 Categories Used to Define Likelihood of Impact (Sediment Quality)

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 likely than not 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 impacting period

Table 4-4 Risk Matrix for Sediment Quality

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 4-5 Risk Rating Legend

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact on a Matter of National or State Environmental Significance
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact on a Matter of National or State Environmental Significance
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

4.2 Methodology

The elements of this Project that may directly or indirectly impact the marine sediment environment have been separated into two broad categories for the purpose of the impact assessment:

- Construction phase: capital dredging and other marine-based construction activities
- Operational phase: maintenance dredging and other marine-based operational activities.

For each of these categories, the assessment primarily focused on the trace metals/metalloids as these are the key contaminants of concern in the context of the Project. Other potential contaminants such as nutrients and potential acid sulfate soils were also considered.

Note that construction phase sediment quality impacts from onshore placement of the dredge material, including consideration of ASS issues, is not assessed in this report. These issues are addressed separately in relevant chapters of the EIS.

Furthermore, this report is principally concerned with the disturbance of sediments during dredging and construction that could release contaminants within sediments. The potential impacts of increased suspended sediments and turbid plumes to water quality and marine ecology values are discussed separately in relevant chapters of the EIS.

4.3 Construction Phase Impacts

4.3.1 Dredging and Sediment Disturbance

Capital dredging during the construction phase of the Project will result in the removal of up to 1 M m^3 of marine sediments. Marine sediments may be mobilised at the dredge site via the following mechanisms:

- Sediment disturbance at the dredge site by the dredge propellers and manoeuvring thrusters.
- Sediment directly disturbed at the dredge site by the dredge head.
- Overflow dredging (if required) – where excess water from the dredged material is drained from the hopper and released back into the water column releasing suspended sediment.
- Spills from the mechanical backhoe dredger – during the process of transferring sediment from the sea floor to the hopper.

Minor disturbance and mobilisation of marine sediments may also occur as a result of other construction activities, particularly the pile driving activities associated with the structural upgrade to the existing shipping wharves.

The most recent sediment sampling and analysis results from Inner Port and Outer Channel sites (Section 3) indicate that the 95% UCL of all potential contaminants of concern (i.e. metals and organic contaminants) were below the relevant NAGD screening levels, with the exception of total mercury concentrations. However, the elutriate and bioavailable concentrations of total mercury were below relevant ANZECC/ARMCANZ (2000) default marine water quality guidelines and NAGD screening levels, respectively. Therefore, it is unlikely that concentrations of contaminants of concern released during dredging pose any significant risk to the surrounding marine environment.

This assessment is in-line with results of annual maintenance dredging sediment sampling and analysis findings that the material as suitable for unconfined marine placement between 1995 and 2016 (Section 3).

Changes in pH due to disturbance and exposure of acid sulfate soils to the atmosphere can lead to water quality impacts. As discussed in Section 3.2.3, potential acid sulfate soil is expected to be present in the very soft to soft clay and silt materials, which represent approximately ~250,000 - 320,000 m^3 of the proposed dredge volume. The remaining material (~460,000 – 580,000 m^3) is expected to be self-neutralising material. However, it is still expected that some acidity would be released from this material if exposed to air for extended periods (Golder 2014). PASS material (that is not self-neutralising) will potentially release acidity if exposed to air for extended periods. There is negligible risk of ASS impacts from the dredging activity (i.e. disturbance of PASS at the dredge head) as there are no pathways for oxidation in seawater. Once the material is in the dredge hopper, under normal operating conditions of the TSHD, the dredge material remains waterlogged in the hopper for a matter of hours, therefore the risk of oxidation is negligible. At the TSHD dredge pump-out location, the dredge material will be pumped via enclosed pipeline into a void filled with water, ensuring the dredge material is waterlogged at all times. Further details on how the PASS will be managed in the Northern Sands DMPA is discussed in relevant chapters of the EIS.

It is assumed that PASS will be managed appropriately in the Northern Sands DMPA such that tailwater discharges into the Barron River are at a neutral pH with negligible impacts.

Therefore, in terms of sediment quality, the potential impacts from sediment disturbance from dredging are considered to be short-term and negligible.

4.3.2 Upgrade to Wharf Infrastructure

Upgrade to the wharf infrastructure will involve installation of independent dolphins requiring steel piles. These piles may be driven by piling rig with crane and hammer from a barge. If required, a drilling rig will be used for rock sockets. It is proposed there will be 21 independent dolphins, with each dolphin requiring four piles. Therefore, 84 piles may require installation during construction.

While there may be some disturbance of bottom sediments during these construction works, the contaminant levels contained within the sediment (in the location at which this construction activity is proposed) has been found to be within acceptable screening levels as per NAGD. Therefore, disturbance of these sediments is expected to pose relatively short-term and negligible impacts.

4.4 Operational Phase Impacts

4.4.1 Future Maintenance Dredging and Placement

Maintenance dredging of the Inner Port and Outer Channel areas is usually undertaken at least annually, with volumes varying over time. It is expected that any future maintenance dredging and dredge material placement during the operational phase of the Project will be undertaken in accordance with NAGD or similar future versions of these guidelines, and results would be assessed in liaison with the required regulatory body to determine the appropriate placement of dredge material. Consequently, neither a build-up nor entrainment of contaminants at the approved marine DMPA would be expected to occur as a result of the placement of maintenance dredge material (based on the analysis of material in the aforementioned studies, and in the absence of any contaminating events or new contaminant sources), and the potential impacts associated with this activity are considered to be long-term but negligible.

