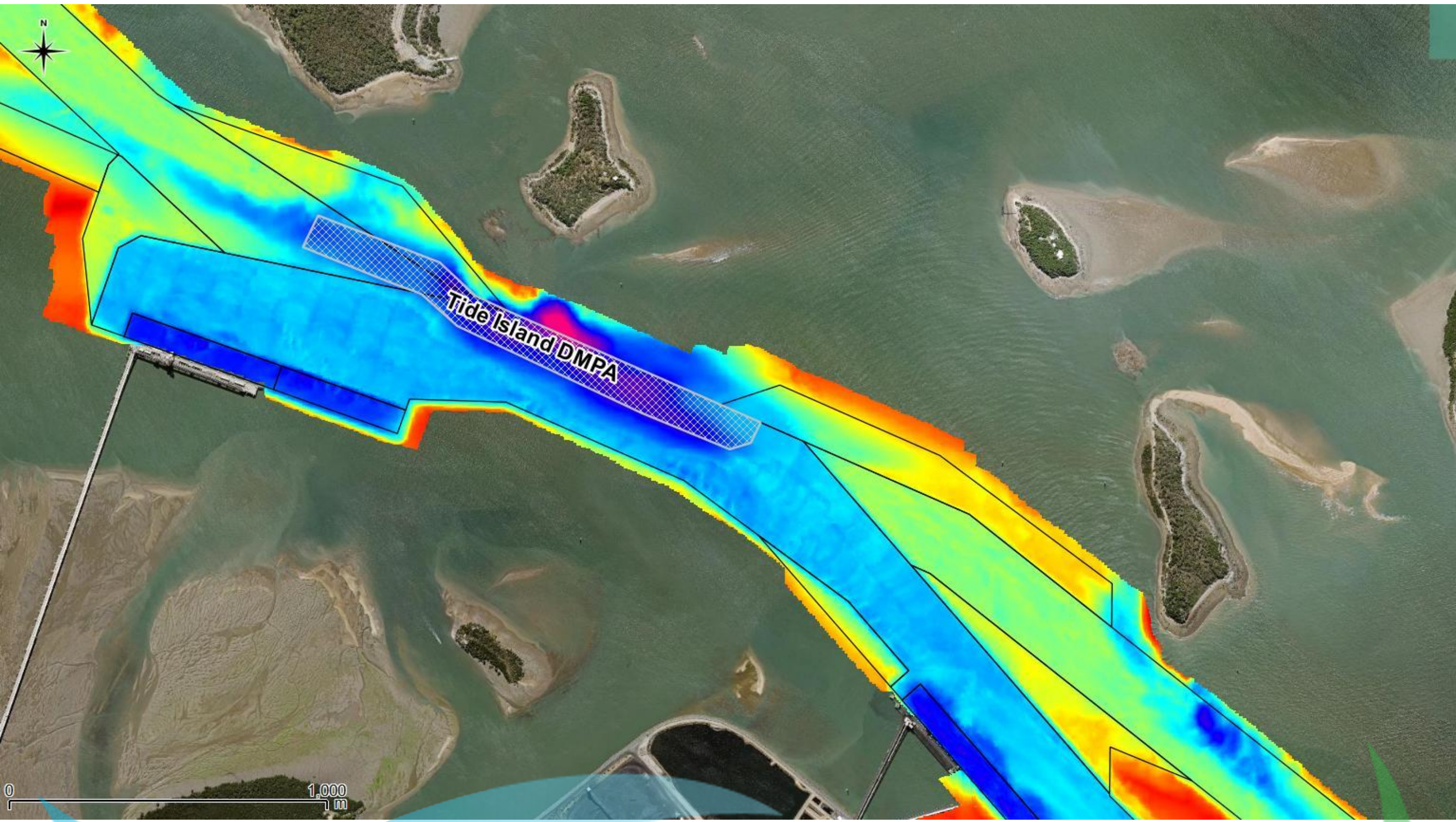
PORT & COASTAL SOLUTIONS

Port of Gladstone Sustainable Sediment Management

Feasibility Assessment: LNG Sustainable Relocation

Final 1.2



Gladstone Ports Corporation
Technical Report
August 2020

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Feasibility Assessment: LNG Sustainable Relocation

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Executive Summary

Gladstone Ports Corporation (GPC) commissioned Port and Coastal Solutions (PCS) to assess the feasibility of a number of alternative options to manage sediment from maintenance dredging for the Port of Gladstone (PoG). The options were identified as part of the Reduce and Beneficial Reuse components of the PoG Sustainable Sediment Management (SSM) Project. The options were assessed by stakeholders as part of the SSM Project and based on the outcome of this, GPC identified four options for further evaluation. This report details the feasibility assessment for one of the options, the sustainable in-channel relocation of sediment from the liquefied natural gas (LNG) Terminals region of the PoG. It involves the release of fine-grained sediment in a naturally deep area of the designated channel close to Tide Island, with the aim of the sediment subsequently being transported within the Inner Harbour and providing additional sediment input to intertidal regions whilst not resulting in an increase in sedimentation in any dredged areas.

An option development was undertaken and as part of this it was concluded that the previously proposed Tide Island dredge material placement area (DMPA) is the most suitable location and that the placed sediment should be predominantly fine-grained silt and clay which could either be from the LNG Terminals region or the Fishermans Landing region. The sediment could be placed by bottom dumping and the total volume of sediment which could potentially be placed there from the two (2) regions could be in the order of 150,000 m^3/yr. Numerical modelling was undertaken as part of the feasibility assessment and the results have predicted that the placement of 40,000 m^3 of dredged sediment at the Tide Island DMPA results in increased suspended sediment concentration (SSC) and deposition within Port Curtis relative to placement at EBSDS. The potential impact of the proposed dredging on water quality and sensitive receptors was predicted using the modelling results and based on this it was found that the placement at the Tide Island DMPA results in a zone of low impact, where the excess turbidity from the dredging activities may cause water quality to deteriorate beyond natural variation, while the placement at EBSDS does not result in a zone of low impact. The zone of low impact for the Tide Island DMPA placement is predicted to predominantly cover designated channels (Jacobs Channel, Clinton Channel and Auckland Channel) as opposed to areas with sensitive receptors. The approach is not predicted to result in any zones of moderate or high impact where excess turbidity from dredging is either likely or most likely to cause water quality to deteriorate beyond natural variation. Based on these results, the risk of any impacts to nearby sensitive receptors is considered to be low.

When the dredge duration and cost of placement at the Tide Island DMPA were compared to ongoing placement at EBSDS, placement at the Tide Island DMPA results in a reduction in both time and cost of more than half. For example, if it is assumed that 75,000 m^3 of sediment is dredged from the LNG Terminal region and placed at the Tide Island DMPA instead of at EBSDS, this would reduce the dredge duration from 10 days to 4.3 days and the cost from $990,000 to $430,000. The reduction in dredging time would also result in a comparable percentage reduction in greenhouse gas (GHG) emissions.

Based on the findings of this feasibility assessment, the approach of sustainable in-channel relocation of sediment from the LNG Terminals and Fishermans Landing regions to the Tide Island DMPA is considered feasible. The Tide Island DMPA has been found to have the potential to be used as a long-term placement option given the volume capacity of the site below declared depths (1 million m^3) and the dispersive nature of the site predicted by the numerical modelling. However, there remains uncertainty as to how much sediment can be placed at the Tide Island DMPA during each annual maintenance dredging campaign. As the results from the numerical modelling indicate that placing sediment at the Tide Island DMPA results in some SSC and deposition increases at the nearby sensitive receptors compared to placement at EBSDS, there is a risk that if too large a volume of sediment is placed at the Tide Island DMPA there could be impacts to these nearby sensitive receptors. Therefore, it is recommended that an initial pilot study is required to confirm whether or not there is a significant build-up of sediment at the Tide Island DMPA and whether the approach has the

potential to result in impacts to any sensitive receptors. Details of the pilot study, which proposes that 10,000 m^3 of sediment is placed at the Tide Island DMPA, and the associated monitoring are provided within this report.

1. Introduction

Gladstone Ports Corporation (GPC) commissioned Port and Coastal Solutions (PCS) to undertake desktop feasibility studies for alternative options to manage sediment from maintenance dredging for the Port of Gladstone (PoG). The options were identified as part of the Reduce and Beneficial Reuse components of the PoG Sustainable Sediment Management (SSM) Project. The options were assessed by stakeholders as part of the SSM Project and based on the outcome of this, GPC selected the following four (4) options for further evaluation:

1) Offshore Beach Nourishment: this involves the placement of sand sized sediment offshore of a beach with the aim of the sediment providing long-term nourishment for the beach;
2) Sustainable In-channel Relocation for the Liquefied Natural Gas (LNG) Region: this involves the release of fine-grained sediment from the LNG Terminals region in a naturally deep area close to Tide Island, with the aim of the sediment subsequently being transported within the Inner Harbour and providing additional sediment input to intertidal regions whilst not resulting in an increase in sedimentation in any dredged areas;
3) Habitat Restoration/Creation: this involves the placement of dredged sediment (could be either fine-grained or sand sized) with the aim of restoring or creating seagrass and/or intertidal shorebird habitat; and
4) Sustainable In-channel Relocation for the Marina: this involves pumping low concentration fine-grained sediment from the Marina to the edge of the Clinton Channel, with the aim of the sediment subsequently being transported within the Inner Harbour and providing additional sediment input to intertidal regions whilst not resulting in an increase in sedimentation in any dredged areas.

This report is related to feasibility of the option associated with Option 2, the sustainable in-channel relocation for the LNG region.

1.1. Project Overview

The SSM Project was identified by GPC as a prerequisite, to allow adaptive long-term environmental management of maintenance dredging, supporting sustainable development and minimising harm to the environment, Port, surrounding areas and communities.

GPC had discerned the need to further improve their understanding of the interactions between maintenance dredging operations (including sea disposal of dredged material) and the local and regional environment, in order to minimise environmental impacts and ensure the ongoing sustainability of these operations. To progress this need GPC previously entered an informal agreement with the Great Barrier Reef Marine Park Authority (GBRMPA), to investigate this interaction at the Great Barrier Reef Marine Park (GBRMP) - Port Limits boundary. All PoG infrastructure and activities occur within Port Limits, which are within the Great Barrier Reef World Heritage Area (GBRWHA) (as inscribed in 1981) but outside of the GBRMP, with the exception of oceanic areas to the east of Facing Island and the south-east of Wild Cattle Cutting.

