TOONDAH HARBOUR

CHAPTER 9
SURFACE WATER QUALITY

9. Surface Water Quality

9.1. Introduction

The Water Quality technical studies were completed by frc environmental. Details of the key personnel involved in the study are provided in Appendix 1-F. The water quality technical report is included as Appendix 2-G. Stormwater and receiving water quality modelling have been extracted from the Coastal Processes Technical Report (Appendix 2-E).

9.1.1 Scope of Study

This section addresses the surface water quality requirements of the EPBC Act EIS Guidelines and other legislative requirements. It includes:

- An assessment of baseline water quality, and comparison to the relevant water quality objectives (WQO), comprising the:
  - Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018);
  - Moreton Bay environmental values and water quality objectives (DERM 2010a) for aquatic ecosystem, moderately disturbed water area - Area C2 (Central Bay) and for aquatic ecosystem, high ecological value – Area HEVa1284;
  - Redland Creeks environmental values and water quality objectives (DERM 2010b) for aquatic ecosystem, moderately disturbed mid estuary; and
- An assessment of impacts on marine water quality resulting from construction and ongoing uses (i.e., dredging, excavation, reclamation, construction and increased use). The assessment of impacts is based on the outcomes of coastal processes and dredge plume modelling provided in Chapter 8 of the EIS.

9.1.2 Water Quality Objectives

In Queensland the process for identifying WQO is outlined in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP Water and Wetlands). The purpose of this policy is to achieve the objective of the *Environmental Protection Act 1994* in relation to waters and wetlands by:

- Identifying environmental values for waters and wetlands;
- Identifying management goals for waters;
- Stating water quality guidelines (WQG) and WQO to enhance or protect the environmental values;
- Providing a framework for making consistent, equitable and informed decisions about waters; and
- Monitoring and reporting on the condition of waters.

The State of Queensland has used the framework outlined in the National Water Quality Management Strategy (NWQMS) to develop water quality management plans for waters throughout Queensland (site specific guideline values). The NWQMS advises that site specific guidelines should be used in preference to National default guidelines. The site-specific guidelines and supporting maps for south-east Queensland are provided under Schedule 1 of the EPP Water and Wetlands, with interactive maps also provided online (DES 2022).

Environmental values (EVs) for water are the qualities that make it suitable for supporting aquatic ecosystems and human use. These EVs need to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use (DERM 2010a).

WQGs are numerical concentrations (or descriptive statements) for key indicators (e.g., total concentration of nitrogen) that protect an EV. WQGs are used to develop WQOs (DERM 2010a).

WQO are long term goals for water quality management. They are numerical concentrations (or descriptive statements) of indicators that will support and protect the designated EVs. They are based on scientific criteria and WQGs and may be modified by other inputs (e.g., social, cultural and economic) (DERM 2010a).

Different types of waters, and the management intent for each type, are defined in the EPP Water and Wetlands:

- **High ecological value (HEV) waters:** The biological integrity of HEV water is effectively unmodified or is highly valued. In HEV waters, WQOs are to be maintained. In Moreton Bay there is another sub-category of HEV waters: HEV waters (achieve). The management intent for these waters is to achieve the WQOs.
- **Slightly disturbed waters:** Physical and chemical indicators of slightly disturbed waters are slightly modified, and they have the biological integrity of HEV waters. In slightly disturbed waters, water quality is to be improved where needed, to achieve WQOs.
- **Moderately disturbed waters:** In moderately disturbed waters biological integrity is adversely affected by human activity to a relatively small but measurable degree. In moderately disturbed waters, water quality needs to be maintained, or improved where needed, to meet WQOs.
- **Highly disturbed waters:** are significantly degraded by human activity. In highly disturbed waters, water quality needs to be improved to meet the WQOs.

EVs and WQOs for Moreton Bay are provided in the EPP Water and Wetlands: Moreton Bay EVs and WQO (DERM 2010a). Water types and management intents for Moreton Bay are shown in Map 10.1, and for the area in the vicinity of the Project in Map 10.2.

Under the EPP Water and Wetlands, the Project footprint and surrounds are in moderately disturbed waters (Area C2). The northern section of the MIA (refer to Figure 6-2) is in HEV waters (maintain, Area C1). Offshore of the proposed expanded Channel, between Cassim and Coochiemudlo Islands there is an area of HEV waters (achieve, Area HEVa1284). EPP Water and Wetlands water types are shown on Figure 9-1.

The management intent for Area C2 is for water quality to comply with the WQO and for the median depth distribution of the seagrass *Zostera muelleri* of 2.2 m AHD to be maintained.

The WQO for HEV Area C1 are to maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas, and to maintain the existing median depth distribution of the seagrass *Z. muelleri* of 2.2 m AHD.

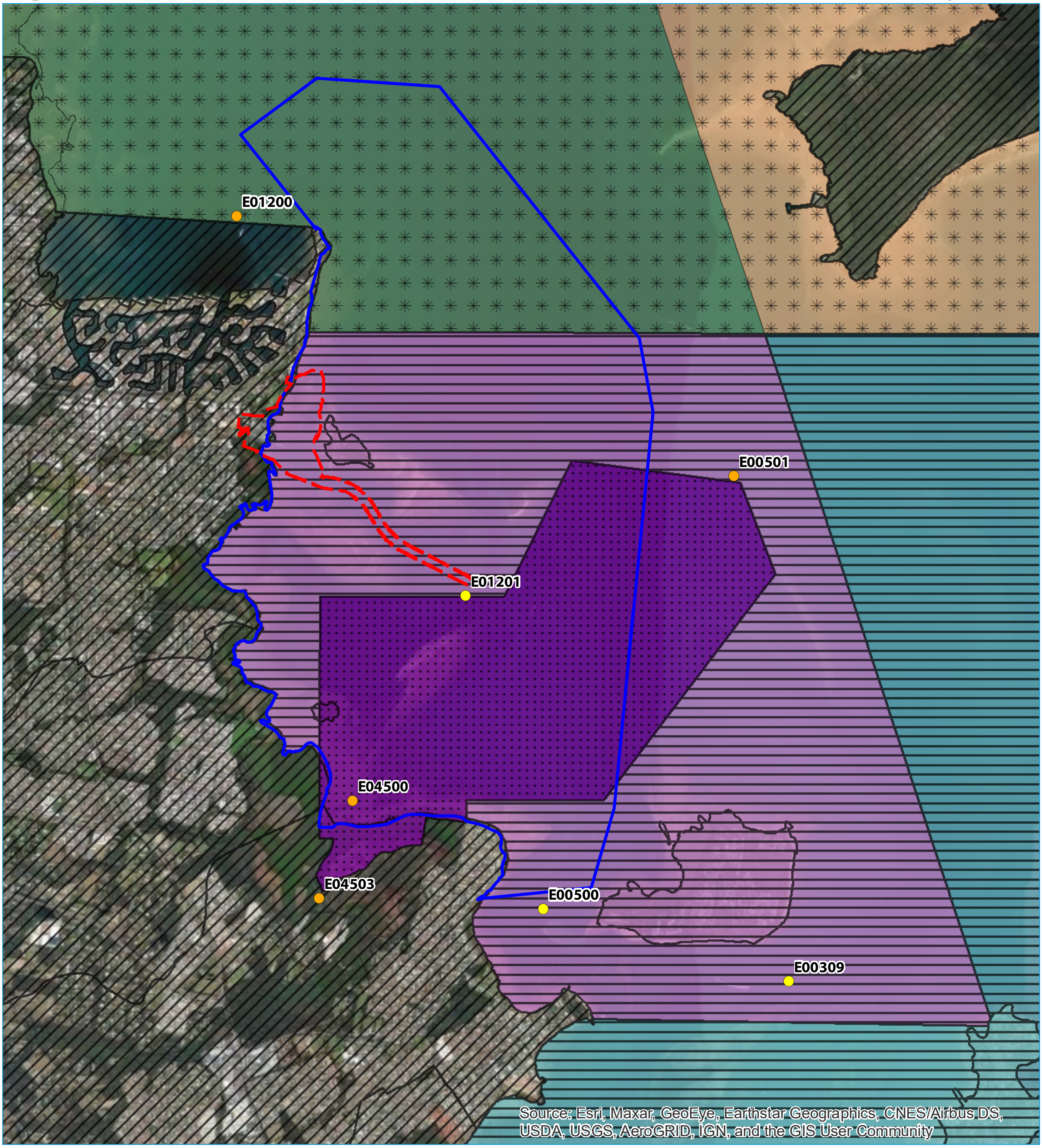
The WQO for area HEVa1284 are to achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas, and to maintain the existing median depth distribution of *Z. muelleri* of 1.9 m AHD.

In addition to the EPP Water and Wetlands stormwater treatment requirements are specified in the State Planning Policy (SPP). Table 9-1 outlines the SPP Stormwater Management Design Objectives relevant to the Project.

Table 9-1: State Planning Policy Stormwater Management Design Objectives.

Pollutant	Criteria
Total suspended solids	80% reduction
Total phosphorus	60% reduction
Total nitrogen	45% reduction
Gross pollutants (5 mm or larger)	90% reduction

Figure 9-1: EPP Water and Wetland Status and EHMP Water Quality Sites



Toondah Harbour EIS

Legend

- Project Footprint
- Marine Investigation Area

EHMP Sites

- Current water quality site
- Historic water quality site

Management intent

- HEV (achieve) marine
- HEV (maintain) marine
- Moderately Disturbed
- Moderately Disturbed marine

- Central Bay : EHMP zone (part)
- Eastern Bay (south) : EHMP zone (part)
- Marine Parks (Moreton Bay) Zoning Plan 2008: Marine National Park zone
- Moreton Bay : Central Bay enclosed coastal
- Moreton Bay: Eastern Bay and Banks Open coastal waters - oceanic and estuarine influence

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N

0 500 1,000 1,500 2,000 Meters

GDA 1994 MGA zone 56

Scale (A4): 1:55,000

9.1.3 Activities that May Result in Impacts

Changes in surface water quality could occur as a result of a number of Project activities. These include:

- Reclamation and maritime construction works:
  - Excavation of mud, sheet piling and placement of rock to construct the bund walls creating minor turbidity plumes around the works area;
  - Release of contaminants and nutrients into the water column from sediments disturbed by the reclamation process, including ASS;
  - Potential for spills of fuel and other chemicals.

- Dredging:
  - Suspension of contaminants and nutrients present in sediment into the water column;
  - Potential for spills of fuel and other chemicals;
  - Creation of temporary suspended sediment (turbidity) plumes in the water column during dredging and loading of barges with sediment.

- Building and civil works (onshore and within the reclamation):
  - Stormwater runoff from civil and building construction areas transporting surface soils or contaminants into drainage lines and ultimately Moreton Bay;
  - Disturbance of contaminated soils within the Project footprint;
  - Potential for spills of fuel and other chemicals.

- Ongoing operation of the ferry terminal, marina and urban development:
  - Potential for spills of fuel and other chemicals;
  - Potential for long term degradation of water quality from stormwater runoff and stagnation of water within the marina and internal waterways
  - Ongoing maintenance dredging of the Fison Channel and turning basin and internal waterways and marina (noting that maintenance dredging is currently carried out regularly for the existing channel and turning basin);
  - Increased waste generation from residential, retail and commercial uses.

9.2. Assessment Methodology

Water quality, and in particular turbidity, total suspended solids and nutrient concentrations are important determinants in the distribution, composition and ecological health of marine habitats, which are addressed in Chapter 16 of the Draft EIS. Consequently, the current condition of water quality was assessed using existing data and via a field campaign to provide context for potential impacts from the Project.

9.2.1 Desktop Methods

Available literature and data for water quality in the vicinity of the Project footprint was collated and reviewed, including data collected as part of the Ecological Health Monitoring Program (EHMP) by Healthy Land and Water (HLW) and during the maintenance dredging of Toondah Harbour and the Fison Channel in 2019.

9.2.1.1 *Analysis of EHMP Data*

HLW has collected water quality data throughout Moreton Bay and catchments as part of the EHMP approximately each month since 2000. The following data is recorded at each site:

- turbidity (NTU);
- chlorophyll *a* (µg/L);
- phaeopigments (µg/L);
- total nitrogen (mg/L);
- ammonia (mg/L);
- oxides of nitrogen (mg/L);
- organic nitrogen (mg/L);
- total phosphorus (mg/L);
- ortho phosphorus (filterable reactive phosphorus) (mg/L);
- dissolved oxygen (% saturation);
- pH;
- Secchi depth (m);
- salinity (g/L);
- electrical conductivity (mS/cm);
- water temperature (°C).

Data for seven sites near the Project footprint (Figure 9-1) were compared to the relevant WQOs (Table 9-2). As outlined in the EPP Water and Wetlands:

- For sites in HEV areas (C1 and HEVa1284), the 75^{th} confidence interval ranges of the 20^{th}, 50^{th} and 80^{th} percentiles of water quality data were compared to the WQO, where the WQO is not within the 75^{th} confidence interval for a percentile, the water quality parameter does not comply with the WQO.
- For all other sites, the 50th percentile was compared to the WQO.

Figure 9-1 shows the classification of the waters in the vicinity of the Project footprint and the location of EHMP water quality monitoring sites. Comparison tables are included in Appendix 2-G. The management intent of HEV waters is to maintain their natural values and condition, while the intent in moderately disturbed waters is to improve their natural values and condition towards HEV condition.

Table 9-2: EHMP Sites and Relevant Water Area WQO.

EHMP Site	Site Description	Water Type	Water Area	WQO Comparison[3]	Human Health Primary Contact WQO
E01200	Offshore of Raby Bay, 4 km north east of the PDA	enclosed coastal	C1	75th CL of percentiles	pH: 6.5– 8.5 DO: >80%
E01201	Offshore of the end of the proposed Channel	open coastal	HEVa1284	75th CL of percentiles	pH: 6.5 – 8.5 DO: >80%
E04500	Mouth of Eprapah Creek, to the south of the PDA closest inshore EHMP site	enclosed coastal	HEVa1284[1]	75th CL of percentiles	pH: 6.5 – 8.5 DO: >80%
E04503	Eprapah Creek 0.6 km upstream from the mouth	middle estuary	HEVa1284[1]	75th CL of percentiles	pH: 6.5 – 8.5 DO: >80%
E00309	Northern Broadwater, 7 km south east of the PDA	enclosed coastal	C2	median	pH: 6.5 – 8.5 DO: >80%
E00500	Moreton Bay, just south of the Investigation Area	enclosed coastal	C2	median	pH: 6.5 – 8.5 DO: >80%
E00501	Moreton Bay East of the Investigation Area	open coastal	C2	median	pH: 6.5 – 8.5 DO: >80%

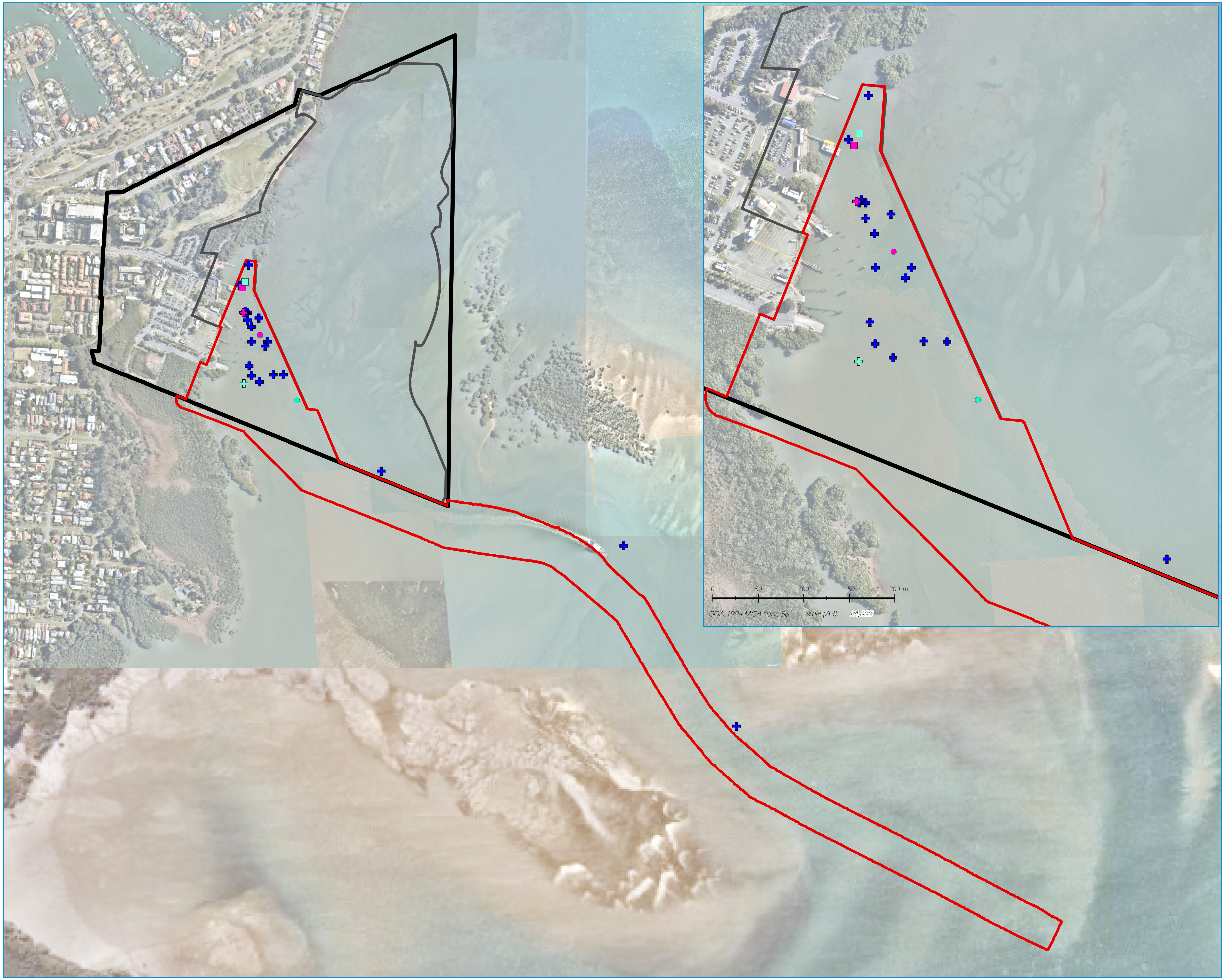
[1] These objectives were used for lower Eprapah Creek as waters shown on the plan as being mid estuary and occurring within/adjoining Moreton Bay may have water quality characteristics more in common with their adjacent downstream water areas and under such circumstances.
[2] Data collection stopped at these sites in August 2014.
[3]The statistic that is compared to the WQO (CL = Confidence Limit).

