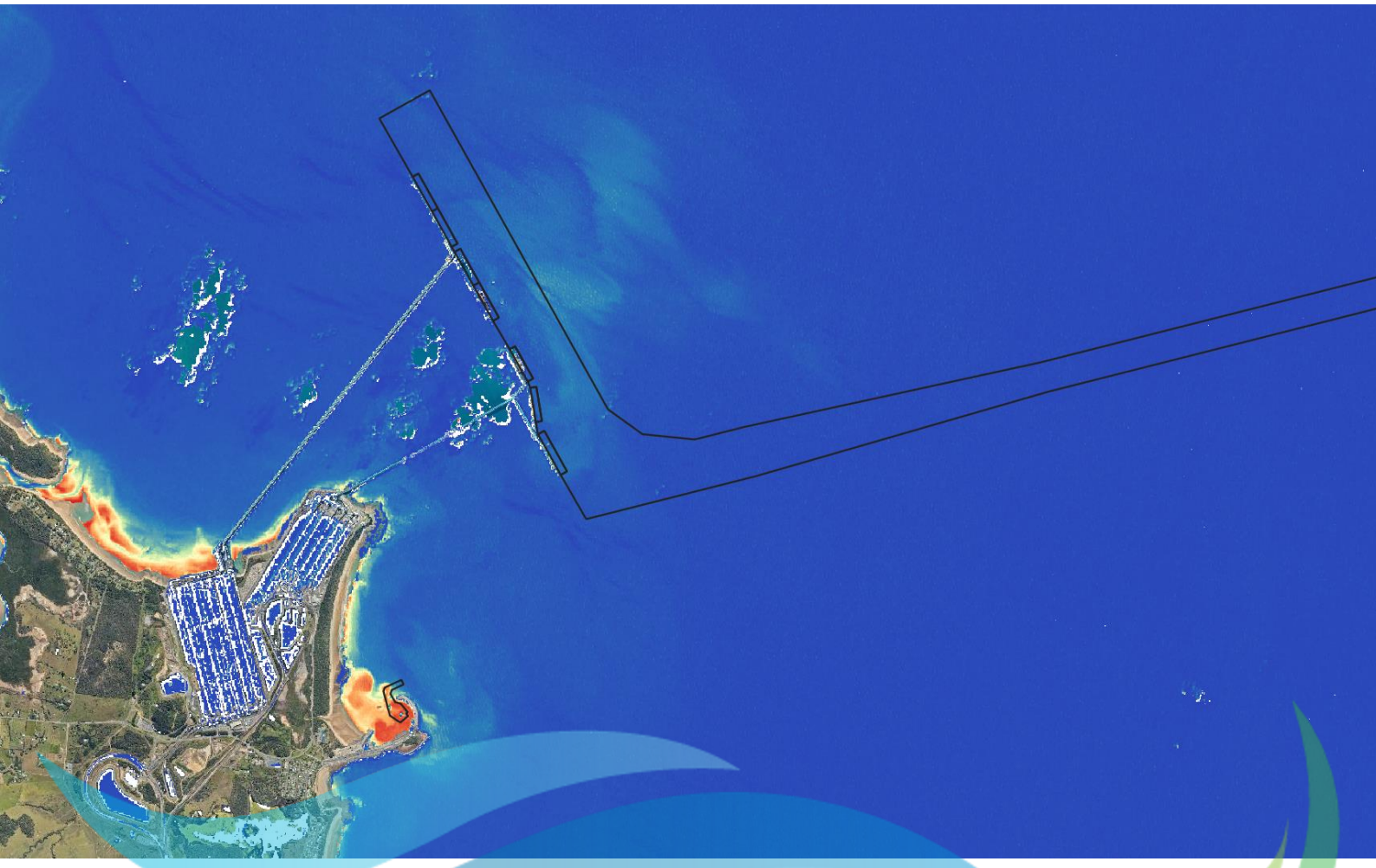
PORT & COASTAL SOLUTIONS

Port of Hay Point, 2024 Maintenance Dredging

Summary of Turbidity Monitoring

Report No. P084_R02v02



North Queensland Bulk Ports Corporation

Technical Report
December 2024

PORT & COASTAL SOLUTIONS

Port of Hay Point, 2024 Maintenance Dredging

Summary of Turbidity Monitoring

Report No. P084_R02v02

December 2024

North Queensland Bulk Ports Corporation Ltd

Version	Details	Authorised By	Date
1	Draft	Andy Symonds	28/11/2024
2	Final	Andy Symonds	10/12/2024

Document Authorisation		Signature	Date
Project Manager	Andy Symonds		10/12/2024
Author(s)	Andy Symonds		10/12/2024
Reviewer	Anna Symonds		10/12/2024

Disclaimer

PORT AND COASTAL SOLUTIONS PTY LTD
ABN 66 630 775 423

A | 46 Elanora Drive, Burleigh Heads, QLD, 4220
E | info@portandcoastalsolutions.com.au
W | www.portandcoastalsolutions.com.au
P | +61 (0)458 735 747

PORT & COASTAL
SOLUTIONS

CONTENTS

1. Introduction 1
   1.1. Project Overview 1
   1.2. Report Structure 2
2. Monitoring Requirements 4
   2.1. Impact Monitoring 4
   2.1.1. Marine Water Quality 4
   2.2. Adaptive Monitoring 6
   2.2.1. Marine Water Quality 7
3. 2024 Maintenance Dredging Program 8
   3.1. Impact Monitoring 8
   3.2. Adaptive Monitoring 8
4. Turbidity Analysis 10
   4.1. Quality Assurance 10
   4.2. Turbidity Thresholds 10
   4.3. Results 11
   4.3.1. Metocean Conditions 11
   4.3.2. Turbidity Conditions 11
   4.3.3. Water Column Profiling 16
   4.3.4. Satellite-Derived Turbidity 17
   4.3.5. Threshold Exceedance 26
5. Implementation 27
   5.1. Implementation Summary 27
6. Summary 28
7. References 29

PORT & COASTAL
SOLUTIONS

FIGURES

Figure 1. Layout of the Port of Hay Point along with metocean and water quality monitoring sites. 3
Figure 2. Location of metocean and water quality monitoring sites around the Port of Hay Point. 6
Figure 3. Metocean conditions over the 2024 maintenance dredging program. 13
Figure 4. Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Slade Islet over the 2024 maintenance dredging program. 14
Figure 5. Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Round Top Island over the 2024 maintenance dredging program. 14
Figure 6. Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Victor Island over the 2024 maintenance dredging program. 15
Figure 7. Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Freshwater Point over the 2024 maintenance dredging program. 15
Figure 8. Measured turbidity profile through the water column on 17/10/2024 at Victor Island. 16
Figure 9. Measured turbidity profile through the water column on 17/10/2024 at Victor Island. 16
Figure 10. Low-resolution satellite turbidity data for the regional area at 09:50 on 20/08/2024 18
Figure 11. High-resolution satellite turbidity data for the Hay Point region at 10:21 on 27/08/2024 20
Figure 12. High-resolution satellite turbidity data for the Apron and HTTH area at 10:21 on 27/08/2024 21
Figure 13. High-resolution satellite turbidity data for the Hay Point region at 10:21 on 11/09/2024 22
Figure 14. High-resolution satellite turbidity data for the Apron and HTTH region at 10:21 on 11/09/2024 23
Figure 15. High-resolution satellite turbidity data for the Hay Point region at 10:21 on 21/09/2024. 24
Figure 16. High-resolution satellite turbidity data for the Apron and HTTH area at 10:21 on 21/09/2024. 25

TABLES

Table 1. Summary of key parameters to be measured by the Environmental Monitoring 4
Table 2. Marine water quality monitoring sites 5
Table 3. Benthic and surface turbidity intensity thresholds for the trigger and control sites 11
Table 4. Turbidity intensity and duration thresholds for the four adaptive monitoring sites based on a 20 day period 11
Table 5. Benthic and surface turbidity intensity threshold exceedances from 15/08/2024 to 24/09/2024. 26

Executive Summary

North Queensland Bulk Ports Corporation (NQBP) commissioned Port and Coastal Solutions (PCS) to undertake work to support the 2024 maintenance dredging program at the Port of Hay Point. This included the following:

- source satellite imagery for the Hay Point region and process the imagery to output satellite-derived turbidity to show the spatial distribution of turbidity over the duration of the dredging program in addition to 10 days pre- and post-dredging;
- obtain metocean data for the Hay Point region over the whole pre-, during and post-dredging period to help interpret the satellite-derived turbidity data;
- provide a post dredging technical report following completion of the maintenance dredging and the post monitoring period. This report will present both the satellite derived turbidity and in-situ benthic and surface turbidity data for the pre-, during and post-dredge periods and discuss the metocean conditions, the associated natural variability in turbidity and potential impacts of the maintenance dredging to turbidity in the region.

The key findings from the assessment are as follows:

- in general, the environmental monitoring undertaken as part of the Port of Hay Point 2024 maintenance dredging program has been implemented in the manner stated in the Management Plans;
- during the maintenance dredging program the benthic turbidity at all sites remained below the 90th percentile duration exceedance. This shows that despite the fact there was a large wave event mid-way through the 2024 maintenance dredging program which resulted in naturally high turbidity in the region over multiple days, the turbidity at all four impact and adaptive monitoring sites was well within the range of natural conditions over the duration of the 2024 maintenance dredging program;
- the duration exceedance of the surface turbidity measured as part of the adaptive management was shown to differ to the benthic turbidity exceedance durations. As a result, the surface turbidity thresholds have been updated as part of this assessment so that the exceedance durations for both the benthic and surface turbidity are comparable. It is suggested that these updated surface turbidity thresholds should be adopted for any future adaptive monitoring;
- satellite derived TSM data were sourced throughout the 2024 maintenance dredging program to show the regional scale turbidity (from Broad Sound to the Whitsunday Islands) and the local scale turbidity around the Port of Hay Point and to identify any plumes resulting from the maintenance dredging and bed levelling activities;
- the satellite derived TSM showed that the regional scale turbidity remained similar throughout the period, with high TSM in Broad Sound and low TSM throughout the remainder of the area. Localised natural plumes were shown to be present throughout the region; and
- plumes resulting from the dredging activity, placement of dredged sediment and bed levelling activity were identified through the satellite derived TSM imagery:
  - DMPA: plumes due to recent placements were typically within or directly to the north of the DMPA (this is the net transport direction in the area due to the dominant southeasterly winds) and had a TSM of 5 to 10 mg/l. The imagery did not show any evidence of plumes from placement at the DMPA being transported to the west towards Round Top Island (or towards any of the other impact/adaptive monitoring sites);
  - Apron and Berths: plumes due to the maintenance dredging and bed levelling were observed within the Hay Point apron and berths. The plumes had a TSM of up to 15

mg/l, but this TSM remained localised to where the plume was generated with any residual plume following the dredging shown to consistently be below 10 mg/l. The imagery showed that the plumes could be transported to the north (towards the DMPA) or to the south (towards Victor Island, but no plumes were shown to extend this far) due to the local currents in the area; and

- HTTH: a consistent plume was observed within HTTH over the majority of the dredge program as a result of regular bed levelling and maintenance dredging activity within the harbour. The localised plume within HTTH was shown to be up to 50 mg/l (when both bed levellers were operating along with the TSHD Brisbane). The imagery consistently showed that the high concentration plume was retained within HTTH.