Maintenance dredging is conducted to provide and operate effective and efficient port facilities and services under the *Transport Infrastructure Act 1994*. The PoG maintenance dredging and disposal activities associated with the main channels, swings basins and berth pockets are usually undertaken annually, with dredged material placed at the approved East Banks Sea Disposal Site (EBSDS - first approved in 1980). In addition, the sediment removed by maintenance dredging of some areas of the PoG (e.g. the Marina and the Boyne River) has historically been placed on land.

In association with obtaining a Sea Dumping Permit for maintenance dredging, a five (5) year Deed of Agreement (the Deed) was signed on the 14th August 2015, between GPC and the Department of the Environment and Energy[1] (DoEE) to:

- undertake research and monitoring relating to the consequences of dumping maintenance dredged material into the marine environment. It is noted that among other things the research and monitoring may include;
  - establishment of a quantitative sediment budget and sediment dynamics model for Port Curtis (the large natural harbour the PoG is located within), Queensland, including quantifying impacts and extent of sediment transport and resuspension from Dumping Activities at the EBSDS with specific reference to sensitive receptors and potential impacts on the GBRWHA; and
  - monitoring changes in water quality (including turbidity and benthic photosynthetic active radiation (BPAR)) resulting from, or as a consequence of, dumping activities.
- investigate the possibility of avoiding or reducing the need for further dumping of maintenance dredged material into the marine environment, including the possibility of beneficially reusing the sediment; and
- report to the DoEE the results of any research, monitoring or investigation undertaken by GPC in accordance with the Deed.

The Deed reiterates GPC's existing commitments to monitor and manage maintenance dredging and associated sea disposal activities in an environmentally responsible manner. To address the requirements of the Deed, an 'Implementation Strategy' (the Strategy) was prepared by GPC and approved by DoEE, which provides a schedule of proposed programs to be conducted over the term of the Deed. The Deed forms part of GPC's Environmental Management System (EMS) which is certified to ISO 14001:2015, ensuring a robust risk identification, control and improvement process is implemented and maintained.

In addition to the Deed, a Maintenance Dredging Strategy (MDS) has been developed for the ports that are situated within the GBRWHA (DTMR, 2016). The MDS provides a framework for the sustainable, leading practice management of maintenance dredging. It is a requirement of the MDS that each Port within the GBRWHA develop and implement a Long-term Maintenance Dredging Management Plan (LMDMP). The LMDMPs are aimed at creating a framework for continual improvement in environmental performance. The Department of Transport and Main Roads (DTMR) have provided guidelines to assist in the development of the LMDMPs which can be applied to ports Queensland wide (DTMR, 2018). The guidelines note that the LMDMPs should include, as well as other aspects, the following:

- an understanding of port-specific sedimentation conditions and processes;
- management approaches (including dredge avoidance and reduction); and
- long-term dredging requirements based on sedimentation rates, port safety and port efficiency needs.

The SSM Project has therefore helped to fulfil the requirements of the Deed as well as providing input to the LMDMP. The feasibility assessments of the options shortlisted from the SSM Project will be used by GPC to determine which options should be considered further and potentially progressed to a trial to further assess feasibility.

1.2. Port of Gladstone

The majority of the PoG is located within Port Curtis on the east coast of Queensland, approximately 525 km north of Brisbane (Figure 1). Port Curtis is a macro-tidal estuarine system that includes an intricate network of rivers, creeks, inlets, shoals, mud banks, channels and islands. Strong tidal flows, wind and swell wave energy and riverine input from

[1] DoEE has now changed to the Department of Agriculture, Water and the Environment (DAWE).

the Calliope and Boyne catchments, contribute to the sediment transport processes which influence the region.

In the 2018/19 financial year, the PoG handled 124 million tonnes of commodities. This was predominantly made up of coal, alumina/aluminium related products and LNG, although other products including cement, petroleum, industrial chemicals, grain and containers were also handled (GPC, 2017).

The PoG covers 4,448 hectares (ha) of land which includes more than 700 ha of reclaimed land. There are 10 main wharf centres, which together comprise 20 wharves (Figure 1):

1. RG Tanna Coal Terminal: four (4) wharves;
2. Barney Point Terminal: one (1) wharf;
3. Auckland Point Terminal: four (4) wharves;
4. Fishermans Landing: four (4) wharves;
5. South Trees: two (2) wharves;
6. Boyne Wharf: one (1) wharf;
7. Curtis Island LNG Precinct, Australia Pacific LNG (APLNG): one (1) wharf;
8. Curtis Island LNG Precinct, Queensland Curtis LNG (QCLNG): one (1) wharf;
9. Curtis Island LNG Precinct, Gladstone LNG (GLNG): one (1) wharf; and
10. Wiggins Island Coal Terminal (WICT): one (1) wharf.

Figure 1. PoG wharf locations (GPC, 2017).

The PoG consists of approximately 50 km of shipping channels to ensure safe navigation from the entrance of the Port to the wharves (Figure 2). Sediment management practises are undertaken to ensure that the depths of the channels and berths are maintained at their original declared depths (Table 1). The sediment management practises include maintenance dredging, bed levelling and drag barring. Annual maintenance dredging and bed levelling/drag barring practises are undertaken in the PoG, with some areas requiring sediment management at least annually while others require less frequent management. The annual maintenance dredging of the PoG has historically been undertaken by the Trailing Suction Hopper Dredger (TSHD) Brisbane and for this assessment it is assumed that the ongoing maintenance dredging will be undertaken by a similar dredger.

Capital dredging has historically been undertaken in the PoG as the Port has grown. Most recently, between 2011 and 2013, capital dredging associated with the construction of three (3) LNG terminals and the Wiggins Island Coal Terminal (WICT) was undertaken. Table 2 provides details of the maintenance and capital dredging, which has been undertaken at the PoG when sediment has been placed at the EBSDS over the last 12 years. It is important to note that the table does not include the volume of sediment removed from the Marina and a number of other areas of the PoG (e.g. Boyne River) as to date the sediment from these areas has been placed on land. Historic maintenance dredging of the Marina has included the removal of 352,000 m^3 (in-situ volume) in 2009 and 305,000 m^3 (in-situ volume) in 2015.

Table 1. PoG Channels and associated declared depths for maintenance dredging (GPC, 2015).

Channel	Declared Depth (m LAT)
Outer Harbour	
Wild Cattle Cutting	-16.1
Boyne Cutting	-16.1
Golding Cutting	-16.1
South Bypass Channel	-7.3
Gatcombe Channel	-16.3
Gatcombe Bypass	-12.5
Inner Harbour	
Auckland Channel	-15.8
Auckland Bypass	-6.8
Clinton Channel	-16.0
Clinton Bypass	-13.0
Targinnie Channel	-10.6
Jacobs Channel	-13.0
Marina	-4.5
WICT departure channel	-16.0

Table 2. PoG dredging volumes where sediment was placed at the EBSDS over the last 12 years.

Year	Maintenance Dredging (in-situ m^3)	Capital Dredging (in-situ m^3)
2007	160,972	
2008	17,995	
2009	282,000	
2010	0 (dredging was at start of 2011)	
2011	309,000	
2012	150,000	5,113,475
2013	0 (dredging was at start of 2014)	
2014	550,366	
2015	68,000	
2016	455,000	
2017	209,456	
2018	211,102	
2019	231,855	
Total (2007-2019)	**2,434,644**	**5,113,475**

Note: PoG Sea Dumping Permit requires to report in-situ cubic metres delivered by the dredger to the EBSDS. For maintenance dredging the in-situ cubic metres are derived from dredge logs hopper dry tonnes by applying a conversion of factor of 1.1 (e.g. 1 m^3 (in-situ) = 1.1 tonne (dry weight)).

Capital dredging has been reported as in-situ cubic metres, taken from contract documentation as calculated between pre-dredge hydrographic surveys and the contract design dredge depth. This calculation can be considered indicative of the amount delivered to EBSDS.

A breakdown of the volumes of sediment dredged throughout the different areas of the PoG during the 2019 annual maintenance dredging[2] is shown in Figure 3. The plot shows that almost 90,000 m^3 was removed from the Golding, Boyne and Wild Cattle Cuttings, approximately 100,000 m^3 was removed from the areas to the north of the RG Tanna Wharf (north of Clinton Channel, WICT berths, Targinnie Channel and Jacobs Channel/LNG Terminals region) and the remaining volume (approximately 46,000 m^3) was removed from the area between the RG Tanna Wharf and the eastern end of the Gatcombe Channel. As the PoG Sea Dumping Permit requires GPC to report the in-situ cubic metres that are delivered by the dredger to EBSDS, the reported dredge volumes and sedimentation (measured as the in-situ change in volume based on bathymetric data) will not correlate directly. This is because the dredge volumes placed at EBSDS do not include the volume of sediment which is removed from the seabed by the dredger and subsequently lost during overflowing when the dredger is filling its hopper. Based on monitoring during previous maintenance dredging and advice from expert dredging consultants, the efficiency of the TSHD Brisbane ranges from 50% to 70% when undertaking maintenance dredging in the PoG (BMT WBM, 2017), although this will vary significantly depending on the sediment type being dredged. This means that between 30% and 50% of the sediment which is dredged from the seabed is lost during the dredging due to overflow, drag head disturbance and propeller wash and of this amount it has been estimated that approximately 15% remains in suspension as a plume and the remainder is locally deposited back into the channel (BMT WBM, 2017). The sediment which is locally redeposited in the channel might subsequently be re-dredged, redistributed by bed levelling, settle into naturally deeper areas of the channel which don't require dredging or be transported away from the region by currents and be deposited outside of the dredged areas.

The PoG can be separated into Inner and Outer Harbour regions as different sediment transport processes influence them; the Outer Harbour region extends from the Wild Cattle Cutting to the Gatcombe Channel and the Inner Harbour is the area inshore from Auckland Channel, which is sheltered from offshore wave activity by Curtis and Facing Islands (Figure 2).