9.2.1.2 *Analysis of Data from Dredge Campaign in 2019*

Toondah Harbour and the Fison Channel were dredged between 9 May 2019 and 2 August 2019 using two different dredgers, the ‘Faucon’ and the ‘Port Frederick’. To comply with the environmental authority (EA) for this work, depth profiles of turbidity and pH were monitored down-current and up-current of the dredging activity each week.

In the Environmental Authority the up-current site was defined as 50-100 m up-current from any location where sediment was disturbed during the regular conduct of the dredging activity, and the down-current site was defined as less than, but not more than 350 m down-current of the dredging activity. Water quality was monitored 22 times during the course of the dredging, with the collection positions varying each time with the location of the dredging activity, and the direction of the current (Figure 9-2). Water quality measurements were only collected during tidal flows. The turbidity and pH at the down-current monitoring point were compared to the background value (BV) the average of readings from the depth profiles at the up-current point on that day.

Figure 9-2: Water Quality 2019 Maintenance Dredging Campaign



Legend

- Toondah Harbour PDA
- Qld DCDB
- Dredge Area
- Reclamation Area

Non-compliance 350m downcurrent

- Thursday, 16 May 2019 - Barge position - 9:02:00 AM
- Thursday, 16 May 2019 - Up current - 9:02:00 AM
- Thursday, 16 May 2019 - Down current - 9:02:00 AM

No non-compliance 350m downcurrent

- Friday, 10 May 2019 - Down current - 11:50:00 AM
- Friday, 10 May 2019 - Barge position - 11:50:00 AM
- Friday, 10 May 2019 - Up current - 11:50:00 AM

Compliant

- Monitoring Barge Position

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0 100 200 300 400 m

GDA 1994 MGA zone 56 Scale (A3): 1:9,000

N

DATE: 20/07/2022

Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial Imagery (Nearmap.com 2020)

9.2.2 Field Methods

9.2.2.1 *Turbidity Loggers*

Seagrass beds are located within and in areas surrounding the Project footprint (refer to Chapter 16). The lower depth limit, and hence the distribution of seagrass, in this area is likely limited by light availability. Dredging may decrease the amount of available light by increasing the amount of suspended sediment in the water column, and thereby increasing turbidity. Consequently, turbidity was measured at the deepest end of the seagrass bed in the MIA in order to characterise existing conditions.

Water quality loggers (YSI 600OMS Sonde) were installed as close as possible to the sediment surface at five sites (Figure 9-3):

- Site L1: mid-distance from the proposed dredging, and close to shore (22 September 2015 to 30 January 2018);
- Sites L2: close to ferry movements in the existing channel and the proposed dredging (22 September 2015 to 30 January 2018);
- Site L3: mid-distance from the proposed dredging, offshore, but close to Sandy Island, and near coral outcrop (22 September 2015 to August 2019);
- Site L5: close to the existing channel and the proposed dredging (2 February 2018 to 28 August 2019); and
- Site L6: close to the existing channel and the proposed dredging, inshore (2 February 2018 to 28 August 2019).

Each site was at the deepest end of a seagrass bed. While seagrass was sparse near each logger, it persisted through the logging period. Typical turbidity logger site setup is shown on Figure 9-4. While the distribution of coral is also impacted by light availability (and hence turbidity) the distribution of coral near the proposed dredging is limited, and consequently water quality was not measured specifically over coral outcrops.

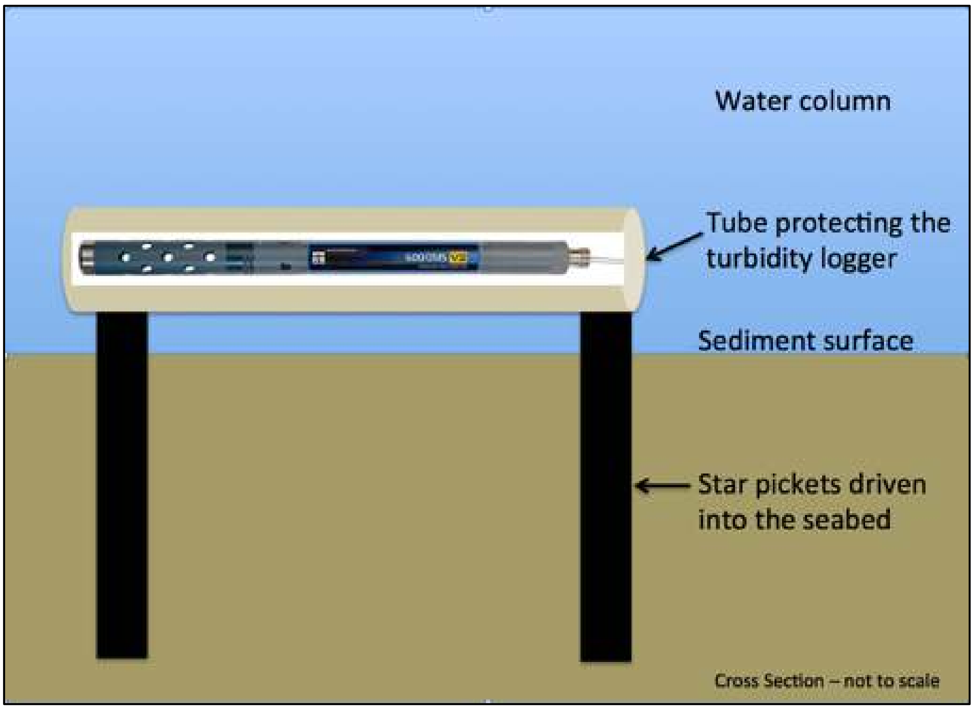

Figure 9-3: Deployment of Turbidity Logger.

Figure 9-4: Project Specific Turbidity Logging Locations

Toondah Harbour EIS

Legend

Project Footprint

Marine Investigation Area

2018-2019 frc loggers

2015-2019 frc loggers

2015-2017 frc loggers

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N

0 500 1,000 1,500 2,000 Meters

GDA 1994 MGA zone 56

Scale (A4): 1:44,000

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Turbidity (measured in NTU) was recorded every 15 minutes at each site. Data was downloaded, and the loggers calibrated every two weeks, except where weather conditions did not allow safe access. In these instances, the loggers were calibrated as soon as safely possible. The loggers were calibrated with turbidity standards of 0, 126 and 1000 NTU, and the sensors cleaned every 15 minutes to prevent fouling and bubbles forming on the optical surface.

9.2.2.2 *Analysis of Data*

Prior to analysis turbidity data was 'cleaned', with likely erroneous readings removed where:

- All data where the specific conductivity value was less than 20 mg/L, as low conductivity measurements indicated periods when the logger was exposed at low tide, or being serviced.
- All turbidity values less than -3 NTU, with the remaining negative turbidity values (i.e., negative values greater than -3 NTU) converted to 0 NTU.
- All turbidity values within periods (i.e., the time between two calibration dates) where negative turbidity values comprised more than half of the recorded readings.
- Isolated turbidity spikes above 50 NTU, where a spike was defined as exceeding the mean of the preceding and succeeding two samples (i.e., half hour prior and following) by a factor of 10, since momentary spikes in data may indicate passing debris (e.g. plant detritus) or small animals (OzCoasts 2020) and are not reflective of actual turbidity.
- Turbidity values where obvious drift was observed, where drift was defined as when the baseline turbidity values (i.e., 6 hour rolling average) regularly increased until the next calibration where the baseline values immediately decreased.
- All turbidity values within periods where negative values and isolated spikes comprised more than a third of the recorded readings.

Once data was reviewed and cleaned it was compared to the relevant WQO and statistically analysed. Basic statistical analyses comprised calculations of the 10th, 20th, 50th, 80th and 90th percentiles, mean values, minimum values and maximum values. Box and whisker plots were created to help infer any long-term trends in turbidity. Data was then analysed using SPSS Statistics to determine if there were any statistical differences or correlations with season (winter, spring, summer and autumn), wind direction, tide height, and ferry activity (logger at site L2).

The ferry timetables were used to estimate the time each ferry passed Site L2. As Site L2 is five minutes by ferry from the terminal, five minutes were subtracted from the arrival time, and five minutes added to the departure time. Turbidity records were then allocated to categories, depending on the time since the last ferry. The following categories were used:

- Ferry passed within 0-5 minutes of the sample time;
- Ferry passed within 5-10 minutes of the sample time;
- Ferry passed within 10-15 minutes of the sample time; and
- Ferry passed the logger more than 15 minutes from the sampling time.

In order to assist in assessing impacts to key receptors such as seagrass and coral, rolling two-week averages of daytime (6 am to 6 pm) turbidity were calculated.

9.2.3 Surface Water Quality Modelling

9.2.3.1 *Stormwater Modelling*

Stormwater modelling was undertaken to assess the generation, transportation, and management and treatment of stormwater flows and pollutant loads from the Project footprint and the upstream catchment. Existing conditions and different development stages were considered so that an assessment of the additional stormwater contribution from the proposed reclamation areas could be estimated. More specifically, the model results were used to:

- Estimate multi-year stormwater flows and pollutant loads being generated at the Project footprint;
- Develop a stormwater treatment strategy that, at minimum, achieves State Planning Policy for pollutant reductions; and
- Produce stormwater boundary conditions (i.e., flow rates and pollutant concentrations) for receiving water modelling assessments to support analysis of:
  - Stormwater dispersion characteristics as it entered the Project footprint and adjacent waterways, and
  - Potential for vertical density stratification development in the proposed internal waterways.

The catchment and stormwater runoff were modelled using eWater's Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 6.3.0. MUSIC is capable of simulating the generation, transportation and management/ treatment of flows and pollutant loads from the Project footprint and the upstream catchment. MUSIC is the industry standard for stormwater quality assessments in Australia and therefore is well suited to the assessments required for the Project.

Stormwater modelling technical studies are included in Appendix 2-E: Coastal Processes and Hydrodynamics Technical Report. A description of the methodology utilised for the assessment is included in section 3.3 of Appendix 2-E.

9.2.3.2 *Receiving water quality modelling*

Receiving water quality modelling was undertaken using the coastal processes model (refer to Chapter 8) and outcomes of the stormwater modelling. More specifically, the coastal processes model described earlier was adopted for the relevant simulations and its results analysed for the different Project stage scenarios. In this context, the model will be referred to as the Receiving Water Quality Model (RWQM).

Water quality assessments undertaken included:

- Flushing analysis of the Project internal waterways and turning basin;
- Stormwater dispersion analysis to determine fate and transport of associated pollutant loads in the internal waterways and adjacent waters; and
- Density vertical stratification analysis to assess the potential for development of extensive density stratification periods (i.e., strength and duration) under varied environmental conditions.

9.3. Existing Values

9.3.1 General Description of Moreton Bay Water Quality

Moreton Bay is one of the largest estuarine bays in Australia and supports a diverse range of ecosystems. While water quality in the bay deteriorates following heavy rainfall and floods, these are usually short-term changes, lasting from weeks to months (Maxwell PS *et al*. 2013, Saeck *et al*. 2019, Saeck *et al*. 2013). Water quality in Moreton Bay, including nutrients and water clarity, has been monitored for decades. Nutrients are important as they stimulate primary productivity, but an over-abundance of nutrients can lead to algal growth and a subsequent loss of critical habitats, such as seagrass meadows. Water clarity is important as key habitats such as seagrass beds and coral communities require light to photosynthesise, and high sediment loads can also result in the sediment deposition and smothering of habitats.

There are considerable pollutant pressures along the western shoreline of Moreton Bay, largely due to sediment export from the upper catchments (Saeck *et al*. 2019). Additionally, there are over 30 sewage and industrial treatment plants discharging directly into Moreton Bay and its estuaries (Gibbes *et al*. 2014), as well as numerous discharges into the freshwater creeks, which are a significant source of nitrogen and phosphorus. Over the past 20 years, in the western, central and southern areas of the bay, the concentration of total phosphorus has frequently exceeded guidelines, although recently it appears to have decreased (Saeck *et al*. 2019). In contrast, the concentration of total nitrogen has generally remained consistent over the past 18 years.

Toondah Harbour is approximately 20 km south of the Brisbane River estuary and approximately 17 km north of the Logan River estuary. It is considered to be in the 'Central Bay' in the EHMP.

Since 2001, the concentration of total nitrogen and total phosphorus has decreased in both the Brisbane and Logan estuaries, attributed to changes in extractive industry use, and improvements in industrial and sewage discharges (Saeck *et al*. 2019). The minor increased concentration of total nitrogen noted across Moreton Bay (i.e., in the north-central and north-eastern zones) are likely due to historic contributions (i.e. 2011 floods) that are trapped in the bay sediments and get resuspended over time, since water coming from the estuaries has slowly been improving.

Water clarity typically decreases after heavy rainfall and flood events, due to increased catchment run-off and stimulation of pelagic productivity due to an increase in nutrients. Water clarity is also affected by resuspension of sediment by wind. In the western bay, mean annual turbidity is significantly higher in years with higher-than-average north or south-easterly winds (Saeck *et al*. 2019).

The ecosystem health of the bay and its catchments has been monitored, and report cards produced for the past 20 years. The 2020 report card (Healthy Land and Water 2020) indicated that in 2019-2020:

- Oceanic circulation appears to have flushed some mud out of the bay, although a significant mud patch remained in the Central Bay.
- There was an increase in the distribution of seagrass in the bay.
- Water quality averaged over all of the Central Bay (the section of the bay that includes the Project footprint) was in excellent condition, although turbidity and the concentration of total nitrogen were often over the WQO.

The 2021 report card (Healthy Land and Water 2021) indicated that:

- Water quality had slightly improved in the Central Bay, with nitrogen, algae and turbidity remaining stable.
- Due to continued resuspension and flushing into the deeper parts of the bay and limited inputs from the catchment, the extent of mud is likely to have remained very low.

However, the floods in 2022 are likely to have increased turbidity, and the extent of mud in the bay, with up to five times more silt and mud than in the 2011 floods (HLW pers comm. 2022).

Priority management actions for the Central and Western Bay in the 2021 report card comprised:

- Measures to reduce sediment running off development and construction sites and high-risk erosion sites; and
- Continued investment in minimising wastewater treatment plant and other industrial discharges, to maintain long term improvements in water quality.

9.3.2 Assessment of EHMP Data

Turbidity was frequently above the 50th and 80th percentile WQO across all sites reviewed (Figure 9-5 and Figure 9-6), however median turbidity complied at sites E01200 and E00501. Turbidity was highly seasonal, with lowest turbidity in winter (June/July) and highest turbidity in late summer and early autumn (February/March).

