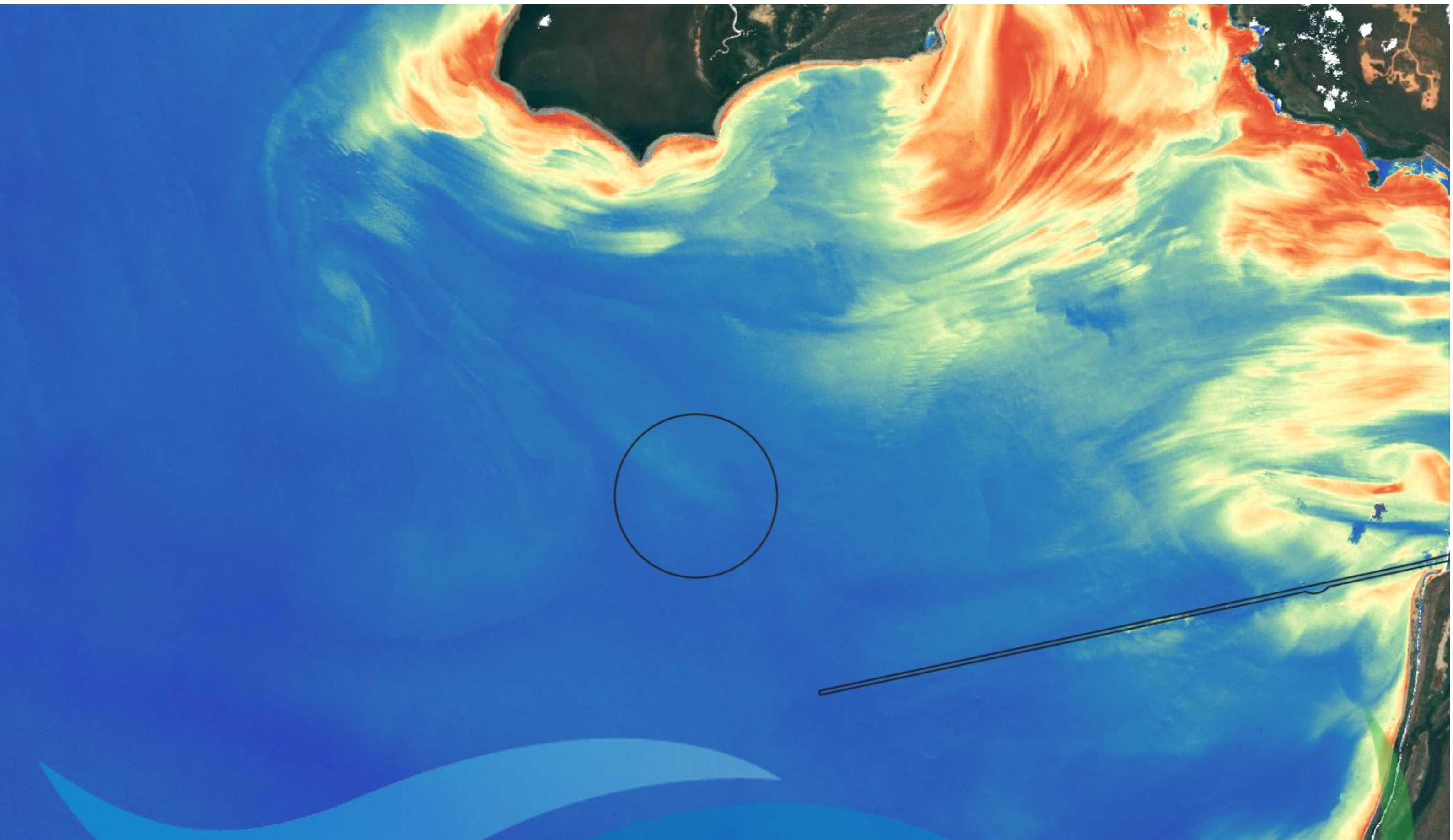
Port of Weipa, 2025 Maintenance Dredging

Summary of Turbidity Monitoring

Report No. P099_R02v2



Technical Report
August 2025

Port of Weipa, 2025 Maintenance Dredging

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North Queensland Bulk Ports Corporation Ltd

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Executive Summary

North Queensland Bulk Ports Corporation (NQBP) commissioned Port and Coastal Solutions Pty Ltd (PCS) to undertake work to support the 2025 maintenance dredging program at the Port of Weipa (the Port). This included the following:

1) to analyse the turbidity and metocean conditions over the duration of the dredge program, including 7 days pre- and post-dredging;
2) to assess the relative contribution of the maintenance dredging and placement activities on the natural turbidity at the measurement sites;
3) to better understand the spatial extent of any plumes resulting from the maintenance dredging and placement activities based on satellite-derived total suspended matter (TSM) data; and
4) provide a technical report which presents and interprets both the in-situ benthic turbidity data and satellite-derived TSM data collected over the entire pre-, during and post-dredging periods.

The 2025 maintenance dredging program was undertaken by the Trailing Suction Hopper Dredger (TSHD) Brisbane and involved the relocation of 396,000 m^3 of sediment from the dredged areas of the Port to the Albatross Bay Dredge Material Placement Area (DMPA). The data showed that during the dredging program the turbidity around the Port of Weipa was generally driven by the natural conditions (predominantly the astronomical tide, although a number of wave events also resulted in elevated turbidity), with higher turbidity occurring during spring tides with a larger tidal range. The key findings from the turbidity data analysis are detailed below:

- the exceedance analysis of the in-situ measured benthic turbidity data showed that the duration exceedances were below the average duration exceedance at all sites during the dredging period. The results therefore show that the turbidity over the period was well within the natural variability for the region;
- all of the plumes resulting from maintenance dredging (including those from both dredging and placement) were found to remain relatively close to where they were created. Plumes generated in the South Channel were shown to have the potential to migrate to the north and south of the channel and in an offshore direction. Overall, the results showed that little net residual transport occurs in the region, this was also noted during the 2019 to 2024 maintenance dredging programs and as part of the Port of Weipa Sustainable Sediment Management assessment (PCS, 2019, 2020, 2021, 2022, 2023, 2024b). Based on this, it can be assumed that the majority of the sediment suspended by the maintenance dredging and bed levelling is subsequently redeposited close to where it was either dredged or placed;
- the dredging and placement activities associated with the Port of Weipa 2025 maintenance dredging program were found to result in visible plumes. Plumes were observed close to the TSHD Brisbane during dredging, adjacent to the South Channel and within and adjacent to the Albatross Bay DMPA. The size and concentration of the plumes was variable depending on the dredging and placement activities;
  - the largest plume, which was due to repeat maintenance dredging loads in the South Channel, was up to 7 km in length and 1.2 km in width and was present adjacent to the South Channel and had a concentration of 4 to 7 mg/l. Satellite imagery indicated that a localised plume was regularly present around the South Channel as this was where the majority of the maintenance dredging was undertaken; and
  - plumes in the DMPA from the placement of dredged sediment were typically less than 600 m in length and only persisted for short durations (less than 1 hour and 45 minutes). The observed plumes were consistent with placement by the TSHD Brisbane during previous annual maintenance dredging programs.

- the Port of Weipa 2025 maintenance dredging program did not influence the regional turbidity in the area. The dredging only influenced the local turbidity close to where dredging was undertaken in the Port and where placement occurred at the Albatross Bay DMPA. Natural variations in turbidity driven by the tide and wave conditions over the monitoring period were larger than the variations in turbidity due to the maintenance dredging. The satellite imagery showed that the turbidity in the area of the seagrass meadows in the Inner Harbour was controlled by natural processes over the 2025 maintenance dredging program, with no visible plumes from the dredging activity observed in the seagrass meadows; and
- the post dredging satellite imagery showed that less than 1 day after dredging ended there were no plumes from the dredging or placement activities in the South Channel, Inner Harbour or DMPA. This is in agreement with findings from previous dredge programs (2020, 2022, 2023 and 2024) where satellite imagery showed that the turbidity had returned to natural conditions within days of the dredging activity finishing (PCS, 2020, 2022, 2023 and 2024b).

1. Introduction

North Queensland Bulk Ports Corporation (NQBP) commissioned Port and Coastal Solutions Pty Ltd (PCS) to undertake work to support the 2025 maintenance dredging program at the Port of Weipa (the Port). This included the following:

- source satellite imagery for the Port of Weipa 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 7 days pre- and post-dredging;
- obtain metocean data for the Weipa region over the whole pre-, during and post-dredging period to help interpret the satellite-derived turbidity data;
- provide a pre-dredging technical note prior to the dredging commencing which presents the satellite-derived turbidity data and metocean conditions and provides an overview of the natural turbidity and the relative influence of different drivers (e.g. waves and tidal currents) during the pre-dredging period;
- provide a during dredging technical note after 10 to 14 days of the maintenance dredging which presents results from the satellite-derived turbidity monitoring over this initial dredging period and discusses the potential impacts of the dredging on the turbidity in the region; and
- provide a post-dredging technical report following completion of the maintenance dredging and the post-dredging monitoring period. This note will present both the satellite derived turbidity and in-situ benthic 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.

Following completion of the 2025 maintenance dredging program and the 7 day post-dredging period, this technical report presents and discusses the metocean and turbidity data collected.

1.1. Project Overview

The Port of Weipa is located in the Gulf of Carpentaria, on the north-west coast of the Cape York Peninsula in Northern Queensland (Figure 1). The Port is within Albatross Bay, a large embayment, with the wharves and berths located in the Embley River (Figure 1 and Figure 2).

In the 2024/25 financial year, the Port of Weipa handled just over 16 million tonnes of commodities, including bauxite (>95%), fuel, cattle and general cargo. Rio Tinto Alcan (RTA) currently operates most of the port facilities for the export of bauxite (aluminium ore) from the nearby RTA mine.

The layout of the Port of Weipa is shown in Figure 1. The Port consists of:

- a main shipping channel in Albatross Bay called the South Channel; and
- an Inner Harbour, which is within the Embley River and consists of four shipping berths (Lorim Point East and West, Humbug Wharf and Evans Landing) and the Approach and Departure Channels (Figure 2).

The Port has approximately 622 hectares of channels, swing basins and berths where depths are maintained by maintenance dredging. NQBP currently has a 10-year Sea Dumping Permit for the Port of Weipa, which allows for an average of just over 1,000,000 m^3 of sediment to be removed by maintenance dredging per annum up to January 2031. This dredge volume includes a contingency for events such as cyclones and so is not realised on an annual basis.

Since 2002 maintenance dredging at the Port of Weipa has been undertaken annually by the Trailing Suction Hopper Dredger (TSHD) Brisbane, with volumes ranging from approximately 300,000 m^3 to 2,400,000 m^3. The sediment, which has historically been removed by maintenance dredging, has been relocated to the offshore Dredge Material Placement Area (DMPA) located in Albatross Bay (Figure 1). Following the 2020 maintenance dredging program the DMPA was moved to the west, by the distance of its radius (1.1 nautical miles), to provide additional capacity for the future. The moved DMPA has been used as the placement site for the annual maintenance dredging programs since 2021.

Based on detailed bathymetric analysis by PCS (2018) it was found that the annual sedimentation at the Port was highly variable depending on the wave conditions which occurred during the wet season, with the occurrence of Tropical Cyclones (TCs) in the region being a key driver for larger waves and increased sedimentation. The analysis also found that the majority of the sedimentation occurred in the South Channel, with limited sedimentation occurring in the Inner Harbour region (see Figure 3 for locations).

Wave conditions in the Gulf of Carpentaria during the 2024/25 wet season were relatively calm, with no wave events where the significant wave height (H_s) exceeded 2 m. Based on the wave conditions since the 2024 maintenance dredging program the sedimentation was estimated by PCS (2025a) to be in the order of 180,000 m^3 in the South Channel (excluding the channel batters) and in the order of 70,000 m^3 in the Inner Harbour.

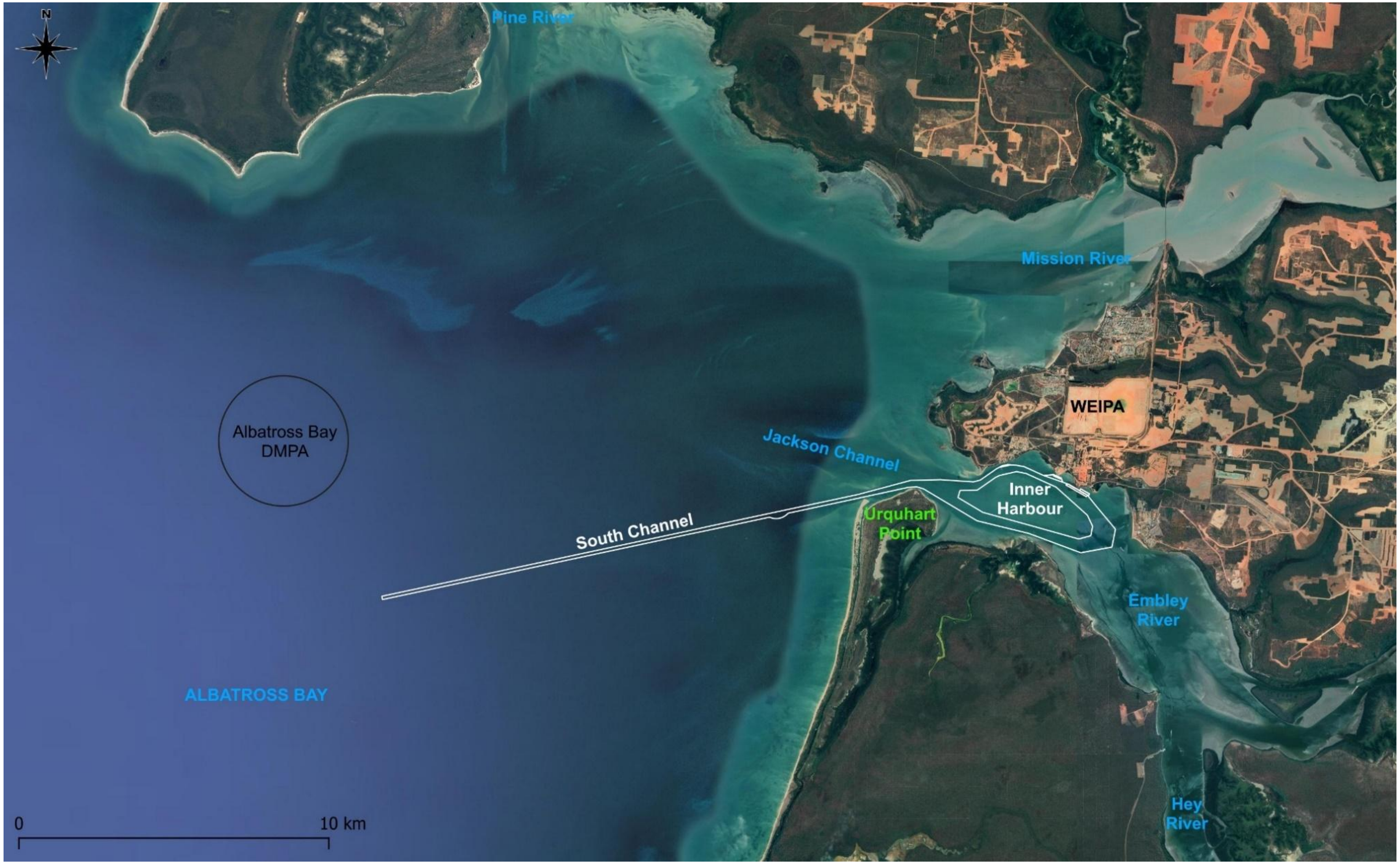

Figure 1. Layout of the Port of Weipa.