1.3. Report Structure

The report herein is set out as follows:

- background information relative to the proposed alternative option is provided in **Section 2**;
- development of the option is detailed in **Section 3**;
- a summary of the results from the numerical modelling is given in **Section 4**;
- the feasibility assessment of the option, along with recommendations, is presented in **Section 5**; and
- a summary of the key findings from this assessment is provided in **Section 6**.

Unless stated otherwise, levels are reported to Lowest Astronomical Tide (LAT). Volumes presented throughout are in-situ cubic metres calculated from surveyed bathymetry.

[2] Use of the term 'annual maintenance dredging' in this report refers to the maintenance dredging of the main channels, basins and berths of the PoG by the TSHD Brisbane each year and the subsequent placement of the sediment at EBSDS. This does not include the maintenance dredging of other areas where the sediment is currently placed on land (e.g. the Marina).

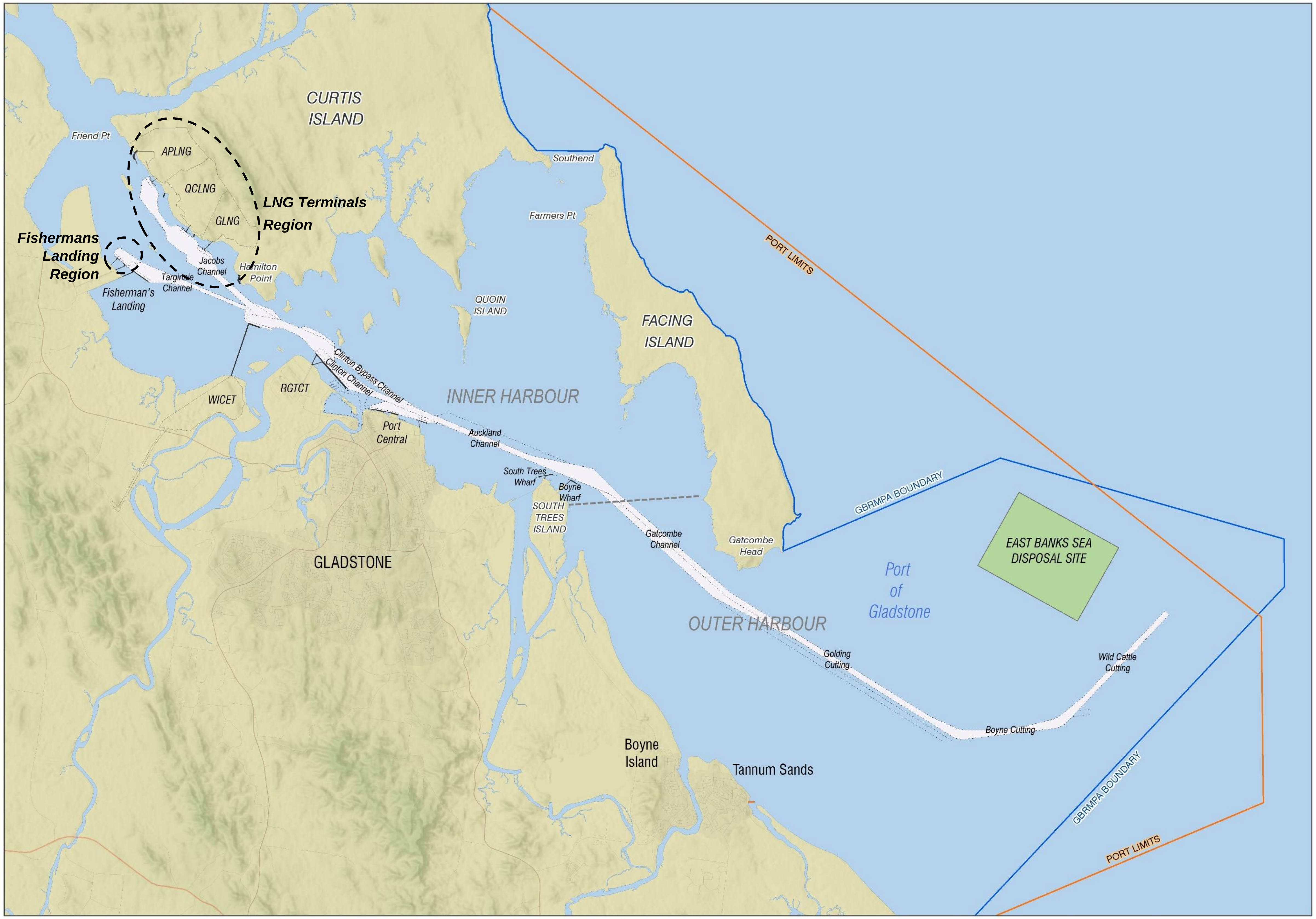

Figure 2. Port of Gladstone declared channels and sea disposal site.

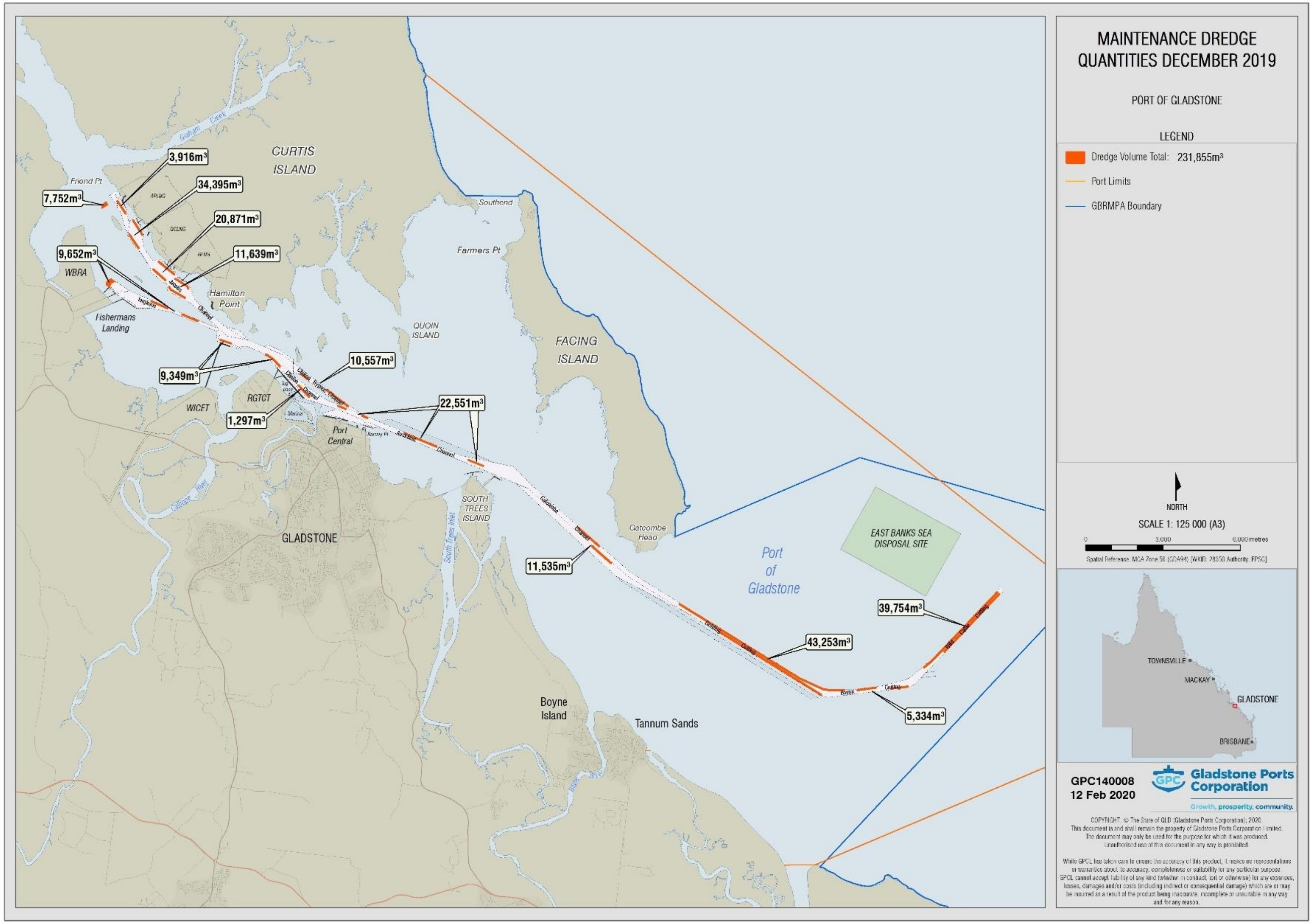

Figure 3. Port of Gladstone annual maintenance dredging volumes from 2019.

2. Background

This section provides details of the sustainable relocation option proposed as part of the reduce assessment for the PoG SSM Project (PCS, 2019a). In addition, further justification as to why the sediment management option is required is provided.

2.1. Option Details

Recent industry guidance has been promoting the approach of sustainable relocation where the dredged sediment is retained within the marine environment and within the natural sediment system (CEDA, 2010; RHDHV, 2016). This is because it has been recognised that the complete removal of dredged sediment (and especially sediment from maintenance dredging) from a natural system has the potential to alter the morphological evolution and ecological functioning of the system (Laboyrie *et al.*, 2018). Therefore, the overall aim of the sustainable relocation approach is to maintain and/or supplement the natural sediment supply to ensure the natural processes and habitats of the system are sustained.

As part of the stakeholder consultation process, all possible options were scored and the LNG sustainable relocation option came out as the equal second ranked option, with a score 5% higher than ongoing placement at EBSDS (Table 3).

Table 3. Summary of scores for existing alternative options (GPC, 2019).

Option	Score
Existing Approach – Placement at EBSDS	133
1) Offshore Beach Nourishment	143
2) Sustainable Relocation, LNG Terminals Region	139
2) Habitat Restoration, Seagrass	139
3) Sustainable Relocation, Marina	133
3) Habitat Restoration, Coastal	133
3) Jet Arrays	133
4) Onshore Beach Nourishment	130

2.2. Requirement

The PoG quantitative sediment budget developed as part of the SSM Project identified a potential for insufficient new sediment being available in Port Curtis to balance the deposition requirements to keep up with predicted future sea level rise (PCS, 2019b). As a result, the approach of sustainable relocation has been considered. The natural response of many intertidal habitats, such as mudflats and mangroves, to sea-level rise is to accrete to ensure that the elevation of the habitat relative to the tidal levels remains the same. However, the sediment budget predicted that there is the potential that some intertidal areas might not be able to accrete at a comparable rate to maintain a stable relative sea level. As such, if natural sediment which has recently deposited in dredged areas is consistently removed from the system and placed offshore in a retentive placement area, there is a risk that the habitats in Port Curtis cannot accrete as quickly as sea level rise, which could result in a change in both the flora and fauna in the area. Therefore, the approach for the PoG involves the dredging of recently deposited sediment and the subsequent release of it into the active sediment system, where some of it will subsequently be transported to areas which rely on an ongoing supply of sediment.