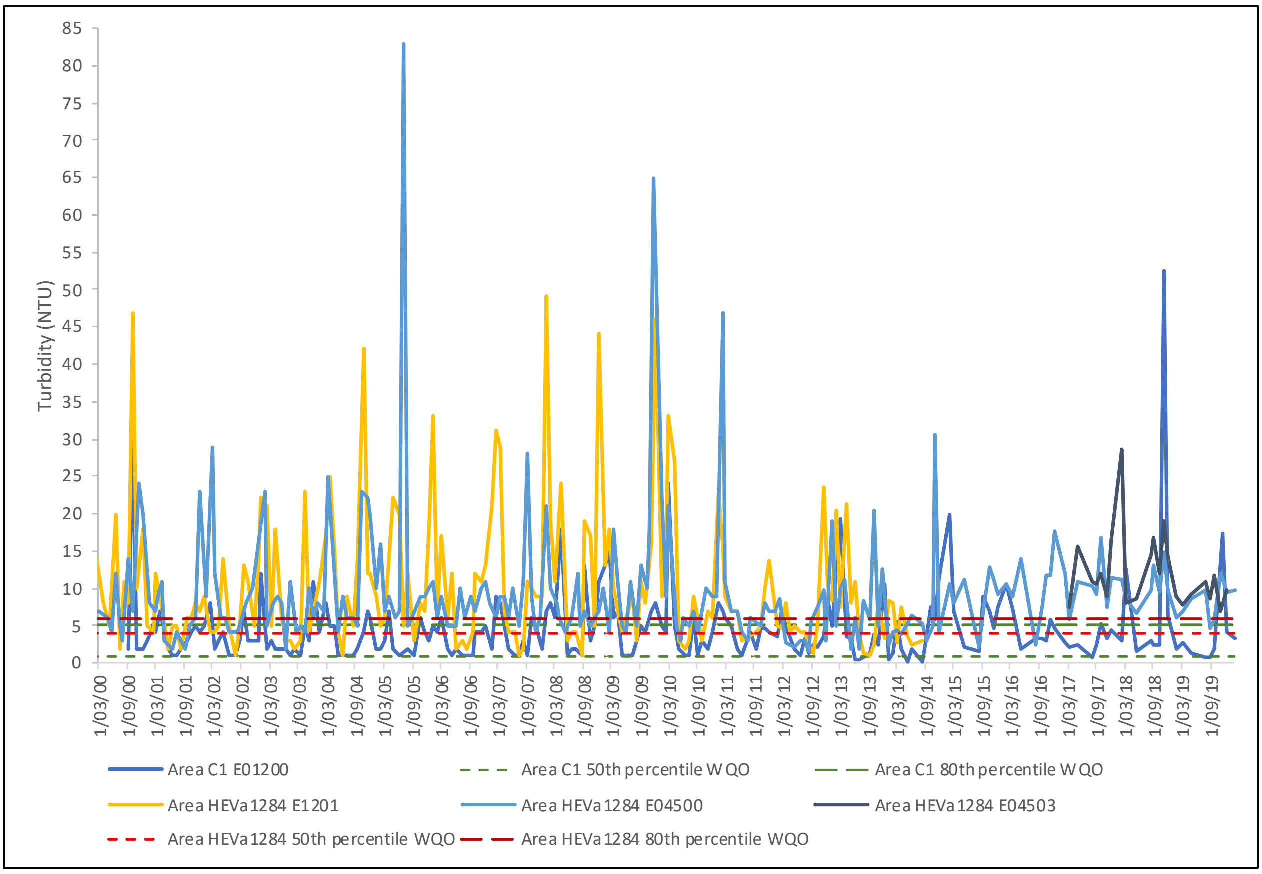


Figure 9-5: Turbidity at Sites C1 and HEVa1284 (in HEV waters) and the 50th Percentile WQO.

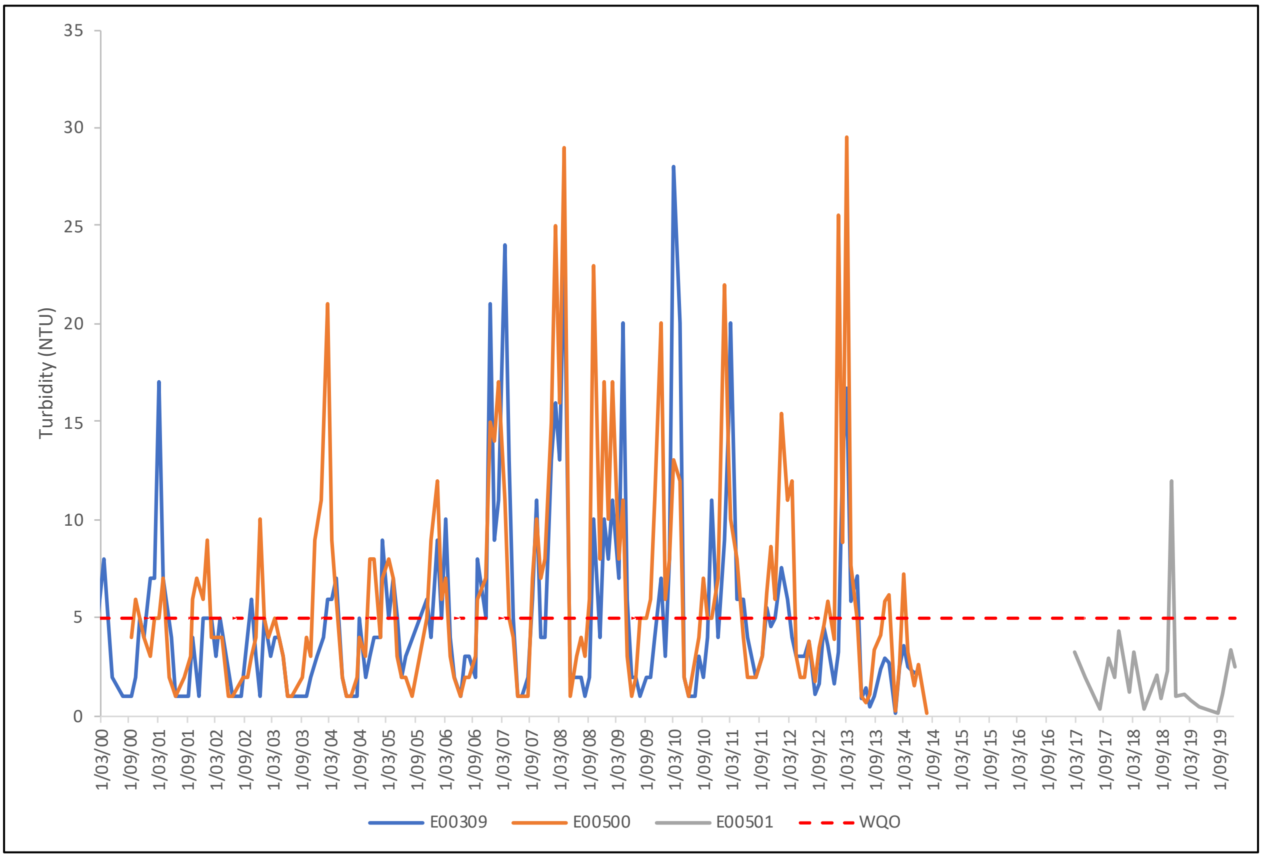


Figure 9-6: Turbidity at Sites in Area C2 (in Moderately Disturbed Marine Water) and the WQO.

9.3.2.1 *Comparison of EHMP data to WQO*

In the HEV areas, over the period 2000 to 2020, the following were indicative of poorer water quality than the WQO:

- At site E01200 (offshore of Raby Bay) turbidity, and the concentration of chlorophyll *a*, total nitrogen and organic nitrogen were higher than the WQO, and dissolved oxygen and Secchi depth were lower.
- At site E01201 (offshore of the end of the proposed channel) turbidity was higher than the WQO, and Secchi depth was lower.
- At site E04500 (mouth of Eprapah Creek) turbidity and the concentration of chlorophyll *a*, total nitrogen, oxidised nitrogen, ammonia, organic nitrogen, total phosphorus and filterable reactive phosphorus were higher than the WQO, and dissolved oxygen and Secchi depth were lower.
- At site E04503 (Eprapah Creek) turbidity and the concentration of chlorophyll *a*, total nitrogen, ammonia, organic nitrogen and total phosphorus were higher than the WQO, and dissolved oxygen and Secchi depth were lower.

A summary of median water quality in comparison to the relevant WQO is included in Table 9-3. A full comparison is included in Appendix 2-G.

In the moderately disturbed coastal area, the following were indicative of poorer water quality than the WQO:

- At site E00309 (Moreton Bay, south of the MIA) the concentration of chlorophyll *a* was higher than the WQO, and Secchi depth was lower.
- At site E00500 (Moreton Bay, south of the MIA) turbidity was higher than the WQO, and Secchi depth was lower.
- At site E00501 (Moreton Bay, east of the MIA) the concentration of organic nitrogen was higher than the WQO, and depth was lower.

A summary of median water quality in comparison to the relevant water quality objectives are included in Table 9-4. A full comparison is included in Appendix 2-G.

Table 9-3: Median Water Quality Data and the 50th Percentile WQO for Sites within HEV Areas.

	HEV Area C1		HEV Moreton Bay Area HEVa1284			
Parameters	**WQO[1]**	**Site: E01200**	**WQO[2]**	**Site: E01201**	**Site: E04500**	**Site: E04503**
Percentile	**50th**	**50th**	**50th**	**50th**	**50th**	**50th**
Turbidity (NTU)	1	3	4	8	7	7
Chl *a* (µg/L)	0.8	0.9	1	1	1.3	1.3
Total nitrogen (µg/L)	130	150	150	150	220	220
Oxidised N (µg/L)	2	1	2	1	4	4
Ammonia N (µg/L)	3	2	3	1	5	5
Organic N (µg/L)	120	144	150	146	201	201
Total phosphorus (µg/L)	15	14	22	19	39	39

	HEV Area C1		HEV Moreton Bay Area HEVa1284			
Filterable reactive phosphorus (µg/L)	5	5	10	6	18	18
Dissolved oxygen (% saturation)	100	99	100	105	90.6	90.6
pH	8.2	8.1	8.2	8.2	8.0	8.0
Secchi depth (m)	4.5	1.9	2	1.1	1	1

[1] WQO are for Area C1 – Central Bay (Table 2). [2] WQO are for Area HEVa1284 – Central Bay (Table 2).

Table 9-4: Median Water Quality Data Compared to the WQO for Sites within Moderately Disturbed Coastal Areas.

	Moreton Bay Area C2				Redland Creek mid-estuary Area S2		
Parameters	**WQO[1]**	**E00309**	**E00500**	**E00501**	**WQO[2]**	**E04501**	**E04502**
Percentile	**50th**	**50th**	**50th**	**50th**	**50th**	**50th**	**50th**
Turbidity (NTU)	< 5	4	5	2	<8	11	9
Chl *a* (µg/L)	< 1.0	1.1	0.9	0.5	<4	3	3
Total nitrogen (µg/L)	< 160	150	150	160	<300	690	820
Oxidised N (µg/L)	< 2	1	1	1	<10	140	210
Ammonia N (µg/L)	< 5	1	1	2	<10	71	100
Organic N (µg/L)	< 150	136	142	156	<280	434	480
Total phosphorus (µg/L)	< 20	15	16	5	<25	77	120
Filterable reactive phosphorus (µg/L)	< 8	5	5	1	<6	34	53
Dissolved oxygen (% saturation)	95-105	103	104	96	85-105	77	63
pH	8.2 - 8.4	8.2	8.2	8.1	7.0-8.4	7.6	7.2
Secchi depth (m)	**> 2.7**	**2**	**1.5**	**2.7**	**>1**	**0.7**	**0.7**

[1] WQO are for Area C2 – Central Bay (Table 2). [2] WQO are for Area S2 – Mid Estuary (Table 2)

Red text indicates the water quality data was worse than the WQO, Blue text indicates the water quality data was better than the WQO

9.3.2.2 *Seasonal Data at EHMP Sites in the Marine Investigation Area (MIA)*

To determine seasonal variation in water quality in areas close to the Project footprint, water quality data was also summarised for each season at the three EHMP sites in, or closest to, the MIA: site EO1201 near the end of the proposed channel; site EO4500, at the mouth of Eprapah Creek; and site E00500, to the immediate south of the MIA (refer to Figure 9-1).

Overall, turbidity, Secchi depth, chlorophyll *a*, and nutrients were highly variable, both between and within seasons, and were generally highest in summer. In summary:

- Turbidity was highest during summer, and lowest in winter for all three sites; the median turbidity was highest at HEV open coastal site E01201.
- Chlorophyll *a* was highest during summer and lowest in winter for all three sites; the highest median concentration was at HEV enclosed coastal site E04500.
- Total nitrogen was highest during summer and lowest in winter at all three sites; the highest summer median concentration was at HEV enclosed coastal site E04500, which also showed higher variation in nitrogen concentrations throughout all seasons.
- The median concentration of filtered reactive phosphorous was highest during autumn and lowest during winter and spring at sites E01201 and E00500; HEV enclosed coastal site E04500 had the highest median concentration during winter and lowest in spring and summer, and had the highest median concentration of these three sites.
- Dissolved oxygen (% saturation) was fairly stable throughout the seasons at all three sites, with the highest median concentrations between winter and spring; the lowest median % saturation of dissolved oxygen was at site E04500 during autumn.

The median Secchi depth was highest during winter and lowest during summer, with the lowest median Secchi depth at HEV open coastal site E01201 during winter.

To determine seasonal variation in water quality in areas close to the proposed works, water quality data was also summarised for each season at the three EHMP sites in, or closest to, the MIA: site EO1201 near the end of the proposed channel; site EO4500, at the mouth of Eprapah Creek; and site E00500, to the immediate south of the Investigation Area (Appendix 2-G).

Overall, turbidity, Secchi depth, chlorophyll *a*, and nutrients were highly variable, both between and within seasons, and were generally highest in summer. In summary:

- Turbidity was highest during summer, and lowest in winter for all three sites; the median turbidity was highest at HEV open coastal site E01201;
- Chlorophyll *a* was highest during summer and lowest in winter for all three sites; the highest median concentration was at HEV enclosed coastal site E04500;
- Total nitrogen was highest during summer and lowest in winter at all three sites; the highest summer median concentration was at HEV enclosed coastal site E04500, which also showed higher variation in nitrogen concentrations throughout all seasons;
- The median concentration of filtered reactive phosphorous was highest during autumn and lowest during winter and spring at sites E01201 and E00500; HEV enclosed coastal site E04500 had the highest median concentration during winter and lowest in spring and summer, and had the highest median concentration of these three sites;
- Dissolved oxygen (% saturation) was fairly stable throughout the seasons at all three sites, with the highest median concentrations between winter and spring; the lowest median % saturation of dissolved oxygen was at site E04500 during autumn; and

- The median Secchi depth was highest during winter and lowest during summer, with the lowest median Secchi depth at HEV open coastal site E01201 during winter.

9.3.3 Assessment of Data from the Dredge Campaign in 2019

While visible plumes were sometimes associated with the maintenance dredging undertaken by RCC in 2019 (Plate 9-1), turbidity only exceeded the background value (BV) twice. Both exceedances were during operation of the trailing suction hopper dredge, not the backhoe dredge. The exceedances were on:

- 10 May 2019 when the BV was 17 NTU and the downstream value was 32.4 NTU.
- 16 May 2019 when the BV was 10 NTU and the downstream value 350 m from the dredge was 27.4 NTU.

In both instances, dredging stopped, and turbidity returned to background values by the following day.

Turbidity was monitored by loggers during the dredge campaign at sites L6, L5 and L3 (refer to Figure 9-4). Turbidity was highly variable during dredging, with for example, peaks in turbidity at site L6, which was located within the harbour area, commonly occurred prior to dredging commencing and coinciding with low tide (Figure 9-7 and Figure 9-8). This means peaks in turbidity in the harbour due to existing conditions and use (e.g., ferries and boats) could exceed peaks resulting from dredging.

Plate 9-1: The 'Faucon' During Maintenance Dredging on an Incoming Tide at Toondah Harbour.