1. Introduction

North Queensland Bulk Ports Corporation (NQBP) commissioned Port and Coastal Solutions (PCS) to undertake work to support the 2024 maintenance dredging program at the Port of Hay Point. This included the following:

- source satellite imagery for the Hay Point region and process the imagery to output satellite-derived turbidity to show the spatial distribution of turbidity over the duration of the dredging program in addition to 10 days pre- and post-dredging;
- obtain metocean data for the Hay Point region over the whole pre-, during and post-dredging period to help interpret the satellite-derived turbidity data;
- provide a post dredging technical report following completion of the maintenance dredging and the post monitoring period. This report will present both the satellite derived turbidity and in-situ benthic and surface turbidity data for the pre-, during and post-dredge periods and discuss the metocean conditions, the associated natural variability in turbidity and potential impacts of the maintenance dredging to turbidity in the region.

The Marine Park Permit (G19/40185.1) has one condition (condition number 34) which is directly relevant to this assessment, this condition requires the following:

- within six months of completion of each dredge campaign, NQBP must publish a report on their website addressing compliance with the requirements of the Environmental Thresholds Report (PCS, 2024), Maintenance Dredging Environmental Management Plan (NQBP, 2024a) and the Marine Environmental Monitoring Program (NQBP, 2024b), as verified by an independent audit.

This report reviews the Impact and Adaptive monitoring required by the three reports in terms of marine water quality and checks whether the monitoring therefore conformed with the Marine Park Permit.

1.1. Project Overview

The Port of Hay Point is located on the central east coast of Queensland, approximately 15 km south of Mackay and close to the neighbouring communities of Louisa Creek, Salonika Beach and Half Tide Beach. It is one of the largest coal export ports in the world and consists of two separate export terminals, Dalrymple Bay Coal Terminal (DBCT) and Hay Point Coal Terminal (HPCT) which service mines in the Central Bowen Basin of Queensland. The Port includes seven berths (four at DBCT and three at HPCT), an apron and a departure path which extends approximately 11 km offshore of the berths to naturally deep water and is predominantly located within the Great Barrier Reef Marine Park (GBRMP) (Figure 1). In addition, there is an existing, designated Dredge Material Placement Area (DMPA) for the Port of Hay Point with an area of 18.4 km^2 located approximately 6 km (from the centre of the apron to the centre of the DMPA) to the north of the Port.

Since 2010 there have been three dredging programs undertaken at the Port of Hay Point:

- 2010 Maintenance Dredging: a total of 216,070 m^3 of sediment was removed from the Port of Hay Point by the TSHD Brisbane. However, the program was planned to return all areas back to their design depths, but due to industrial action by the dredge crew the program was stopped early and never completed;
- 2011 Capital Dredging: 275,000 m^3 of sediment was removed to create the HPCT berth 3; and
- 2019 Maintenance Dredging: a total of 353,740 m^3 of sediment was removed from the Port of Hay Point by the TSHD Brisbane.

To remove sedimentation that had built up in the Port since 2019, along with any sediment which remained above design depth following the 2019 maintenance dredging and

sedimentation in Half Tide Tug Harbour (HTTH) (which was not dredged during the previous maintenance dredging programs), the Port of Hay Point 2024 maintenance dredging program commenced at 17:53 on the 25th August 2024 and was completed at 06:50 on the 14th September 2024. The dredging was undertaken by the *TSHD Brisbane* over a 21-day dredging program. Over the dredging program, 152 dredge loads were relocated to the Hay Point DMPA, with an average of just over 7 loads per day. In addition, 451 hours of bed levelling was also undertaken in HTTH by the *Pacific Titan* and *Pacific Tiger* between the 25th August and the 14th September 2024. Following completion of the maintenance dredging on the 14th September, bed-levelling continued until the 6th October 2024 (approximately 3 weeks after the *TSHD Brisbane* completed the dredging) to level out the seabed in the dredged areas, ensure there were no high spots remaining after the dredging and to assist with maintenance work at the HTTH public boat ramp.

1.2. Report Structure

The report herein is set out as follows:

- details of the monitoring requirements are provided in **Section 2**;
- a summary of the environmental monitoring undertaken as part of the Port of Hay Point 2024 maintenance dredging program is detailed in **Section 3**;
- analysis of the turbidity data collected during the 2024 maintenance dredging program is presented in **Section 4**;
- a summary of the conformance with the approval conditions is provided in **Section 5**; and
- a summary of the report findings is presented in **Section 6**.

Figure 1. Layout of the Port of Hay Point along with metocean (blue) and water quality (yellow) monitoring sites.

2. Monitoring Requirements

The Environmental Thresholds update (PCS, 2024), Maintenance Dredging Environmental Management Plan (EMP) (NQBP, 2024a) and the Marine Environmental Monitoring Plan (MEMP) (NQBP, 2024b) have all been reviewed to determine the environmental monitoring requirements in terms of water quality.

The MEMP explains how the monitoring program has been split into three tiers:

1) Ambient monitoring: ongoing monitoring to provide a long-term baseline environmental condition;
2) Impact monitoring: undertaken before, during and after each maintenance dredging program to detect impacts; and
3) Adaptive monitoring: real-time monitoring during each maintenance dredging program to prevent incidents of serious environmental harm.

The monitoring requirements for the three tiers are summarised in Table 1. As the ambient monitoring is aimed at providing a long-term baseline environmental condition rather than monitoring related to a maintenance dredging program, it is only the performance of the impact and adaptive monitoring that must be implemented during each maintenance dredging program that are considered here. The specific requirements of these two monitoring tiers are discussed further in the following sections in terms of the marine water quality.

Table 1. Summary of key parameters to be measured by the Environmental Monitoring (NQBP, 2024b).

Parameter	Ambient	Impact	Adaptive
Marine water quality	✓	✓	✓
Island fringing corals	✓	✓	
Seagrass and benthic habitat	✓		
Invasive marine pests	✓		
Sediment quality	✓	✓	
Marine megafauna			✓

2.1. Impact Monitoring

The impact monitoring is focused on the marine water quality and the island fringing corals as these are the receptors most likely to be adversely impacted by the dredging (NQBP, 2024b). The impact monitoring is aimed at detecting any unpredicted changes in environmental condition and avoiding impacts from maintenance dredging. In addition, the marine water quality data collected can also be used to validate predictive natural and dredge plume modelling. Details of the monitoring requirements for the parameters required as part of the impact monitoring for marine water quality are provided in the following section.

2.1.1. Marine Water Quality

The marine water quality impact monitoring is required at the same four monitoring sites as the ambient water quality monitoring sites, these are shown in Figure 2 and detailed in Table 2.

As part of the marine water quality impact monitoring, the monitoring is required to commence four weeks prior to the commencement of dredging and finish four weeks post completion of the dredging. The following types of monitoring and parameters are required at the four monitoring sites:

- Physio-chemical and nutrients: monitoring of the following parameters to be undertaken weekly during the dredging:
  - Water temperature;
  - Salinity;
  - pH;
  - Dissolved oxygen (%);
  - Turbidity;
  - Secchi disk depth (measure of optical clarity); and
  - Light attenuation.
- Metals, chlorophyll a and pesticides/herbicides: monitoring four weeks prior and post dredging. This component of the monitoring is not assessed as part of this study and so further details are not provided here.
- Data loggers: monitoring every 10 minutes using data loggers, with the following parameters being measured:
  - Turbidity;
  - Sediment deposition;
  - Pressure;
  - Water temperature;
  - Photosynthetically Active Radiation (PAR); and
  - Current speed and direction.

Table 2. Marine water quality monitoring sites (NQBP, 2024b).

Location	Site ID	Latitude	Longitude
Freshwater Point	1	-21.42	149.34
Round Top Island	3B	-21.17	149.26
Slade Island	5	-21.09	149.24
Victor Island	10	-21.32	149.32

Figure 2. **Location of metocean (blue) and water quality (yellow) monitoring sites around the Port of Hay Point.**

2.2. Adaptive Monitoring

The adaptive monitoring is aimed at real-time observations to detect changes in environmental condition and allow assessment as to whether the changes are natural or related to dredging and disposal activities. As part of the ET report it was concluded that turbidity should be adopted for adaptive management, while PAR and deposition were not considered to be suitable parameters for adaptive management (RHDHV, 2018). The turbidity thresholds which were detailed in the updated ET report (PCS, 2024) enable impact avoidance and management measures to be adopted before any potential impairment to the local ecosystem occurs. Details of the monitoring requirements for the parameters required

as part of the adaptive monitoring in terms of marine water quality are provided in the following sections.

2.2.1. Marine Water Quality

The four ambient water quality monitoring sites were selected as appropriate sites for adaptive monitoring of water quality:

- Round Top Island: trigger site during periods with prevailing southerly winds;
- Victor Island: trigger site during periods with prevailing northerly winds;
- Freshwater Point: control site during periods with prevailing southerly winds; and
- Slade Island: control site during periods with prevailing northerly winds.

Data loggers were used for the adaptive monitoring with loggers providing telemetered real-time measurements every 10 minutes from four weeks prior to the dredging commencing to four weeks post completion of the dredging. The following parameters were recorded and/or modelled post-completion:

- Turbidity and total suspended solids (TSS) (derived from turbidity data based on site specific correlations between turbidity and suspended solids);
- Electrical Conductivity (EC);
- pH;
- Dissolved Oxygen (% saturation); and
- Water temperature.

Based on nine and a half years of measured turbidity data at each of the four adaptive monitoring sites, relative intensity and duration thresholds were adopted for the turbidity monitoring. These thresholds were developed based on the assumption that as long as the turbidity remains within the natural range where no impacts to the sensitive receptors have been observed, then the sensitive receptors should not be negatively impacted. Depending on the duration of time that the turbidity intensity thresholds are exceeded at the sites and how the trigger and associated control sites behave relative to each other (as specified in the EMP and MEMP), adaptive management measures maybe required. Four different management zones (Management Zone A to D) were defined with escalating management responses required for each subsequent management zone:

- Zone A, Normal: Normal operating conditions;
- Zone B, Investigate: Investigate to determine if increased turbidity is dredging related;
- Zone C, Respond: Investigate to determine if increased turbidity is natural or dredging related and if dredging related then instigate management actions; and
- Zone D, Stop Dredging: Instigate stop dredging and disposal measures.

In addition to the in-situ data collected by the data loggers, the MEMP also notes that daily visual analysis of satellite imagery (specifically satellite-derived turbidity) will be undertaken to compare the actual plume location with the predicted plume location from the numerical modelling.

The MEMP also notes that monitoring of metocean conditions will be undertaken during dredging programs, with tide, wind and weather warnings all monitored. The data are primarily to be used to inform the dredge operations.

3. 2024 Maintenance Dredging Program

Impact and adaptive monitoring were initiated as part of the 2024 maintenance dredging program, details of the marine water quality monitoring undertaken are provided in the following sections.