2.3. Analogues

The approach of sustainable relocation of dredged sediment is not a commonly practised solution in Australia, although there are a number of locations globally where it is adopted. Examples of three (3) analogues from Europe are provided below:

- Scheldt Estuary: in 2001 alternative relocation sites in subtidal areas near sandbars and in deep parts of secondary channels within the estuary were implemented (TIDE, 2013). The aim of these alternative relocation sites was to promote the morphological management of the estuary system and ensure that ongoing maintenance dredging did not result in a deficit of sediment to the system while also enhancing the functioning of ecosystems in the estuary. The majority of sediment which is dredged within the estuary is located to placement sites within the estuary, with almost 25 million m^3 relocated within the estuary in 2010. To help optimise and refine the relocation sites ongoing monitoring is undertaken which is used to help inform what type and volume of sediment is placed in them each year. The monitoring included a silt tracer study of four different sites to investigate the retention and dispersion of sediment from potential relocation sites. Research to investigate the morphological implications of placements in a channel to the adjacent intertidal zone found that there was an expansion of the intertidal zone and an increase in its bed level (de Vet *et al.*, 2020);
- Mud Motor: the Mud Motor was a pilot study developed in the Netherlands to test whether dredged sediment could be placed through sustainable relocation to provide a semi-continuous source of sediment to nearby saltmarsh areas (Figure 4). The aim of the mud motor was therefore to supplement and accelerate the natural marsh growth without resulting in a direct disturbance. Numerical modelling was undertaken to determine the preferred location for the placement site, which was in a natural tidal channel which leads to the intertidal area requiring regeneration. The average annual maintenance dredging volume of the adjacent Port of Harlingen is 1.3 million m^3 and as part of the Mud Motor pilot study approximately 300,000 m^3 and 170,000 m^3 was placed at the Mud Motor placement site in 2016 and 2017 respectively, with the remaining volume being placed at the other approved placement sites (Baptist *et al.*, 2019). The dredged sediment was placed by bottom dumping through the hopper doors. Extensive monitoring was undertaken as part of the pilot study, which included the release of 100 kg of very fine tracer particles in two (2) different colours mixed with the dredge material in the hopper of the dredger and released at two (2) sites, in-situ loggers and repeat bathymetric surveys. Results from the monitoring showed that sediment was transported from the Mud Motor placement site to the intertidal area requiring regeneration, but it was not possible to prove that the mud motor contributed to increased sedimentation in this area (partially due to the high natural variability) (Baptist *et al.*, 2019). It is worth noting that the results from the tracer study showed that the approach resulted in more sediment being transported onto the intertidal areas towards the high water areas and with consistent increase in deposition over time compared to the modelling which predicted more transport in an alongshore direction and limited deposition on the upper intertidal areas. It was noted that following the cessation of placement at the Mud Motor in 2017, no long - term effect from the Mud Motor was observed. This could be related to limitations in the field monitoring or could indicate that the sediment placed at the Mud Motor had already been transported away from the placement site and was likely widely dispersed over a large area. Therefore, it is possible that for a beneficial reuse approach such as this to result in measurable benefits it is necessary for the activity to continue for a longer period, with a larger total volume of sediment being placed; and
- Humber Estuary: high suspended sediment concentrations (SSC) in the Estuary mean that substantial maintenance dredging is required in a number of locations. The whole of the Humber Estuary (subtidal and intertidal), including the navigation channels, has been designated as an area of nature conservation importance under the European Union (EU) Habitats and Birds Directives. One of the listed features is the Estuary status which means that the structure and functioning of the Estuary is protected. Scientists are of the

opinion that sediment is naturally being lost from the Estuary and that this is hindering the ability of the mudflats and saltmarsh to accrete in line with sea level rise. This is causing deterioration in the status of these habitats and reducing the favourable condition of the whole Estuary. Therefore, if the sediment removed by maintenance dredging is also removed from the system the effect would be exacerbated. Placement sites within the Estuary were therefore identified, with many of these specifically selected to be dispersive (Figure 5). It was subsequently found that sediment placed in the dispersive sites was generally transported into the background suspended sediment load quickly (over a single tidal cycle). The dredged sediment is released as close as possible to the location where it was dredged to help maintain the sediment in the system so that it can continue to carry out its natural morphological functions (SedNet, 2014). Approximately 7 million m^3 is deposited annually within the Estuary system at the designated placement sites (CEDA, 2010).

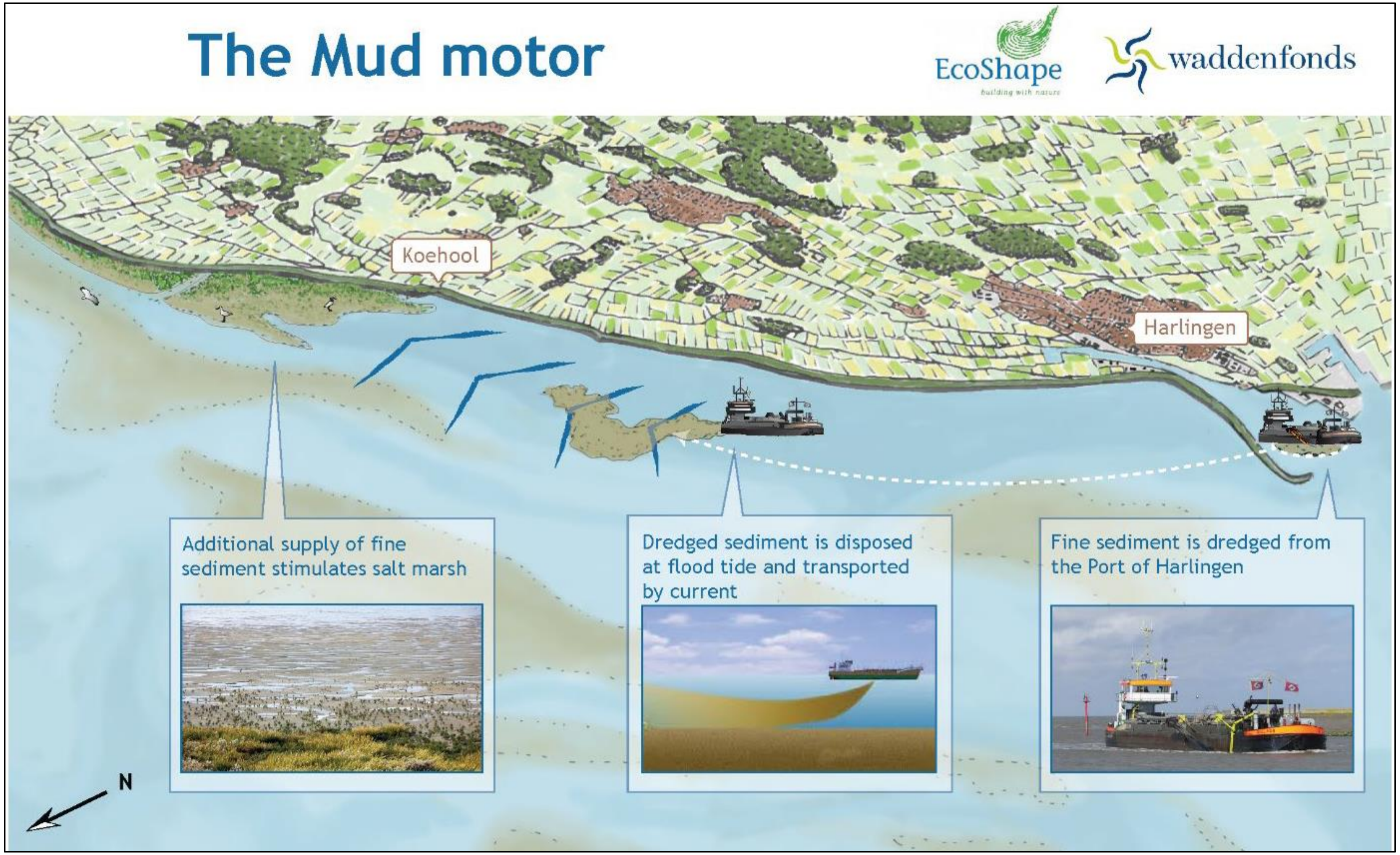

Figure 4. Schematic showing the Mud Motor approach. (Baptist *et al.*, 2019).