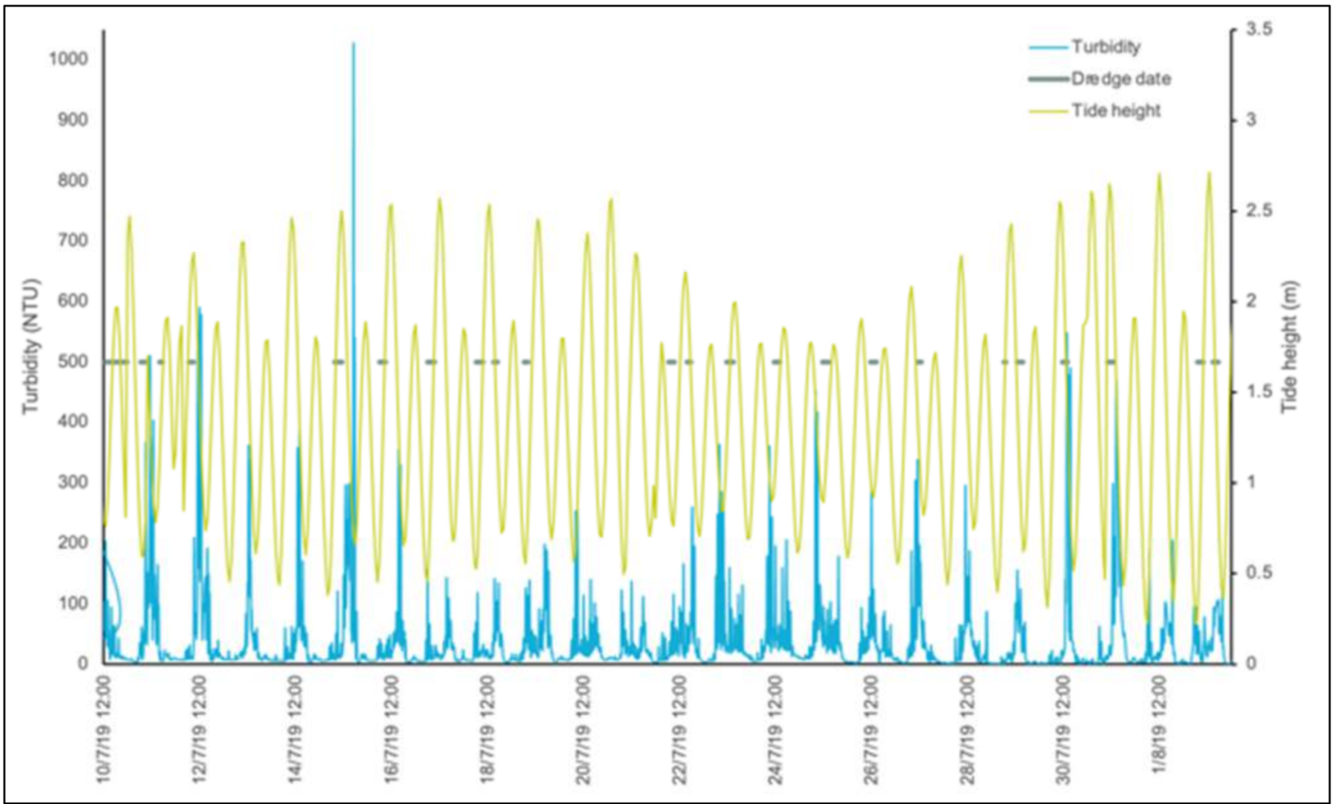


Figure 9-7: Turbidity at L6 from 11 July to 2 August 2019 during Maintenance Dredging.

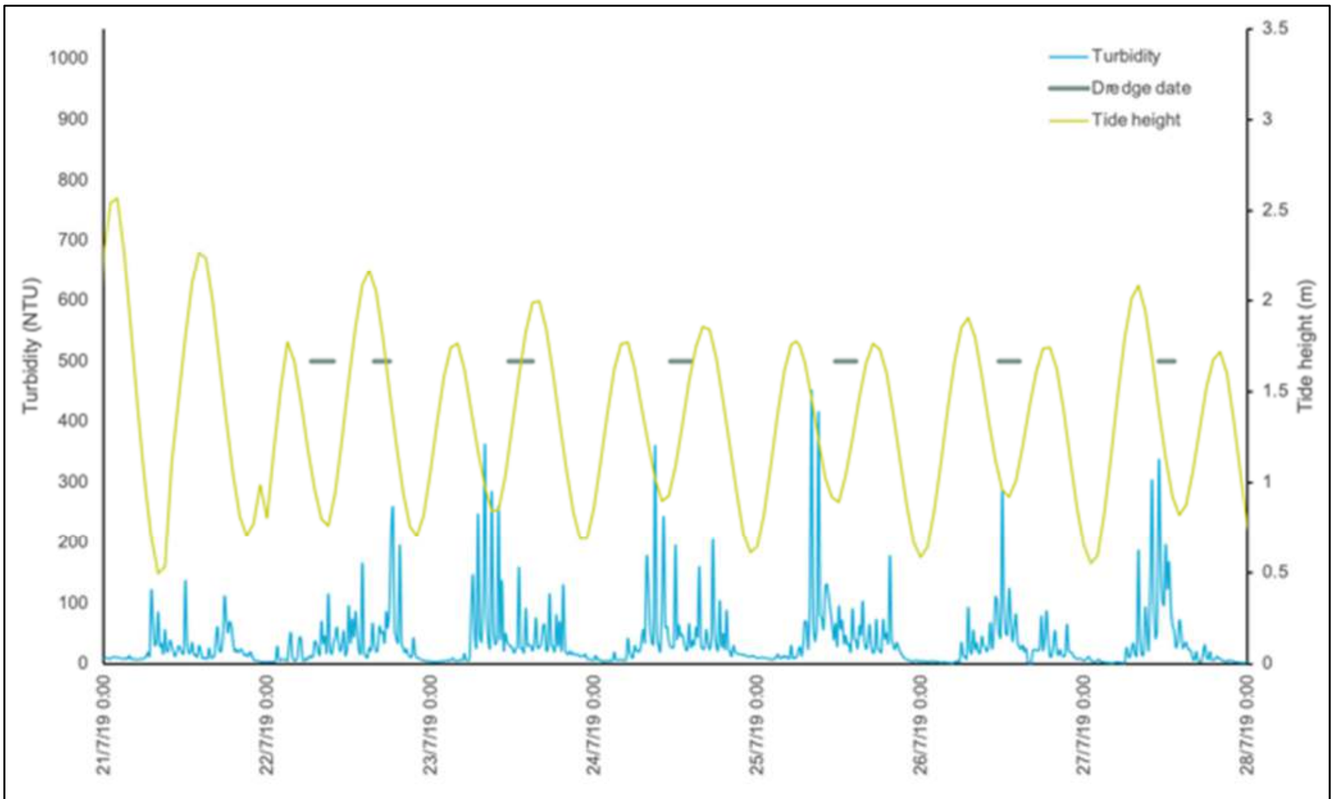


Figure 9-8: Turbidity at L6 from 21 July to 28 July 2019 during Maintenance Dredging.

9.3.4 Assessment of Turbidity Logger Data

Overall, turbidity recorded by the loggers was highly variable with the median significantly exceeding the WQO at each site. Median turbidity (NTU) was typically lowest in July of each year at each site, ranging from 0.7 (at site L2 in Jul 2017) to 14.4 (at site L6 in July 2019). Turbidity was lowest at site L3 (overall median: 6 NTU), the site furthest offshore and away from the busiest recreational and commercial boating activity. Overall, median turbidity was similar at sites L1 (11.2 NTU), L2 (10.9 NTU) and L5 (11.5 NTU) and was highest at L6 (22.2 NTU), which was in the harbour, and closest to ferry activity. Turbidity 'spikes' exceeding 100 NTU often occurred at all of the sites and could be attributed to a number of environmental factors such as tidal movement and storm events. The summarised turbidity data and statistical analyses are presented in Appendix 2-G.

9.3.4.1 *Seasonal Effects*

The median turbidity at each logger exceeded the WQO in every season, except during winter at L1 (4.7 NTU) and L3 (1.9 NTU). These two loggers were furthest from Fison Channel and less likely to be impacted by ferry operations. At each logger, turbidity was lowest in the winter months, with medians ranging from 1.9 NTU (at site L3) to 8.4 NTU (at site L6), and highest in either spring or summer, ranging from 6.7 NTU (Spring at site L3) to 33.7 NTU (Spring at site L6). Statistical analysis indicated there was seasonal variation in turbidity levels, however the differences were minor (Appendix 2-G).

9.3.4.2 *Impact of the Ferry on Turbidity*

Data from each logger was assessed to determine if current ferry activities had an impact on turbidity. There were significant differences in turbidity related to ferry activity at sites L1, L2, L5 and L6; however, there was no effect of ferry activity at site L3, the site furthest offshore and away from the Fison Channel.

The difference in turbidity at sites L1, L2, L5 and L6 were due to higher turbidity recorded when ferries had passed within 15 minutes than when no ferries had passed within 15 minutes. For example, the median turbidity at site L6 when ferries passed within 15 minutes ranged from 29 to 39 NTU, compared to 11 NTU when ferries passed more than 15 minutes from the time the data was recorded.

9.3.4.3 *Tidal Impacts*

Turbidity was correlated with tide height, with higher turbidity recorded at low tides (Figure 9-9). This correlation was significant at all sites and was likely due to the interaction of waves and the bottom substrate that is more prevalent at low tide.

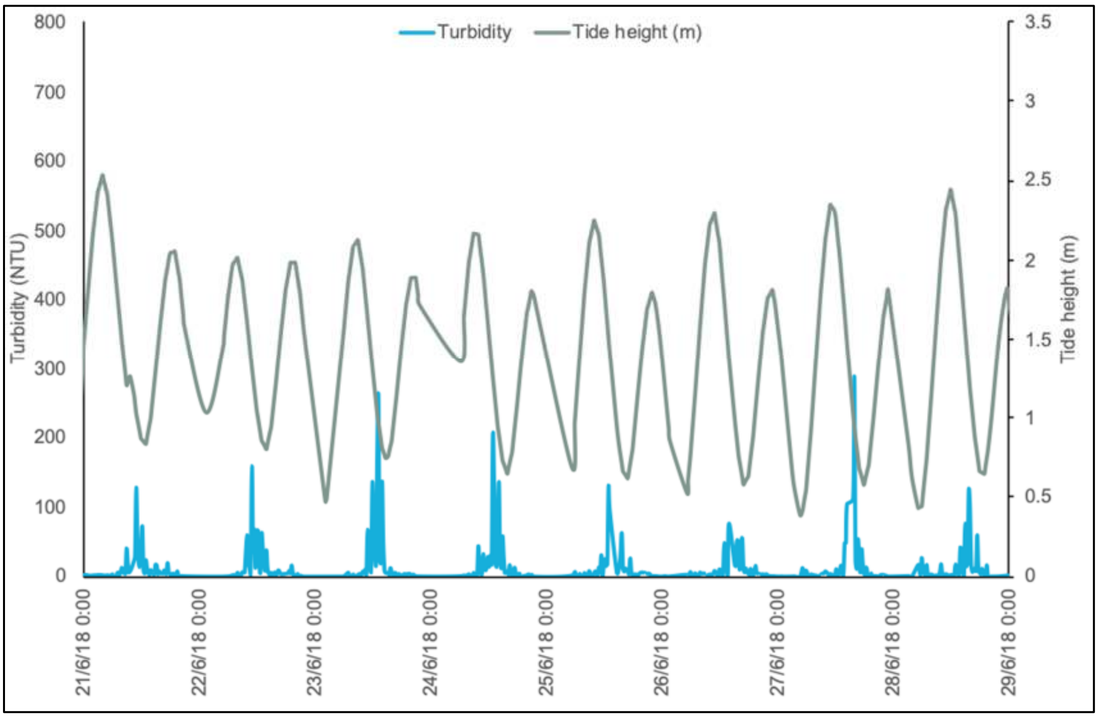


Figure 9-9: Turbidity and Tide Height at Site L5, 21 June 2018 to 29 June 2018.

9.3.4.4 *Turbidity During Daylight Hours*

The rolling two-week daytime average turbidity was consistently above the WQO at each logger (Figure 9-10 to Figure 9-14). That is, seagrass and other benthic habitat in the vicinity of the loggers is tolerant of persistently high turbidity. Average daylight turbidity was highest in the spring at L1 (32.2 NTU), L5 (45.7 NTU) and L6 (68.3 NTU), and highest in the summer at L2 (60.4 NTU) and L3 (21.4 NTU), with overall daylight turbidity highest at L6 (average: 57 NTU), the site nearest to the harbour.

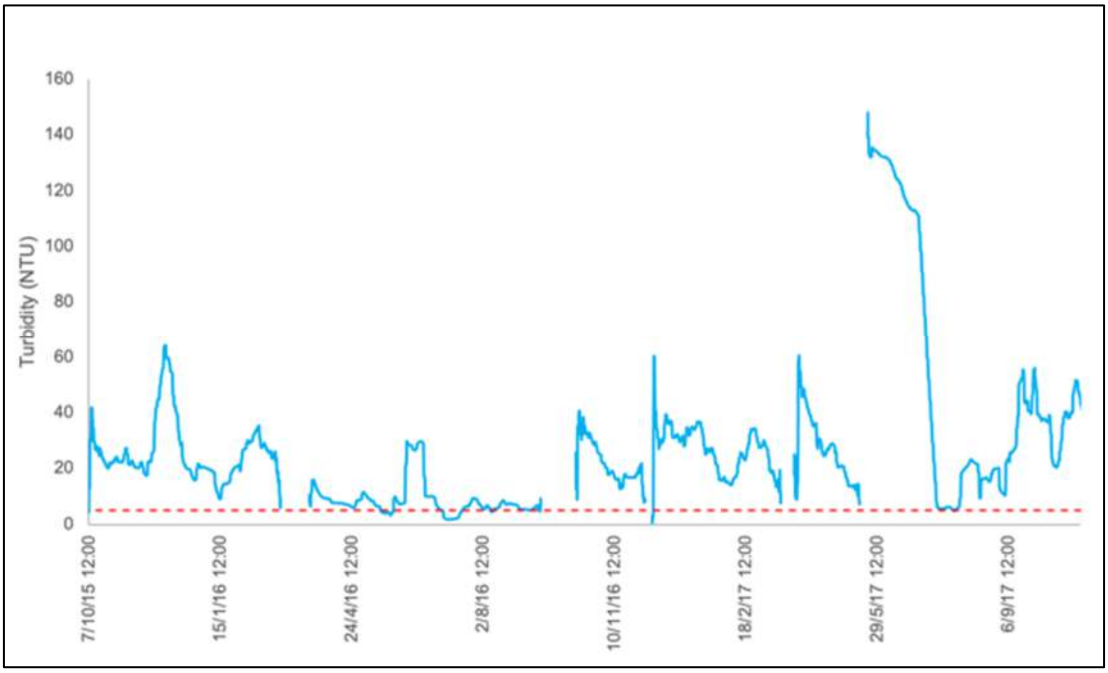


Figure 9-10: Rolling Two-week Average Turbidity at L1: 10 July 2015 to 11 November 2017.

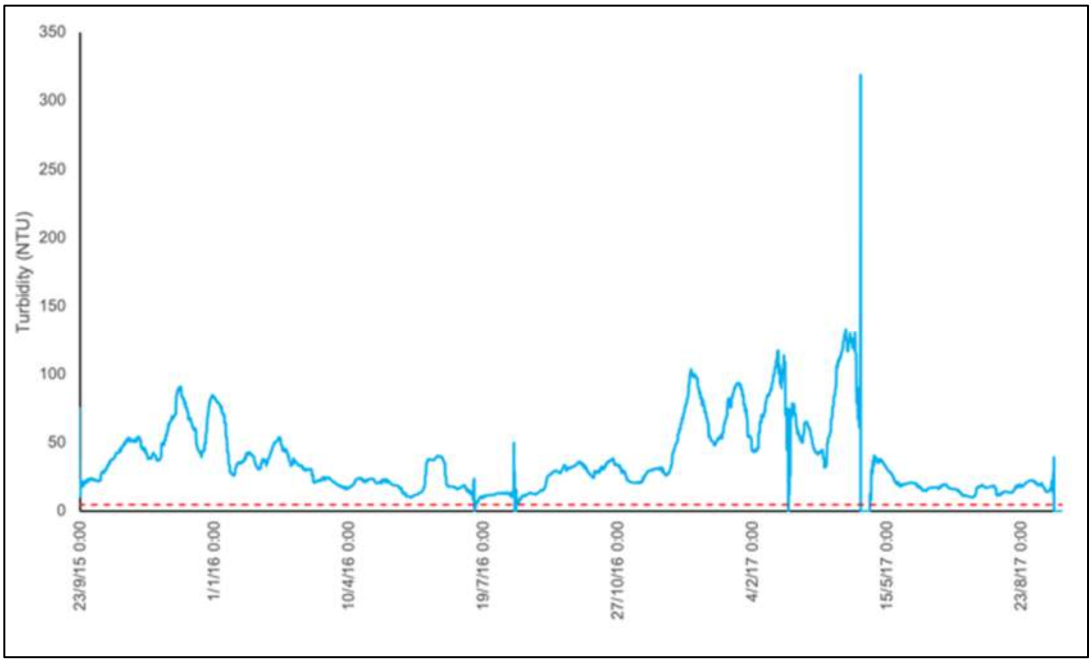


Figure 9-11: Rolling Two-week Average Turbidity at L2: 22 September 2015 to 1 September 2017.