3.1. Impact Monitoring

The marine water quality monitoring which has been collected as part of the impact monitoring can be separated into two separate components:

- Vessel based sampling: the physio-chemical depth profiling was undertaken from a vessel. In addition, PAR was measured through the water column and based on these measurements the vertical light attenuation coefficient was calculated. This provides significantly more accuracy than secchi disk measurements and so has been used in its place. Four separate sampling trips were undertaken:
  - 15-16/07/2024 (39 days pre-dredging): all physio-chemical, parameters measured at all four sites;
  - 27/08/2024 (2 days after dredging commenced): all physio-chemical parameters measured at all four sites;
  - 10/09/2024 (16 days after dredging commenced): all physio-chemical parameters measured at all four sites; and
  - 16/10/2024 (32 days post-dredging): all physio-chemical parameters measured at all four sites.
- Data loggers: the impact marine water quality monitoring made use of the same loggers as for the ongoing ambient water quality monitoring. As such, data collection was ongoing pre- and post-dredging and so data were collected more than four weeks pre-dredging, continued throughout the dredging and continued to be collected for over four weeks post dredging. The data loggers measured all the required parameters every 10 minutes at the four monitoring sites detailed in Table 2.

3.2. Adaptive Monitoring

Marine water quality monitoring has been collected as part of the adaptive monitoring at the four sites specified in the MEMP from 28/07/2024 (four weeks pre-dredging) to 12/10/2024 (four weeks post-dredging). The monitoring was undertaken using dual YSI EXO3 sondes which were deployed at the surface (approximately 0.75 m below the water surface) and telemetered to provide real-time measurements every 10 minutes. The instruments provided measurements of the turbidity, water temperature, conductivity (salinity), pH and dissolved oxygen (% saturation). Real-time surface turbidity monitoring was undertaken, as opposed to real-time benthic turbidity monitoring, as this method was considered to reduce the risk of data loss and increase the confidence in the data. The following conditions within the Hay Point region were taken into consideration to determine the water quality monitoring approach:

- due to the large tidal range and strong tidal currents in the Hay Point region there is a high probability of ongoing data loss when trying to transmit real-time benthic data. This is because a cable is required to connect the instrument at the seabed to the modem on the surface buoy, but due to the metocean conditions there is a risk that the cable could become entangled or damaged;
- the risk of data loss when using a near-surface logger is low, as both the instrument and modem are located on the same buoy and so there are no long cables required; and
- in the Hay Point region the large tidal range and strong tidal currents result in the turbidity being relatively well mixed through the water column.

Metocean conditions were monitored over the duration of the adaptive monitoring period. This included real-time wind data at Half Tide Tug Harbour (from the Bureau of Meteorology (BoM)), predicted water levels for the Port of Hay Point (from the Queensland Government, Transport and Main Roads), real-time wave data at the Hay Point waverider buoy (from the Department of Environment, Science and Innovation) and weather forecasts/warnings provided by the BoM.

To better understand the spatial extent of both the natural turbidity in the Hay Point region and any plumes resulting from the maintenance dredging activity, satellite imagery were used. High-resolution imagery from the Sentinel-2 (10 m) sensor and low-resolution imagery (approximately 300 m) from the Sentinel-3 sensor were sourced and processed over the 2024 maintenance dredge monitoring period.

4. Turbidity Analysis

Turbidity was determined to be the most appropriate parameter to identify potential impacts to sensitive receptors resulting from the 2024 maintenance dredging program, as this parameter was adopted for the real-time adaptive monitoring with specific management measures required when certain thresholds were exceeded.

This section analyses the turbidity data collected as part of the adaptive monitoring and calculates the duration of time that the turbidity intensity thresholds were exceeded.

4.1. Quality Assurance

A quality assurance and quality control (QA/QC) check was undertaken by Vision Environment (VE) in real-time and following completion of the data collection on the surface turbidity data collected as part of the adaptive monitoring. Where the QA/QC showed that data from both sondes were reliable the data were averaged and when data from one sonde were considered unreliable just the data from the sonde considered to be providing reliable data were adopted.

A QA/QC check was also undertaken by James Cook University (JCU) on the benthic turbidity data collected as part of the impact monitoring, with data flagged when values were considered unreliable. The unreliable data were removed by PCS prior to analysis.

An hourly moving average turbidity was calculated for both the surface and benthic measured turbidity data to remove short duration spikes which typically occur in this type of data.

4.2. Turbidity Thresholds

Turbidity thresholds were calculated at the four adaptive management sites based on 9.5 years of benthic turbidity data collected as part of the long-term ambient water quality monitoring undertaken by JCU (PCS, 2024). The thresholds were determined using an hourly moving average benthic turbidity and include a benthic turbidity intensity threshold and a duration of time the intensity threshold has been exceeded over a set period of time. These thresholds were adopted as part of the adaptive management for the Port of Hay Point 2024 maintenance dredging program. However, to allow the benthic turbidity thresholds to be applied to the surface turbidity data being collected as part of the adaptive monitoring it was necessary to correlate available concurrent benthic and surface turbidity data. Concurrent surface and benthic turbidity data collected at the four adaptive management monitoring sites over the 2019 maintenance dredging program (three months of data in total) were analysed to determine suitable benthic to surface turbidity correlations (PCS, 2024). The benthic and correlated surface turbidity intensity thresholds are provided in Table 3. The benthic intensity and duration thresholds which were applied for the 2024 maintenance dredging program are shown in Table 4. The surface intensity thresholds detailed in Table 3 were applied along with the duration thresholds shown in Table 4 to allow the real-time surface turbidity data to be used to inform adaptive management activities during the maintenance dredging program.

Table 3. Benthic and surface turbidity intensity thresholds for the trigger and control sites (PCS, 2024).

Location	Benthic Turbidity Intensity Threshold (NTU)	Surface Turbidity Intensity Threshold (NTU)
Slade Islet (control)	31	6
Round Top Island (trigger)	12	6
Victor Island (trigger)	25	9
Freshwater Point (control)	43	13

Table 4. Turbidity intensity and duration thresholds for the four adaptive monitoring sites based on a 20 day period (PCS, 2024).

Location	Intensity Threshold (NTU)	Average Duration (hrs)	90th Percentile Duration (hrs)	Maximum Duration (hrs)
Slade Islet (control)	31	14	52	102
Round Top Island (trigger)	12	14	55	114
Victor Island (trigger)	25	14	45	128
Freshwater Point (control)	43	14	31	313

4.3. Results

Results from the turbidity monitoring undertaken as part of the adaptive and impact monitoring for the 2024 maintenance dredging program are presented in the following sections along with metocean data.

4.3.1. Metocean Conditions

The metocean conditions over the 2024 maintenance dredging program (including 10 days pre- and post dredging) are shown in Figure 3. The plots show that over the pre-dredge period and the first half of the dredging program the wind and wave conditions were relatively calm (wind speed typically below 15 knots and significant wave height (H_s) typically below 0.5 m). In the middle of the dredge program there was a large wave event which resulted in a peak H_s of 2 m at the Hay Point WRB along with strong (>25 knots) winds from the southeast, the event resulted in elevated wind and wave conditions for approximately 2.5 days. After this event the wind and wave conditions returned to being relatively calm until the last day of the dredge program when the wind speed increased above 20 knots and the H_s increased to 1.8 m. The wind and wave conditions then remained elevated for approximately 4.5 days before returning to relatively calm conditions. There was very little rainfall over the period, meaning that river discharge over the period would also have been low and so would not be expected to impact the water quality in the region.

4.3.2. Turbidity Conditions

The quality checked measured benthic and surface turbidity data over the 2024 maintenance dredging period are shown in Figure 4 to Figure 7 at the four adaptive/impact monitoring sites. The variation in turbidity at the four sites generally corresponds to the metocean conditions:

- the benthic and surface turbidity at all four sites was generally low from the 15th August to the 3rd September. The only exception to this was at Round Top Island where multiple short duration peaks in benthic turbidity of 10 to 15 NTU were measured from the 29th August to the 2nd September. However, the surface turbidity does not show elevated

turbidity which would be expected if the turbidity was due to a larger scale plume (e.g. from the dredging) and as a result the elevated turbidity is likely to be due to a local process influencing the measurements;

- between the 3rd and 8th September there was elevated benthic and surface turbidity at all four sites. This corresponded with the large wave and strong wind event, with a peak H_s of 2 m and a peak wind speed of over 25 knots. The benthic and surface turbidity was elevated again at all four sites between the 14th and 20th September due to another large wave and strong wind event; and
- over the period between the two wind/wave events the benthic and surface turbidity at all four sites returned to low values.

Generally the benthic and surface turbidity show comparable temporal patterns and the benthic turbidity values are either similar to or higher than the surface turbidity values (as would be expected). The only exception to this is during periods of low turbidity when the measured surface turbidity can be up to 7 NTU higher than the benthic turbidity. These differences appear to either be due to the surface loggers minimum measuring value being higher than the benthic loggers, or due to an offset in the surface turbidity measurements (such as between 27th August and 3rd September at Slade Islet). However, these differences have not influenced the duration that the turbidity exceeded the thresholds at any of the sites.

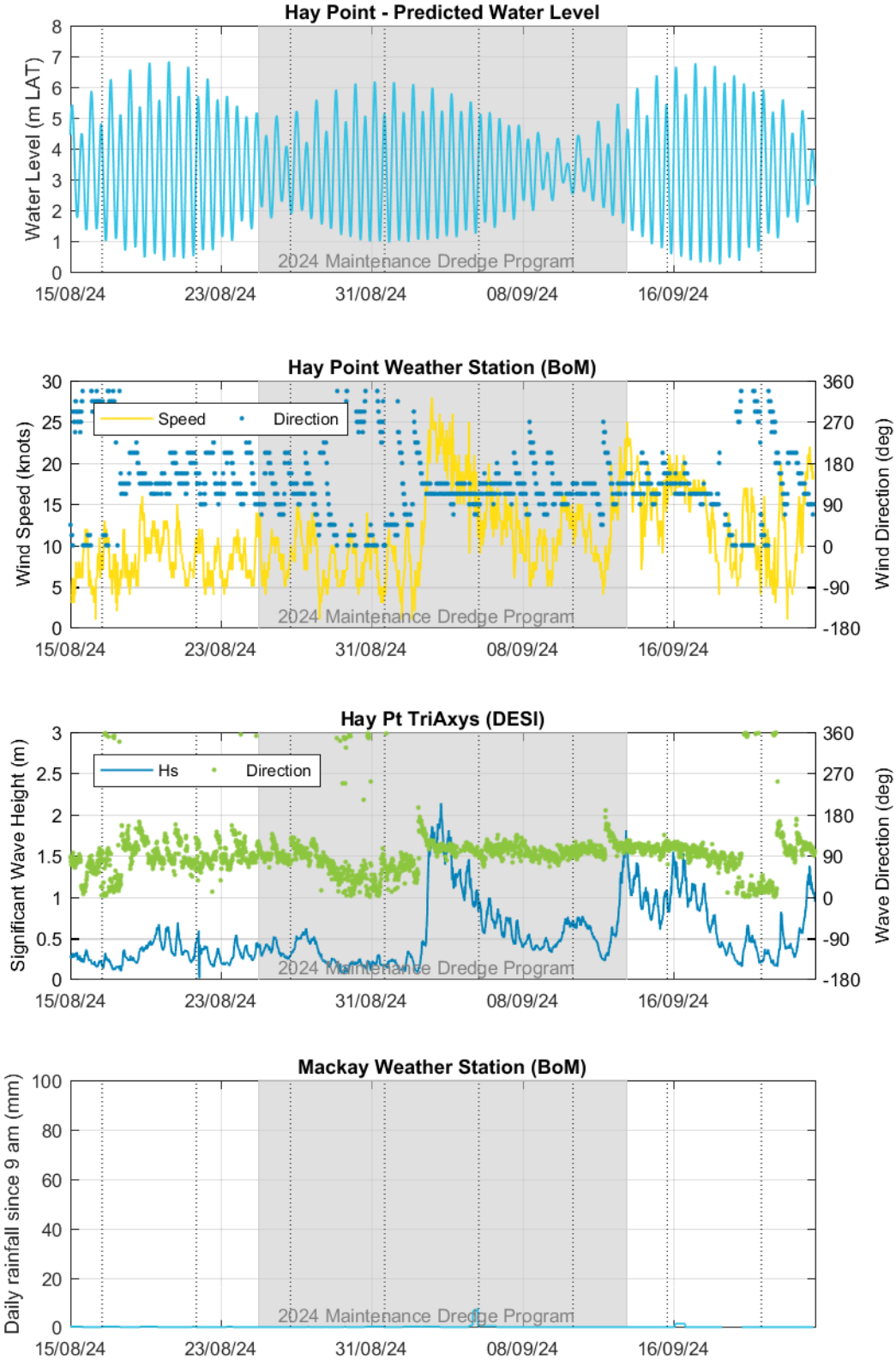


Figure 3. **Metocean conditions over the 2024 maintenance dredging program.** *Note: the dashed vertical lines show times when high resolution satellite images were captured.*