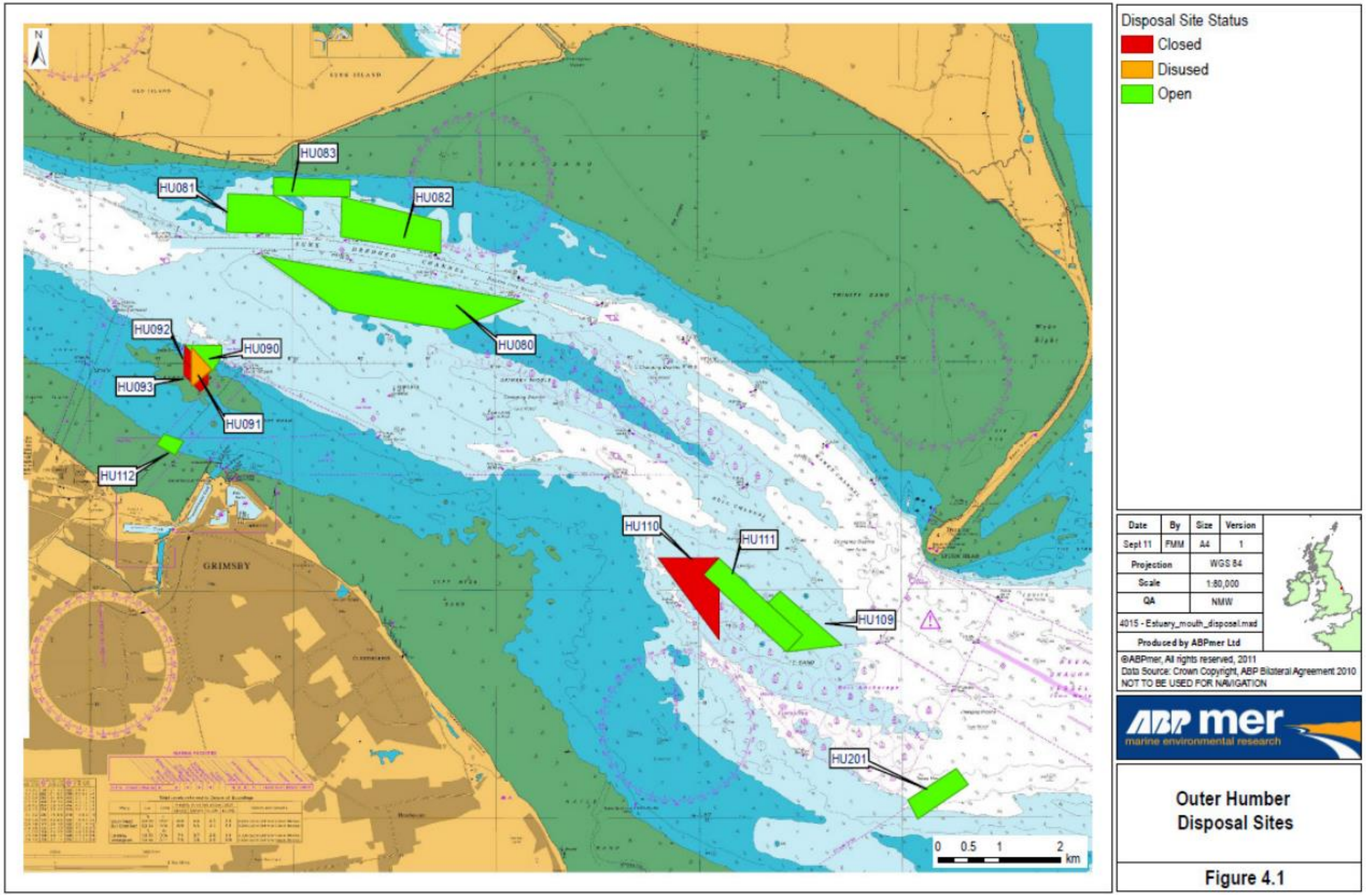

Figure 5. Dredge material disposal sites in the Outer region of the Humber (Lonsdale, 2013).

3. Option Development

For this feasibility assessment, it is necessary to further develop and refine the LNG region sustainable relocation option. The option development includes confirming the proposed placement site boundary, detailing the type, volume and frequency of sediment, specifying the dredging approach and estimating the cost relative to ongoing maintenance dredging and placement at EBSDS.

As part of the option development, the operators of the TSHD Brisbane as well as other dredging contractors have been consulted to ensure that the placement site location and the dredging approach are realistic.

As previously noted in Section 2.1, the option is aimed at keeping sediment in the natural system to help maintain and/or supplement the natural sediment supply to ensure the natural processes and habitats of the system are sustained.

3.1. Site Selection

As part of the PoG SSM Project reduce assessment a potential sustainable relocation site for sediment from the LNG region was identified in the channel adjacent to Tide Island (PCS, 2019a). The site was selected on the basis of the following:

- it is naturally dispersive with very high tidal current speeds. This will mean that any sediment placed at the site should be transported away and there will be little to no build-up of sediment within the relocation site;
- it is located relatively close to the LNG region (similar sediment type) and where sediment has the potential to be transported to a number of different mudflat, intertidal and mangrove regions. Being close to the LNG region will allow the approach to be efficient in terms of dredge cycle times. Sediment having the potential to be transported to numerous mudflat, intertidal and mangrove regions means the site has the potential of fulfilling its aim of supplying sediment to existing natural habitats in the region;
- it is a naturally deep section of channel which has approximately 1 million m^3 of capacity below declared depths. This means that if some of the sediment placed in the relocation site is retained the approach will not influence navigation; and
- it is located within the PoG designated channels and was previously used as a placement site for capital dredging in 1981. There is some uncertainty associated with the approval process required for the approach as it will involve dredged sediment being placed outside of the designate offshore placement site, but the site being located within the designated channels and having been used as a previous placement site could simplify the approval process.

Within the PoG there are limited areas where the designated channels are naturally deeper than the declared depths (only the southern area of the Auckland Channel and parts of the Gatcombe Channel), with no other areas having such a large capacity below the declared depths and no other areas close to the LNG region. Therefore, based on the above the Tide Island site proposed in the reduce assessment is still considered the most suitable for placing dredged sediment from the LNG region at this stage. The proposed location of the dredge material placement area (DMPA) is shown in Figure 6 along with the bathymetry which shows depths in the DMPA are mainly between 18 and 22 m below LAT.

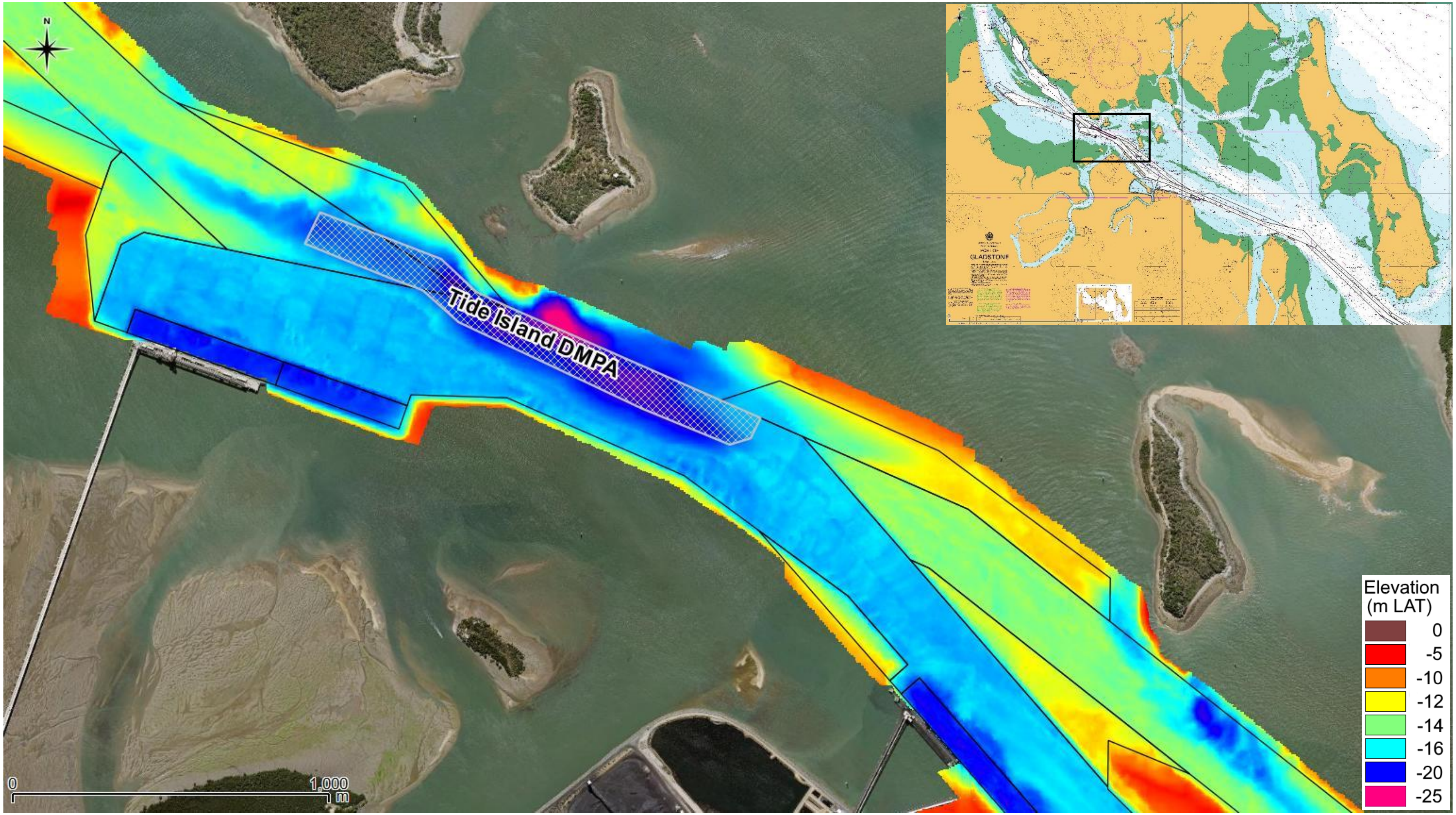

Figure 6. Proposed sustainable relocation dredge material placement site for the LNG region.

3.2. Sediment Requirements

As the primary aim of the sustainable relocation approach is to keep sediment, which is removed from the channels by maintenance dredging, in the natural sediment system, it is important that sediment which is placed at the proposed DMPA will have the potential to subsequently be resuspended and transported away from the area. As such, the sediment placed at the DMPA should be fine-grained silt and clay which can be transported in suspension.

Based on previous sediment sampling, including sampling specifically targeting areas of ongoing sedimentation, sediment from the aprons and berths of the LNG Terminals (herein referred to as the LNG Terminals) is predominantly fine-grained (~90% silt and clay and ~10% sand) along with sediment from the Fishermans Landing berths 4 and 5 and the adjacent northern end of Targinnie Channel (herein referred to as the Fishermans Landing region) (see Figure 2 for region locations). The sediment from these two (2) ocations are therefore considered to be potentially suitable for placement at the Tide Island DMPA. Based on the analysis of historic bathymetric data relative to design depths, the total maintenance dredging requirement of the LNG Terminals has been estimated to be between 150,000 and 190,000 m^3/yr, while the Fishermans Landing region has been estimated to be between 2,000 and 20,000 m^3/yr (PCS, 2018).