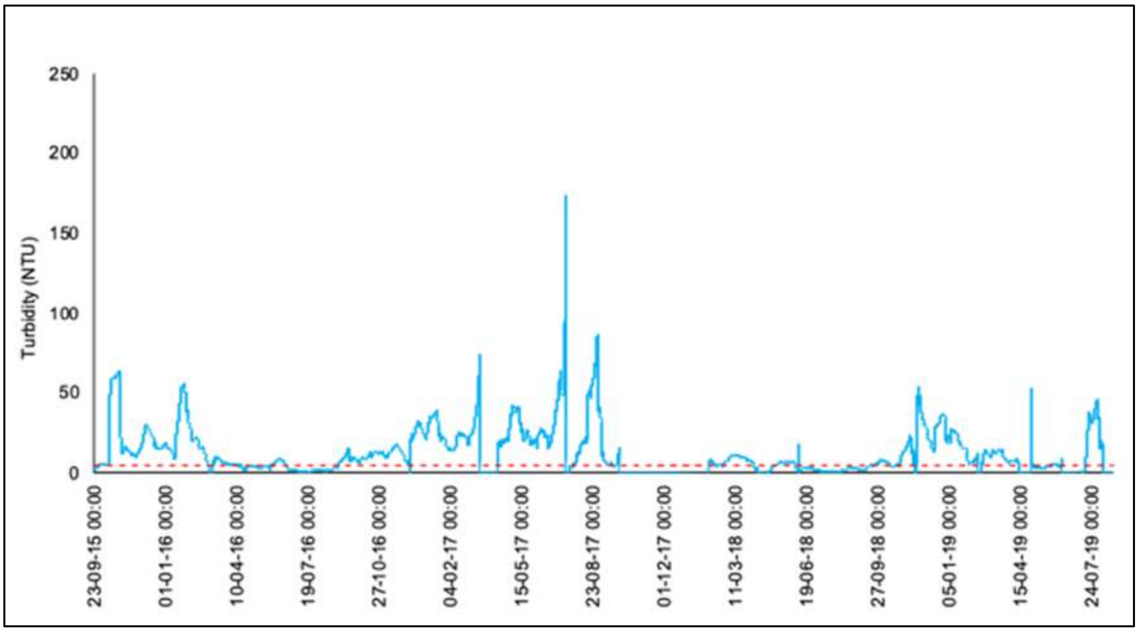


Figure 9-12: Rolling Two-week Average Turbidity at L3: 22 September 2015 to 25 July 2019.

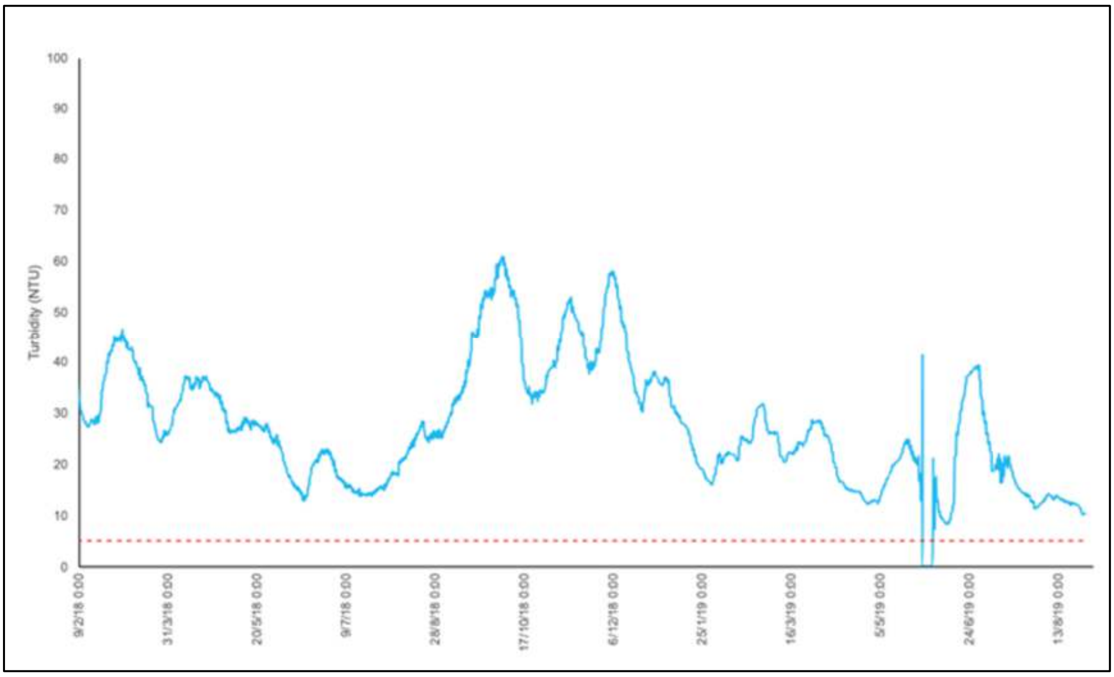


Figure 9-13: Rolling Two-week Average Turbidity at L5: 2 February 2018 to 28 August 2019.

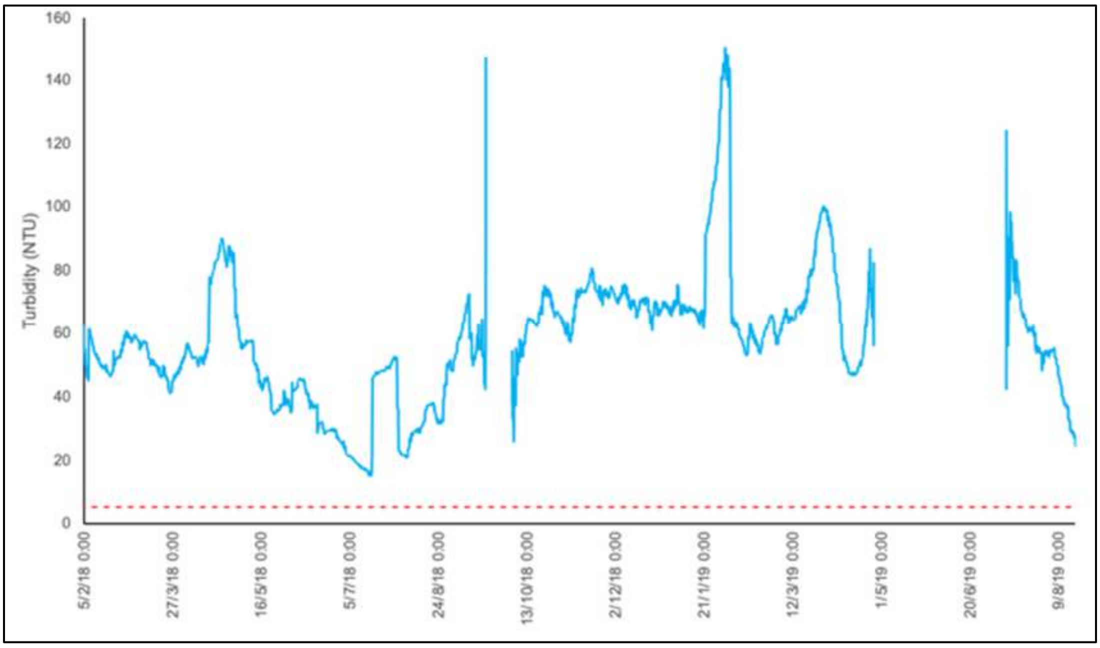


Figure 9-14: Rolling Two-week Average Turbidity at L6: 5 February to 20 August 2019.

9.3.5 Key Assessment Outcomes

Water quality in the vicinity of the Project footprint is highly variable and influenced by several environmental factors, including tidal state, season and wind. Overall, turbidity was frequently higher than the WQO of 5 NTU. Turbidity was higher in spring and summer than in autumn and winter, in particular at the loggers around low tide. This is likely due to wave action in the shallow water resuspending sediment.

The concentrations of nutrients and chlorophyll *a* were typically above the WQO and highest in summer and lowest in winter.

9.4. Potential Impacts

Potential impacts to water quality from the Project may occur from the following activities:

- Changes to turbidity and sedimentation associated with dredging and reclamation;
- Changes to flushing rates associated with reclamation;
- Changes in water quality due to stormwater;
- The release of contaminants from the disturbance of sediment;
- The release of contaminants from the disturbance of soil and ground water;
- Spills of hydrocarbons and other contaminants; and
- Disturbance of potential acid sulfate soils.

Hydrodynamic and coastal processes at the site, as well as the quantity and quality of local catchment stormwater runoff and its subsequent deposition into the environment were modelled by BMT. The methods and outcomes of modelling are described in Chapter 8 of the Draft EIS (the Coastal Processes Technical Report is also included as Appendix 2-E). This information is not repeated in the sections below, however cross references have been included where appropriate. The exception to this is stormwater modelling which is reported entirely in the sections below.

9.4.1 Changes to Turbidity Associated with Dredging and Reclamation

Potential impacts on turbidity associated with two dredging campaigns were modelled by BMT and are summarised in Section 8. The modelling took into account Project status at the time dredging occurs. For example, Stage 1 dredging will occur after the northern reclamation is fully enclosed but prior to any works occurring on the southern reclamation.

Depth-averaged turbidity values were extracted from a range of points to characterise likely impacts. Turbidity plume modelling was also reviewed with some outputs reproduced here from Chapter 8 and Appendix 2-E to highlight the likely extent of turbidity plumes. It should be noted that modelling does not take into account the use of silt curtains during the dredging process therefore modelling outputs would be considered worst case. While silt curtains are in place turbidity plumes would not extend outside of the immediate dredge area.

In summary:

- Changes to turbidity due to dredging will be limited to the dredge campaigns, with turbidity returning to ambient levels once dredging ceases.
- Turbidity in the vicinity of the Project footprint is already high, prone to ‘spikes’ in response to wave activity, and regularly exceeding water quality objectives.
- The modelled increases in turbidity during the dredging campaigns are typically short-lived (around 20 NTU for a few hours per day immediately outside the entrance channel) and are usually less than ambient maximums (which often exceed 100 NTU in nearshore areas).
- A combination of regional forcing and intertidal dynamics results in the net northward transport of the dredge sediment plume, particularly over the ebbing tide phase.
- In both dredging stages, the plume is advected to the east, before sweeping northward once it meets the ebb tide current running through Moreton Bay.
- Significantly, from an ecological perspective, the period of high turbidity is not increased by the proposed dredging, as peaks due to dredging coincide with ambient high turbidity.

Modelling of turbidity plumes during the first dredging campaign indicates that:

- The dredge plume is mostly contained within the dredge envelope, with modelled changes to median turbidity outside the dredge channel less than 2 NTU, and to the 95th percentile less than 10 NTU.
- Typically, the eastern extent of the dredge plume reduces to very low levels before reaching Sandy Island. The northern transport of the dredge plume then begins with the northward flowing currents on the ebbing tide, before being cut off from the plume source in Fison Channel as the water level drops and the plume is blocked by the intertidal mudflats surrounding Cassim Island (Figure 9-15). The dredge plume extends to Cleveland Point, but levels are very low (generally less than 5 NTU above ambient).
- This northern transport of the plume results in slight increases to the median turbidity over seagrass, coral, algae and rubble habitats (< 5 NTU, Figure 9-16). Potential impacts to these communities from dredging and other Project activities are assessed in Section 16.5.
- Short term increases in turbidity (95th percentile) cover a slightly broader area however these occur when background turbidity is already naturally high and are associated with strong north easterly wind conditions.

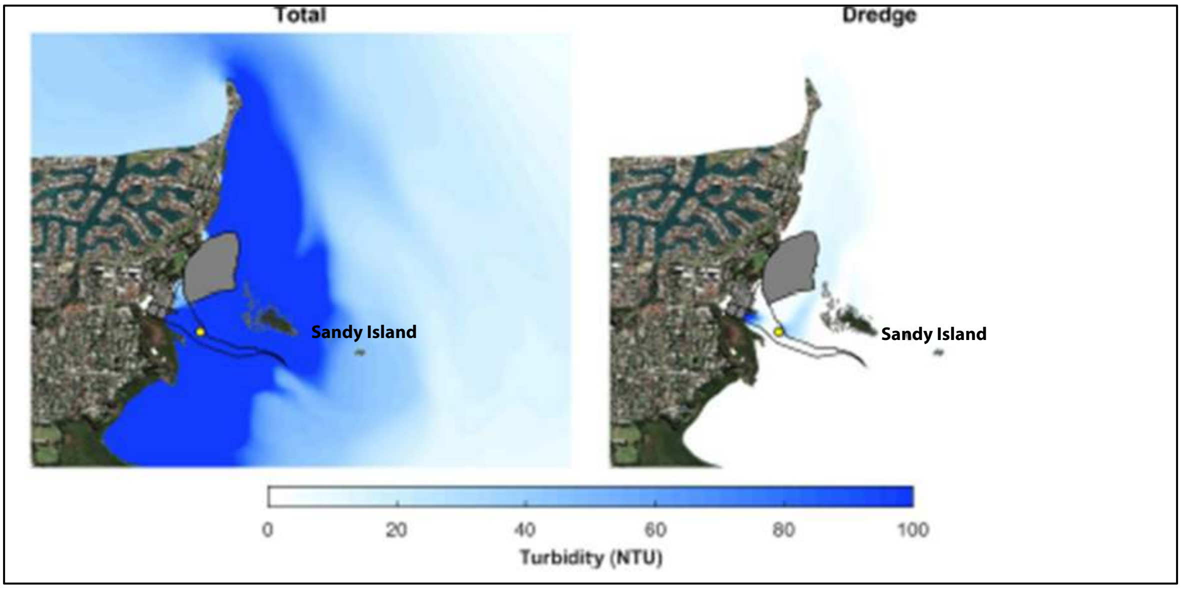


Figure 9-15: Snapshot of Stage 1 Dredging Depth-Averaged Turbidity – Depicting Eastern and Northern Advection of Dredge Plume.

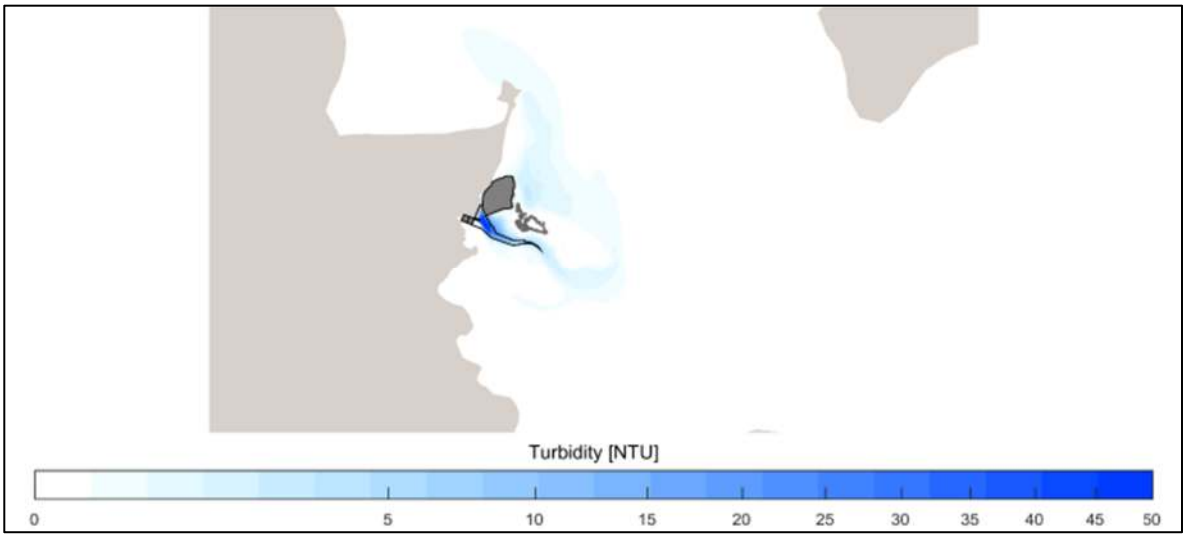


Figure 9-16: Dredge campaign 1: median increase in turbidity due to dredging.