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Figure 2. Close up of the Port of Weipa Inner Harbour area.

1.2. Report Structure

The report herein is set out as follows:

- a summary of the dredge program is provided in **Section 2**;
- details of the turbidity monitoring undertaken are provided in **Section 3**;
- analysis of the in-situ turbidity and satellite-derived data is presented in **Section 4**; and
- a summary of the findings is detailed in **Section 5**.

Unless stated otherwise, levels are reported to Chart Datum (CD). Zero metres CD is equal to the Lowest Astronomical Tide (LAT) at the Port of Weipa. Volumes presented throughout are in-situ cubic metres and time is presented in 24 hour format relative to Australian Eastern Standard Time (AEST).

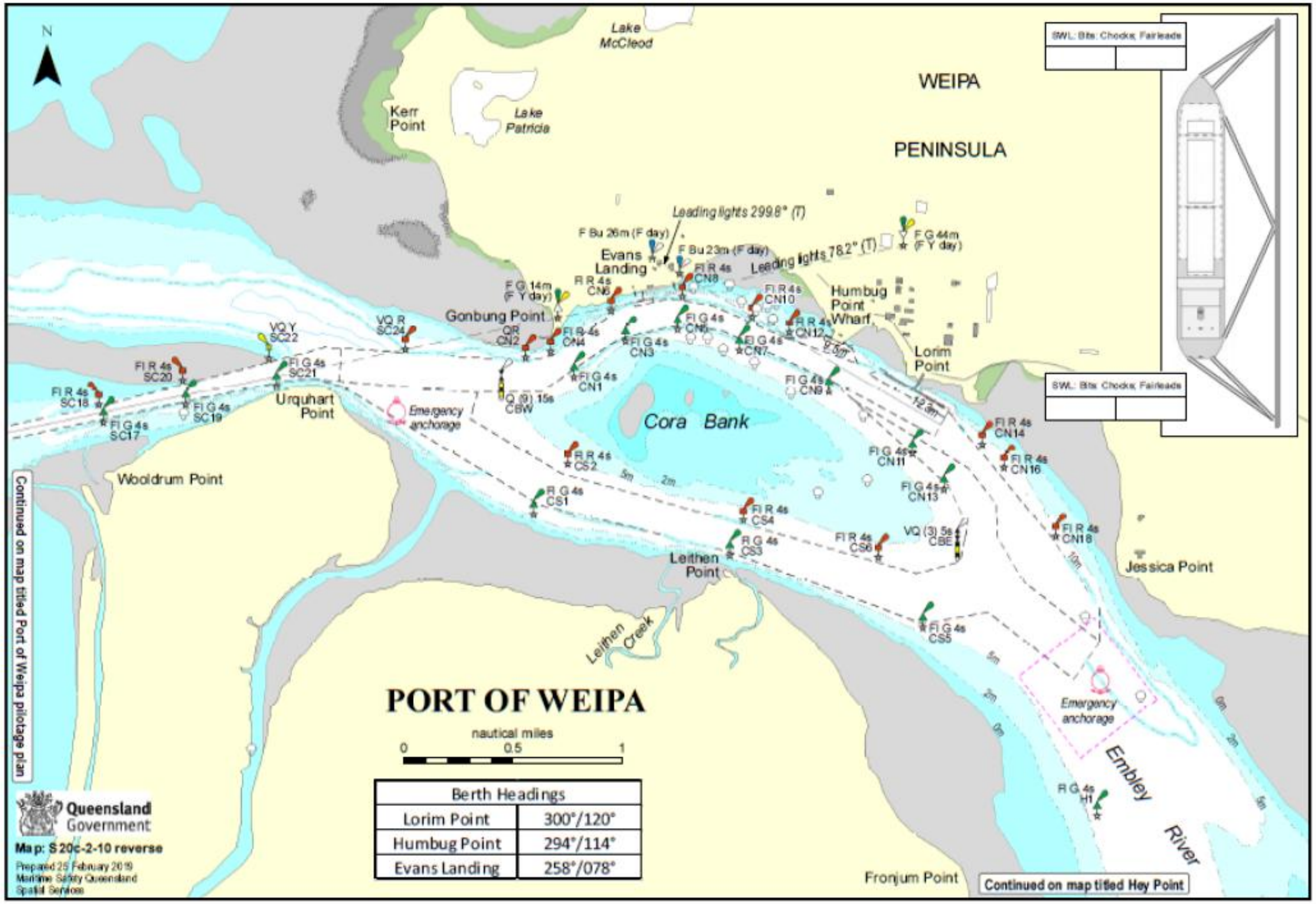
2. Dredge Program

The Port of Weipa 2025 maintenance dredging program commenced at 16:14 AEST on the 8th May 2025 and was completed at 17:56 AEST on the 8th June 2025. Over the 31 day period a total of 256 dredge hopper loads were relocated to the Albatross Bay DMPA, with an average of just over eight loads per day. Based on analysis of the pre- and post-dredge bathymetric surveys the total in-situ volume of sediment removed from the dredge areas of the Port of Weipa during the program was approximately 396,000 m^3 (PCS, 2025b).

The majority of the maintenance dredging was focussed in the South Channel, although some maintenance dredging along with bed levelling was undertaken in the Inner Harbour. It is important to note that the maintenance dredging requirement within the South Channel was not uniform, with approximately 60% of the dredge loads removed from between SC10 and SC14 (Figure 3) which represents approximately 20% of the total length of the South Channel (3.7 km of the total 17.5 km length of the channel). Although only 6% of the dredge loads were from the Inner Harbour, bed levelling was also undertaken in the Inner Harbour. The bed levelling targeted sedimentation in the southeastern corner of the Approach Channel, along sections of the Departure Channel adjacent to Cora Bank and within the berth pockets and their approaches (Figure 4).

The dredged sediment was placed at the Albatross Bay DMPA, with the location of the placements within the DMPA being rotated between the five separate regions of the DMPA to ensure an even distribution over the DMPA.

Figure 3. Location of the Port of Weipa ambient monitoring sites (WQ1, WQ2 and WQ4), DES waverider buoy (WRB) and South Channel (beacons SC2 – SC24).



Source: MSQ (2019)

Figure 4. Location of the Port of Weipa and beacons within the Inner Harbour.

2.1. Metocean Conditions

To provide an understanding of the metocean conditions over the pre-, during and post-dredging periods, the following data have been sourced:

- Water Level: the predicted water level for the Port of Weipa (provided by the Bureau of Meteorology (BoM));
- Wind and Rain: measured wind and rainfall at the BoM Weipa Aero weather station (ID 027045); and
- Waves: measured wave conditions at the Albatross Bay waverider buoy (WRB) (Figure 3) (provided by the Department of the Environment, Tourism, Science and Innovation (DETSI)).

The metocean conditions over the entire monitoring period are shown in Figure 5, with shading indicating the maintenance dredging period. The figure shows the following:

- throughout the majority of the period the metocean conditions were fairly consistent and representative of calm to moderate dry season conditions;
- the winds were consistently from the east through to south over the period. The wind speed was more variable, with peak speeds during the day varying between 7 and 20 knots while the overnight speeds were consistently lower with peak speeds of up to 9 knots;
- rainfall was very low throughout the whole period. The highest daily rainfall of 3 mm occurred over the 7 day pre-dredge period while the highest daily rainfall over the dredging was 2 mm; and
- the wave direction varied between waves from the east to southeast (offshore at Weipa) and southwest (onshore at Weipa). Wave directions from the southeast correlated with periods of smaller H_s (up to 0.5 m), while directions from the southwest typically correlated with periods of larger H_s. There were three wave events during the dredge period and one during the 7 day post-dredge period when the H_s exceeded 0.7 m, with a peak H_s of 1 m during one of the wave events during the dredging and the wave event post-dredging. The wave direction during all of these wave events were from the southwest as a result of longer period swell waves when local winds were relatively calm.

Overall, the monitoring period is considered to be relatively calm in terms of wave conditions, although resuspension of fine-grained sediment in Albatross Bay is likely to have occurred during the wave events which occurred during and after the dredge period.

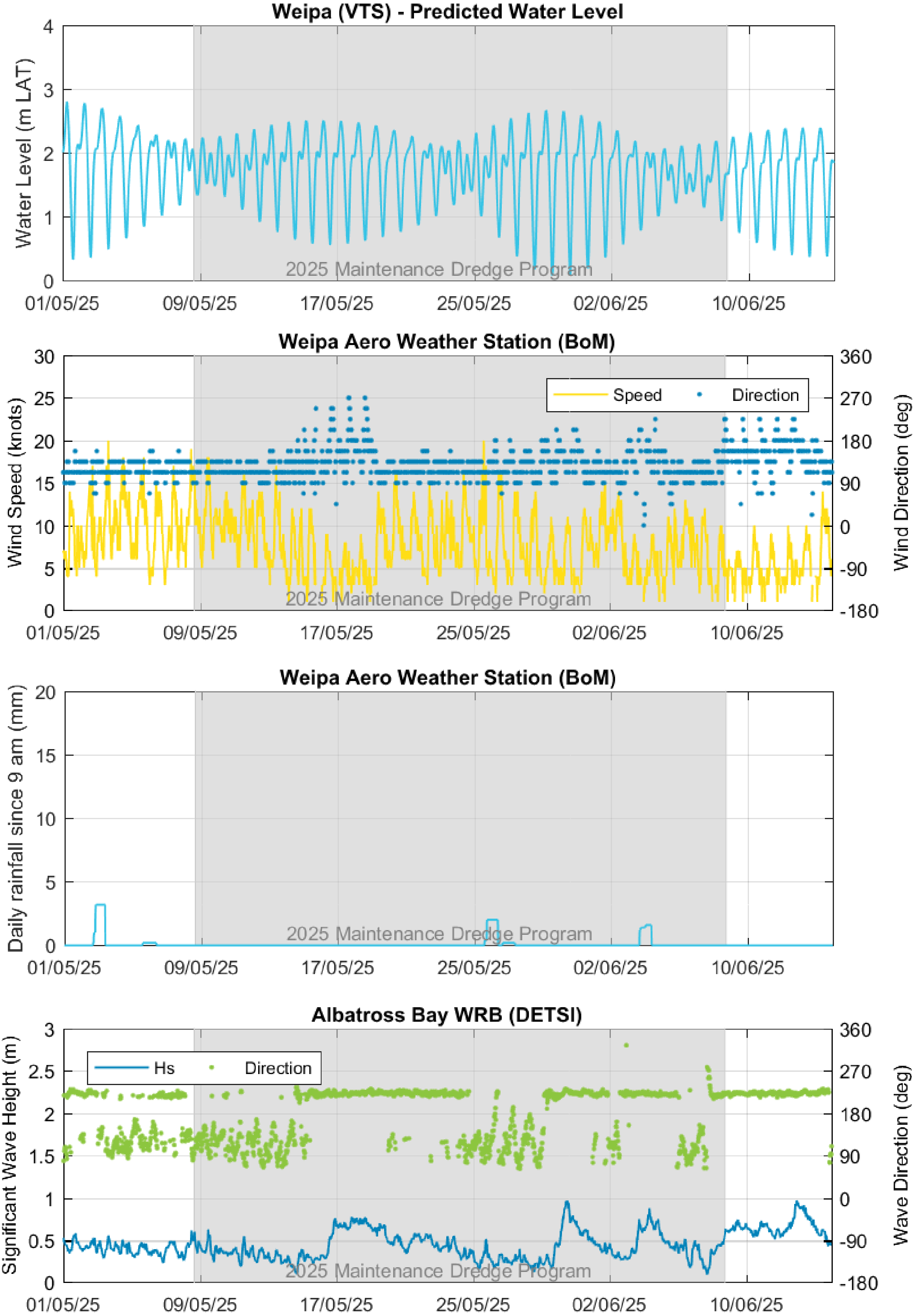


Figure 5. **Metocean conditions at Weipa over the monitoring period, with water level (upper), winds (upper middle), rainfall (lower middle) and waves (lower).**

3. Turbidity Monitoring

As part of the ongoing ambient water quality monitoring which NQBP have setup, benthic turbidity data have been collected by James Cook University (JCU) since January 2018 at monitoring sites around the Port of Weipa. The instruments measure near bed turbidity in Nephelometric Turbidity Unit equivalent (NTUe)[1]. There were originally two sites in Albatross Bay (WQ2 and WQ5), but one of these sites (WQ5) was decommissioned in July 2018 and there are currently two sites (WQ1 and WQ4) in the Inner Harbour (Figure 3). The water depth at the three monitoring sites is approximately 4.5 m (ranging from 4.4 m at WQ1 to 4.8 m at WQ4).

The instruments were serviced prior to the 2025 maintenance dredging program commencing and after completion of the maintenance dredging and the 7 day post-dredging period. Measured data up to the 30th July 2025 were provided by JCU for analysis as part of this assessment.