The reported volume of sediment relocated from these two (2) areas to EBSDS by recent maintenance dredging campaigns is lower than the calculated maintenance dredging requirements detailed above (LNG Terminals average = 65,000 m^3 and Fishermans Landing region average = 10,000 m^3). As noted in the quantitative sediment budget the in-situ volume change in the LNG Terminals region, calculated based on pre- and post-dredging bathymetric surveys, during recent maintenance dredging campaigns was similar to the maintenance dredging volumes calculated based on the historical sedimentation (PCS, 2019b). For example, in 2017 approximately 210,000 m^3 was calculated as the in-situ change in volume in the LNG Terminals due to the maintenance dredging compared to approximately 68,000 m^3 which was reported based on the dredge logs as having been relocated to EBSDS. There are two (2) reasons for this (PCS, 2019b):

- the reported dredge volumes placed at EBSDS do not include the volume of sediment which is removed from the seabed by the dredger and subsequently lost during overflowing when the dredger is filling its hopper. As noted in Section 1.2 this could result in an underestimation of up to 50%; and
- the PoG wide average conversion factor of 1.1 tonne of dry sediment in the hopper of the dredger being equal to 1 m^3 in-situ volume will vary depending on the sediment type, with a lower conversion for fine-grained silt and clay (e.g. 0.5) and a higher value for sand and gravel sized sediment (e.g. 1.6). Therefore, for areas where the sediment was predominantly fine-grained silt and clay like the LNG Terminals region the in-situ volume of the sediment transported by the dredger to EBSDS could be more than double the ins-situ volume calculated using the conversion factor of 1.1.

Based on the above, the volume of fine-grained silt and clay which will require ongoing maintenance dredging in the LNG Terminal and Fishermans Landing regions is estimated to be in the region of 150,000 to 200,000 m^3/yr (in-situ volume).

As part of the reduce assessment of the PoG SSM Project it was proposed that half of the annual sedimentation which requires management in the LNG region could be managed through sustainable relocation and placed at the Tide Island DMPA, while the other half continues to be placed at EBSDS. However, if the sustainable relocation of sediment at the Tide Island DMPA is successful (i.e. it does not result in a significant increase in sedimentation in any dredged areas or any impacts to sensitive receptors and no tidal constraints are identified for the placement), then a larger volume could potentially be placed at the site. As has been the case with the sustainable relocation in the Scheldt Estuary, it would be beneficial to continue monitoring the placement over time to help optimise it and determine how much sediment could be placed at the site. It could therefore be feasible (and beneficial) for all of the fine-grained sediment dredged from the LNG Terminals and Fishermans Landing region to be placed at the Tide Island DMPA each year.

3.3. Dredging Approach

The proposed dredging approach for this option is similar to the dredging approach for placing sediment at EBSDS with the following differences:

- the Tide Island DMPA is 5 km away from the LNG Terminals region compared to 45 km for EBSDS. Based on this the travel time from the LNG Terminals region to the placement sites (assuming a fully laden vessel speed of 10 knots) would be 15 minutes for the Tide Island DMPA and 2 hours 30 minutes for EBSDS; and
- due to the close proximity of the Tide Island DMPA to the LNG Terminals region, minimal overflow would be required as the short dredge cycle time would mean it was unnecessary to try and fill the hopper with as much sediment as possible through overflowing. In contrast, due to the long distance to EBSDS from the LNG Terminals region, longer duration overflow is necessary to ensure the hopper is filled to capacity with sediment. Based on this it has been assumed that the average dredging time for sediment placed at the Tide Island DMPA is 30 minutes (10 minutes overflow), while for sediment placed at EBSDS it has been assumed to be 60 minutes (40 minutes overflow).

The placement of the dredged sediment at the Tide Island DMPA would be undertaken in a similar way to how sediment is currently placed at EBSDS, with the dredger opening the hopper doors and releasing the sediment while sailing through the DMPA. Similar to the placement at EBSDS it is assumed that the placement would take 10 to 15 minutes.

3.4. Cost Estimate

To estimate the time and cost implications of the LNG Terminals region sustainable relocation approach compared to ongoing placement at EBSDS, it is necessary to determine the volume of sediment that would be placed at the Tide Island DMPA. As noted in Section 3.2 the volume of sediment placed there would be dependent on results from an initial pilot study, but over time the full volume of sediment from the LNG Terminals and Fishermans Landing regions of 150,000 to 200,000 m^3/yr could potentially be placed there. For the cost estimate two (2) volumes have been assumed, 75,000 m^3/yr and 150,000 m^3/yr. The following additional assumptions have also been made:

- the TSHD Brisbane sails at an average speed of 10 knots when fully laden and 12 knots when unladen;
- the dredger has a hopper capacity of 2,900 m^3 and the average duration to fill the hopper when placing sediment at EBSDS is one (1) hour (including 40 minutes of overflow), with the dredger having removed on average 2,000 m^3 of in-situ sediment during this time[3]. The average duration to fill the hopper when placing sediment at the Tide Island DMPA is 30 minutes (including 10 minutes of overflow), with the dredger having removed on average 1,000 m^3 of in-situ sediment during this time;
- the average distance from the LNG Terminals region to EBSDS is 45 km and from the LNG region to the Tide Island DMPA it is 5 km;
- the average daily operational downtime for the dredger is 10%;
- the daily dredging cost (assuming the TSHD Brisbane and including associated bed levelling and surveying costs) is approximately $100,000. This does not include any

[3] This value takes into account the additional sediment which is removed from the seabed by the dredger but subsequently lost from the dredge hopper by overflow. The value has been estimated based on a comparison of dredge logs and in-situ bathymetric changes during previous maintenance dredging campaigns.

allowance towards the mobilisation of the vessel as the dredging would only constitute a portion of the annual maintenance dredging; and

- it would take the dredger 15 minutes to bottom dump (either at EBSDS or at the Tide Island DPMPA).

Based on the above assumptions, the duration of time and associated costs for the maintenance dredging of 75,000 m^3 and 150,000 m^3 of sediment from the LNG Terminals region has been estimated for the two (2) placement options below:

- EBSDS: the placement of 75,000 m^3/yr of sediment from the LNG Terminals region to EBSDS is estimated to take approximately 10 days to complete and cost $990,000. Dredging double the volume would double the time (20 days) and cost ($2.0 million); and
- Tide Island DMPA: the placement of 75,000 m^3/yr of sediment from the LNG Terminals region to the proposed Tide Island DMPA is estimated to take 4.3 days to complete and cost $430,000. Dredging double the volume would double the time (8.6 days) and cost ($860,000).

4. Numerical Modelling

To further assess the feasibility of the LNG Terminals region sustainable relocation option, numerical modelling has been undertaken by BMT (BMT, 2020). The aims of the modelling are:

- to optimise the approach to minimise sedimentation within the dredged areas of the PoG;
- to predict any impacts due to plumes resulting from the initial placement of the sediment; and
- to predict the subsequent transport and ultimate fate of the sediment.

Therefore, the modelling will help to determine whether the approach could impact any sensitive receptors and will also help to determine the likelihood of the sediment being transported to intertidal and subtidal habitats that require ongoing sedimentation.

The numerical model adopted for this study was the same BMT TUFLOW FV model of the PoG which was adopted as part of the PoG SSM Sediment Budget assessment (BMT, 2019a). The model has undergone extensive calibration and validation processes as part of previous projects, with the most extensive being as part of the Gatcombe and Golding Cutting Channel Duplication Project EIS (BMT, 2019b). The calibration and validation has included the following:

- Hydrodynamics: long-term water level and Acoustic Doppler Current Profiler (ADCP) current profile data as well as current velocities across key transects over a full tidal cycle;
- Waves: long-term data from the Gladstone waverider buoy as well as data from ADCPs;
- Sediment Transport: the ambient (natural) sediment transport model was calibrated and validated using more than 12 months of in-situ measured turbidity data. However, the model has not been calibrated for erosion/deposition and so uncertainty remains as to the accuracy of the model for these parameters; and
- Dredge Plume: the source terms of plume generation during dredging activities have been developed over a period of time and are based on input from expert dredging consultants and measurements carried out during monitoring of dredging activity by boat-mounted ADCP (BMT WBM, 2017).

The model was further refined and validated as part of the SSM Project, and an additional model calibration exercise was undertaken using data collected specifically as part of the SSM Project during monitoring campaigns in 2018 and 2019 (BMT, 2019a). This included additional data from in-situ monitoring during both natural conditions and over the duration of a maintenance dredging campaign and ADCP transects during natural conditions.

Despite the extensive model calibration and validation exercises which have been undertaken it was noted as part of the PoG Sediment Budget that there were limitations and uncertainties with the numerical model (PCS, 2019b). These were mainly due to the complexities of the processes which the model is trying to replicate and were specifically associated with sediment transport and the erosion and deposition of sediment. Therefore, the results from the numerical modelling can be used to assist in the feasibility assessment by providing an indication of the potential behaviour of the placed sediment, but it must be noted that there is some uncertainty in the results. Despite these uncertainties it is considered that the model can be used as a tool to compare different placement options and can therefore be used to help determine whether alternative placement options might be feasible.

4.1. Optimisation

To determine whether the sedimentation resulting from the placement of dredged sediment at the Tide Island DMPA differs significantly as a result of when during the tide the sediment is placed, initial placement optimisation simulations were undertaken using the numerical model. Separate model simulations have been undertaken with a single load of sediment placed at the Tide Island DMPA during either the flooding tide or at high water or during the ebbing tide or at low water during a spring tide. Each simulation was then run for a week following the placement to allow the subsequent transport of the sediment to occur. The simulations assume that 85% of the placed sediment goes straight to the seabed and that 15% of the sediment remains in suspension as a plume in the water column where it is subsequently advected, dispersed and eventually deposited.