Modelling of turbidity plumes during the second dredging campaign indicates that:

- Like stage 1the dredge plume is mostly contained within the dredge envelope although there is a slightly larger spatial impact than in the stage 1 campaign.
- Typically, there is an eastward advection of the dredge plume along Fison Channel, particularly at the end of the ebbing tide after water levels have dropped and exposed the Cassim Island mudflats (Figure 9-17). The northward transport of the plume over the ebbing tide is further offshore than in the first campaign, as the plume is advected to the east of Cassim Island.
- Increases to the median turbidity outside the dredge envelope are predominantly less than 5 NTU (Figure 9-18). Short term increases in turbidity are predominantly less than 10 NTU outside the dredge envelope and occur when background turbidity is already high.
- There are some small, short-term increases (95th percentile) to turbidity north of the dredge channel, around Cassim Island and to the north of the Project footprint over seagrass and rubble habitats. Potential impacts to these communities from dredging and other Project activities are assessed in Section 16.5.

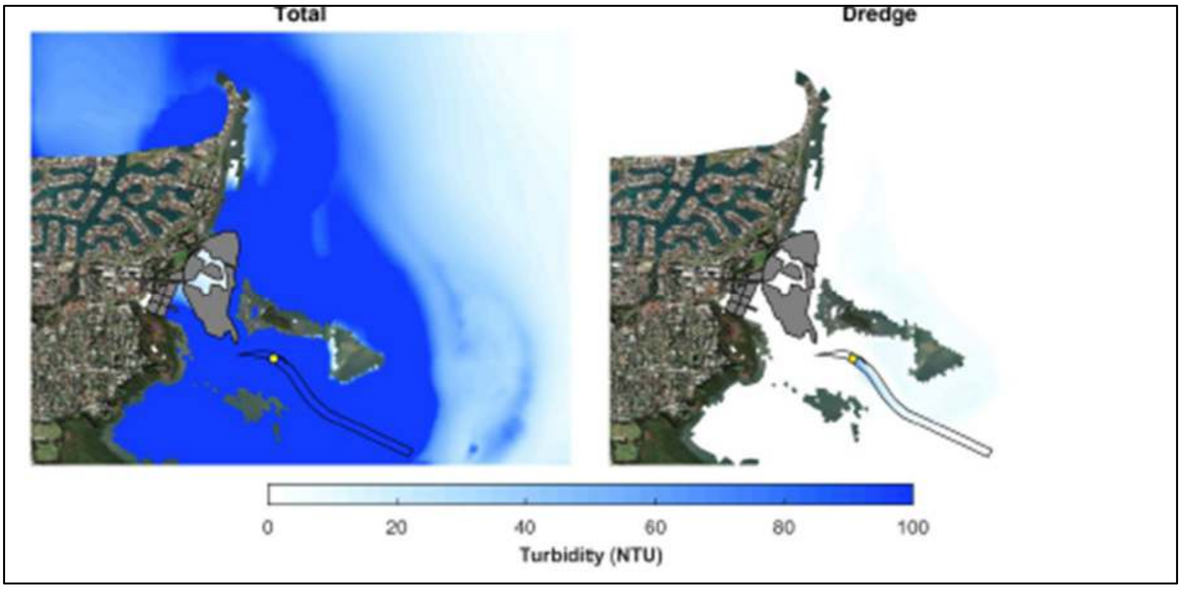


Figure 9-17: Snapshot of Stage 2 Dredging Depth-Averaged Turbidity – Depicting Eastern and Northern Advection of Dredge Plume.

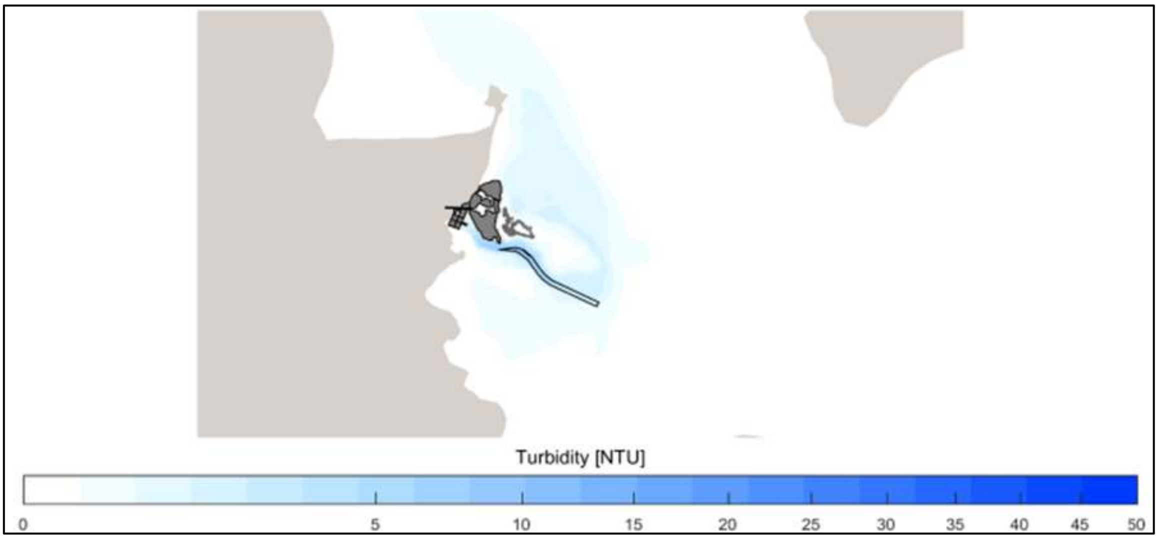


Figure 9-18: Dredge campaign 2: median increase in turbidity due to dredging.

9.4.2 Changes to Flushing Rates Associated with Reclamation

Creation of the new landforms and waterways may impact the turnover of water (flushing rate), in particular in the new marina basin and internal waterways. This may impact water quality, with poor flushing rates sometimes resulting in eutrophic conditions.

Flushing rates were modelled using estimates of e-folding time. The e-folding time is a measure of how long it takes for the water within a confined area to be exchanged, and consequently is an indicator of whether water quality problems will develop due to limited exchange between a waterway and adjacent waters (see e.g., Gómez *et al*. 2014). Modelling was carried out for Stage 1 Phase 3, Stage 1 Complete, and Stage 2 Complete, and also assessed with and without connections between the internal waterways and Moreton Bay.

Modelling indicated that:

- There was little variation in flushing time with water depth;
- Connections between the internal waterways and Moreton Bay (Figure 9-19) increased flushing rates;
- The longest flushing times were in Stage 1 Complete and Stage 2 Complete in the central marina, where flushing times were up to approximately six days in neap tide conditions (i.e., worst-case conditions; Figure 9-20); and
- Other sections of the internal waterways had faster flushing rates generally between three to five days.

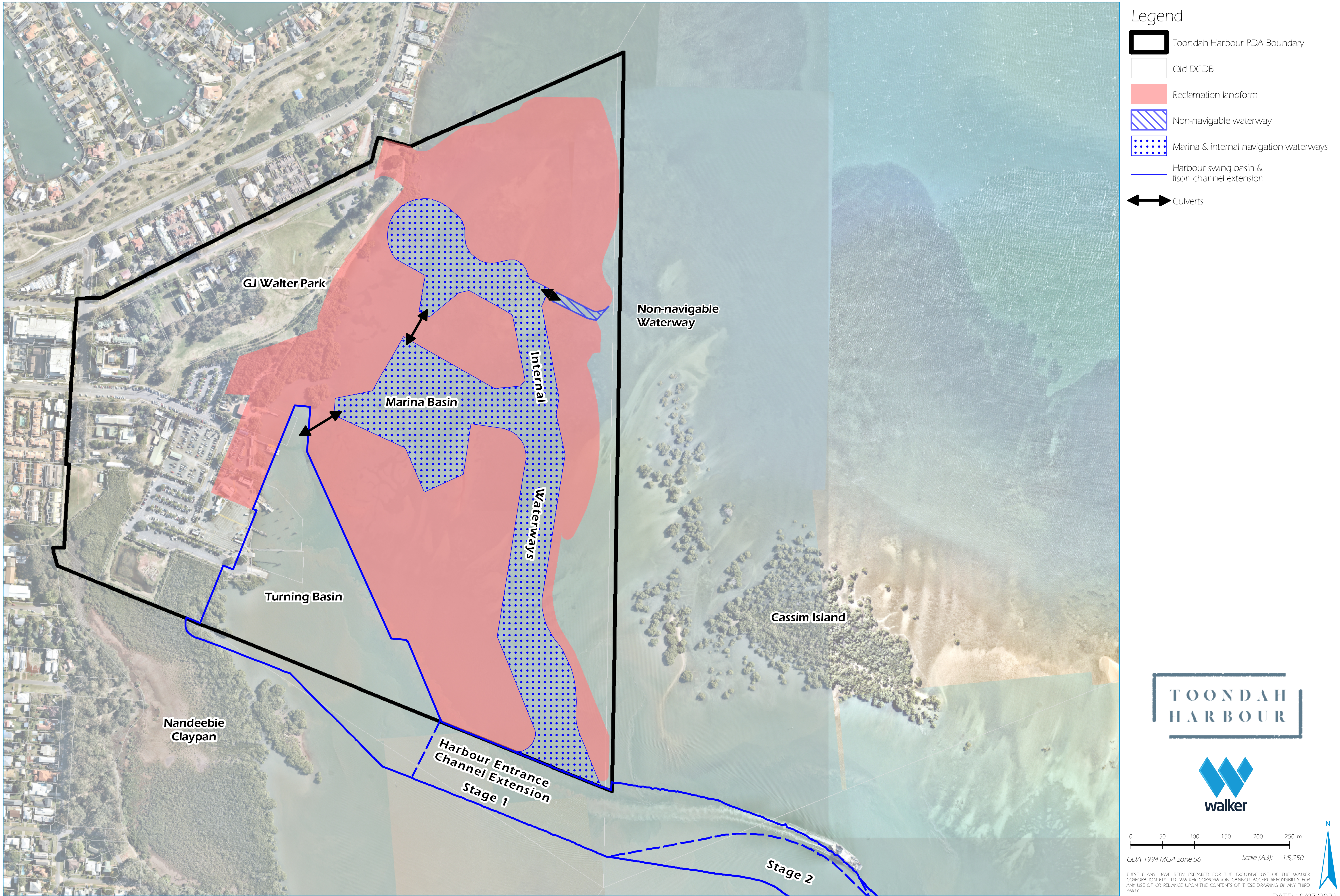
Modelling and assessment were also carried out for the nearby e Raby Bay Canal Estate to provide a comparison to the Toondah Harbour Project. The modelling found that flushing rates in sections of Raby Bay regularly exceeded eight days and a literature and database review did not identify any known or reported water quality issues in or near Raby Bay. Given flushing rates at Toondah Harbour will be faster than Raby Bay water quality issues associated with poor flushing are considered unlikely.

The appropriate flushing time for water in marina developments depends on the nature of the runoff entering the marina, water quality in the marina and surrounding area, and potential impact on the receiving water and associated ecology. Short periods (e.g., less than 10 days) are preferred, as this will prevent adverse impacts to water quality in the marina, such as excessive algal growth, or decreases in the concentration of dissolved oxygen (USEPA Coastal Marinas Assessment Handbook).

Given the short flushing times phytoplankton growth and any consequent blooms and eutrophication in the marina are likely to be limited by the relatively turbid water of this area (Section 9.3.2 to Section 9.3.4), and there is consequently unlikely to be any excessive algal growth in the marina.

The flushing times are also sufficiently short to maintain high concentrations of dissolved oxygen in the water in the marina.

Figure 9-19: Connections Between Internal Waterways and Moreton Bay



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Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial Imagery (Nearmap.com 2020)

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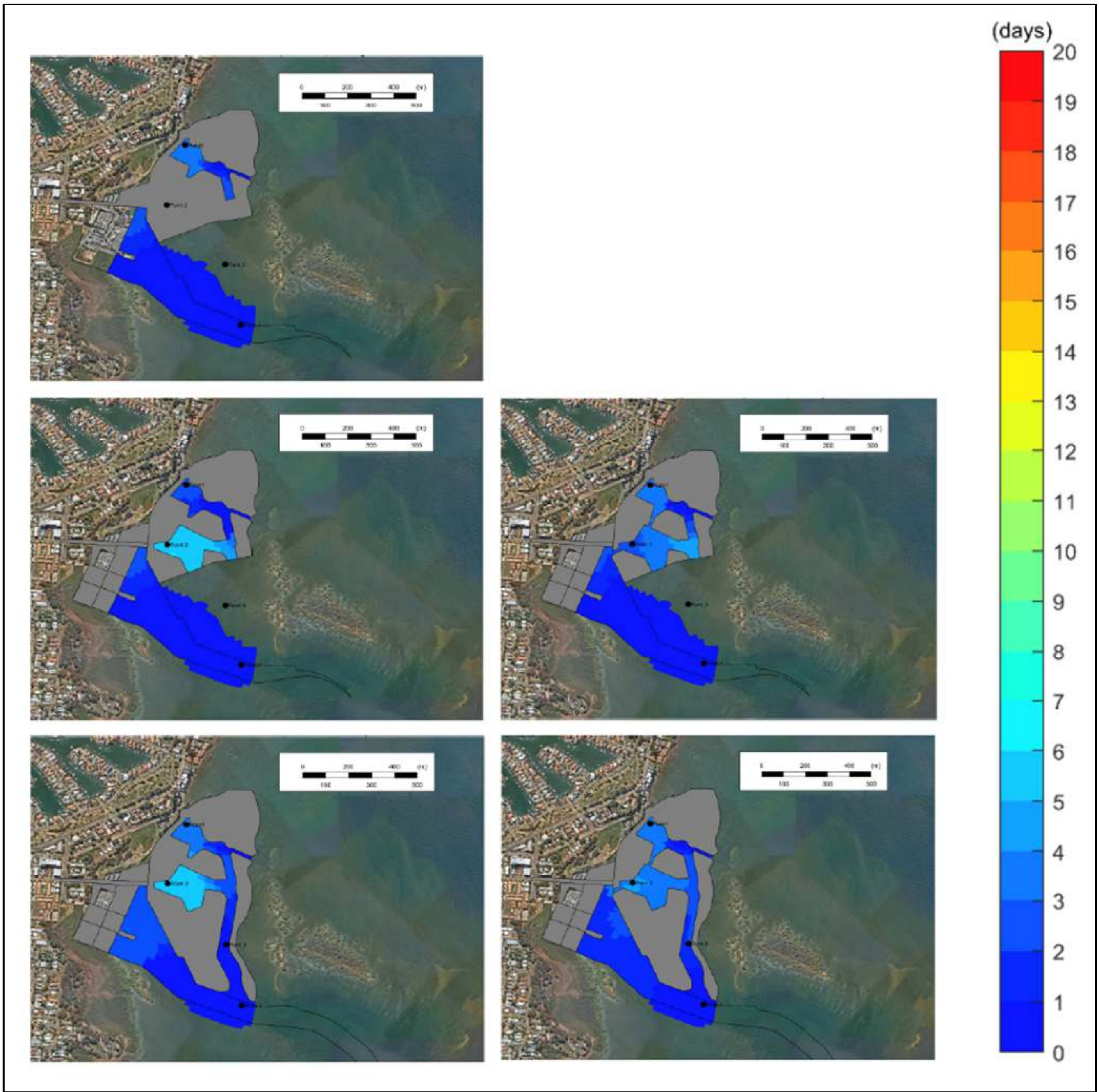

Figure 9-20: Flushing Times for Neap Tide Conditions for Stage 1 Phase 3 (top), Stage 1 Complete (middle) and Stage 2 Complete (bottom), without (left) and with (right) Internal Culverts.

9.4.3 Changes in Water Quality Due to Stormwater

Creation of the new channels and landforms, and the development of infrastructure and buildings on the landforms has potential to impact the quality and quantity of stormwater entering Moreton Bay. Stormwater flows and associated pollutant loads were modelled using MUSIC and used as input to a water quality model for the receiving environment. The concentration of total suspended solids (TSS), total nitrogen (TN) and total phosphorous (TP) from stormwater discharge were modelled. Modelled concentrations are indicative of the expected increase above background concentrations.

MUSIC modelling was carried out using mitigation measures to achieve a higher standard of pollutant reduction than required by the SPP Stormwater Management Design Objectives. Measures employed will include streetscape rain gardens (or 'at source' bioretention systems) to treat runoff from roads and carparks. Runoff from the lots will be treated in larger bioretention basins before being discharged from the site. Rain gardens will also be incorporated into the foreshore parkland area. Additional measures will include rainwater harvesting and reuse, gully baskets and a small increase in the treatment performance of the streetscape and foreshore parkland bioretention systems, through an increase in the extended detention depth. A conceptual stormwater management plan is shown on Figure 9-21.

The modelling indicated that the reduction in pollutants is greater than required by the SPP (Table 9-5). Additional reductions are anticipated where the storm water treatment devices have educational signage. That is, the implementation of stormwater management measures will minimise any risk to the marine environment resulting from stormwater runoff.