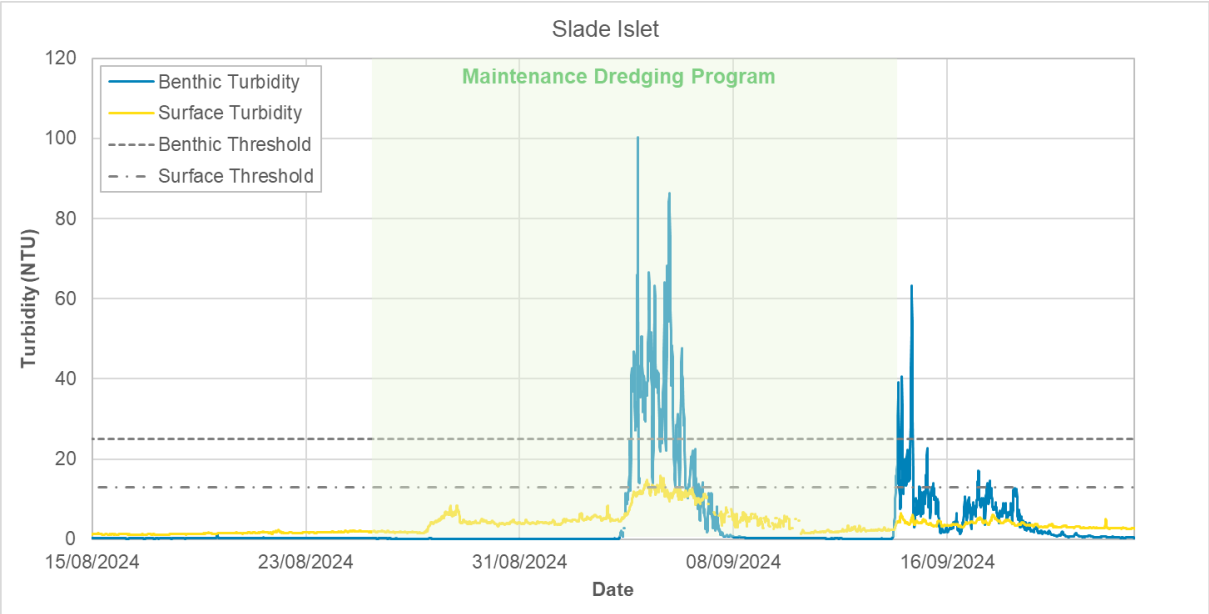


Figure 4. **Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Slade Islet over the 2024 maintenance dredging program.**

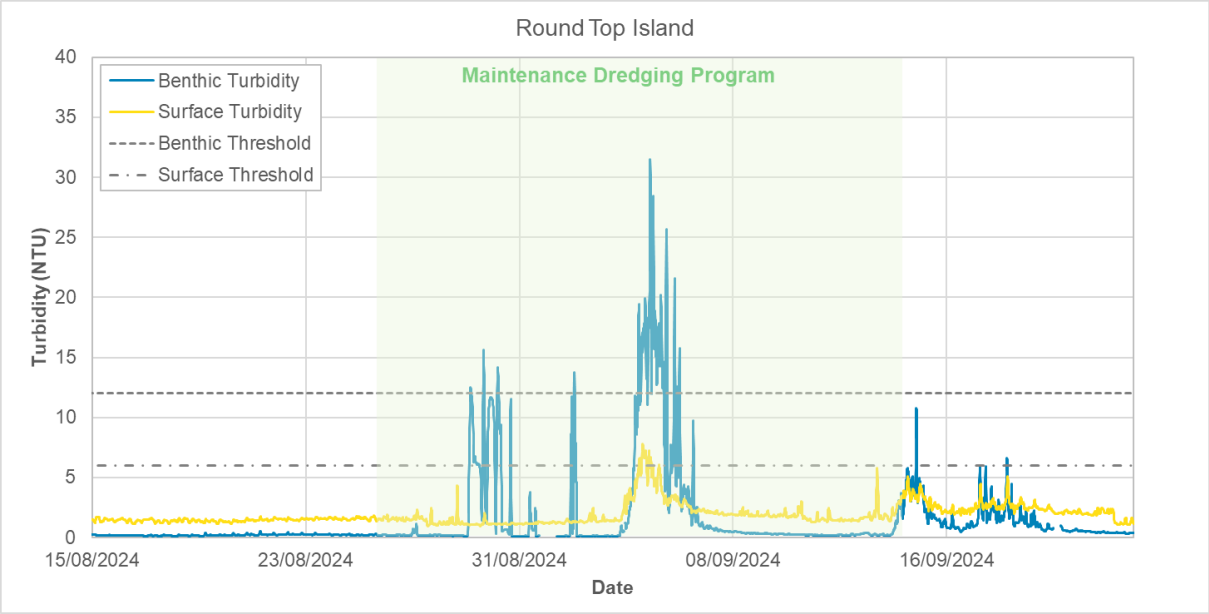


Figure 5. **Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Round Top Island over the 2024 maintenance dredging program.**

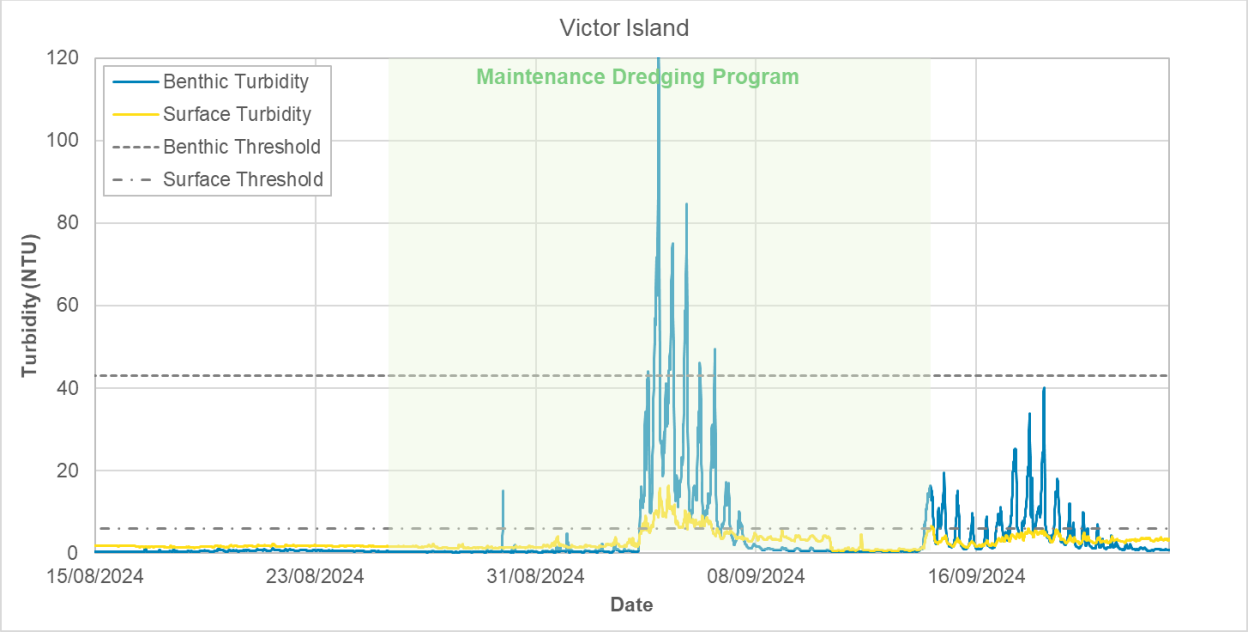


Figure 6. **Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Victor Island over the 2024 maintenance dredging program.**

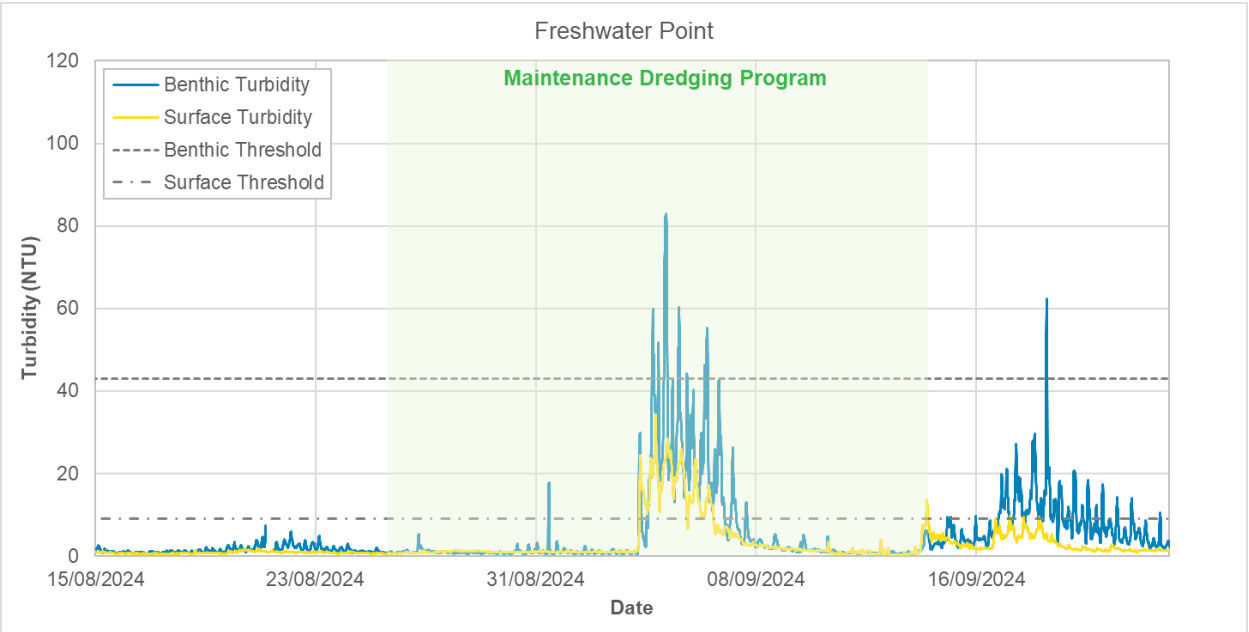


Figure 7. **Hourly moving average surface and benthic turbidity and turbidity intensity thresholds at Freshwater Point over the 2024 maintenance dredging program.**

4.3.3. Water Column Profiling

Water column profile measurements of turbidity were undertaken by VE as part of the vessel-based impact monitoring. The measurements showed zero turbidity during all measurements except for at Victor Island and Freshwater Point during the post dredge measurements. This is partially a result of the measurements having been vessel-based meaning that the data are representative of calmer wind and wave conditions when turbidity was low.