A summary of the results from the simulations is shown in Table 4. The results show that between 9% and 12% (average 11%) of the sediment placed at the Tide Island DMPA is predicted to be deposited in the PoG channels one (1) week after the sediment was placed at the DMPA. In addition, between 13% and 15% of the placed sediment is predicted to remain within the DMPA area one (1) week after being placed. The results show that the time of release does not alter the amount of the sediment predicted to be deposited in sensitive receptor locations, with 5% predicted to be deposited in areas where seagrass has historically been observed and 0% predicted in coral reefs. The reason that there is relatively little difference between the different release times is that the majority of the sediment (85%) is placed on the seabed and this sediment will be gradually eroded over multiple tidal cycles, meaning that sediment released on the flood and ebb tide will both be subject to resuspension and transport during subsequent opposite stages of the tide. The deposition in historical seagrass regions is not expected to be a direct concern as seagrass meadows can tolerate relatively high natural deposition, but this will be further assessed as part of the longer duration model simulation and would also need to be confirmed through targeted monitoring during any pilot studies or trials. The modelling predicts that the longer-term fate of all the sediment placed at the Tide Island DMPA (the suspended sediment in the plume and the sediment which falls straight to the seabed in the DMPA) is similar regardless of when in the tide the sediment was placed. However, the short-term advection and dispersion of the plume resulting from the placement of sediment at the Tide Island DMPA differs depending on the state of the tide and the resultant tidal currents.. Therefore, as the modelling results show only small differences in the amount of sediment predicted to be deposited in the dredged channels of the PoG, and no difference in the deposition in sensitive receptors, no tidal constraint is required for the longer duration model simulation. This means that the modelling will assume that the dredger can place sediment throughout the tidal cycle at the Tide Island DMPA.

Table 4. Percentage of placed sediment deposited in different areas.

Release Time	Channels (%)[1]	Historical Seagrass (%)	Reefs (%)
High Tide	9	5	0
Ebb Tide	10	5	0
Low Tide	11	5	0
Flood Tide	12	5	0
Average	11%	5%	0%

[1] the area of the Tide Island DMPA is excluded from the channel area. Between and 13% and 15% of the sediment was in the Tide Island DMPA at the end of the simulation.

4.2. Assumptions

The numerical modelling has been undertaken to represent the placement of sediment as realistically as possible based on the details provided in Section 3. Based on the placement optimisation model simulations detailed in Section 4.1 it has been assumed that placement can occur at the Tide Island DMPA throughout the tide. A number of additional assumptions have also been required:

- separate model simulations have been undertaken for the placement of 40,000 m^3 (in-situ volume) of sediment from the LNG Terminals region to either the Tide Island DMPA (dredge duration of two (2) days) or to EBSDS (dredge duration of five (5) and a half days). A smaller volume was selected for the modelling compared to the volumes used for the cost estimate, so that the results would be representative of a volume which might be placed at the Tide Island DMPA following a successful pilot study as opposed to the full volume of sediment which could ultimately be placed at the site;
- the simulations included the release of sediment from both the dredging and placement activities;
- source terms adopted for the modelling were from rates derived based on monitoring during previous maintenance dredging campaigns undertaken by the TSHD Brisbane as previously noted in Section 4 (BMT WBM, 2017). It was assumed that 2% of the fines in the sediment was released by the draghead and propwash, 12% of the fines was released by the overflow and that for the placement 85% of the load went straight to the seabed and 15% of the load formed a plume in the water column which was evenly distributed through the water column (BMT, 2020); and
- the model simulations were three-months in duration, from 01/09/2019 to 01/12/2019.

The placement at EBSDS assumes that the dredging would be 60 minutes per load with 40 minutes of overflow (replicating the current maintenance dredging approach), while the placement at the Tide Island DMPA assumes the dredge activity would be 30 minutes per load with only 10 minutes of overflow. The reason for the difference is related to differences in the dredge cycle times. The longer dredge cycle time (just over six (6) hours) when sediment is placed at EBSDS means that the dredger has to ensure the hopper is as full as possible for efficiency purposes. The dredge cycle is five (5) times shorter for the placement at the Tide Island DMPA and as the aim of the option is for the placed sediment to be transported away following placement it is preferable for the hopper to not be completely full to capacity to limit consolidation of sediment in the hopper.

4.3. Results

A summary of the key modelled results for the two (2) placement options is provided in the following sections. Further details of the modelling results can be found in BMT (2020).

Plots of the model results have been provided by BMT as both map plots showing the spatial extent of the turbidity and deposition and time series plots showing how the SSC and deposition vary over time. Time series plots have been created at sensitive receptor sites located within Port Curtis (Figure 7).

Modelling results of suspended sediment have been provided by BMT in both nephelometric turbidity units (NTU) and SSC in mg/l. The conversion factor adopted by BMT to change between these two (2) units was 1.6 (e.g. 1 NTU = 1.6 mg/l), this was developed based on previous water quality monitoring and sampling in the PoG (BMT WBM, 2016). It is important to note that it is not possible to develop a standard conversion between NTU and SSC. The conversion will vary depending on factors such as the instrumentation, sediment type and the natural and anthropogenic conditions and therefore it is proposed that a new conversion will be developed as part of any future monitoring undertaken for the PoG feasibility studies.

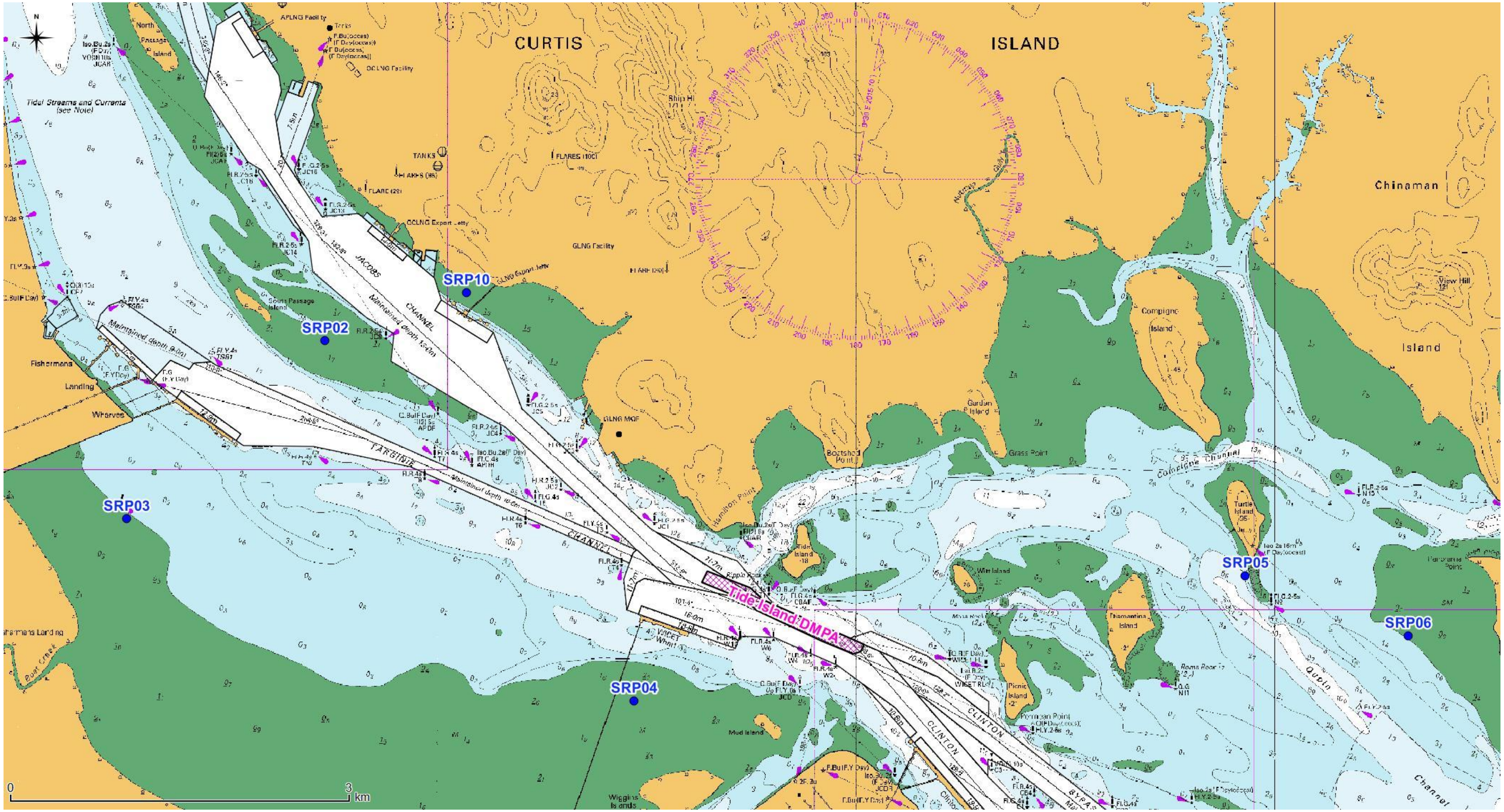

Figure 7. Location of sensitive receptor model output points relative to the Tide Island DMPA.

4.3.1. Tide Island DMPA

To show the model predicted spatial distribution of turbidity resulting from the option, the maximum 95th percentile turbidity was calculated over a two-week sliding window over the course of the three-month simulation. The 95th percentile represents the value that the turbidity was below for 95% of the time over the two-week window, and then the maximum value for each model cell was selected out of all the two-week sliding windows included in the three-month simulation. The model predicted maximum 95th percentile turbidity as well as the predicted final deposition thickness at the end of the three month simulation are shown in Figure 8 and Figure 9, respectively. The model predicted deposited sediment present in various areas at the end of the three-month simulation is summarised in Table 5.

The turbidity plot shows that the only areas where the turbidity is predicted to exceed 6 NTU are the Tide Island DMPA and in the Auckland Channel. The 95th percentile turbidity shows that suspended sediment is predicted to be transported through the main channels of the PoG extending north of the LNG Terminals and to the southern entrance of Port Curtis. Away from the main channels the turbidity is predicted to remain low, with 95th percentile values of less than 2 NTU present throughout much of Port Curtis.

The final deposition plot shows that the model predicts widespread deposition within Port Curtis, with deposition predicted over large areas of intertidal and subtidal away from the main channels. The summary of deposited sediment (Table 5) shows that less than 5% of the placed sediment was predicted to be retained within the DMPA, although an additional 10% was predicted to remain close to the DMPA. In addition, more than 10% of the sediment is predicted to be deposited in the historic intertidal seagrass regions. The results also show that just over 10% of the placed sediment is predicted to be deposited in the dredged channels of the PoG, with the majority of this (9.3%) predicted to be in the Jacobs Channel region (including LNG Terminal berths and aprons). A small amount of the sediment (0.1%) is predicted to be deposited at the coral reefs in Port Curtis, with the main area of coral reef at risk of increased deposition being the coral surrounding Turtle Island.