The data return for the measured turbidity data over the 2025 maintenance dredging monitoring period, which includes 7 days pre- and post-dredging and 31 days of dredging (45 days in total), was 99% at WQ1 and WQ2 and 93% at WQ4. The lower data return at WQ4 was due to the measurements having a lot of spikes which were removed from the dataset as they failed the JCU quality control (QC) either due to the rate of change being too large or due to them being identified as spikes by the JCU QC process.

3.1. Previous Analysis

Benthic turbidity data from the ongoing ambient monitoring were analysed by PCS (2020, 2021b, 2024a) to understand the natural variability in turbidity at the three monitoring sites. The analysis undertaken as part of the Environmental Thresholds component of the Port of Weipa Sustainable Sediment Management (SSM) Project recommended that the 90th percentile turbidity should be adopted as a turbidity intensity threshold as it approximately correlates with published benthic Photosynthetically Active Radiation (PAR) thresholds for the species of seagrass which are present in the Weipa region.

Monitoring during the 2023 maintenance dredging program at the Port of Weipa showed that the benthic turbidity at both WQ1 and WQ4 (the Inner Harbour sites) were naturally high which resulted in the duration exceedance at both sites being significantly higher than at WQ2 during the 2023 dredging program (PCS, 2023). Based on this, the turbidity intensity thresholds at the three monitoring sites were updated prior to the 2024 maintenance dredging program to ensure that the thresholds were based on measured turbidity data which can be considered to represent the existing natural turbidity at the sites. It was noted that the measured turbidity at WQ1 and WQ4 had increased since December 2021 and so the updated thresholds at these sites were based on measured data from December 2021 to October 2023, while at WQ2 the turbidity was not found to have increased and so at this site the analysis was based on data from January 2018 to October 2023. Updated trigger limits were defined using the same approach as the previous trigger limits and separate values were defined for wet and dry seasons. The updated 90th and 95th percentile turbidity intensity thresholds for the dry season period at the three ambient water quality monitoring sites are shown, along with the previous values, in Table 1. The table shows that the thresholds at WQ1 and WQ4 have increased, with a significant increase at WQ4, while at WQ2 there has been a slight reduction in the threshold as a result of the updated analysis undertaken by PCS (2024a).

[1] The international turbidity standard ISO7027 defines turbidity readings in NTU for 90 degree backscatter, while the JCU instrumentation uses 180 degree backscatter. In recognition of this fact, the units are reported as NTU equivalent (NTUe).

Table 1. Dry season benthic turbidity thresholds derived by PCS (2024a) along with previous values detailed by PCS (2021b).

Location	Updated 90th Percentile Turbidity Threshold (NTUe)	Previous 90th Percentile Turbidity Threshold (NTUe)
WQ1	25	19
WQ2	19	23
WQ4	95	27

4. Data Analysis

This section presents in-situ turbidity data and satellite-derived turbidity data to provide an understanding of the variability in turbidity in the Weipa region and to determine the potential impact of the maintenance dredging activity on water quality in the region.

4.1. In-situ Turbidity Analysis

The measured benthic turbidity data at the three monitoring sites, along with the predicted water level for the Port of Weipa (sourced from BoM), the measured wave conditions in Albatross Bay (from the DETSI WRB in Albatross Bay) and measured wind conditions at the Weipa Aero weather station (sourced from BoM) are shown in Figure 6, while individual plots of the turbidity at each monitoring site are shown in Figure 7. The figures show that there is a tidal signal present in the turbidity data at all three sites, with a clearer signal at WQ1 and WQ2, resulting in higher turbidity during spring tides and lower turbidity during neap tides.

The turbidity data at WQ4 is consistently higher than at the other two sites throughout the monitoring period. Over the monitoring period the higher peaks in turbidity at WQ4 range from 100 to 250 NTUe, while at WQ1 (the other site in the Inner Harbour) all peaks except for one remain below 100 NTUe. As previously discussed in Section 3.1, higher turbidity at WQ4 was observed during previous maintenance dredging programs and as a result the turbidity intensity thresholds were updated. This update to the thresholds should ensure that despite the measured turbidity at WQ4 being higher than at the other two sites, the exceedance duration is not higher than at the other sites unless the dredging has resulting in increased turbidity in the area.

At WQ2 the measured turbidity data over the monitoring period typically remained below 100 NTUe, with peaks of less than 10 NTUe during neap tides and the higher peaks of up to 20 to 100 NTUe during spring tides. Peak in turbidity of 100 to 150 NTUe coincided with spring tides and the two wave events when the peak H_s was 1 m (one during the dredging and one in the post-dredging period).

Based on the benthic turbidity data at all monitoring sites it appears that the turbidity while dredging during the 2025 maintenance dredging program was predominantly controlled by the metocean conditions. To further assess any potential increase in turbidity at the sites due to maintenance dredging, the duration of time the updated benthic turbidity intensity thresholds (shown in Table 1) were exceeded is assessed in the following section.

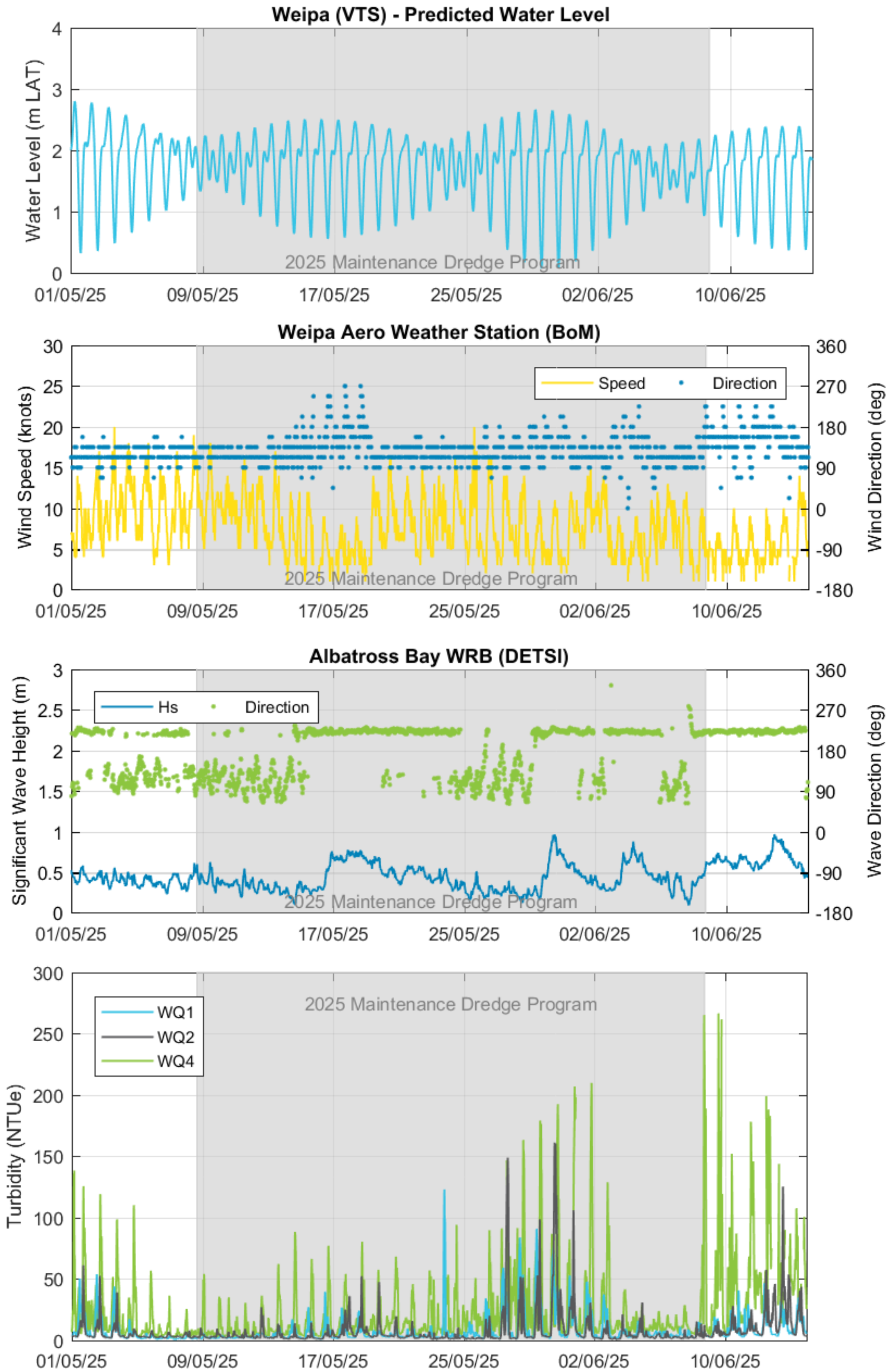
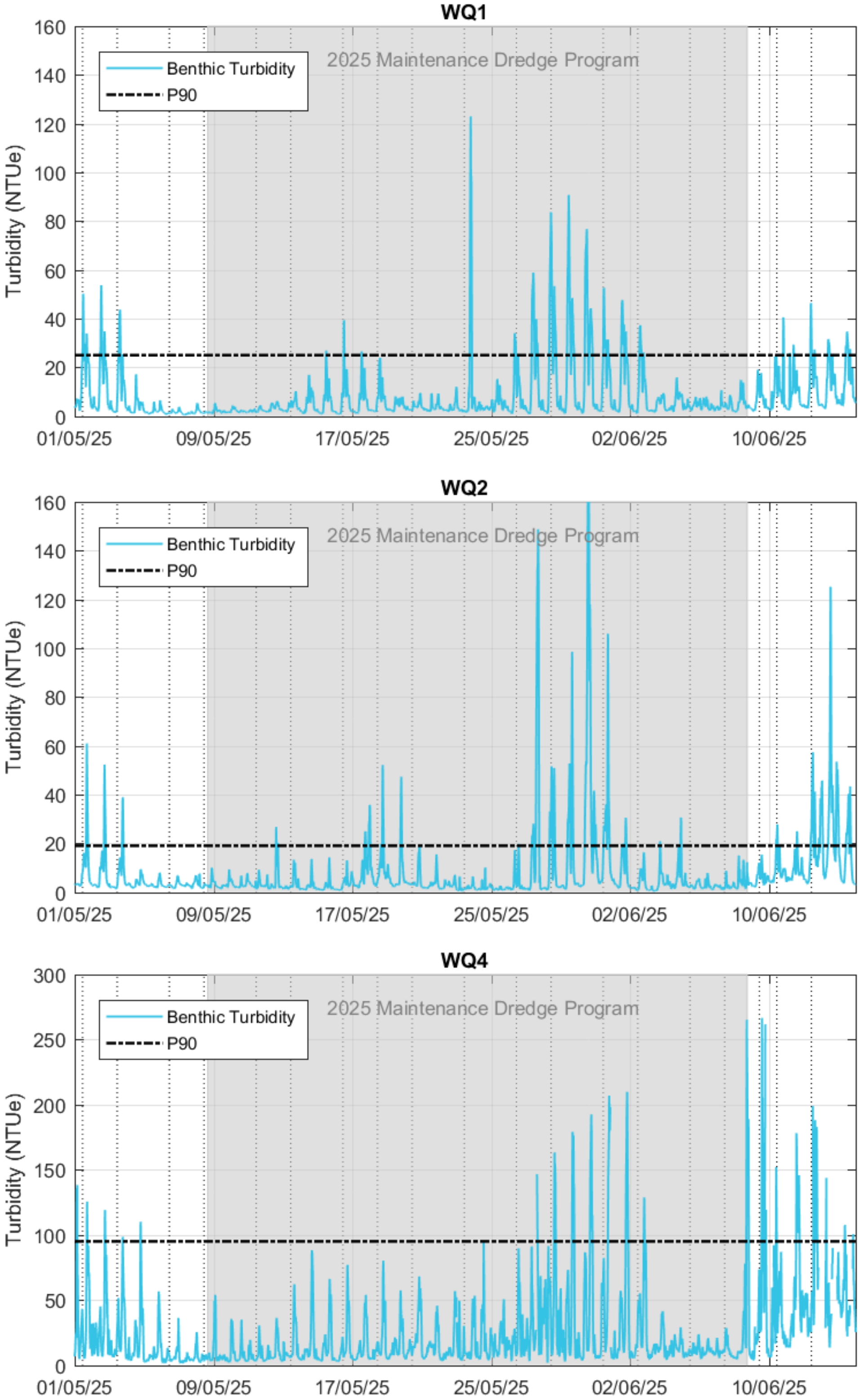


Figure 6. Metocean and turbidity conditions at Weipa over the monitoring period, with water level (upper), waves (upper middle), winds (lower middle) and turbidity at the three monitoring sites (lower).



Note: Vertical dotted lines indicate periods when Sentinel-2 satellite images were obtained and analysed.

Figure 7. Measured turbidity data and percentile thresholds at the three Weipa monitoring sites over the monitoring period, with WQ1 (upper), WQ2 (middle) and WQ4 (lower).

4.1.1. Exceedance

The duration of time that the 90th percentile benthic turbidity intensity thresholds were exceeded at the three monitoring sites was calculated over 7 days pre-dredging, the during dredging period and 7 days post-dredging as part of the 2025 maintenance dredging program (Table 2). The timeseries plots presented in Figure 6 show that the metocean conditions were relatively consistent and calm throughout the majority of the period, with some small wave events occurring during the dredging and in the post-dredge period. Overall, the pre-dredge period can be considered to represent the calmest conditions, while more energetic wave conditions occurred during the dredging and post-dredging periods.

The exceedance durations show lower exceedances during the 7 day pre-dredge period compared with the subsequent dredging and post-dredging periods. However, at all three sites the 7 day post-dredging period has a much higher exceedance duration relative to the time period. This indicates that the elevated wave conditions, combined with the spring tides, over the post-dredging period resulted in naturally higher turbidity exceedance durations.

The suggested duration triggers for the 90th percentile turbidity intensity threshold for both 20 and 40 day dredge periods are presented in PCS (2024a). These duration triggers were suggested as possible adaptive management thresholds which could be adopted sequentially to minimise the risk of any impacts to sensitive receptors. The dry season duration triggers have been scaled to represent the duration of the dredge period (31 days) and the duration of the dredge period including the 7 days pre- and post-dredging (45 days) (Table 3). The table does not include the maximum duration trigger as neither the average nor the 90th percentile duration triggers were exceeded at any of the sites.