Water column profiles of turbidity are shown for the post dredge measurements at Victor Island in Figure 8 and for Freshwater Point in Figure 9. The plots show that during these periods with calm wind/wave conditions there is limited variation in turbidity through the water column.

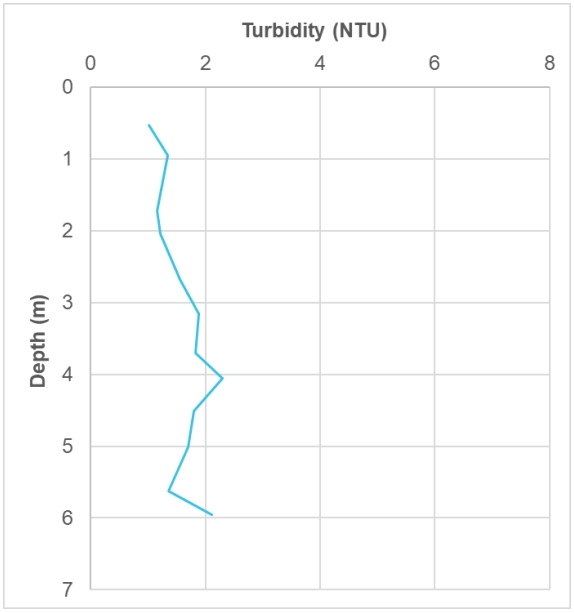


Figure 8. Measured turbidity profile through the water column on 17/10/2024 at Victor Island.

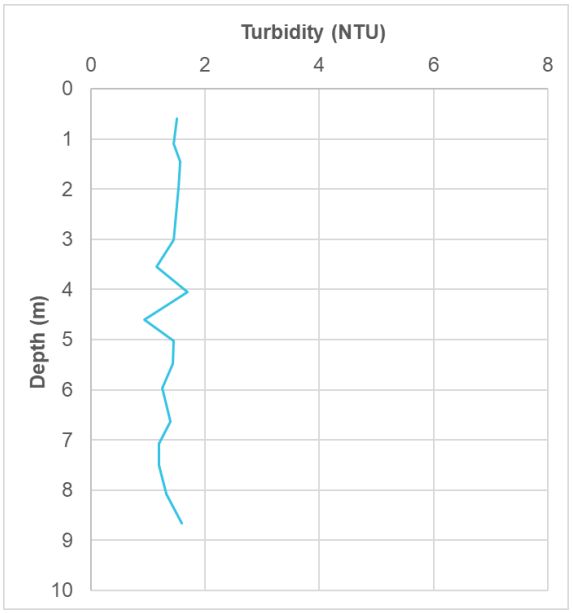


Figure 9. Measured turbidity profile through the water column on 17/10/2024 at Victor Island.

4.3.4. Satellite-Derived Turbidity

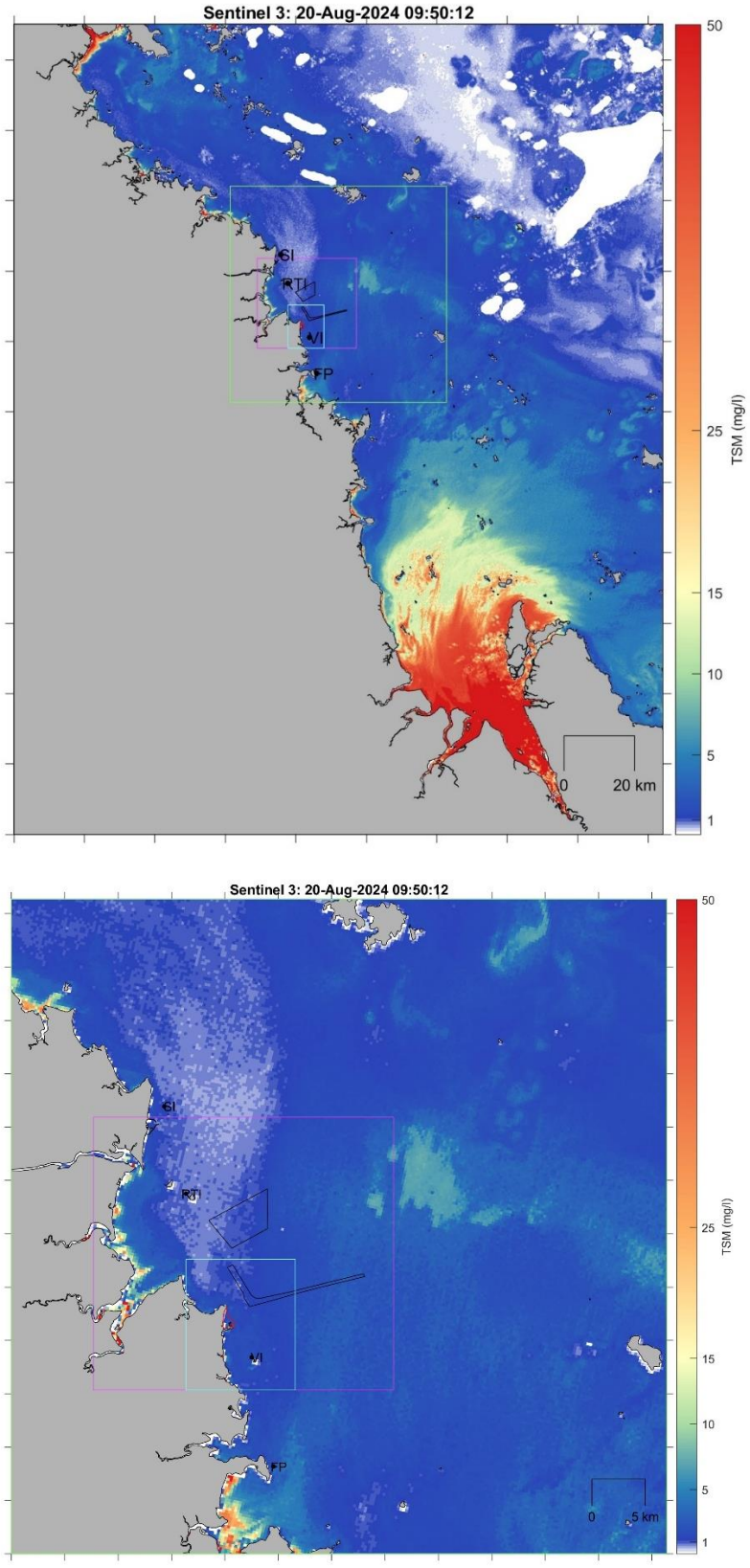
To better understand how the turbidity has varied spatially during the 2024 maintenance dredging program the satellite-derived turbidity data obtained as part of the adaptive monitoring have been analysed. Satellite-derived turbidity data is a valuable resource which can provide a reliable spatial overview of the variability in turbidity (Fearns et al., 2017). This type of data can greatly assist the interpretation of in-situ data sets, especially when attempting to gain a better understanding of the spatial variability in turbidity over a large area, such as the Hay Point region. High-resolution imagery from the Sentinel-2 (10 m) sensor and low-resolution imagery (approximately 300 m) from the Sentinel-3 sensor were sourced over the 2024 maintenance dredge monitoring period.

The satellite data are restricted by cloud cover and the wind/wave events over the period coincided with high cloud cover meaning that limited usable imagery was available around these natural resuspension events. However, plumes from the maintenance dredging and bed levelling activity are more visible during periods of low natural turbidity and so the imagery has been able to provide valuable information during these conditions.

The available imagery was post processed to calculate the satellite-derived turbidity based on the approach of Brockmann et al. (2016). This approach provides an estimate of total suspended matter (TSM) and has been validated in various studies (Kyryliuk and Kratzer, 2019). The low-resolution imagery was sourced for the area extending from Broad Sound to the south up to the Whitsunday Islands to the north (distance of approximately 280 km), while the high-resolution imagery was sourced from Cape Palmerston to the south up to Keswick Island to the north (distance of approximately 75 km, to cover the area where the four impact/adaptive monitoring sites are located). Low-resolution imagery were captured most days, while high-resolution imagery were captured every 5th day. After being processed, the imagery was plotted at a range of spatial scales to show the natural turbidity in the whole region (just the low-resolution imagery), the turbidity in the Hay Point region, the turbidity throughout the Port of Hay Point and the DMPA and the turbidity in HTTH and the apron and berth pockets.

The low-resolution imagery was used to provide an understanding of the regional scale processes which influence turbidity in the region and to identify any larger scale plumes from the maintenance dredging, while the high-resolution imagery was used to understand the natural turbidity in the Hay Point region and to identify any plumes from the maintenance dredging and bed levelling activities.

The regional scale turbidity remained relatively similar over the whole period, an example of the TSM from the low-resolution imagery during the pre-dredging period is provided in Figure 10. The plot shows high turbidity to the south in Broad Sound (up to 50 mg/l) and then relatively low turbidity throughout the remainder of the region (typically less than 10 mg/l). There are also natural plumes of around 10 mg/l present throughout the region, with a large plume directly offshore from the DMPA. The elevated TSM around Broad Sound is a result of the high tidal currents in this area resulting from the tidal amplification which occurs in this area. The low-resolution satellite derived turbidity data obtained as part of the project, showed that the 2024 maintenance dredging program at the Port of Hay Point did not influence the regional scale TSM, with this being predominantly controlled by tidal currents and wind/wave conditions.