Table 9-5: State Planning Policy Operational Performance Criteria and Modelled Outcomes.

Pollutant	**Criteria (% Reduction)**	**Toondah Harbour (% Reduction)**
Total Suspended Solids	80	87
Total Phosphorous	60	80
Total Nitrogen	45	60
Gross Pollutants/ litter (5 mm or larger)	90	100

The stormwater flows and associated pollutant loads obtained from this MUSIC modelling were used in dispersion simulations to better understand the impact of stormwater flows, and in particular TSS, TN and TP on the water quality of the surrounding area. Stormwater dispersion was simulated for:

- The existing conditions;
- Stage 1 complete; and
- Stage 2 complete.

Detailed results of this modelling are presented in section 6.3 of Appendix 2-E including details of the predicted stormwater quality and quantity outputs.

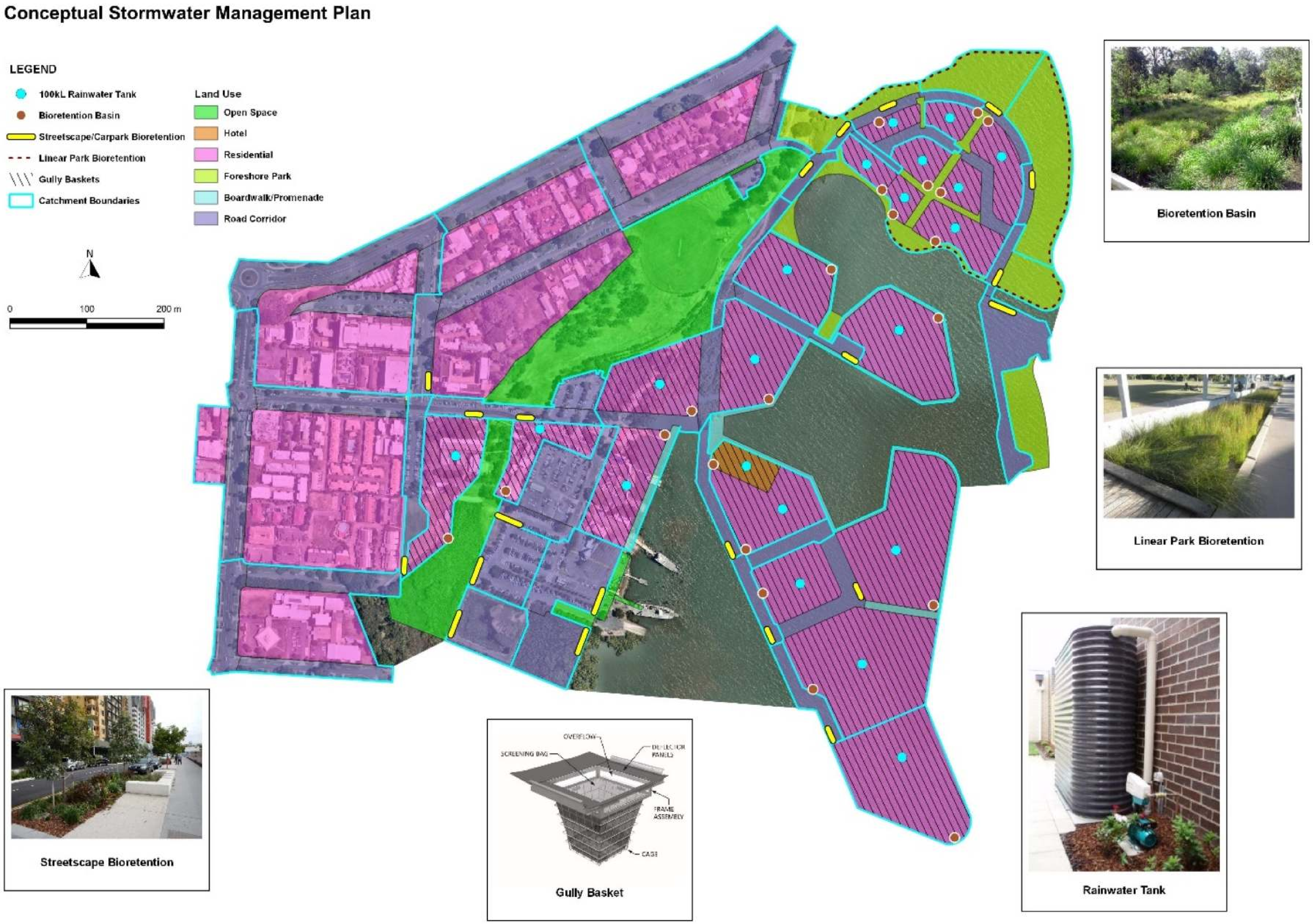

Figure 9-21: Toondah Harbour Conceptual Stormwater Management Plan.

In summary, modelling indicated that in the developed cases compared to the pre-development case:

- There were likely to be increases in the concentration of TSS, TN and TP in the internal marina and ferry terminal turning basin, due to confinement in these waterways, however the magnitude of the increases to TN and TP are relatively small compared to background levels.
- Increases to TN and TP are relatively small compared to the WQO and concentrations measured at EHMP sites (Table 9-6and Table 9-7). For example, the WQO and 50th percentile of the EHMP sites in the vicinity of the proposed development for TN is 160 µg/L, and the predicted increase in the central marina is <0.8 µg/L;
- Outside the footprint there was likely to be very little change in concentration of TSS, TN, and TP, with the differences from existing conditions (80th percentiles) for:
    - TSS: always below 0.2 mg/L (Stage 1 Complete) and 0.4 mg/L (Stage 2 Complete)
    - TN: always below 2.0 µg/L, and
    - TP is always below 0.80 µg/L. There was likely to be an improvement in water quality in the intertidal area southwest of the ferry terminal, with the increase in treated stormwater flows mitigating the impact of the existing untreated flows.
- In the intertidal area southwest of the ferry terminal, in wet weather conditions, the 80th percentile concentration of:
    - TSS is likely to decrease from 226 mg/L in the existing case to 105 mg/l in the developed cases
    - TN is likely to decrease from 1.5 mg/L in the existing case to 1.3 mg/l in the developed cases
    - TP is likely to decrease from 0.31 mg/L in the existing case to 0.25 to 0.26 mg/l in the developed cases.

That is, changes to stormwater runoff due to the development are unlikely to negatively impact water quality, and consequently aquatic habitats, fauna and flora, outside of the Project footprint. Inside the Project footprint there may be some slight increases in TSS, TN and TP, however modelling indicates that water in the internal channels of the reclamation area is likely to be flushed quickly and is unlikely to result in eutrophication of these areas (BMT 2022).

Table 9-6: Increases in the Concentration of the 50th Percentile of TN and TP in the Central Marina Compared to Background and WQOs.

Parameter (µg/L)	Modelled Increase	WQO	Sites in Area C2[1]	Site E01201	Site E04500	All Sites[2]
Total nitrogen	<0.8	<160	150	150	220	160
Total phosphorous	<0.14	<20	15	19	39	20

[1] 50th percentile of Sites E0309, E0500 and E0501 in Area C2
[2] 50th percentile of Sites E0309, E0500 and E0501, EO1201 and E04500

Table 9-7: Increases in the Concentration of the 80th Percentile of TN and TP in the Central Marina Compared to Background and WQOs.

Parameter (µg/L)	Modelled Increase	WQO	Sites in Area C2[1]	Site E01201	Site E04500	All Sites[2]
Total nitrogen	<7	<160	182	190	340	240
Total phosphorous	<1.3	<20	23	29	82	36

[1] 50th percentile of Sites E0309, E0500 and E0501 in Area C2
[2] 50th percentile of Sites E0309, E0500 and E0501, EO1201 and E04500

In summary, modelling indicates changes to the stormwater discharge and treatment associated with the Project are likely to result in:

- No change in water quality in the nearest HEV Area;
- Very minor increases in concentrations within the Project footprint; and
- An overall decrease in concentrations in the intertidal area to the southwest of the ferry terminal (i.e., excluding the Project footprint, an overall improvement in water quality in Area C2 – a moderately disturbed area).

Potential impacts to aquatic ecological communities from these changes to water quality and sedimentation are discussed in the Marine Ecology section of the EIS (Chapter 16).

9.4.4 Release of Contaminants from the Disturbance of Sediment

The disturbance of sediment can result in the release of contaminants. Sediment in the Proposed Channel was assessed according to the National Assessment Guidelines for Dredging 2009 (NAGD; DEWHA 2009) and summarised in Chapter 7 of the Draft EIS Chapter.

NAGD

The NAGD were developed to determine whether there are any contaminants in the sediment, and consequently whether it is suitable for disposal at sea. As the sediment is being used in the reclamation areas, any contaminants in the sediment would only cause an impact during the dredging process, and if contaminants were dissolved in the seawater. The concentration of potential contaminants in the sediment from the dredging area were low (below the available NAGD Screening Levels, and predominantly below the laboratory's detection limits), and consequently the risk of release of contaminants from the dredged sediment is considered to be negligible.

In the proposed reclamation area, the 95% UCL for arsenic, chromium, lead, and nickel exceeded the NAGD Screening Levels, but were less than the High Trigger Values. These concentrations were similar, or within the range of previously recorded concentrations in the channel and are most likely a result of the local geology, with high concentrations of metals in the laterite dominated intertidal rock platforms in the area.

ASC NEPM

The mean, 95% UCL and maximum of all parameters in the proposed dredge area and reclamation area were below (and complied with) the ASC NEPM HIL, HSL, ESL and ML (where available) and in many instances were below the laboratory's detection limits. Of the parameters that do not have an ASC NEPM investigation or screening levels, and that were above the LOR, the concentration was similar to previously recorded and are unlikely to be of concern. In accordance with the flowchart for the assessment of site contamination, no further action is required.

The sediment in the proposed dredge and reclamation areas is not considered to be contaminated and is of low risk to human and ecological health. That is, there is not a significant risk of release of contaminants to the water column by the suspension of the sediment in the water column due to dredging or other proposed activities.

As the proposed reclamation area will be bunded during works, the risk of sediment mixing with the surrounding water is low.

This issue is not discussed further in this report, as there is not an impact to water quality from contaminants in the dredge material.

9.4.5 Release of Contaminants from the Disturbance of Soil and Groundwater

The potential for contamination associated with current and former land use of the site, including GJ Walter Park and the current Toondah Harbour on Emmett Drive, Cleveland was investigated (refer to Chapter 7). No risks to human health or to the environment were identified, that could not be managed on-site. However, it was noted that further detailed investigations are required to better define the extent and severity of contaminated areas and develop measures to manage potential contamination issue and, where required, remediate these sites prior to construction commencing.

As management measures will be put in place prior to the commencement of works that may disturb potentially contaminated areas there will be minimal risk of any impacts outside of already contaminated areas (refer to section 7.5). Management measures such as storage of fuels and chemical required for construction in bunded areas away from drainage lines and development and implementation of an erosion and sediment control plan (ESCP) also reduces potential impacts to surface water quality. The ESCP will include ongoing monitoring requirements, such as daily visual inspections to ensure the sediment fences and basins are operating as designed.

Impacts to groundwater were also assessed (refer to Chapter 10). Potential impacts were expected to be of low risk to the groundwater regime and sensitive receptors, as they are short to medium term and localised within the PDA area. Any risks will be further mitigated through ongoing monitoring and management, to ensure the risk to surrounding areas, including Moreton Bay is very low.

9.4.6 Tailwater Release into Moreton Bay

Under normal operations tailwater is not anticipated to be released from the reclamation area into the receiving environment as it will be collected and reused on site for dust suppression. Tailwater will be tested for contaminants prior to being reused on site to ensure no impacts occur from this process. As groundwater will be mostly excluded from entering the reclamation area by the sheet pile cut off wall (refer to section 10.4.3) potential contaminant sources are sediments within the reclamation and dredge material from Fison Channel. Analysis did not identify any contaminants at levels of environmental concern within the dredge area, while some metals were present at elevated levels at one location within the reclamation area (refer to section 7.3.1). While only metals were identified at elevated levels contaminants tested in tailwater may include trace metals, PCB's, OCPs and hydrocarbons.

While the reclamation area contains significant capacity for managing tailwater, there is potential for releases to occur during or after extreme rain events. A water management plan will be developed outlining normal management of reclamation operations as well as measures to be put in place in the event of significant rain events. This may include pumping water from tailwater ponds into other areas of the site such as the dry marina basin so that water can be tested and treated prior to being released not the surrounding environment (if required).

With these management and monitoring measures in place impacts from tailwater to the surrounding environment are expected to be very low.

9.5. Adaptive Management and Monitoring Measures

Where an activity is anticipated to have an impact on surface water quality, mitigation measures to reduce severity of impacts and measures for detection and management of potential impacts are proposed in Table 9-8. Stormwater management, dredging activities and reclamation works have been designed to minimise impacts to water quality.

Table 9-8: Surface Water Management Measures

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
Dredging resulting in the suspension of sediments into the water column	▪ Implement the water quality monitoring program to monitor dredge plumes and sensitive receptors (refer to section 9.5.1). Where exceedances of monitoring criteria occur, dredging activities will be modified. This may include: o Moving the position of the dredge away from the sensitive habitat; o Stopping dredging to allow turbidity levels to drop or currents to reverse; and o Use of or other management measures to reduce turbidity, such as modifying the dredge technique, should the investigation triggers be reached frequently. ▪ Silt curtains to be utilised around the dredge area wherever practicable.	▪ Dredging will be managed so that there are no long-term impacts to water quality. ▪ Adaptive water quality monitoring programs have been implemented successfully for dredging operations at ports and harbours along the east coast (refer to DTMR Annual Maintenance Dredging Reviews 2019 and 2010), including previous maintenance dredging operations at Toondah Harbour. A site-specific monitoring program will be developed in accordance with relevant guidelines such as the NAGD. Effectiveness is therefore considered high.
Water quality issues within the marina and internal channels due to poor flushing	▪ Include culverts within the design of the Project linking internal waterways to the marina and Moreton Bay increasing flushing times within the Project footprint. ▪ Implement the water quality monitoring program to monitor dredge plumes and sensitive receptors (refer to section 9.5.1).	▪ No water quality issues within the internal waterways and marina related to poor flushing, such as algae outbreaks. ▪ Modelling indicates flushing will exceed minimum requirements identified in the literature and will be better than what currently occurs in Raby Bay therefore management effectiveness will be high.
Suspension of sediments from dredge material and soft upper sediments within the reclamation area into tailwater	▪ Develop water management plan addressing management of tailwater within the reclamation area as well as measures to be put in place in the event of release into Moreton Bay. At a minimum the plan should address the following: o Water balance assessment for the reclamation areas during different stages of the development. o Tailwater quality testing regime to ensure suitability for re-use on site. Monitoring will incorporate testing for any contaminants identified at elevated levels in sediments (refer to	▪ Tailwater will be managed within the bunded reclamation area with minimal releases so that there are no long-term impacts to water quality outside of the footprint. ▪ Low levels of contaminants in the sediments and adaptive water quality monitoring will result in high management effectiveness.

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
	section 7.5). This may include metals, OCPs and hydrocarbons. o If contaminants are present above human health trigger levels, implement appropriate treatments prior to re-use or release from site. o In the event of a controlled or uncontrolled release of tailwater, the primary response will be to cease discharge of tailwater as soon as practicable. ▪ Use geofabric lining with sheet piling to ensure fine sediment does not move through rockwalls. ▪ Develop a construction erosion and sediment control plan and utilise control devices where appropriate.	
Stormwater runoff during construction and ongoing use reducing water quality in Moreton Bay through increased suspended solids and nutrients	▪ Develop a construction erosion and sediment control plan and utilise control devices where appropriate including regular monitoring of effectiveness. ▪ Implement stormwater management devices into the development in accordance with the conceptual stormwater management plan (Figure 9-21). ▪ Undertake a minimum of 2 years monitoring of stormwater treatment devices to ensure pollutant loads meet or exceed the predicted outputs.	▪ Stormwater will be managed onsite so that there are no long-term impacts to water quality outside of the footprint. ▪ Low levels of contaminants in the sediments and adaptive water quality monitoring will result in high management effectiveness.
Fuel or other chemicals spills to ground or water during the construction process and ongoing uses	▪ Store fuels and chemicals in appropriate areas away from sensitive receptors on site in accordance with relevant standards and guidelines. ▪ Retain appropriate spill response materials on site including booms and absorbent materials. Spill kits are to be kept nearby to any fuel or chemical storage area.	▪ Chemicals and fuels will be stored in accordance with relevant safety data sheets and Workplace Health and Safety Queensland's Managing risks of hazardous chemicals in the workplace. Storage and use will be carried out in accordance with site-specific environmental authorities. ▪ Development of management and monitoring plans in accordance with industry standard guidelines will result in high management effectiveness.
Oxidation of PASS in reclamation and other parts of the Project footprint where excavations occur	▪ Implement an ASS management plan in accordance with relevant State and Federal guidelines including a monitoring program for the dredging and reclamation processes. ▪ Keep sediments saturated during the dredging process until they have been treated for potential acidity and placed within the reclamation area. ▪ Apply additional treatment as required to dredge material and soft upper sediments within the reclamation area.	▪ ASS will be monitored and managed in accordance with industry guidelines such as the Queensland ASS Technical Manual Soils Management Guidelines and National ASS Guidelines for the dredging of ASS sediments and associated dredge spoil management so that there are no short or long-term impacts to habitats or fauna.