The exceedance durations at the three sites ranged from 19 to 56 hours over the 31 day dredge period and between 42 and 98 hours over the total 45 day monitoring period which also included the 7 days pre- and post-dredging. Based on the duration of the 31 day dredge period the average exceedance duration is 74 hours, while the average exceedance duration over the total 45 day monitoring period is 108 hours. Therefore, the results show that at all three sites the exceedance durations remained below the average exceedance duration thresholds. The results therefore show that during the dredge period the turbidity was well within the natural variability, with the exceedance durations remaining below the average duration triggers. Based on this, no adaptive management would have been implemented should real-time monitoring have been undertaken at these sites.

Table 2. Duration of exceedance of the benthic turbidity intensity thresholds over each period of the Port of Weipa 2025 maintenance dredging program.

Location	7 days Pre-Dredge (hrs)	Dredge Period, 31 days (hrs)	7 days Post-Dredge (hrs)	Total Duration, 45 days (hrs)
WQ1	8	55	17	80
WQ2	7	56	35	98
WQ4	3	19	20	42

Table 3. Scaled duration triggers for the different periods of the Port of Weipa 2025 maintenance dredging program.

Location	Dredge Period 1: 31 days (hrs)		Dredge Period 1 inc. pre and post: 45 days (hrs)	
	Av. (hrs)	90th (hrs)	Av. (hrs)	90th (hrs)
WQ1	74	119	108	172
WQ2	74	167	108	243
WQ4	74	263	108	381

4.2. Satellite-Derived Data

Satellite-derived turbidity data are a valuable resource which can provide a reliable spatial overview of the variability in turbidity over a large area (Fearns et al., 2017). Analysis of repeat images can be used to assist in understanding how spatial variations in turbidity change over time.

To better understand the spatial extent of both the natural turbidity in the Weipa region and any plumes resulting from the maintenance dredging activity (including from the placement of dredged sediment at the Albatross Bay DMPA), satellite imagery was 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 over the 2025 maintenance dredge monitoring period.

In the Weipa region the repeat satellite coverage is high for the Sentinel-3 sensor (images captured 11 out of every 14 days) and relatively high for the Sentinel-2 sensor (images captured every 2 to 3 days). The reason the temporal coverage is relatively high for the Sentinel-2 sensor is because the area is partially covered by two separate satellite tracks, which means the entire region is not covered for each image (the Inner Harbour is only captured in every second image). The satellite data are restricted by cloud cover, and so imagery can only be used when there is little to no cloud cover in the areas of interest.

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). An assessment of the accuracy of the satellite derived TSM against the in-situ near bed turbidity data was undertaken during the 2021 maintenance dredging program to allow a local calibration of the imagery. The results showed that the satellite derived TSM was able to provide a good representation of the benthic in-situ measured SSC data at the WQ1 and WQ2 monitoring sites (Figure 8).

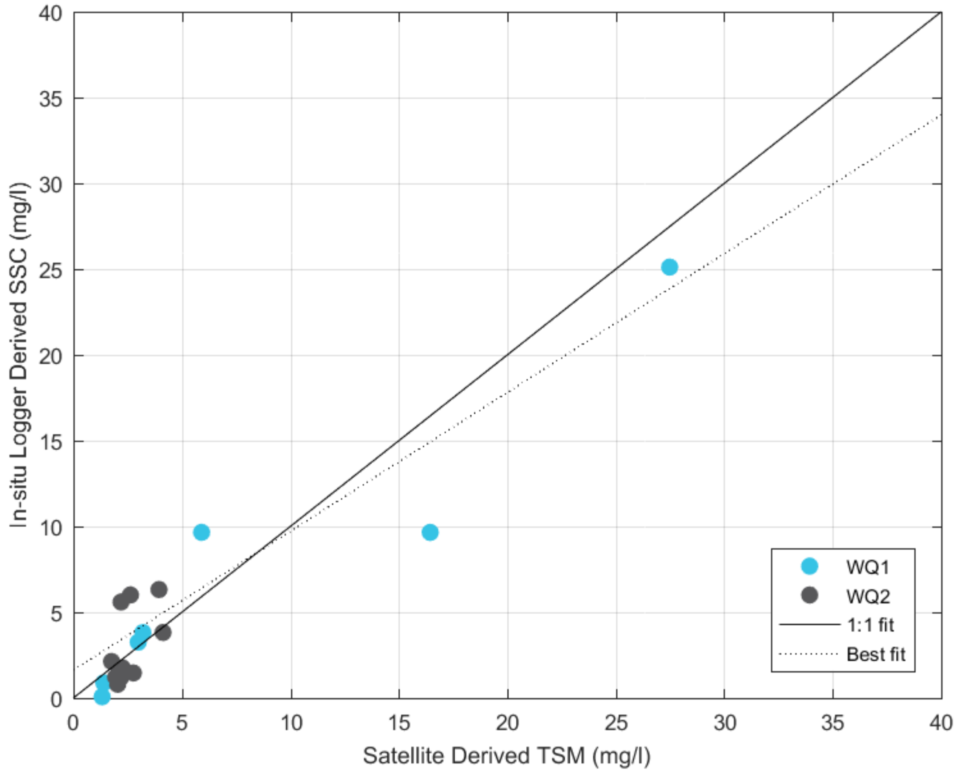
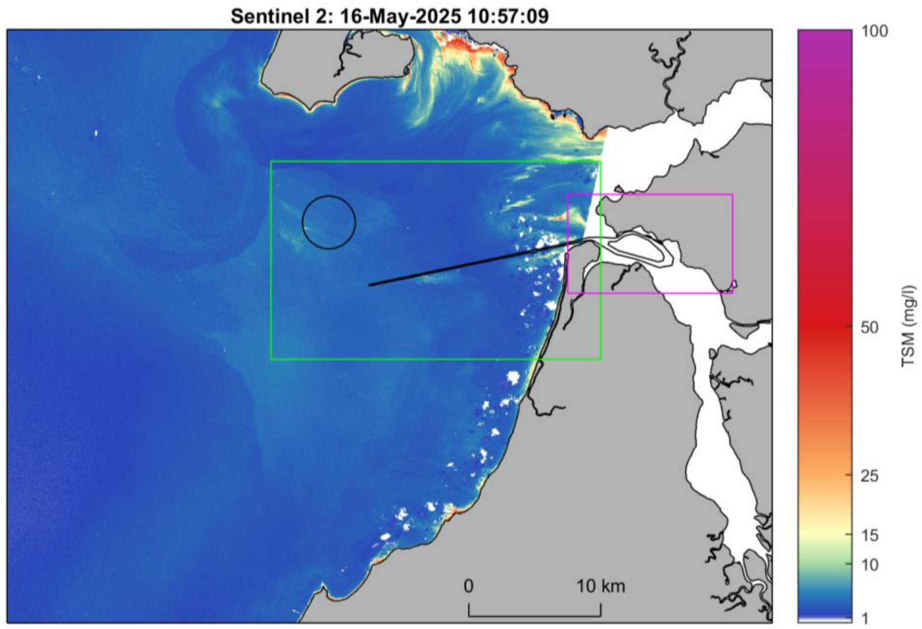


Figure 8. Correlation between satellite derived TSM from Sentinel-2 and in-situ logger derived SSC during the 2021 maintenance dredge monitoring period.

To ensure continuity between the satellite-derived TSM from different sensors a comparison between the TSM images derived from the Sentinel-2 and Sentinel-3 sensors was undertaken during the dredge program (Figure 9). Both images have similar spatial patterns in TSM and magnitudes which gives confidence that both approaches were able to provide comparable TSM values during the dredge program.

Throughout the dredge period PCS provided NQBP with TSM from satellite imagery available from both satellite sensors to provide as much near real-time information about the natural turbidity and any plumes due to the maintenance dredging as possible. From the daily updates provided during the dredging it was noted that the plumes from the maintenance dredging were relatively small and localised and as such they could be difficult to identify from the lower resolution Sentinel-3 imagery. Based on that, the technical note provided during dredging focussed on satellite imagery from the Sentinel-2 sensor (PCS, 2025c). This post-dredging report also focusses on imagery from just the Sentinel-2 sensor.



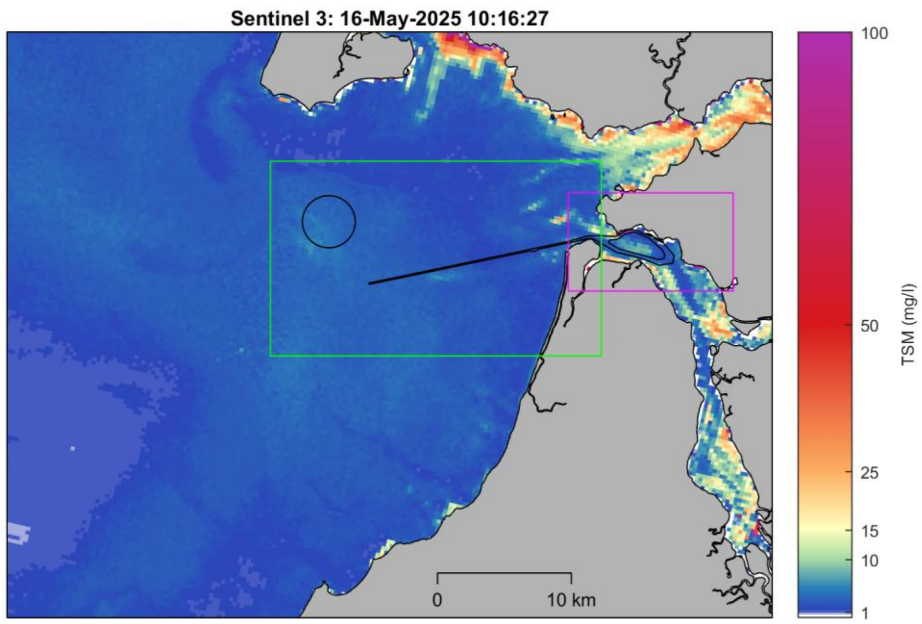


Figure 9. Comparison between satellite-derived TSM from the Sentinel-2 (top) and Sentinel-3 (bottom) sensors for images captured approximately 40 minutes apart.

Over the pre-, during and post-dredging monitoring period a total of 20 high resolution satellite images were captured by the Sentinel-2 sensor. As a result of unusually high cloud cover for this time of year a total of 11 of the images were unusable, with all images over the 7 day pre-dredge period being unusable. An image with low cloud cover was captured the day before the pre-dredge period commenced (30th April 2025) and so this has been used to indicate the natural pre-dredge TSM.

Details of the satellite images analysed as part of this assessment are provided in Table 4. A selection of images are presented to show the range of natural conditions and plumes observed over the period, the images which are presented in this report are highlighted as bold text in the tables while unusable images with high cloud cover are shown as grey text in the tables.

Table 4. Available satellite images over the monitoring period. *Note: the images highlighted in bold are included as figures in this report.*

Date and Time	Satellite Name	Details
	Pre-Dredge	
30/05/2025 10:47	**Sentinel-2**	**Low cloud cover. This image has been used to represent the pre-dredge natural TSM due to high cloud cover over the actual 7 day pre-dredge period.**
01/05/2025 10:57	Sentinel-2	High cloud cover (not usable)
03/05/2025 10:47	Sentinel-2	High cloud cover (not usable)
06/05/2025 10:57	Sentinel-2	High cloud cover (not usable)
08/05/2025 10:47	Sentinel-2	High cloud cover (not usable)
	During Dredging	
11/05/2025 10:57	Sentinel-2	High cloud cover (not usable).
13/05/2025 10:47	Sentinel-2	Moderate cloud cover over Port areas (not usable).
16/05/2025 10:57	**Sentinel-2**	**Low cloud cover, image excludes Inner Harbour area.** **At this time the TSHD Brisbane was sailing back to the South Channel having finished placing a load at the DMPA at 10:39. The load was from dredging in the South Channel (SC8 to SC10) which finished at 9:45.**
18/05/2025 10:47	**Sentinel-2**	**Low cloud cover.** **At this time the TSHD Brisbane was sailing back to the South Channel having finished placing a load at the DMPA at 10:09. The load was from dredging in the South Channel (SC10 to SC12) which finished at 9:12.**
20/05/2025 10:57	Sentinel-2	Moderate cloud cover. At this time the TSHD Brisbane was dredging in the South Channel (SC12 to SC14), this started at 10:37. The most recent load was placed at the DMPA at 9:38.
23/05/2025 10:47	Sentinel-2	High cloud cover (not usable).
26/05/2025 10:57	Sentinel-2	High cloud cover (not usable).
28/05/2025 10:47	Sentinel-2	High cloud cover (not usable).
31/05/2025 10:57	**Sentinel-2**	**No cloud cover, image excludes Inner Harbour area.** **At this time the TSHD Brisbane was dredging in the South Channel (SC10 to SC12), this started at 10:00. The most recent load was placed at the DMPA at 9:10.**
02/06/2025 10:47	Sentinel-2	High cloud cover (not usable).
05/06/2025 10:57	Sentinel-2	Low cloud cover, image excludes Inner Harbour area. At this time the TSHD Brisbane was at Humbug Wharf for a crew change (from 08:00 to 14:20). The most dredging prior

Date and Time	Satellite Name	Details
		to the crew change had been from the South Channel (SC12 to SC14).
07/06/2025 10:47	**Sentinel-2**	**Low cloud cover.** **At this time the TSHD Brisbane was dredging in the South Channel (SC12 to SC14), this started at 10:26. The most recent load was placed at the DMPA at 9:27.**
Post-Dredge		
09/06/2025 10:57	**Sentinel-2**	**No cloud cover.**
10/06/2025 10:47	Sentinel-2	High cloud cover in the western part of Albatross Bay, image excludes Inner Harbour area.
12/06/2025 10:57	**Sentinel-2**	**Patchy cloud cover.**
15/06/2025 10:47	Sentinel-2	High cloud cover (not usable).

4.2.1. Turbidity Analysis

To provide an understanding of natural turbidity levels within the study area and to identify the extent of potential increases in turbidity due to the 2025 maintenance dredging program, the turbidity analysis was undertaken at two different spatial scales, namely:

- regional and local (Albatross Bay and Port of Weipa); and
- dredge vessel (in close proximity to the TSHD Brisbane).