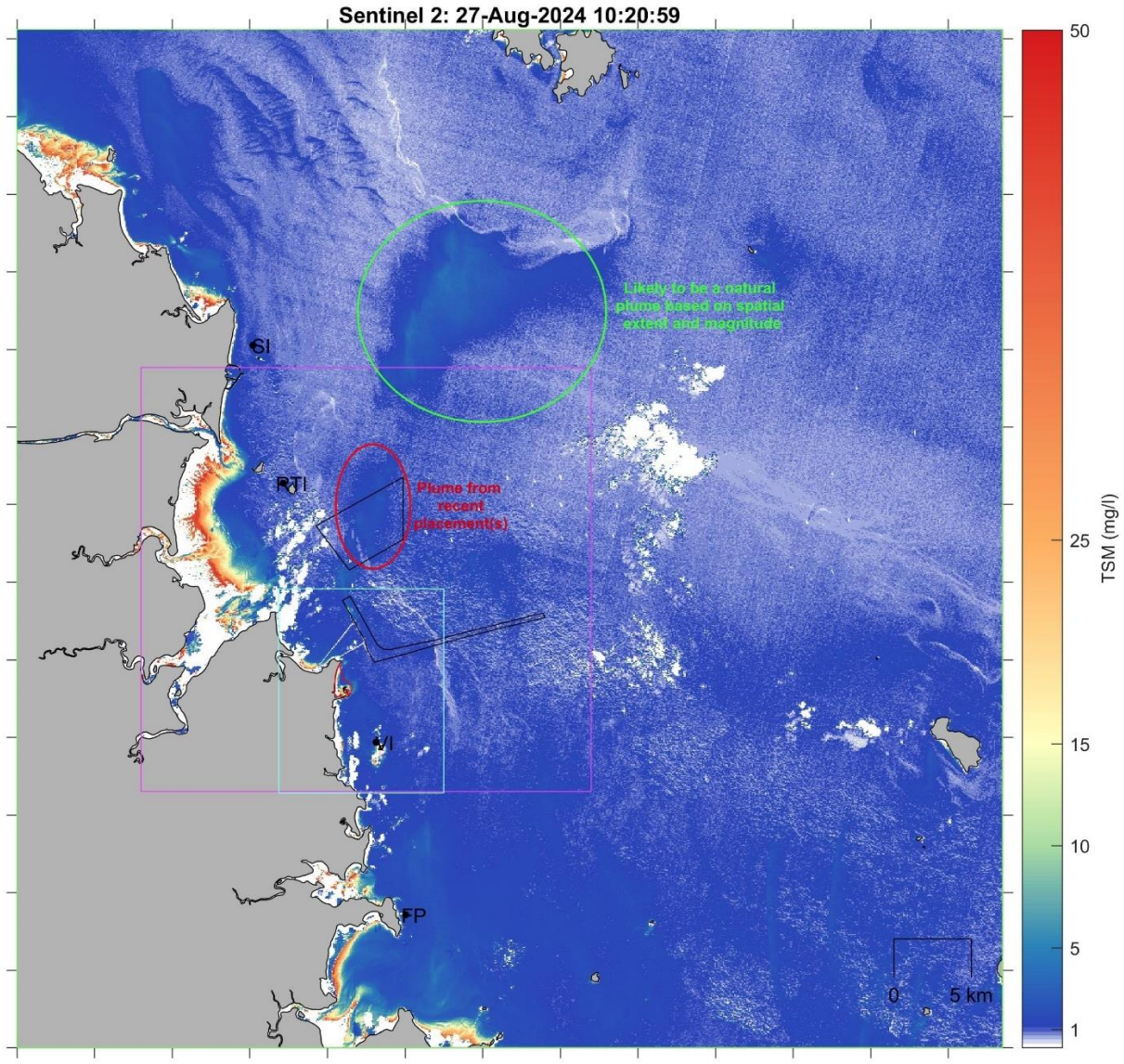
Note: The gaps in the data are due to cloud cover.

Figure 10. Low-resolution satellite turbidity data for the regional area at 09:50 on 20/08/2024 (pre-dredging program).

High-resolution imagery showing plumes resulting from the maintenance dredging and bed leveling activity are presented in Figure 11 to Figure 14. The plots show the following:

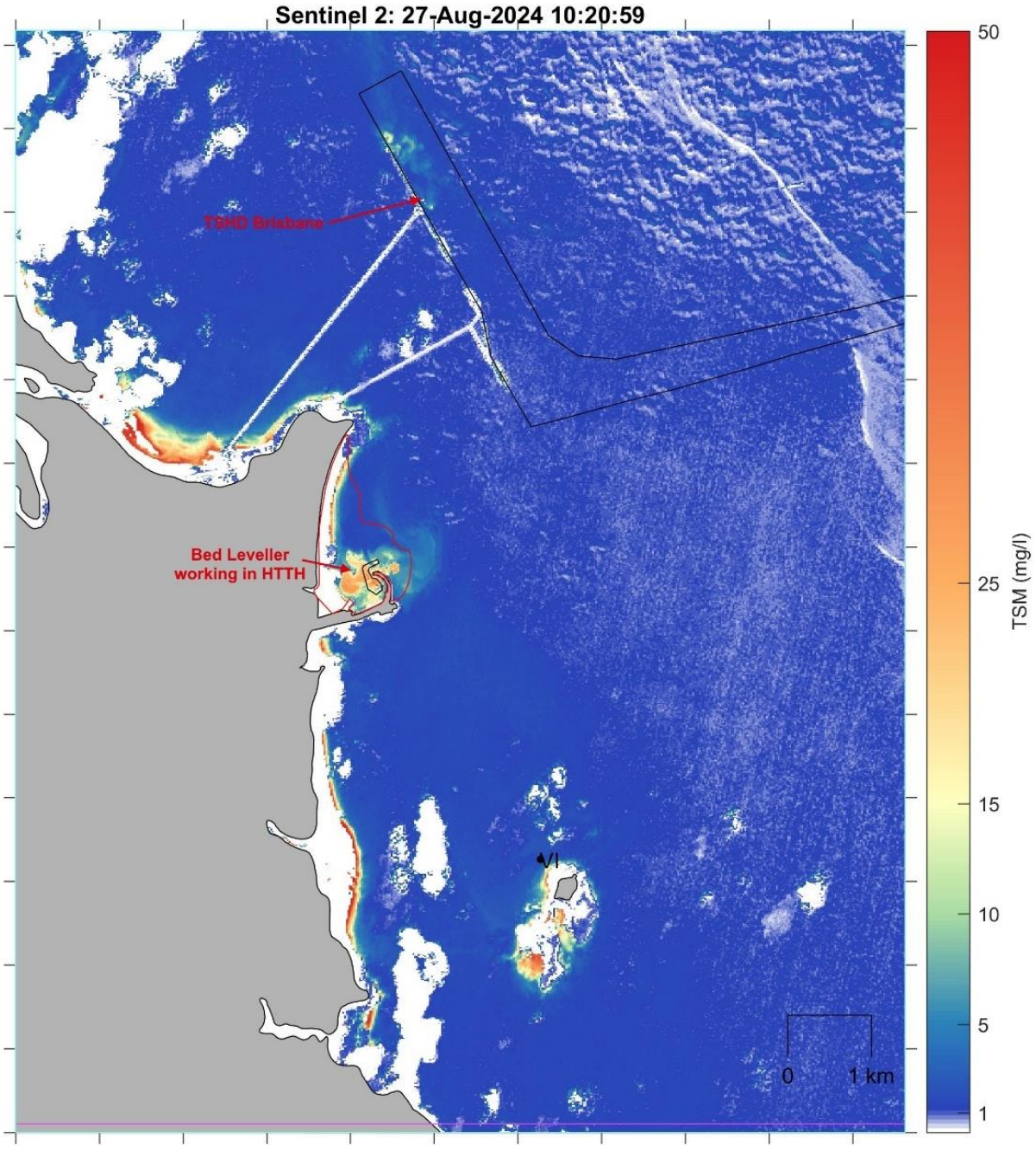
- DMPA: natural plumes and plumes from recent placements were present in the DMPA area. The plumes due to recent placements were typically within or directly to the north of the DMPA (this is the net transport direction in the area due to the dominant southeasterly winds) and had a TSM of 5 to 10 mg/l. The natural plume covered a much larger spatial area (2 to 3 times the size of the DMPA) and also had a TSM of 5 to 10 mg/l. The imagery did not show any evidence of plumes from placement at the DMPA being transported to the west towards Round Top Island;
- Apron and Berths: plumes due to the maintenance dredging and bed levelling were shown by the satellite imagery within the Hay Point apron and berths. The plumes had a TSM of up to 15 mg/l, but the area with this TSM remained localised to where the plume was generated (i.e. adjacent to the TSHD Brisbane or bed leveller), any residual plume following the dredging was shown to consistently be below 10 mg/l. The imagery showed that the plumes could be transported to the north (towards the DMPA) or to the south (towards Victor Island, but no plumes were shown to extend this far) due to the local currents in the area. No plumes were observed in the departure channel; and
- HTTH: a consistent plume was observed within HTTH over the majority of the dredge program as a result of regular bed levelling and maintenance dredging activity within the harbour. The localised plume within HTTH was shown to be up to 50 mg/l (when both bed levellers were operating along with the TSHD Brisbane). The imagery consistently showed that the high concentration plume was fully retained within HTTH, with only lower concentration residual plumes of 5 to 10 mg/l being transported outside of the harbour.

A high-resolution image was captured 7 days after the dredging was completed and this shows that the TSM in the region was low (below 5 mg/l) (Figure 15 and Figure 16). There is a visible plume of up to 15 mg/l present in the berths and apron area, this is due to the ongoing work of a bed leveller in this area combined with resuspension of the bed sediment by propeller wash from tugs and bulk carriers while berthing/departing at the wharf (three vessels were at berth at this time).



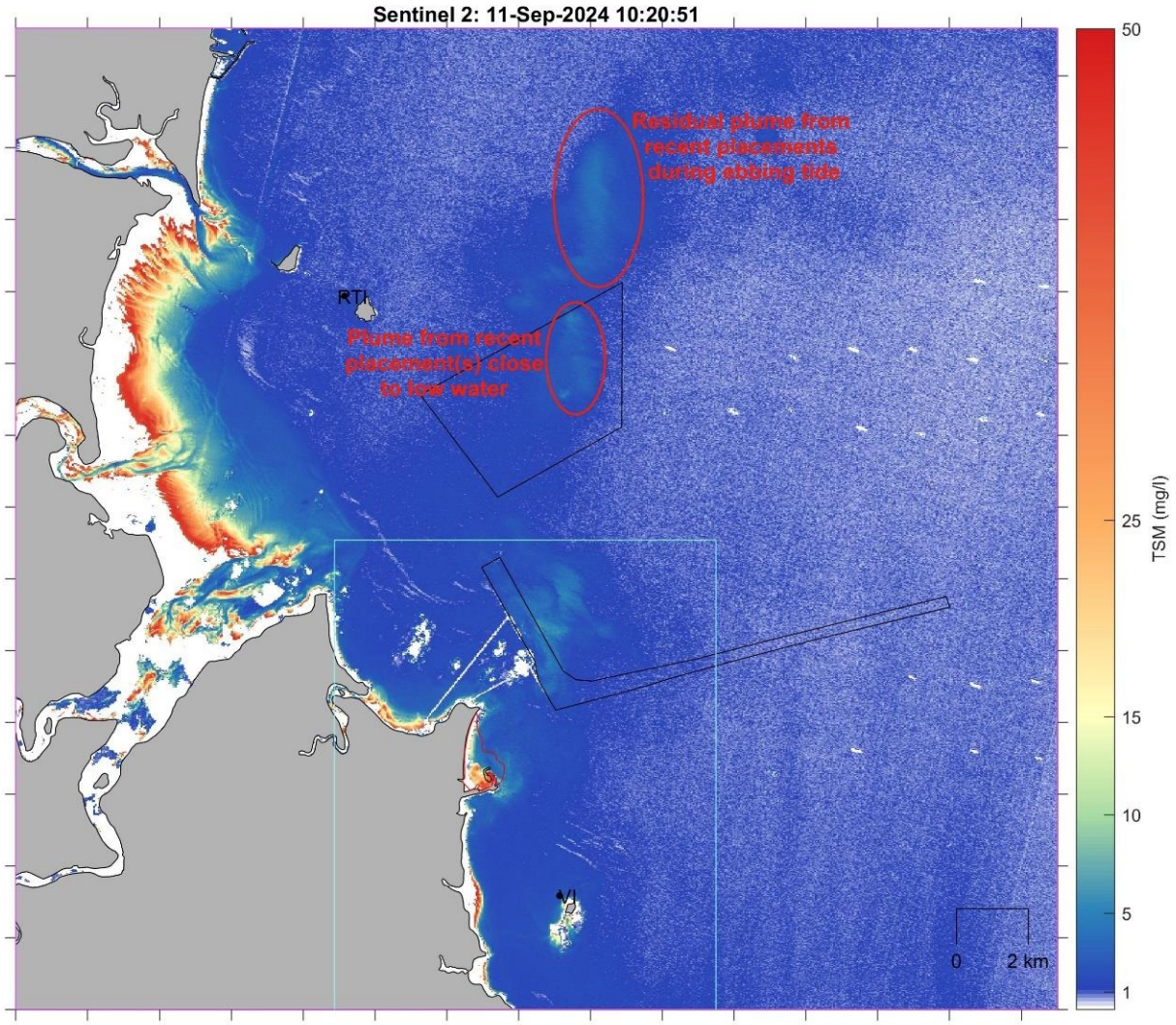
Note: The gaps in the data are due to cloud cover and the black dots represent the location of the monitoring sites.