4.4.2 Increased Shipping

Once operational, it is forecast as part of the Demand Study Update for the project (AEC, 2016) that cruise shipping activity (and associated refuelling activity) will increase by approximately 33 ships by 2031, with an overall upper bound estimate of 183 ship visits per year.

However, it should be noted that a much larger number of these overall ships will be able to access Trinity Wharves compared to the current situation where many of these vessels are only able to moor offshore from Yorkey's Knob.

The increase in shipping and refuelling activity may increase the potential for shipping related contaminants (e.g. hydrocarbons) to enter the marine environment. While these types of contaminants are more likely to effect water quality (i.e. many hydrocarbons float on water), there is potential that some hydrocarbons (e.g. PAHs that are denser than water) can affect sediment quality. However, fuel handling and storage procedures are currently part of the Port's operational procedures for existing port operational activities (ship fuel bunkering facilities are currently provided for marine diesel fuels). These procedures will likely need to be revised based on the change in shipping and Intermediate Fuel Oil (IFO) refuelling activity resulting from the Project. Implementation of these procedures is expected to reduce the risk of significant loads of contaminants entering the marine environment.

Maintenance works on cruise liner vessels is not envisaged to be major, and encompass minor deck works, with activities such as hull and prop cleaning not permitted whilst alongside. Therefore, increased cruise vessel numbers is unlikely to contribute to additional contaminant loads to the sediment from maintenance activities.

Further to this, the Ports North annual sediment quality monitoring program will continue to monitor sediment contamination levels in the port areas to determine if contamination levels change as a result of the Project.

Therefore, based on the implementation of management procedures already in place for existing port operational activities, the potential impacts to sediment quality from increased shipping are considered to be long-term but negligible.

5 Recommended Mitigation Measures

5.1 Mitigation Measures

As mentioned previously, marine sediments in the proposed dredging areas have been assessed as uncontaminated in accordance with the NAGD (Section 3). In this regard, potential impacts to the marine environment from mobilised sediments are considered to be negligible. Nevertheless, it is assumed that the following standard mitigation measures will be employed to ensure the impacts are negligible:

- Dredge material containing PASS in the TSHD hopper should ideally remain waterlogged in the hopper and not be left exposed 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 noted below and in accordance with NAGD or future versions of these guidelines. Also, maintenance dredge material is to be tested in accordance with the frequency intervals outlined in the guidelines to ensure only acceptable, uncontaminated maintenance dredge material will be placed at sea.

Further to the above standard mitigation measures, the following additional mitigation is proposed to reduce the potential impacts further:

- 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.

5.2 Monitoring

In accordance with the current Ports North Annual Sediment Monitoring Program and sampling for maintenance dredging, regular monitoring of sediment quality in the port areas will continue to occur. No additional ongoing marine sediment quality monitoring is needed or proposed specifically as part of the Project.

The Cairns Harbour Long Term Dredge Spoil Disposal Management Plan (LTDSDMP) (Worley Parsons, 2010) provides the long term dredge material placement strategy for the Port. As a result of the Cairns Shipping Development Project, a revision of the LTDSDMP is likely to be required and will be managed by Ports North through consultation with the established Technical Advisory Consultative Committee (TACC).

6 Residual Impacts and Assessment Summary

Table 6-1 provides a summary of the sediment quality issues identified by the impact assessment, including the results of the risk assessment for each issue, the relevant mitigation measures and the resultant residual risk.

Table 6-1 Impact assessment summary

Sediment quality	Initial assessment with standard mitigation (statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. recommended as a result of this impact assessment			
Primary impacting process	**Standard mitigation measures required**	**Consequence of impact**	**Likelihood of impact**	**Risk rating**	**Additional mitigation measures proposed**	**Consequence of impact**	**Likelihood of impact**	**Risk rating**
Mobilisation of contaminated sediments during capital dredging	Sediment tested in accordance with an approved Sampling and Analysis Plan (SAP) – this has been completed	Negligible	Highly unlikely	Negligible	Nil	Negligible	Highly unlikely	Negligible
Oxidation of acid sulfate soils if dredge material is exposed to air for extended period of time	Dredge material containing PASS in the TSHD hopper should ideally remain waterlogged in the hopper and not be left exposed for periods longer than 24 hours	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Potential decline in sediment quality, in or adjacent to Project footprint in the future, as a result of increased shipping	Nil	Negligible	Unlikely	Negligible	Revise and implement fuel handling and spill response procedures in the Port's Operations Procedures	Negligible	Highly unlikely	Negligible
Mobilisation of contaminated sediments during future maintenance dredging and placement at DMPAs	• Revise and implement annual sediment monitoring program for maintenance dredging in-line with current dredging guidelines and legislation • Revise and implement maintenance dredging in-line with approved LTDSDMP (Worley Parsons, 2010) for the new Project footprint	Negligible	Highly unlikely	Negligible	Nil	Negligible	Highly unlikely	Negligible

Notes: LTDSDM = Long-term Dredge Spoil Disposal Management Plan, TSHD = Trailer Suction Hopper Dredge

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