4.2.1.1. Regional and Local Scales

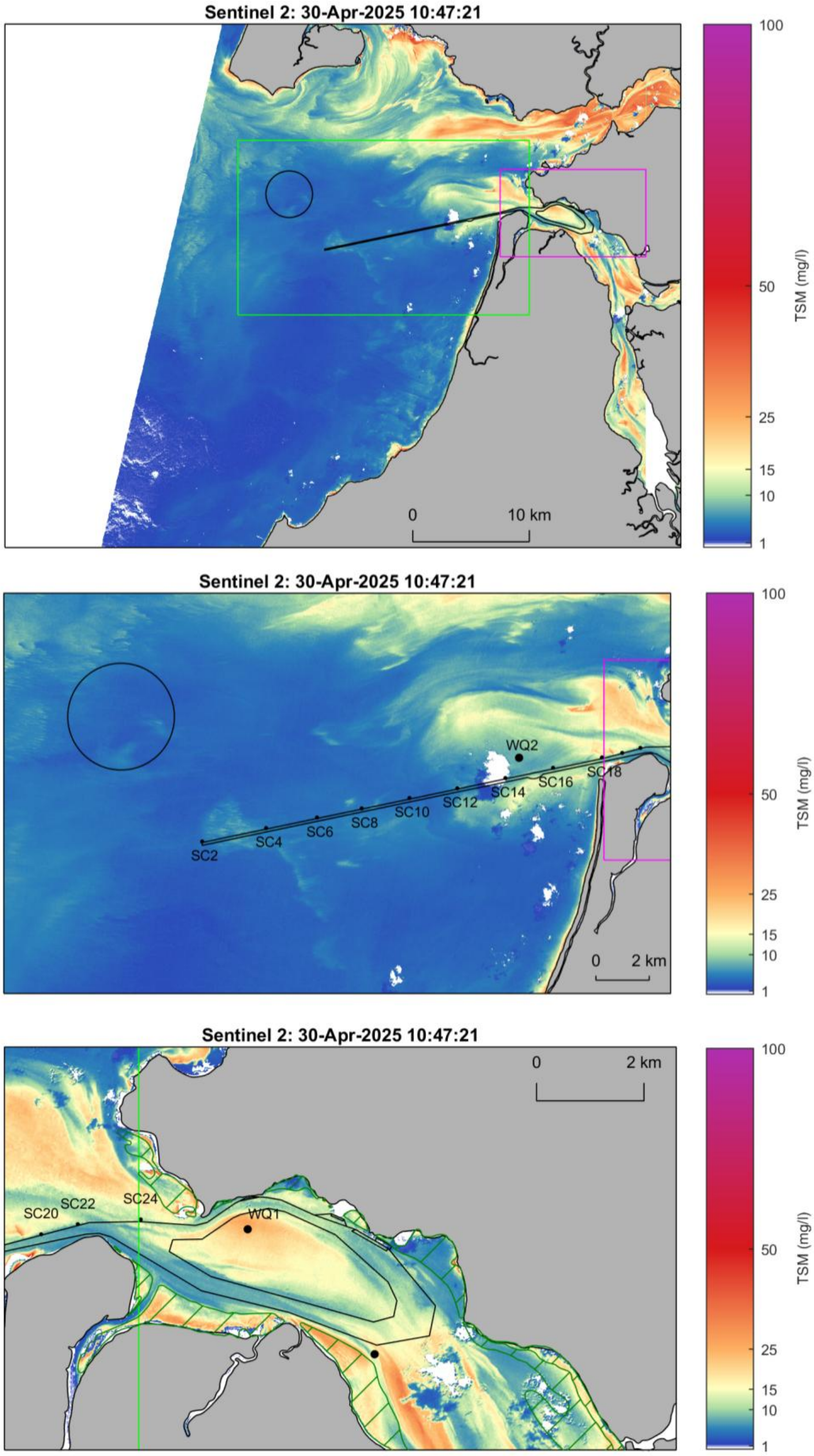
To provide an understanding of how the turbidity varied over the 2025 Maintenance Dredging Program, plots of the satellite-derived TSM in Albatross Bay, the South Channel/Albatross Bay DMPA and the Inner Harbour area are shown for selected satellite images over the pre-, during and post-dredging periods in Figure 10 to Figure 16. The plots show the following:

- the TSM in the Albatross Bay region has been variable over the period, with values typically less than 10 mg/l (approximately 7 NTU) throughout the majority of Albatross Bay, with higher TSM of 25 to 50 mg/l (approximately 18 to 35 NTU) in the shallow areas adjacent to the northern shoreline of Albatross Bay and in the estuaries. The imagery showed elevated TSM throughout much of Albatross Bay on the 30th April, 31st May and 12th June 2025. The high TSM in these images was due to spring tides and/or larger waves occurring at the time of, or prior to, the images being captured (the high TSM on the 30th April 2025 was just due to large spring tides, the other two due to a combination of spring tides and larger waves);
- extensive natural plumes with a TSM of up to 15 mg/l (approximately 11 NTU) were present within Albatross Bay over the majority of the period. These extended up to 10's of kilometres and at times were present adjacent to the South Channel. These plumes were present during the pre- and post-dredge periods and based on this along with the spatial extent of the plumes, the metocean conditions and dredging activity these large scale plumes are considered to have been due to natural processes;
- the images indicate that the TSM in the area of the seagrass meadows in the Inner Harbour has been controlled by natural processes with the natural TSM typically being between 10 and 50 mg/l (approximately 7 to 35 NTU) and consistently being higher than the adjacent channel. No persistent plumes that would be expected to impact seagrass beyond what they are normally exposed to were observed as a result of the maintenance dredging program;
- none of the images captured a visible plume due to maintenance dredging or bed levelling activity within the Inner Harbour. The TSM in the deeper dredged areas of the Inner Harbour typically remained below 10 mg/l (approximately 7 NTU) except during the

periods when spring tides and/or large waves resulted in elevated TSM in Albatross Bay when the TSM in the channel was up to 25 mg/l (approximately 18 NTU); and

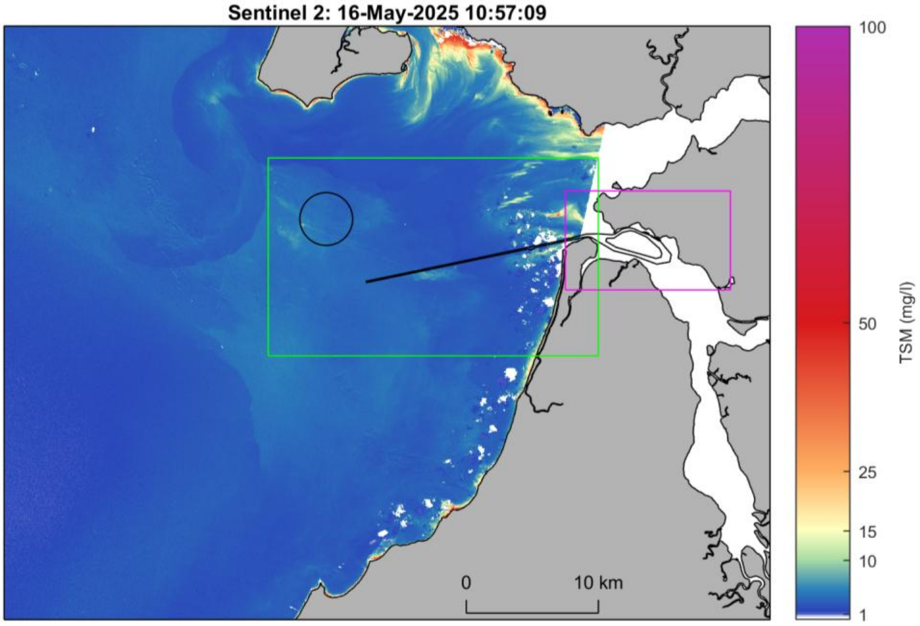
- plots of the satellite-derived TSM over the post-dredging period are shown in Figure 15 and Figure 16. The image captured one day after the dredging finished shows that the localised plumes which were present around the South Channel and DMPA were no longer visible, with the TSM throughout the majority of Albatross Bay and the Inner Harbour less than 10 mg/l (approximately 7 NTU). This indicates that any plumes from the maintenance dredging activity have dispersed prior to this image being captured (approximately 19 hours after the dredging finished). The image captured four days after the dredging finished shows that the TSM in Albatross Bay and the Inner Harbour had increased significantly, with a TSM of around 10 mg/l (approximately 7 NTU) around the DMPA and outer half of the South Channel and between 10 and 25 mg/l (approximately 7 and 18 NTU) along the inner half of the South Channel and in the Inner Harbour. This provides further evidence as to how the natural processes influence the TSM in the region and can result in increased TSM over large areas.

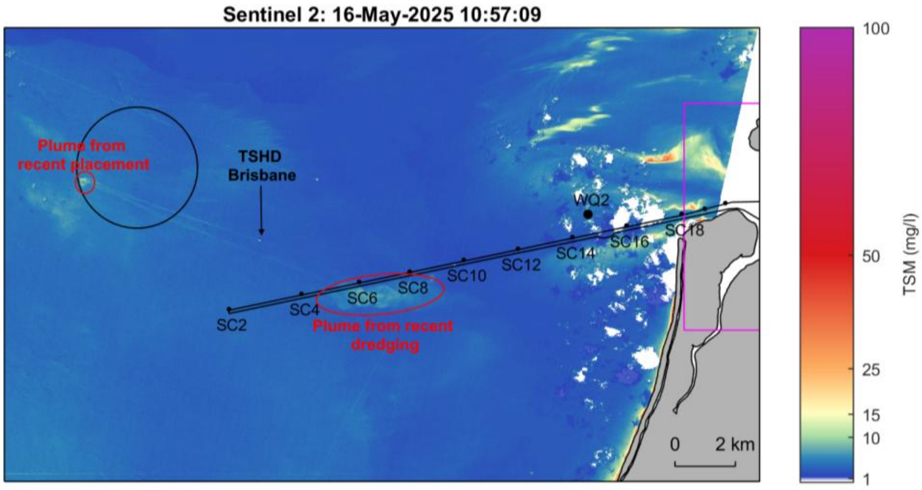
The imagery has also shown plumes with a TSM of up to 15 mg/l (approximately 11 NTU) and spatial extents of up to kilometres around the South Channel and DMPA occurred through the dredge period as a result of the dredging and bed levelling activity. None of the images showed plumes resulting from the maintenance dredging or bed levelling activity extending to any of the three water quality monitoring sites. This indicates that the measured in-situ turbidity at these sites was controlled by natural processes with the maintenance dredging and bed levelling activity having little to no impact. The plumes from the maintenance dredging are further assessed in Section 4.2.1.2.



Note: white areas represent cloud cover and the green hashed areas in the Inner Harbour represents the seagrass extent.

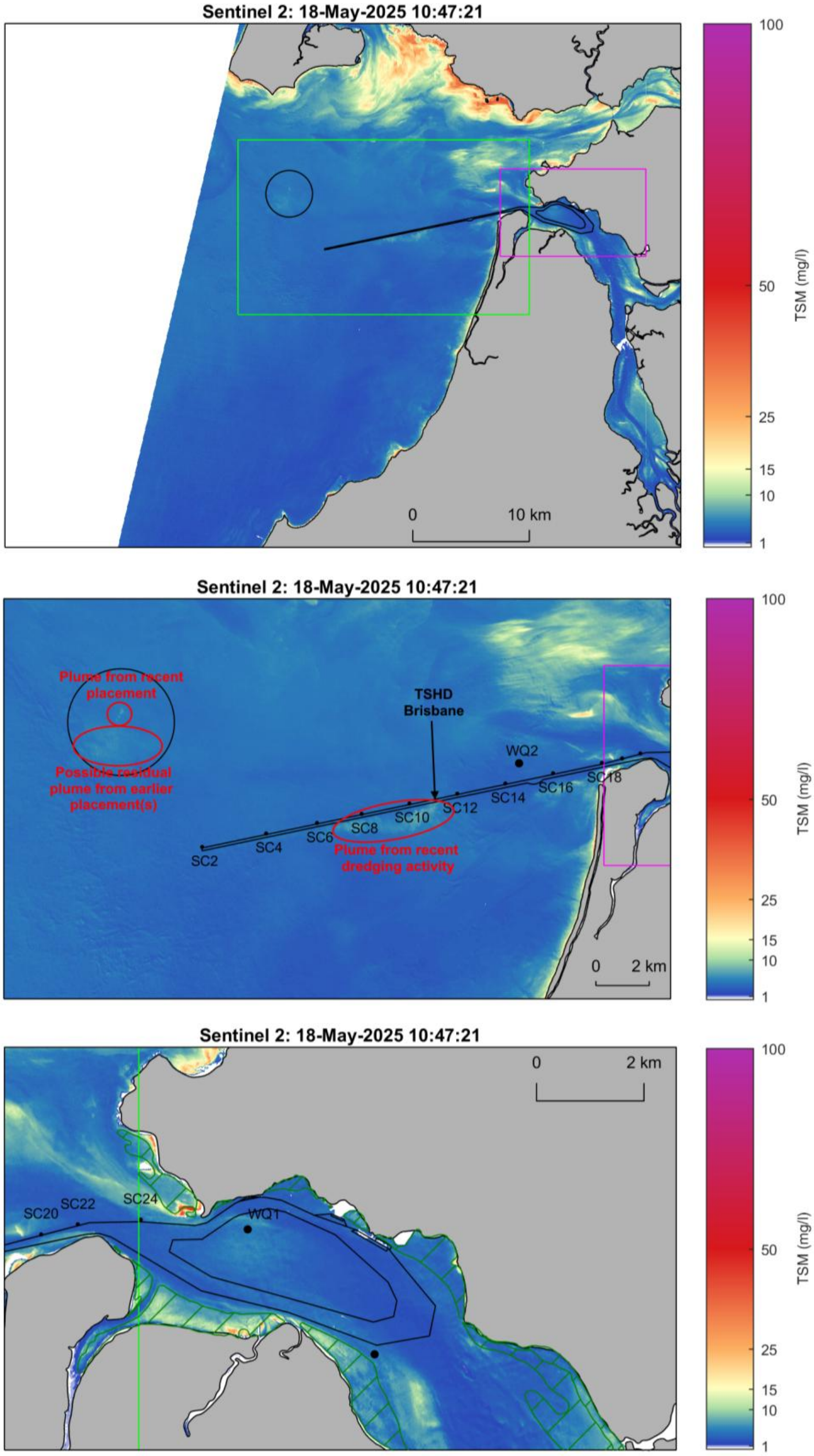
Figure 10. Satellite-derived TSM from the Sentinel-2 sensor on 30/04/2025 (pre-dredging).