Figure 11. High-resolution satellite turbidity data for the Hay Point region at 10:21 on 27/08/2024 (during dredging).



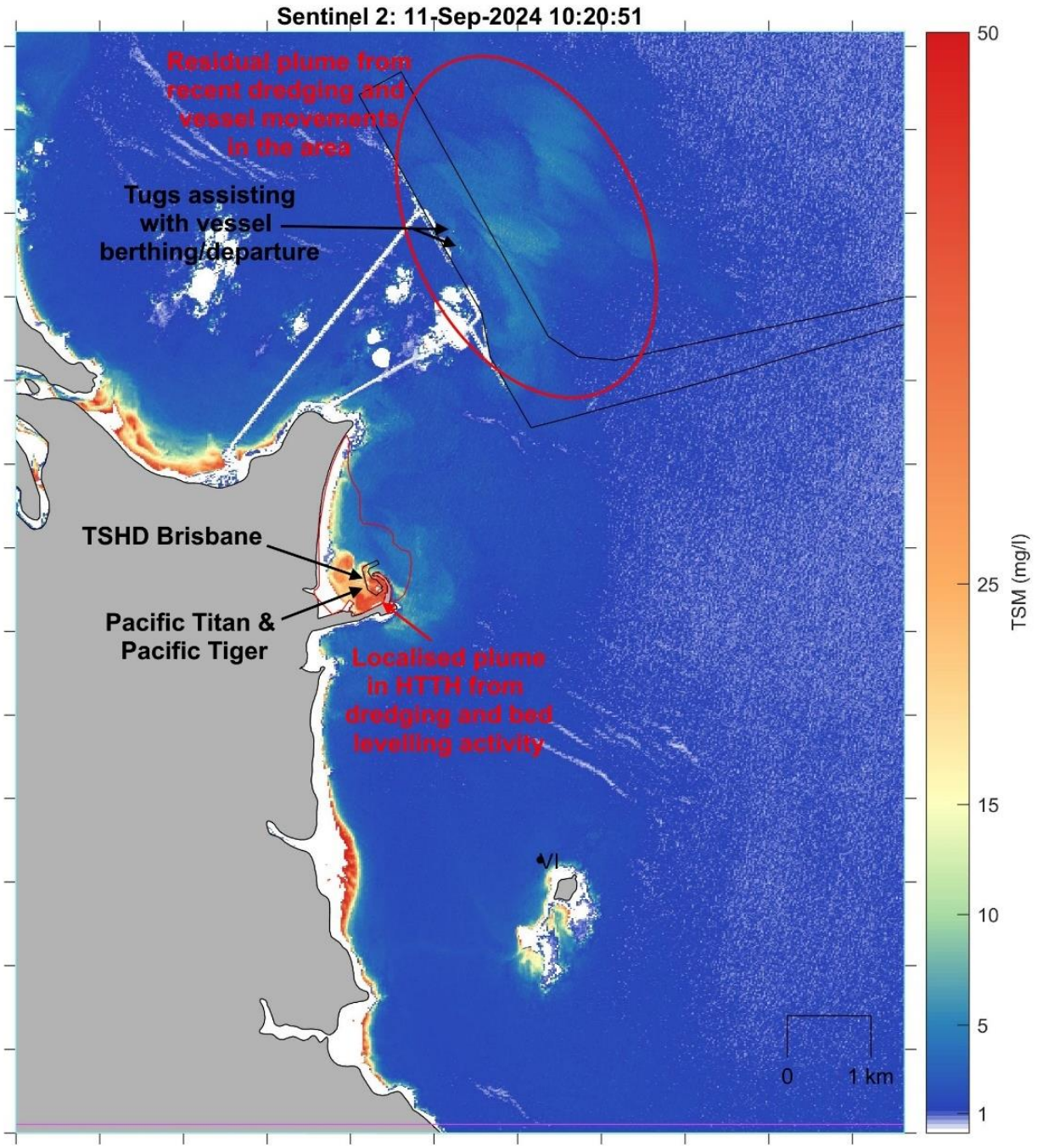
Note: The gaps in the data are due to cloud cover and the black dots represent the location of the monitoring sites.

Figure 12. High-resolution satellite turbidity data for the Apron and HTTH area at 10:21 on 27/08/2024 (during dredging).



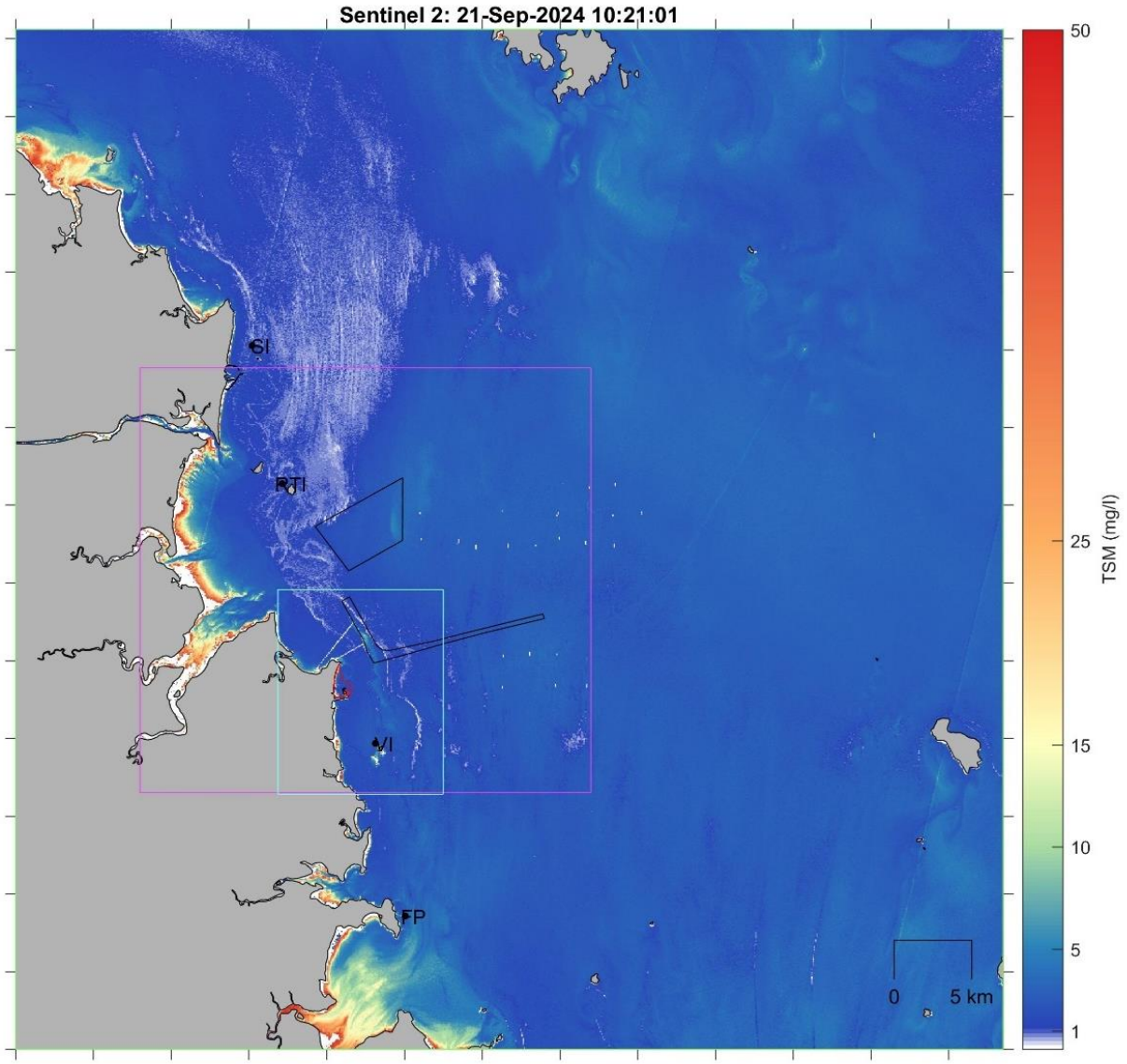
Note: The gaps in the data are due to cloud cover and the black dots represent the location of the monitoring sites.

Figure 13. High-resolution satellite turbidity data for the Hay Point region at 10:21 on 11/09/2024 (during dredging).



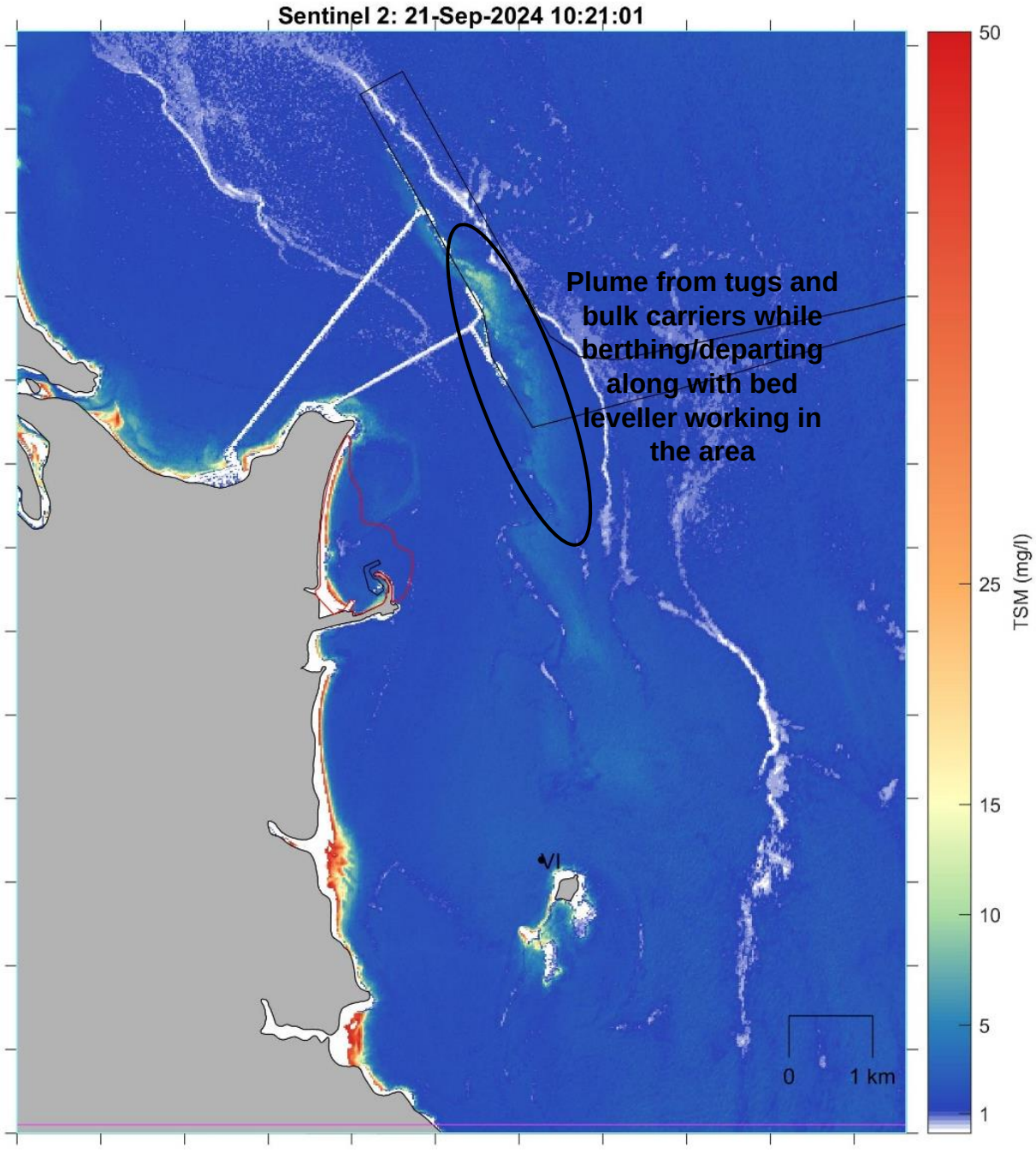
Note: The gaps in the data are due to cloud cover and the black dots represent the location of the monitoring sites.