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
	▪ Carry out daily inspections of the reclamation area to check for visual signs of oxidation. ▪ Carry out ASS and PASS sampling and analysis in accordance with relevant State and Federal guidelines prior to carrying out any on land works. Apply treatment as required to neutralise acid generating potential.	▪ Development of management and monitoring plans in accordance with industry standard guidelines will result in high management effectiveness.

9.5.1 Draft Water Quality Monitoring Plan

Potential impacts to water quality and marine ecology will be managed through an overall trigger action response plan (TARP). In this plan key sensitive receptors will be protected by:

- Using baseline data and modelling to develop trigger levels for a suite of parameters that provide an early warning of potential damage;
- Monitoring these parameters; and
- Providing actions in response to these triggers being met.

All monitoring will be in accordance with methods prescribed in the latest edition of the Monitoring and Sampling Manual (Monitoring and Sampling Manual 2009 Environmental Water (Policy) DES 2018), and a project-specific standard operating procedure that addresses the management of data quality and integrity, including effective calibration and maintenance of water quality meters in accordance with their specifications and the Monitoring and Sampling Manual. Samples will be analysed by a NATA accredited laboratory so that data can be compared to the WQOs for Area C2 (refer to section 9.1.2). The results of water quality monitoring will be made publicly available, as close to real time as possible.

Where water quality parameters exceed predefined trigger levels, further investigation will be required. Where investigation indicates that there may be an adverse impact to key sensitive habitats, a management response will be implemented.

Overall impacts from the Project on sentinel key sensitive habitats in the surrounding area will also be monitored. This will include monitoring water quality, benthic photosynthetically active radiation (BPAR), and habitat condition (addressed in Section 16.6).

9.5.1.1 *Potential Plumes from Dredging and Reclamation*

This component of the water quality monitoring program addresses monitoring of potential plumes from dredging and reclamation activities. The risk from contaminants and nutrient release during dredging and reclamation is considered to be very low (Section 9.4.4), and consequently this part of the monitoring program focusses on changes to turbidity (associated with a potential increase in suspended solids), dissolved oxygen and pH. While the water body is generally well mixed, in the short term these parameters may vary with depth, and so will be measured throughout the water column.

Water quality will be measured up and down current of any active dredging and of any activities from the reclamation works (e.g., construction of bund walls) that may negatively impact water quality[1]. The scope and extent of any plumes from activities will be assessed visually (including the use of drones) throughout the construction phase.

Monitoring sites will include sites up and downcurrent of dredging and other earthworks activities, as well as sites in nearby sensitive habitats that may be impacted by changes in water quality. As in previous dredge campaigns at Toondah Harbour, to assist in correctly attributing the cause of any changes in turbidity, an up-current control site will be monitored, in addition to down-current sites at set distances from the current dredging activities. As the dredge moves throughout the campaign, and the position on any one day cannot currently be predicted, and as the direction of up and down current changes with the tide, it is not possible to map all possible monitoring locations. As an example, barge positions during the last dredge campaign at Toondah Harbour are presented in Figure 9-2.

Water quality depth profiles of turbidity, percent saturation of dissolved oxygen and pH will be collected at sites:

- 50 -100 m up current of activities that result in the disturbance of sediment or water quality;
- ≤350 m downcurrent of activities; and
- 500 m downcurrent of activities and continuing every 250 m to the maximum distance of any visible plume.

Water quality depth profiles will be collected:

- Every day for four days at the commencement of each dredge campaign;
- Every day for four days prior to any reclamation activity that would result in a discharge;
- Every day for four days following any exceedance; and
- Once a week throughout standard dredging activity, and any reclamation activity that would result in a discharge.

Further:

- Each time water quality data is collected, GPS coordinates will be recorded for the up-current control site(s), location(s) of the activity, and downstream monitoring point(s);
- Data will be collected in depth profiles, with measurements at 2 m depth intervals where overall depth is >10 m, or 1 m depth intervals where the overall depth is <10 m, with the deepest reading taken at least 1 m above the substrate;
- Water quality measurements will only be collected during tidal flows, and will be at least one hour either side of the slack tide; and
- All monitoring will be of samples that are representative of the effects of the dredging activity.

Background values (BV) will be calculated as the average of the readings collected from depth profiles at the up-current point.

Triggers for investigation will be based on the comparison of BV to the value ≤350 m downcurrent of activities. The following investigation triggers are nominally recommended:

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[1] Noting that with the current design there are no discharges from the reclamation area, so ambient monitoring during standard reclamation activities would not be required.

- Where the BV for turbidity is less than 100 NTU, then the trigger for investigation is defined as 10 NTU or more above the BV; and
- Where the BV is more than 100 NTU, then the trigger for investigation is defined as 10% or more above the BV.

These triggers have been used previously to monitor dredge activities in Toondah Harbour and no apparent impacts to the surrounding marine environment have been identified (Section 9.3).

The pH at the monitoring point/s 350 m downstream of activities will also be compared to the prescribed minimum and maximum WQO for Area C2, and to the BV.

When an investigation trigger is reached or exceeded, the likely cause will be investigated and determined. The length of the plume will be recorded, and data will be collected and analysed from the nearby sensitive habitats (refer to Figure 16-11) to determine whether pH complies with the WQO, and whether there is a corresponding peak in turbidity or decrease in BPAR that may be due to the dredge or reclamation activities. Where other current data is available (e.g., data from the EHMP) it will also be used in this assessment.

Where the activities result in a plume that may negatively impact nearby sensitive habitats, management measures (including modifying or ceasing dredging) will be implemented to rectify the issue. Specific measures may include:

- Moving the position of the dredge away from the sensitive habitat;
- Stopping dredging to allow turbidity levels to drop or currents to reverse; and
- Use of or other management measures to reduce turbidity, such as using additional silt curtains or modifying the dredge technique, should the investigation triggers be reached frequently.

9.5.1.2 *Water Quality within the Marina*

Modelling indicates that the marina flushing times are sufficiently short to maintain water quality, including high concentrations of dissolved oxygen in the marina (Section 9.4.2).

On connection of the interior waterways to the bay, the site will be inspected daily for visual and olfactory signs of poor water quality, including:

- Floating scums of algae;
- Slicks (oil, chemical);
- Litter;
- Excessive growth of algae; and
- Unpleasant odours.

Water quality will also be monitored monthly for the first twelve months in the areas of the marina with the longest flushing times (i.e., the north-western section of the internal waterway, the central marina, the middle entrance channel and at two background (control) points to the north and south of the Project). Turbidity, pH, conductivity and the percent saturation of dissolved oxygen will be measured in situ in surface water, and 1 m from the bottom. In addition, surface samples will be collected and analysed for the concentration of total nitrogen, oxides of nitrogen, ammonia, oxidised nitrogen, total phosphorus, filterable reactive phosphorus, chlorophyll *a*, and enterococci.

These water quality parameters will also be measured at these sites following two rainfall events each year (nominally > 20 mm within a 24-hour period), and where visual assessment indicates a deterioration in water quality.

Management Trigger: Dissolved Oxygen

After each monitoring event, the percent saturation of dissolved oxygen at each site within the marina will be compared to data from the control sites and to the water quality objectives (WQO).

Where the percent saturation of dissolved oxygen is within WQO (95% to 105%[2]) at the control sites, but is not within the WQO at a site within the marina:

- Monitoring of dissolved oxygen will be increased to daily until levels return to an acceptable level;
- The cause will be investigated by a suitably qualified water quality scientist or engineer; and
- The waterway will be managed to prevent the percent saturation of dissolved oxygen decreasing to less than 85%. Management measures may include aeration, and re-evaluation of stormwater management.

Management Trigger: Nutrients, Chlorophyll a, and Enterococci

The annual median of the monthly concentration of nutrients, chlorophyll *a*, and enterococci from each site within the marina will be compared to the median from the control sites.

Where the median from each site within the marina is higher than the control sites, the medians from the marina will be compared to the WQO.

Indicative triggers for investigation based on this approach and using background concentrations in Area C2 as a guide for likely median concentrations for the control sites, are presented in Table 9-9.

Table 9-9: Indicative Triggers for Investigation within the Marina.

Parameter (µg/L)	Modelled Increase*	Median in Area C2[1]	WQO	Trigger for Investigation
Total nitrogen	<7	150	<160	160
Total phosphorous	<1.3	15	<20	20

[1] 50th percentile of Sites E0309, E0500 and E0501 in Area C2

* Indicates differences with respect to existing concentrations

Where a median from within the marina is higher than the median from the control sites and exceeds the WQO, the cause and impacts will be investigated, and where necessary management actions implemented to rectify this (e.g., aeration, re-evaluation of stormwater management) implemented to improve it.

If after 12 months water quality does not comply with the expectations of the models, is significantly poorer than historical water quality, and/ or is poorer than at the control sites, water quality data will continue to be collected each month, until such time as these expectations are met.

If, after twelve months, water quality in the channels and marina complies with the expectation of the models, or is not significantly different to historical data or to water quality at the control sites, water quality data will only be collected after significant rainfall events (i.e., > 20 mm within a 24 hour period) for three years.

[2] Noting that in Area C2, the median of water quality parameters should comply with the WQO, not individual readings. Thus this will be an early alert.

If, after twelve months, water quality in the channels and marina complies with the expectation of the models, or is not significantly different to historical data or to water quality at the control sites, water quality data will only be collected after significant rainfall events (i.e., > 20 mm within a 24-hour period) for three years.

Ongoing Use and Operations

After the completion of works comprising the establishment of the development footprint and the completion of dredging, monitoring of the marina will be required to assess any changes in water quality due to runoff and altered hydrodynamics. Water quality will be measured in the marina and ferry port harbour, Fison Channel and two background (control) locations, quarterly over two years for:

- Physico-chemical parameters measured in situ (i.e., dissolved oxygen, pH, salinity and turbidity);
- Nutrients (e.g., total nitrogen, total phosphorous, oxides of nitrogen, organic nitrogen, filtered reactive phosphorous, ammonia);
- Total suspended solids; and
- Chlorophyll *a*.

Where the median concentration of nutrients, chlorophyll *a*, or enterococci is higher than the background (control) conditions and exceeds the WQO, the cause and impacts will be investigated, and where necessary management actions implemented to rectify this.

9.5.1.3 *Monitoring Water Quality and BPAR at Key Habitats*

In addition, to determine and manage any adverse impacts to nearby sensitive habitats, turbidity, pH, and benthic photosynthetically active radiation (BPAR) will be monitored at the sites where the ecological condition of key habitat is monitored (Chapter 16 – Marine Ecology; Figure 16-11):

- The closest coral communities near Jercuruba (Peel Island)
- The closest coral communities near Coochiemudlo Island
- Coral communities on the north-east edge of the Cassim Island sandbar
- A coral control site east of Wellington Point
- Seagrass bed north of Oyster Point
- Seagrass bed north of the proposed development
- Seagrass control site north of Point Halloran, and a
- Seagrass control site at Wellington Point.

These sites will be surveyed prior to monitoring commencing to ensure they still support these habitats and varied as appropriate if habitat distribution has changed.

Water Quality

Turbidity, conductivity, Secchi depth, temperature and percent saturation of dissolved oxygen in surface waters will be monitored at each site. Each site will be monitored:

- Immediately prior to, and each month during dredging and reclamation activities
- Each quarter for two years once the final development footprint is established.

This data will be assessed together with the results of the marine ecological assessments at each site (Chapter 16 – Marine Ecology). Where there are significant changes to habitats at potentially impacted coral or seagrass habitats but not at the control sites, the reasons for these changes, including changes to water quality, will be investigated, and appropriate management actions applied.

BPAR

A variety of factors, including genetics, temperature, nutrient and sediment conditions may influence light thresholds (Collier *et al*. 2016). Light thresholds for the management of acute impacts have been developed for all the seagrasses species that occur in the MIA, including the dominant species *Zostera muelleri* and *Halophila ovalis* (Collier *et al*. 2016, Pearson *et al*. 2020, Table 9-10). These thresholds are conservative as they are higher than the maximum biological thresholds (Collier *et al*. 2016). Therefore, they provide an early warning of potential impact and an opportunity to investigate and instigate appropriate management actions to prevent impacts.

Table 9-10: Seagrass Light Thresholds for Species in the MIA.

Species	Classification	Suggested Management Threshold (Mol m^{-2} d^{-1})	Integration Time (days)*	Time to Impact (days)**	Confidence Score+	Application Area
Cymodocea serrulata	opportunistic	5	14	50	4	GBRWHA
Halophila decipiens	colonising	2	1	14	3	GBRWHA
Halophila ovalis^	colonising	2	7	14	3	GBRWHA
Halophila ovalis^	colonising	6	7	28	3	GBRWHA
Halodule uninervis	colonising / opportunistic	5	14	40	3	GBRWHA
Zostera muelleri	colonising / opportunistic	6	14	28	2	GBRWHA
Zostera muelleri	colonising / opportunistic	4.5	14	-	-	Gold Coast

*Averaging time used to describe light history and as first signal to trigger management plan

**Time to impact expected and a management plan should be implemented before this time

^Two thresholds are recommended for this species as it occupies diverse habitats (with a broad range in light levels) and is highly sensitive to disturbance. Both levels should be complied with.

+ A confidence score of 2 indicates a relatively high level of confidence, but based on studies from limited locations, 3 indicates somewhat confident, 4 indicates low confidence.

BPAR will be logged at deepest end of the *Z. muelleri* meadow at each of the four seagrass sites for 14 months prior to works commencing, and throughout the dredging and reclamation campaigns. Two autonomous loggers (OdysseyTM or similar) with wiper units to keep sensors clean will be used to measure BPAR at each site. Light will be recorded as instantaneous light (µmol m^{-2} s^{-1}) every 15 – 30 minutes and will be summed to daily light (mol m^{-2} d^{-1}), which integrates daily light exposure (Bryant *et al.* 2014, McKenzie *et al*. 2016). Daily light will then be reported as a rolling average of the previous 14 days.

Seagrass biomass, average leaf length and density will also be measured in five replicate quadrates each month at each site at the deepest edge of the *Z. muelleri* meadow, for 14 months prior to works commencing.

This data will be compared to data from existing studies to determine a conservative threshold to be used in combination with the water quality monitoring to manage dredging and reclamation activities.

The light threshold will be used to supplement the triggers and dredge management. Where BPAR is below the threshold at the potentially impacted sites for 14 days, an investigation of data will be triggered (including water quality, habitat, BPAR, weather and other relevant data) and possible causes identified.

Where investigation indicates the low BPAR is likely due to dredging or reclamation activities, measures (including modifying or ceasing dredging) will be implemented to rectify the issue.

9.6. Residual Risk of Impact

A risk assessment has been carried out for key activities that may impact on surface water quality. This risk assessment considers the risk posed before and after application of proposed mitigation measures following the methodology outlined in Section 6.1 of the EIS. The risk assessment determined that the risk of significant impact was low after application of mitigation measures (Table 9-11).

Table 9-11: Surface Water Quality Risk Assessment of Key Activities.

Activity	Initial risk assessment					Mitigated risk assessment				
	Scale	Duration	Impact	Likelihood	Risk	Scale	Duration	Impact	Likelihood	Residual risk
Dredging resulting in the turbidity plumes impacting on water quality outside of the Project footprint	Regional	Short	High	Possible	Medium	Regional	Short	Medium	Not likely	Low
Water quality issues within the marina and internal channels due to poor flushing	Local	Long	High	Possible	High	Local	Short	Low	Possible	Low
Suspension of sediments from dredge material and soft upper sediments within the reclamation area into tailwater	Local	Medium	Medium	Possible	Medium	Local	Short	Low	Not likely	Very Low
Increasing nutrient loads into Moreton Bay through stormwater runoff during operations	Local	Short	Low	Possible	Low	Local	Short	Low	Not likely	Very Low
Impacts from construction including erosion of exposed work areas, oxidisation of ASS and chemical or fuel spills	Local	Medium	Medium	Possible	Medium	Local	Short	Low	Not likely	Very Low