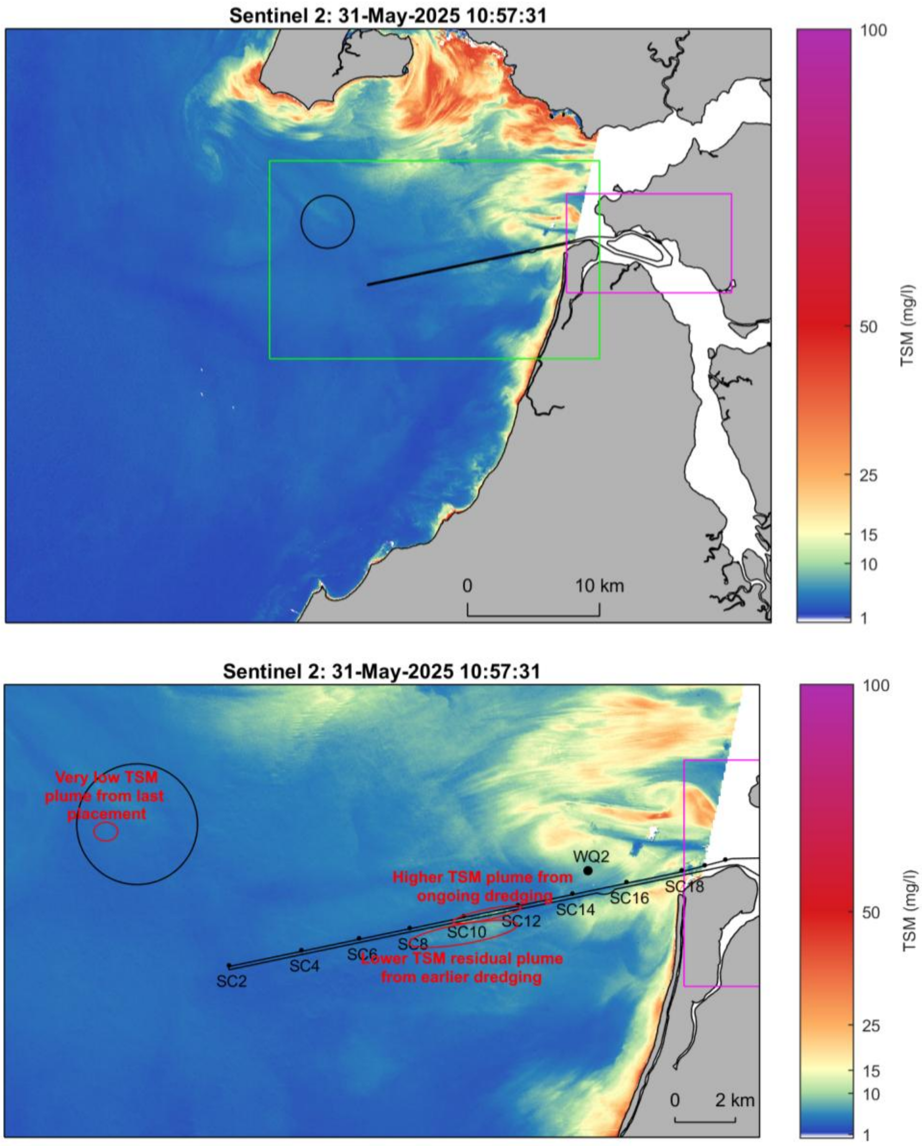
Note: white areas represent cloud cover and red ellipses shows plumes from dredging.

Figure 11. Satellite-derived TSM from the Sentinel-2 sensor on 16/05/2025 (during dredging).



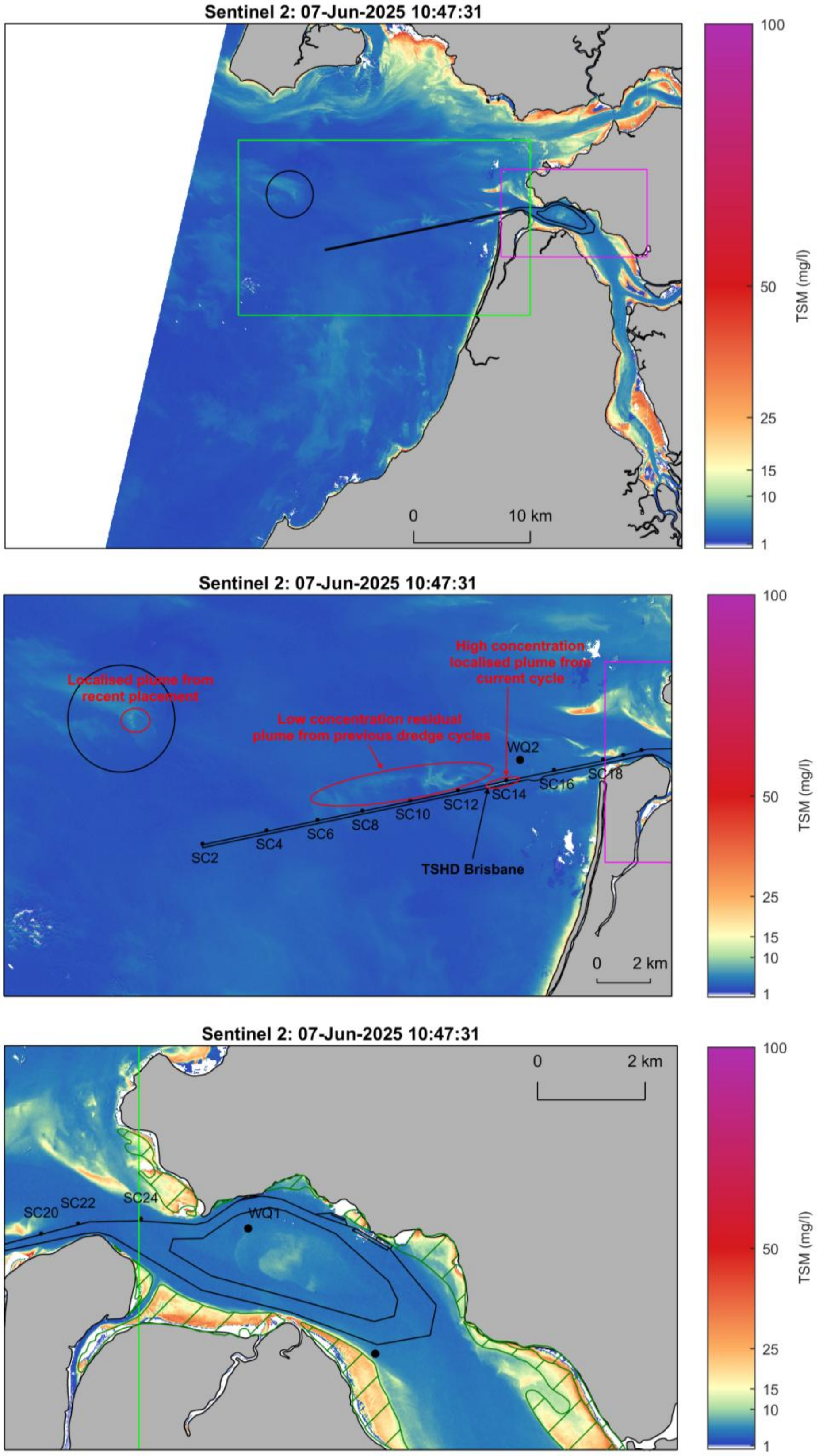
Note: red ellipses show plumes from dredging/bed levelling and green hashed areas in the Inner Harbour represents the latest seagrass extent.

Figure 12. Satellite-derived TSM from the Sentinel-2 sensor on 18/05/2025 (during dredging).



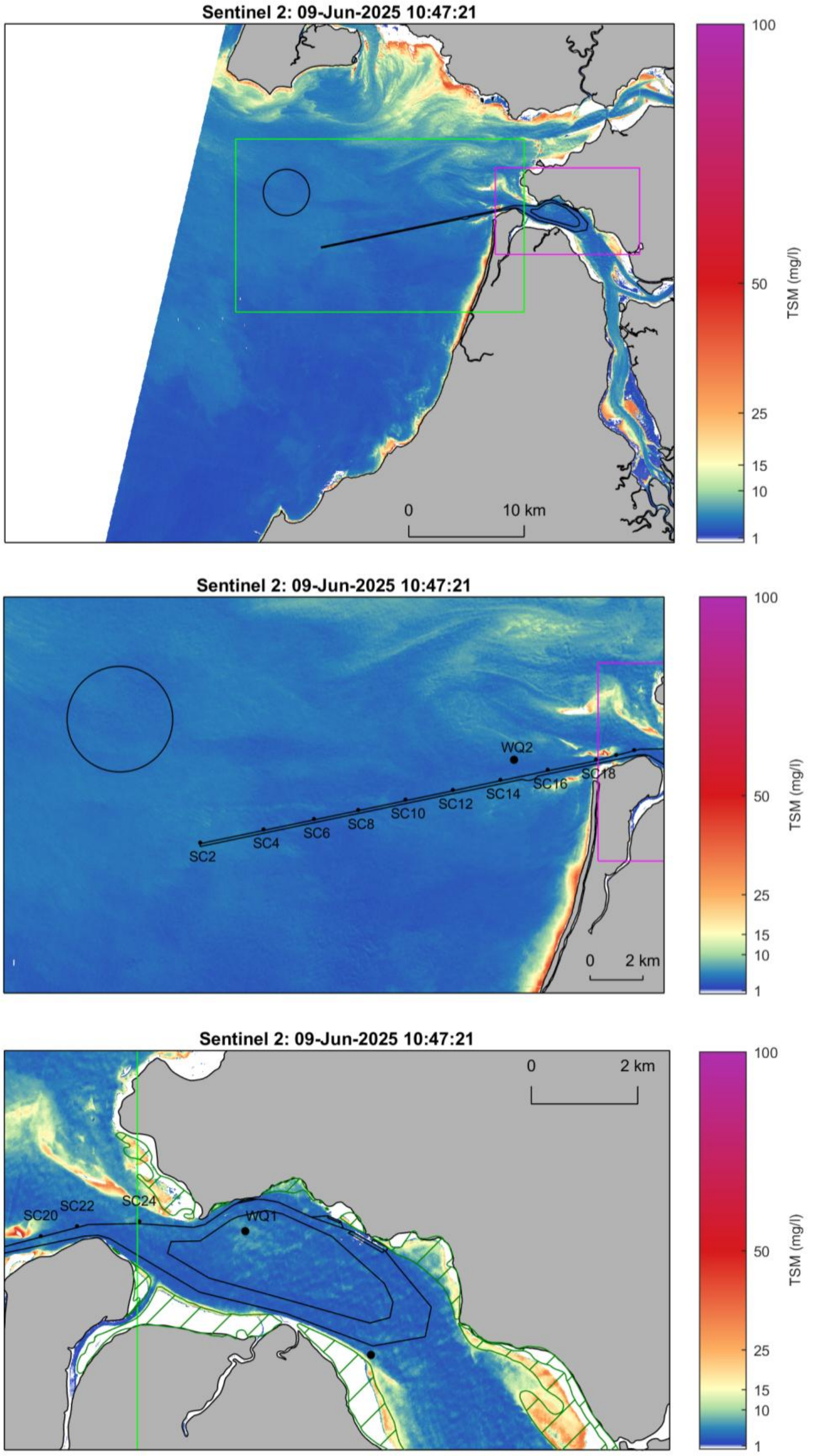
Note: red ellipses show plumes from dredging/bed levelling.

Figure 13. Satellite-derived TSM from the Sentinel-2 sensor on 31/05/2025 (during dredging).



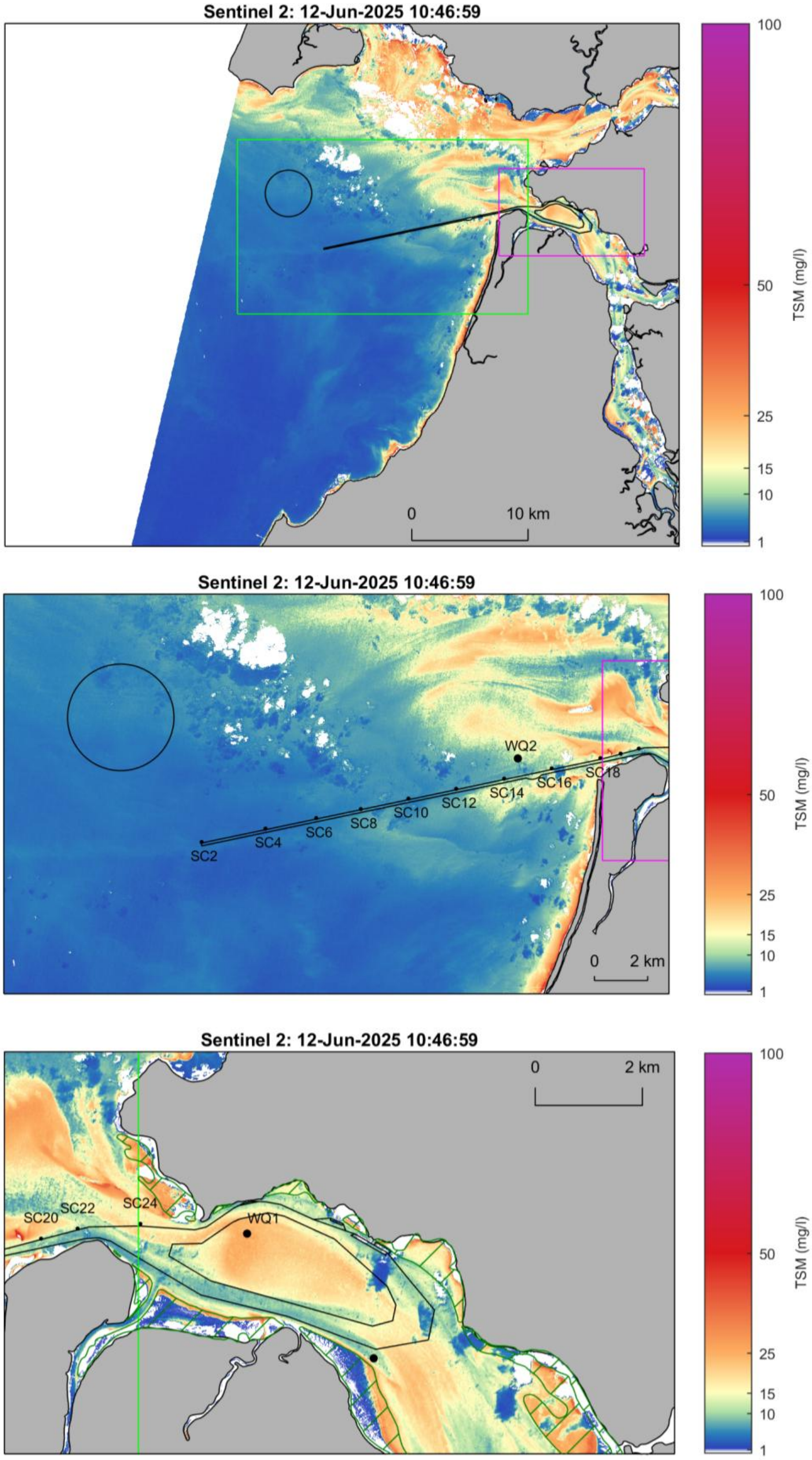
Note: white areas represent cloud cover, red ellipses show plumes and green hashed areas in the Inner Harbour represents the latest seagrass extent.