Figure 14. High-resolution satellite turbidity data for the Apron and HTTH region at 10:21 on 11/09/2024 (during dredging).



Note: The black dots represent the location of the monitoring sites.

Figure 15. High-resolution satellite turbidity data for the Hay Point region at 10:21 on 21/09/2024 (post dredging).



Note: The black dots represent the location of the monitoring sites.

Figure 16. High-resolution satellite turbidity data for the Apron and HTTH area at 10:21 on 21/09/2024 (post dredging).

4.3.5. Threshold Exceedance

The benthic and surface turbidity measured at the four impact/adaptive monitoring sites have been analysed to calculate the duration that the benthic and surface turbidity intensity thresholds were exceeded over 10 days pre-, the 21 days during and 10 days post-maintenance dredging periods (Table 5). The table shows that the longest duration that the turbidity intensity thresholds were exceeded at all four sites occurred during the maintenance dredging program. This correlates with the metocean conditions over the different periods, with the largest wave event being during the dredge period, along with the fact the duration of this period was double the other two periods.

The exceedance durations were low at all four sites during the pre- and post dredging periods, with the highest exceedance duration over these 10 day periods being 3.8 hours at Freshwater Point during the post dredging period.

At Victor Island and Freshwater Point the benthic turbidity exceedance durations remained below the average duration of 14 hours, while at Round Top Island and Slade Islet they were above the average duration but below the 90th percentile durations. This shows that the benthic turbidity at all four sites was well within the range of natural conditions over the duration of the 2024 maintenance dredging program.

The surface turbidity exceedance durations at Victor Island and Freshwater Point were significantly higher than the durations based on the benthic turbidity, with the exceedances being above both the average and 90th percentile durations. In contrast, at Slade Islet and Round Top Island the exceedance durations based on the surface turbidity were three to four times lower than those based on the benthic turbidity. This suggests that the benthic to surface turbidity relationship, based on the measured data from the 2019 maintenance dredging, needs updating to ensure the exceedance durations from both the benthic and surface turbidity measurements are more similar. To achieve comparable exceedance durations, the following revised surface turbidity thresholds are proposed:

- Slade Islet: surface turbidity threshold = 11.3 NTU;
- Round Top Island: surface turbidity threshold = 5 NTU. However, a value this low is not recommended for adopting as a future surface turbidity threshold due to the potential offsets and elevated minimum turbidity measurements associated with the surface loggers and so it is recommended to continue using 6 NTU at this site;
- Victor Island: surface turbidity threshold = 9.7 NTU; and
- Freshwater Point: surface turbidity threshold = 23.5 NTU.

Table 5. Benthic and surface turbidity intensity threshold exceedances from 15/08/2024 to 24/09/2024.

Location	Pre-Dredging (hrs)		During Dredging (hrs)		Post-Dredging (hrs)	
	Surface	Benthic	Surface	Benthic	Surface	Benthic
Slade Islet	0.0	0.0	10.3	41.0	0.0	3.0
Round Top Island	0.0	0.0	8.0	29.5	0.0	0.0
Victor Island	0.0	0.0	58.3	13.7	2.3	0.0
Freshwater Point	0.0	0.0	64.7	9.0	3.8	0.8

5. Implementation

This section provides a summary of how the monitoring undertaken and the results of the monitoring and associated actions adopted performed relative to the requirements of the approval conditions or management plans.

5.1. Implementation Summary

In general, the environmental monitoring undertaken as part of the Port of Hay Point 2024 maintenance dredging program has been implemented in the manner stated in the Maintenance Dredging EMP, the MEMP and the ET report. While some exceptions to the implementation of the impact and adaptive monitoring programs as described in the MEMP were identified, NQBP have confirmed that these were due to errors in revising the MEMP for the 2024 program, are administrative in nature and did not impact on NQBP's ability to monitor changes to sensitive receptors.

It is recommended that the MEMP be revised to better reflect the current monitoring programs as detailed below:

- sediment deposition is monitored as part of the ambient and impact coral monitoring programs, not the water quality monitoring programs;
- PAR is not monitored as part of the adaptive water quality monitoring program, as it isn't considered a suitable parameter to inform adaptive management activities (RHDHV, 2018) and due to the site conditions, it is not realistic to telemeter benthic data. PAR is monitored as part of the ambient and impact water quality monitoring programs;
- pressure is not monitored as part of the adaptive water quality program, as monitoring pressure (which is post-processed to determine water depth) at the real-time surface loggers is not of benefit. Pressure is monitored at all sites as part of the impact monitoring program; and
- current speed and direction are no longer routinely monitored as these do not assist with identifying potential impacts and require specialist equipment. Metocean monitoring data (wind speed, wind direction, wave height, tides) are utilised as these are more appropriate for the purposes of environmental monitoring.

A summary of the environmental monitoring for marine water quality is presented below:

- Impact Monitoring: monitoring undertaken using the data loggers was in accordance with the specified requirements with the exception of the above. The vessel-based physio-chemical profiling was undertaken on average every two weeks rather than every week over the dredging period, this was due to weather conditions;
- Adaptive Monitoring: the monitoring was generally undertaken in accordance with the specified requirements. The only exception to this was that the turbidity was monitored, while TSS was derived based on previous site-specific correlations developed as part of the ongoing ambient water quality monitoring. This approach is consistent with what was implemented and approved by DES for the 2019 maintenance dredging program; and
- Turbidity Thresholds: during the maintenance dredging program the benthic turbidity data showed that none of the sites exceeded the 90th percentile durations.

6. Summary

This report has presented a final analysis and interpretation of the turbidity data measured as part of the Port of Hay Point 2024 maintenance dredging program. The report has reviewed whether the environmental monitoring undertaken as part of the maintenance dredging program has been implemented in the manner stated in the Management Plans.

The key findings from the assessment are as follows:

- in general, the environmental monitoring undertaken as part of the Port of Hay Point 2024 maintenance dredging program has been implemented in the manner stated in the Management Plans;
- during the maintenance dredging program the benthic turbidity at all sites remained below the 90th percentile duration exceedance. This shows that despite the fact there was a large wave event mid-way through the 2024 maintenance dredging program which resulted in naturally high turbidity in the region over multiple days, the turbidity at all four impact and adaptive monitoring sites was well within the range of natural conditions over the duration of the 2024 maintenance dredging program;
- the duration exceedance of the surface turbidity measured as part of the adaptive management was shown to differ to the benthic turbidity exceedance durations. As a result, the surface turbidity thresholds have been updated as part of this assessment so that the exceedance durations for both the benthic and surface turbidity are comparable. It is suggested that these updated surface turbidity thresholds should be adopted for any future adaptive monitoring;
- satellite derived TSM data were sourced throughout the 2024 maintenance dredging program to show the regional scale turbidity (from Broad Sound to the Whitsunday Islands) and the local scale turbidity around the Port of Hay Point and to identify any plumes resulting from the maintenance dredging and bed levelling activities;
- the satellite derived TSM showed that the regional scale turbidity remained similar throughout the period, with high TSM in Broad Sound and low TSM throughout the remainder of the area. Localised natural plumes were shown to be present throughout the region; and
- plumes resulting from the dredging activity, placement of dredged sediment and bed levelling activity were identified through the satellite derived TSM imagery:
  - DMPA: plumes due to recent placements were typically within or directly to the north of the DMPA (this is the net transport direction in the area due to the dominant southeasterly winds) and had a TSM of 5 to 10 mg/l. The imagery did not show any evidence of plumes from placement at the DMPA being transported to the west towards Round Top Island (or towards any of the other impact/adaptive monitoring sites);
  - Apron and Berths: plumes due to the maintenance dredging and bed levelling were observed within the Hay Point apron and berths. The plumes had a TSM of up to 15 mg/l, but this TSM remained localised to where the plume was generated with any residual plume following the dredging shown to consistently be below 10 mg/l. The imagery showed that the plumes could be transported to the north (towards the DMPA) or to the south (towards Victor Island, but no plumes were shown to extend this far) due to the local currents in the area; and
  - HTTH: a consistent plume was observed within HTTH over the majority of the dredge program as a result of regular bed levelling and maintenance dredging activity within the harbour. The localised plume within HTTH was shown to be up to 50 mg/l (when both bed levellers were operating along with the TSHD Brisbane). The imagery consistently showed that the high concentration plume was retained within HTTH.

7. References

Brockmann, C., Doerffer, R., Peters, M., Stelzer, K., Embacher, S., and Ruescas, A., 2016. Evolution of the C2RCC neural network for Sentinel 2 and 3 for the retrieval of ocean colour products in normal and extreme optically complex waters. Proceedings of Living Planet Symposium, Prague.

Fearns, P., Broomhall, M. and Dorji, P., 2017. Optical remote sensing for dredge plume monitoring: a review. WAMSI Dredging Science Node Report, Theme 3, Project 3.1.1., October 2017.

Kyryliuk, D. and Kratzer, S., 2019. Evaluation of Sentinel-3A OLCI Products Derived Using the Case-2 Regional CoastColour Processor over the Baltic Sea. Special Issue, Remote Sensing of Ocean Colour: Theory and Applications.

NQBP, 2024a. Port of Hay Point, Maintenance Dredging Environmental Management Plan, August 2024.

NQBP, 2024b. Port of Hay Point, Marine Environmental Monitoring Plan, August 2024.

RHDHV, 2018. Port of Hay Point: Environmental Thresholds, Maintenance Dredging Management and Monitoring, March 2018.

PCS, 2024. Port of Hay Point, 2024 Environmental Thresholds Update, April 2024.