Figure 14. Satellite-derived TSM from the Sentinel-2 sensor on 07/06/2025 (during dredging).



Note: green hashed areas in the Inner Harbour represents the latest seagrass extent.

Figure 15. Satellite-derived TSM from the Sentinel-2 sensor on 09/06/2025 (post-dredging).



Note: white areas represent cloud cover and green hashed areas in the Inner Harbour represents the latest seagrass extent.

Figure 16. Satellite-derived TSM from the Sentinel-2 sensor on 12/06/2025 (post-dredging).

4.2.1.2. Dredge Vessel Scale

To further analyse the satellite-derived TSM for increases due to the maintenance dredging and bed levelling activity, zoomed in plots of the dredging/placement plumes shown by Sentinel-2 imagery during periods with visible plumes are shown in Figure 17 to Figure 22. The plots show how the plume varies depending on the time after the maintenance dredging activity finished:

- during dredging (Figure 19 and Figure 21): the TSHD Brisbane was dredging a hopper load of silt from the South Channel in the two images, one of the images shows the plume after 20 minutes of dredging while the other shows the plume after 1 hour of dredging (a further 15 minutes of dredging was undertaken for this load). The plots show a higher concentration plume of up to 15 mg/l is present along the track where the vessel dredged (up to 2 km in length), but with the plume width being in the order of 100 to 250 m and with the plume either remaining within or directly adjacent to the South Channel; and
- more than 1 hour after dredging finished (Figure 17, Figure 19 and Figure 21): approximately 1 hour and 10 minutes after the TSHD Brisbane finished dredging a hopper load of silt from the South Channel the resultant plume can be seen to have reduced in concentration to less than 10 mg/l, while the plume extent has significantly increased, with a length of up to 3.5 km and a width of up to 800 m. Additional residual plumes from dredging silt in the South Channel approximately 2 hours and 30 minutes after dredging finished show that the plume extent can be variable, with a plume of 8 mg/l extending 3.5 km in length and 800 m in width to the south of the South Channel in one image and a plume of 4 to 7 mg/l extending 7 km in length and 1.2 km in width to the north of the South Channel in another image. The reason for the difference in size in residual plume is expected to be a result of residual plumes from multiple previous dredge loads combining to form a larger residual plume, with the majority of the residual plume having a low TSM of less than 5 mg/l.

The plots show how the maintenance dredging activity can result in a localised plume in the area where the dredging was undertaken with a concentration of up to 15 mg/l during dredging. Plots of residual plumes from the maintenance dredging show how an hour after the dredging activity finished the plume concentration has reduced to less than 10 mg/l but with the plume extent increases up to 3.5 km in length. The plots also show how the residual plumes from multiple dredge loads can combine to create a plume of up to 7 km in length and 1.2 km in width, but with the majority of this larger plume being a low TSM (< 5 mg/l).

The satellite imagery has not shown any obvious plumes resulting from the bed levelling undertaken by the Pacific Titan. However, monitoring during the 2024 maintenance dredging identified localised plumes from the bed levelling activity and so it is expected that plumes would have been visible, but due to the high cloud cover over the 2025 dredge program no plumes were observed.

To better understand the increases in TSM at the Albatross Bay DMPA, plots of the plume shown by Sentinel-2 imagery after the TSHD Brisbane had placed sediment there are shown for the following:

- 20 minutes after placement (Figure 18): a plume of up to 15 mg/l with a diameter of 400 m is clearly visible in the DMPA. The plume is circular in shape as the dredger turns during placement to ensure the sediment is placed where intended and the hopper is completely emptied. There is no residual plume present from the previous placement, which occurred 2 hours 20 minutes prior to the image being captured;
- 1 hour 20 minutes after placement (Figure 22): a plume of up to 7 mg/l with a length of 600 m and a width of 300 m is visible in the centre of the DMPA. There are no obvious residual plumes present in the DMPA from previous loads (there is a large natural plume with a TSM of up to 5 mg/l), with the previous placement having been more than 12 hours prior to the image being captured (due to delays in the dredging); and

- 1 hour 45 minutes after placement (Figure 20): no distinct plume is present in the DMPA when the load was placed 1 hour 45 minutes prior to the image being captured.

The plumes resulting from the placement of dredged sediment within the DMPA show how quickly the TSM of the plume reduces following placement, while the extent of the plume increases due to the advection and dispersion of the plume. The plume from placements more than 1 hour 45 minutes before the satellite image was captured cannot be clearly distinguished from the natural background TSM in the region.

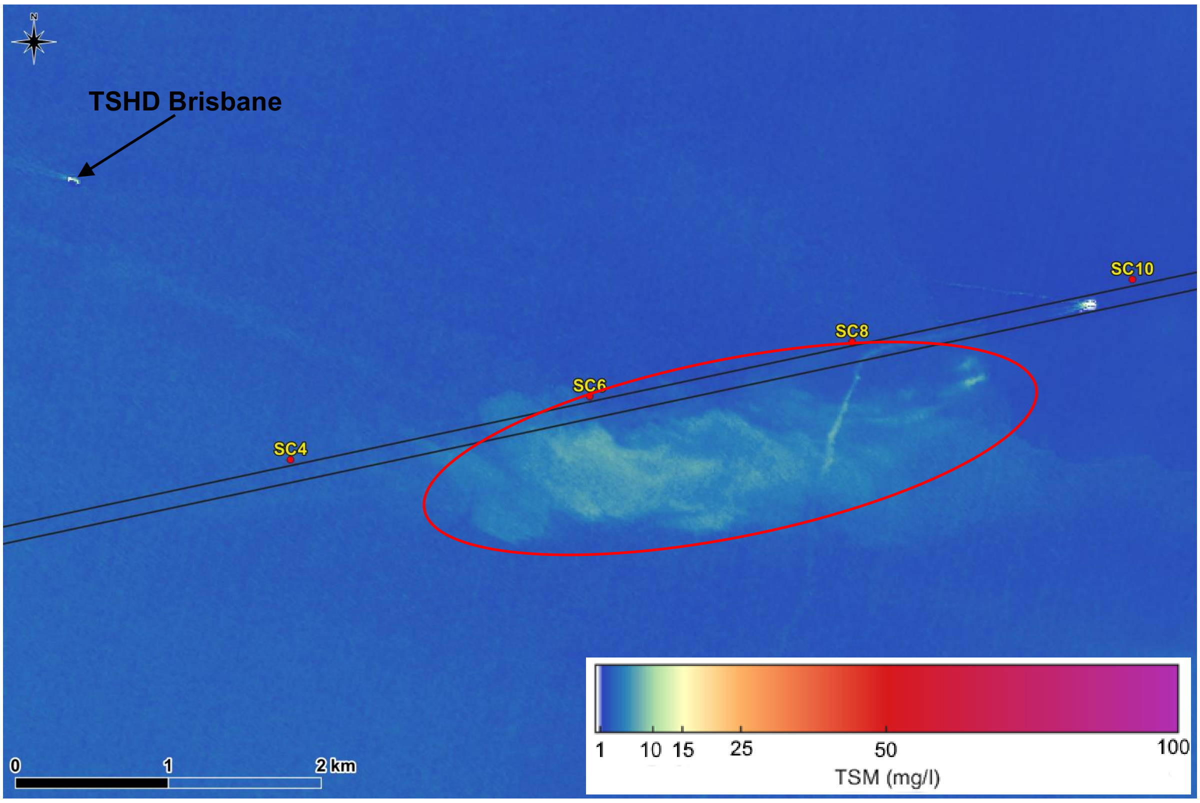


Figure 17. **Satellite-derived TSM of South Channel showing a plume from the TSHD Brisbane approximately 1 hour 10 minutes after it finished dredging between SC8 and SC10 on 16/05/2025 at 10:57 AEST.**

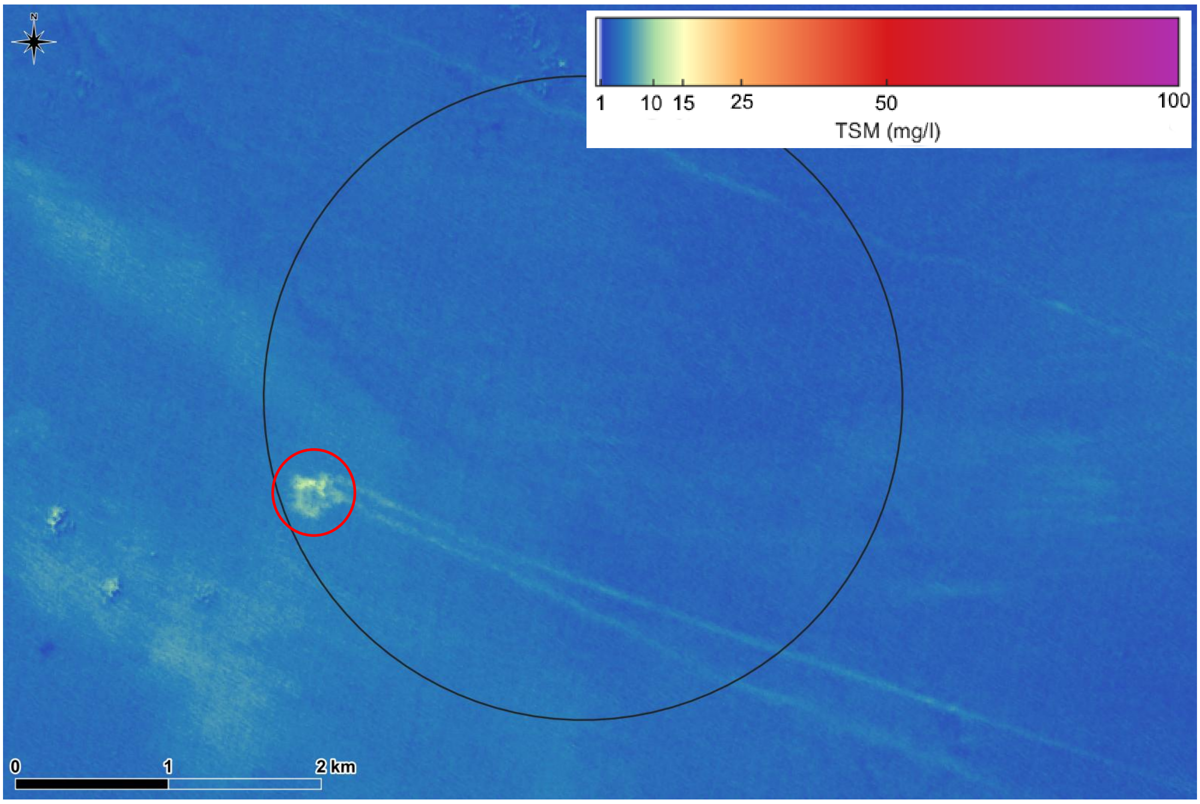


Figure 18. **Satellite-derived TSM of the DMPA showing the plume from the TSHD Brisbane 20 minutes after placing at the DMPA on 16/05/2025 at 10:57 AEST.**

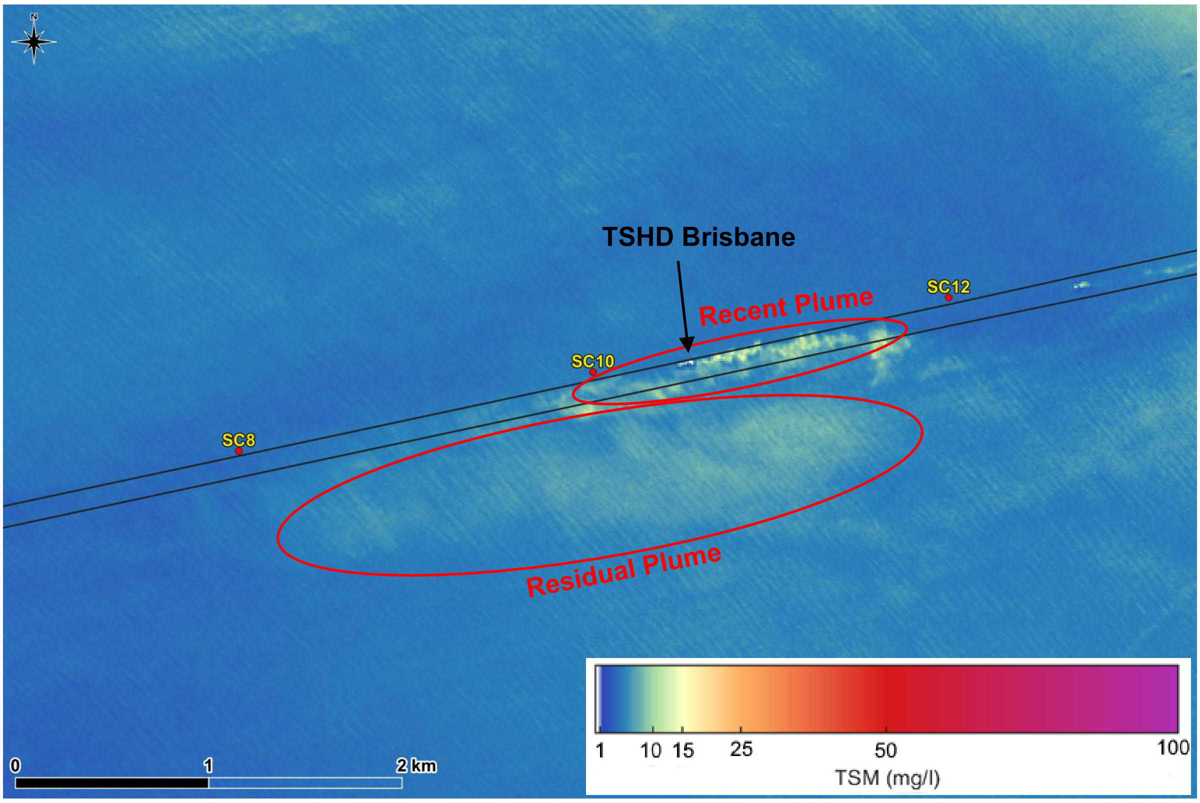


Figure 19. Satellite-derived TSM of South Channel showing a plume from 1 hour of dredging by the TSHD Brisbane along with a residual plume from previous dredge cycles on 31/05/2025 at 10:57 AEST.

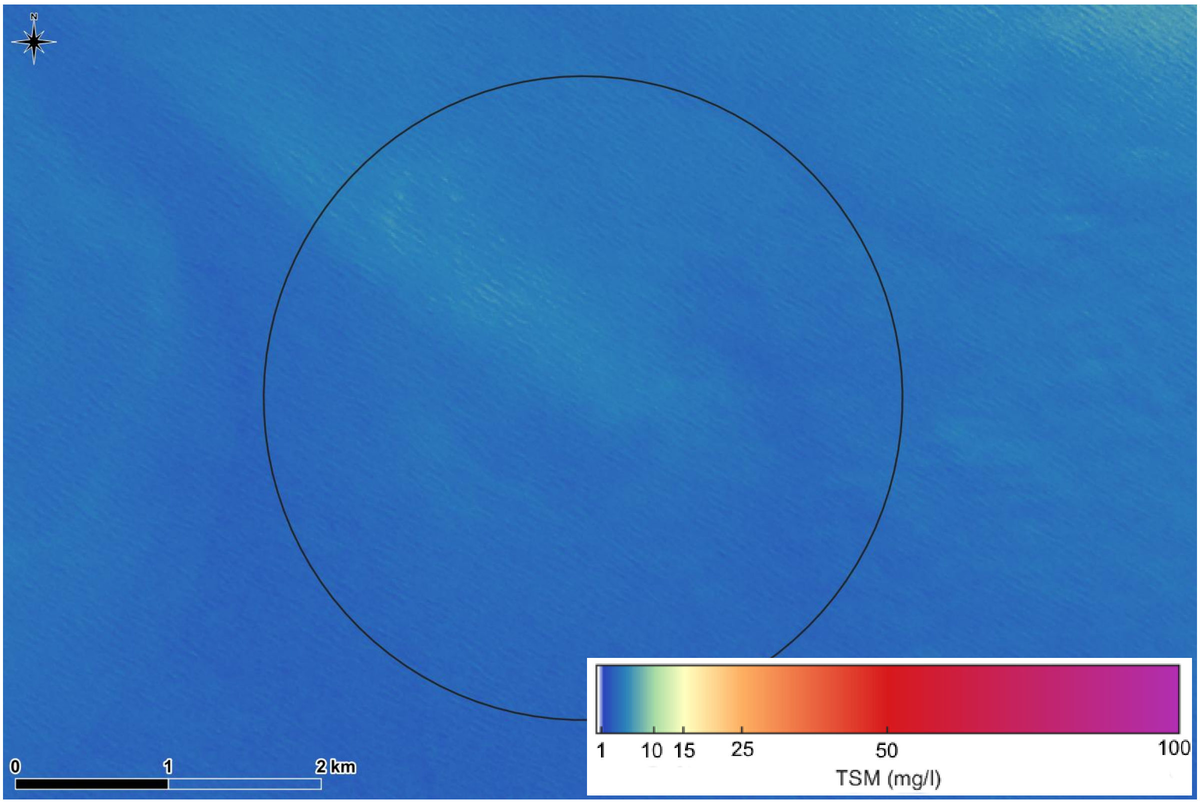


Figure 20. Satellite-derived TSM of the DMPA showing no remaining distinct plume from the TSHD Brisbane 1 hour 45 minutes after placing at the DMPA on 31/05/2025 at 10:57 AEST.

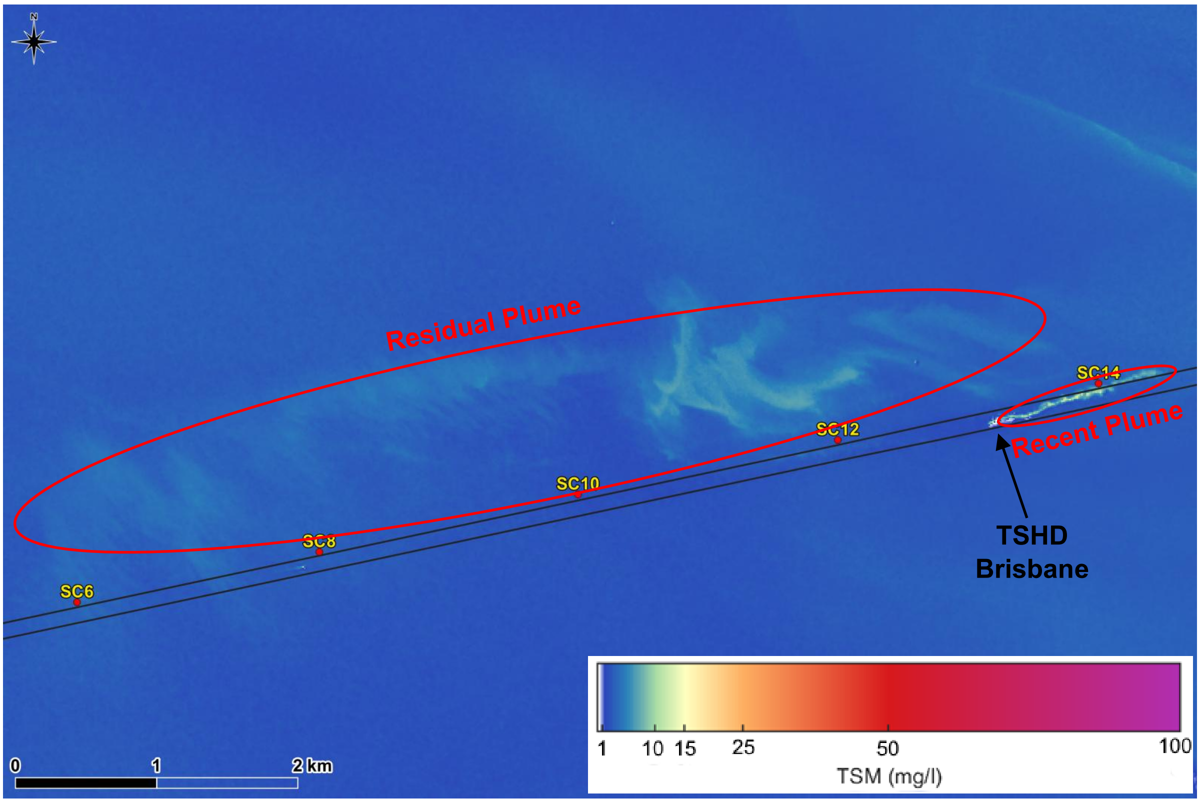


Figure 21. Satellite-derived TSM of South Channel showing a plume from 20 minutes of dredging by the TSHD Brisbane along with a residual plume from previous dredge cycles on 07/06/2025 at 10:47 AEST.

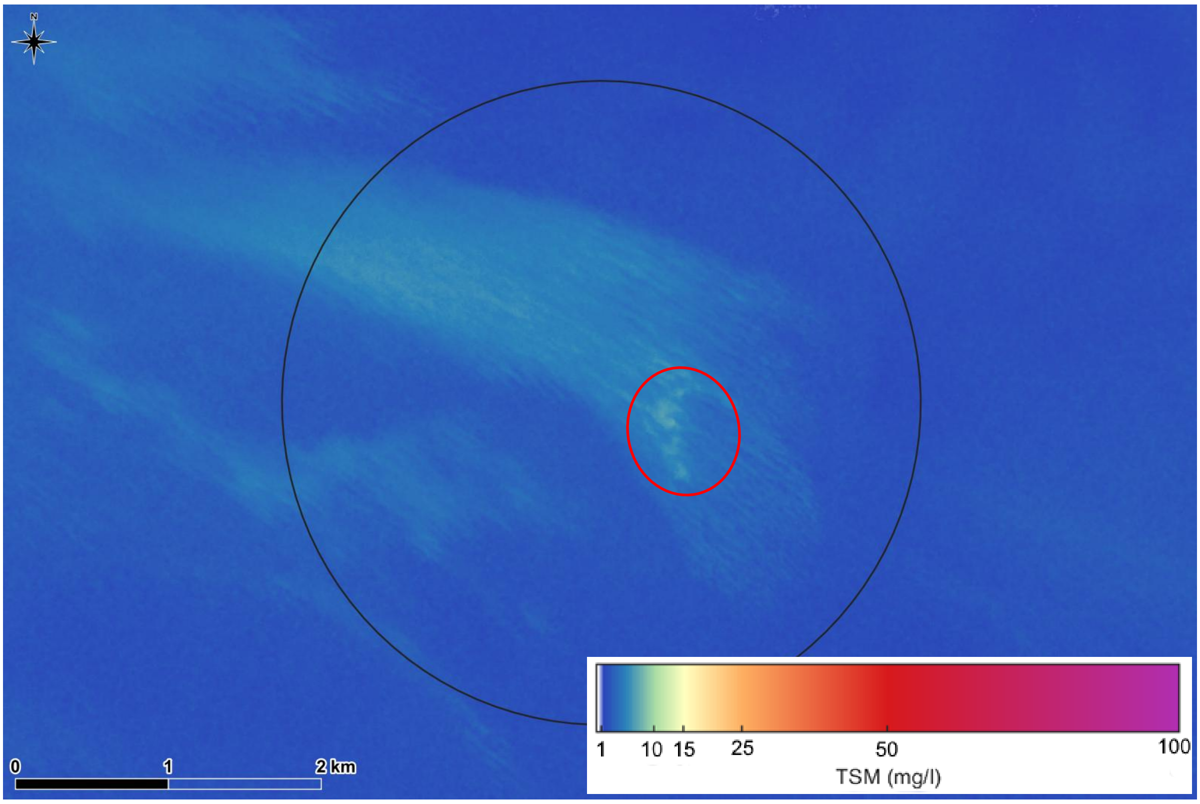


Figure 22. Satellite-derived TSM of the DMPA showing the plume from the TSHD Brisbane 1 hour 20 minutes after placing at the DMPA on 07/06/2025 at 10:47 AEST.

5. Summary

This report has analysed and interpreted turbidity data collected pre-, during and post the Port of Weipa 2025 maintenance dredging program. The 2025 maintenance dredging program was undertaken by the TSHD Brisbane and involved the relocation of 396,000 m^3 of sediment from the dredged areas of the Port to the Albatross Bay DMPA. The data showed that during the dredging program the turbidity around the Port of Weipa was generally driven by the natural conditions (predominantly the astronomical tide, although a number of wave events also resulted in elevated turbidity), with higher turbidity occurring during spring tides with a larger tidal range. The key findings from the turbidity data analysis are detailed below:

- the exceedance analysis of the in-situ measured benthic turbidity data showed that the duration exceedances were below the average duration exceedance at all sites during the dredging period. The results therefore show that the turbidity over the period was well within the natural variability for the region;
- all of the plumes resulting from maintenance dredging (including those from both dredging and placement) were found to remain relatively close to where they were created. Plumes generated in the South Channel were shown to have the potential to migrate to the north and south of the channel and in an offshore direction. Overall, the results showed that little net residual transport occurs in the region, this was also noted during the 2019 to 2024 maintenance dredging programs and as part of the Port of Weipa Sustainable Sediment Management assessment (PCS, 2019, 2020, 2021, 2022, 2023, 2024b). Based on this, it can be assumed that the majority of the sediment suspended by the maintenance dredging and bed levelling is subsequently redeposited close to where it was either dredged or placed;
- the dredging and placement activities associated with the Port of Weipa 2025 maintenance dredging program were found to result in visible plumes. Plumes were observed close to the TSHD Brisbane during dredging, adjacent to the South Channel and within and adjacent to the Albatross Bay DMPA. The size and concentration of the plumes was variable depending on the dredging and placement activities;
  - the largest plume, which was due to repeat maintenance dredging loads in the South Channel, was up to 7 km in length and 1.2 km in width and was present adjacent to the South Channel and had a concentration of 4 to 7 mg/l. Satellite imagery indicated that a localised plume was regularly present around the South Channel as this was where the majority of the maintenance dredging was undertaken; and
  - plumes in the DMPA from the placement of dredged sediment were typically less than 600 m in length and only persisted for short durations (less than 1 hour and 45 minutes). The observed plumes were consistent with placement by the TSHD Brisbane during previous annual maintenance dredging programs.
- the Port of Weipa 2025 maintenance dredging program did not influence the regional turbidity in the area. The dredging only influenced the local turbidity close to where dredging was undertaken in the Port and where placement occurred at the Albatross Bay DMPA. Natural variations in turbidity driven by the tide and wave conditions over the monitoring period were larger than the variations in turbidity due to the maintenance dredging. The satellite imagery showed that the turbidity in the area of the seagrass meadows in the Inner Harbour was controlled by natural processes over the 2025 maintenance dredging program, with no visible plumes from the dredging activity observed in the seagrass meadows; and
- the post-dredging satellite imagery showed that less than 1 day after dredging ended there were no plumes from the dredging or placement activities in the South Channel, Inner Harbour or DMPA. This is in agreement with findings from previous dredge programs (2020, 2022, 2023 and 2024) where satellite imagery showed that the turbidity had returned to natural conditions within days of the dredging activity finishing (PCS, 2020, 2022, 2023 and 2024b).

6. References

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