Time series plots of the model predicted SSC and deposition resulting from natural conditions, the dredging and associated placement at Tide Island DMPA are shown at the closest sensitive receptors to the Tide Island DMPA in Figure 10 to Figure 13. The plots show the following:

- the turbidity and deposition resulting from the dredging and placement at Tide Island DMPA are predicted to be low relative to the natural conditions at the closest sensitive receptor to the Tide Island DMPA (seagrass at SRP04, which is approximately 1.5 km to the south-west of the DMPA);
- the sensitive receptors where the increases in turbidity due to the dredging and placement are predicted to be largest are the two (2) seagrass sites adjacent to the LNG Terminals (SRP02 adjacent to South Passage Island and SRP10 adjacent to the GLNG berth). At these two (2) sites the increase in turbidity during the dredging and placement period (first two (2) days) is predicted to be comparable to the natural turbidity during spring tides (peaks of 15 to 20 mg/l). Two (2) weeks after dredging and placement the increase in turbidity due to the dredging and placement and subsequent reworking of this sediment is predicted to generally be below 5 mg/l at these sites as the sediment is dispersed and some of the sediment transported away from the area, while the natural turbidity can still reach 15 to 20 mg/l during spring tides. There is also predicted to be an increase in deposition over the first month following placement at SRP02 (no net sedimentation at SRP10), with up to 0.2 mm predicted to be deposited while the natural sedimentation over this period is predicted to be 0.1 mm; and
- increases in turbidity and deposition at the closest coral reef at Turtle Island (SRP05) are predicted to be relatively small (<5 mg/l and <0.05 mm) compared to the natural conditions (up to 25 mg/l and up to 0.2 mm).

Table 5. Deposited sediment in different areas at the end of the Tide Island DMPA model simulation.

Area	Mass (t)	% of Total Mass
Tide Is DMPA	1,750	5
Tide Is region[1]	3,540	10
Seagrass in Port Curtis	4,100	12
Coral in Port Curtis	50	0.1
Coral offshore of Port Curtis	0	0
PoG Dredged Areas[2]	3,640	10

[1] *this relates to an area extending between 200 m and 500 m from the Tide Island DMPA in all directions.*
[2] *this excludes the Tide Island region.*
Note: total mass released as part of the simulation = 35,500 tonnes.

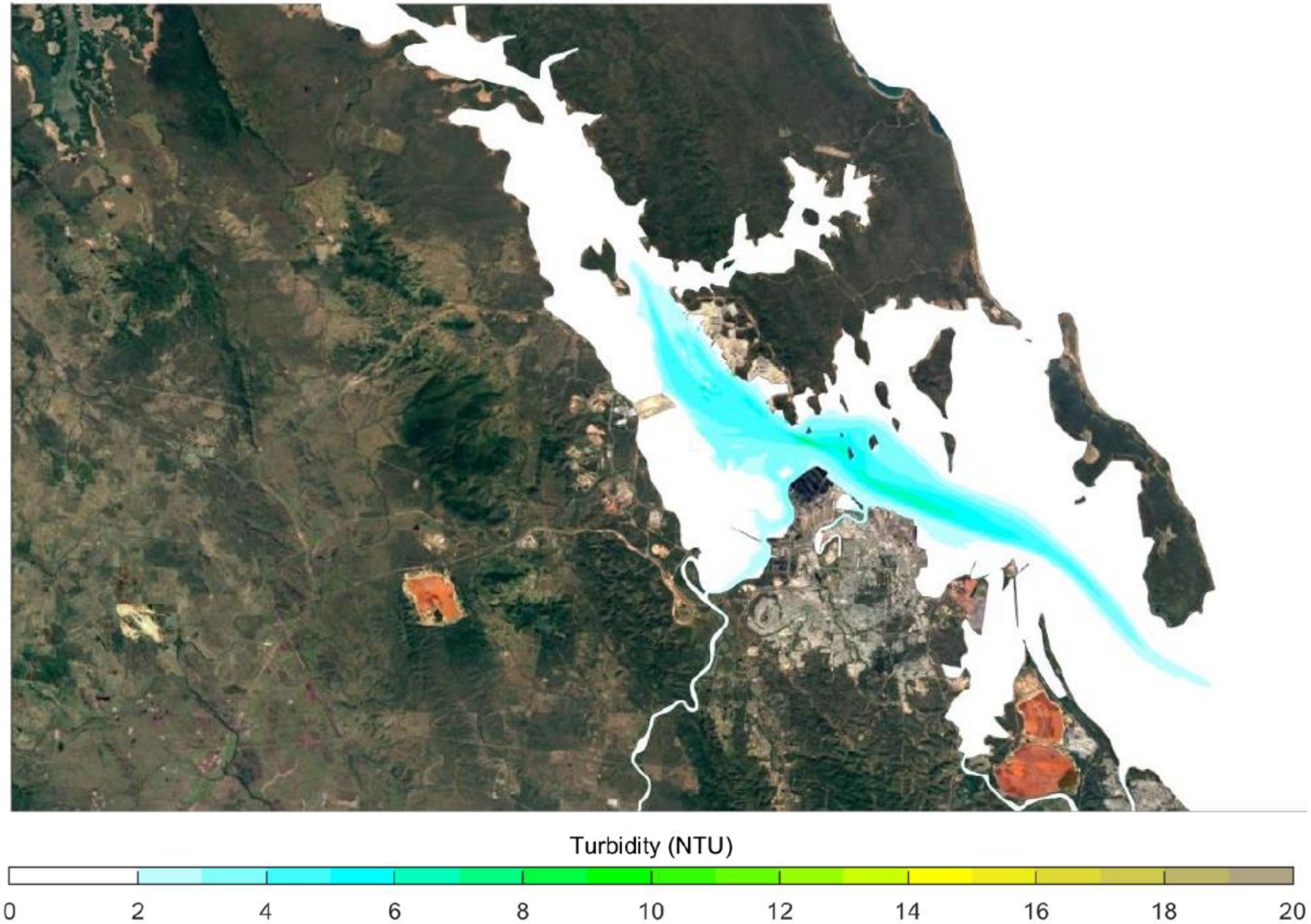

Figure 8. Maximum 95th percentile turbidity over two weeks for the placement activity at the Tide Island DMPA (BMT, 2020).

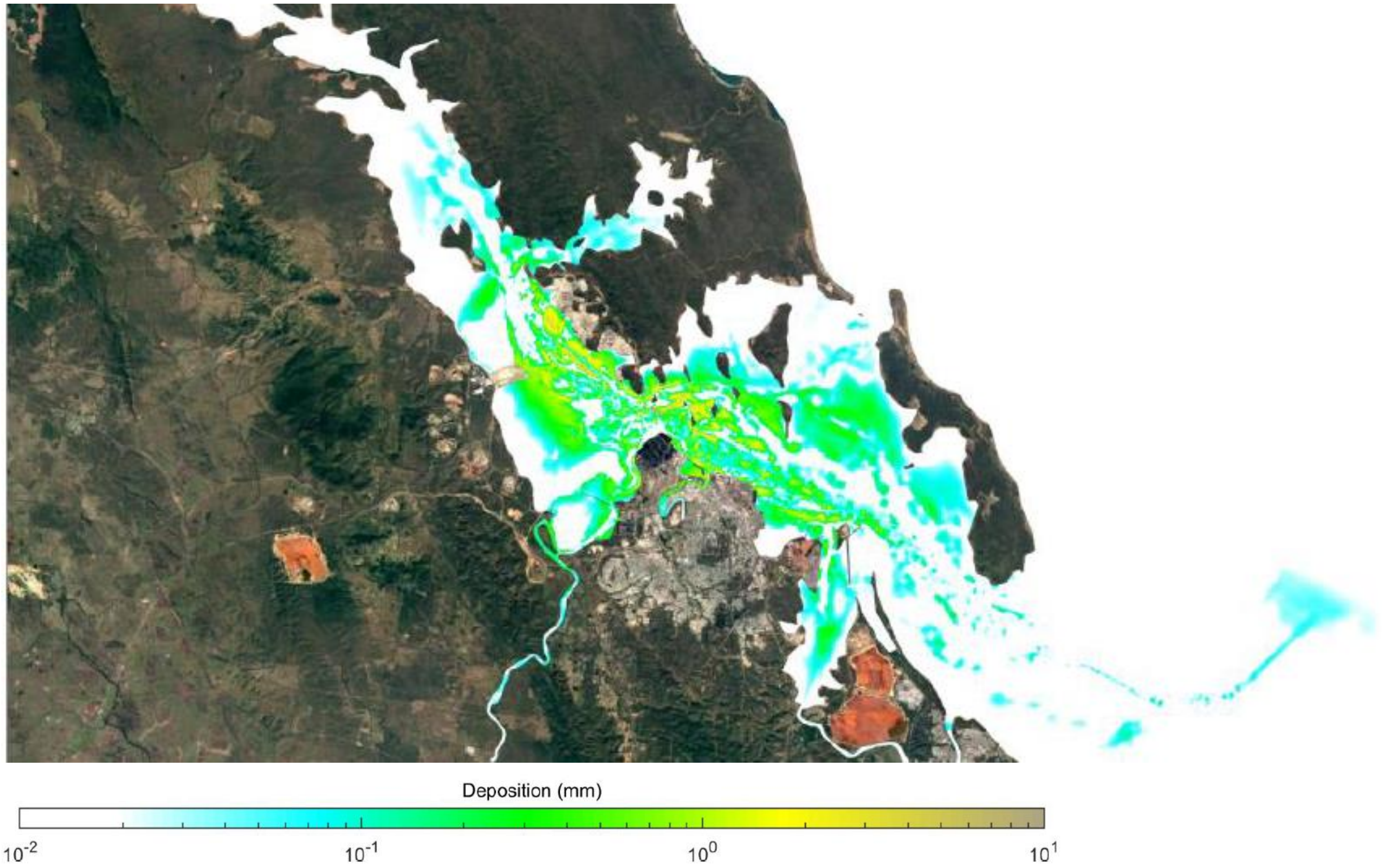

Figure 9. Final deposition of the sediment placed at the Tide Island DMPA after three months (BMT, 2020).

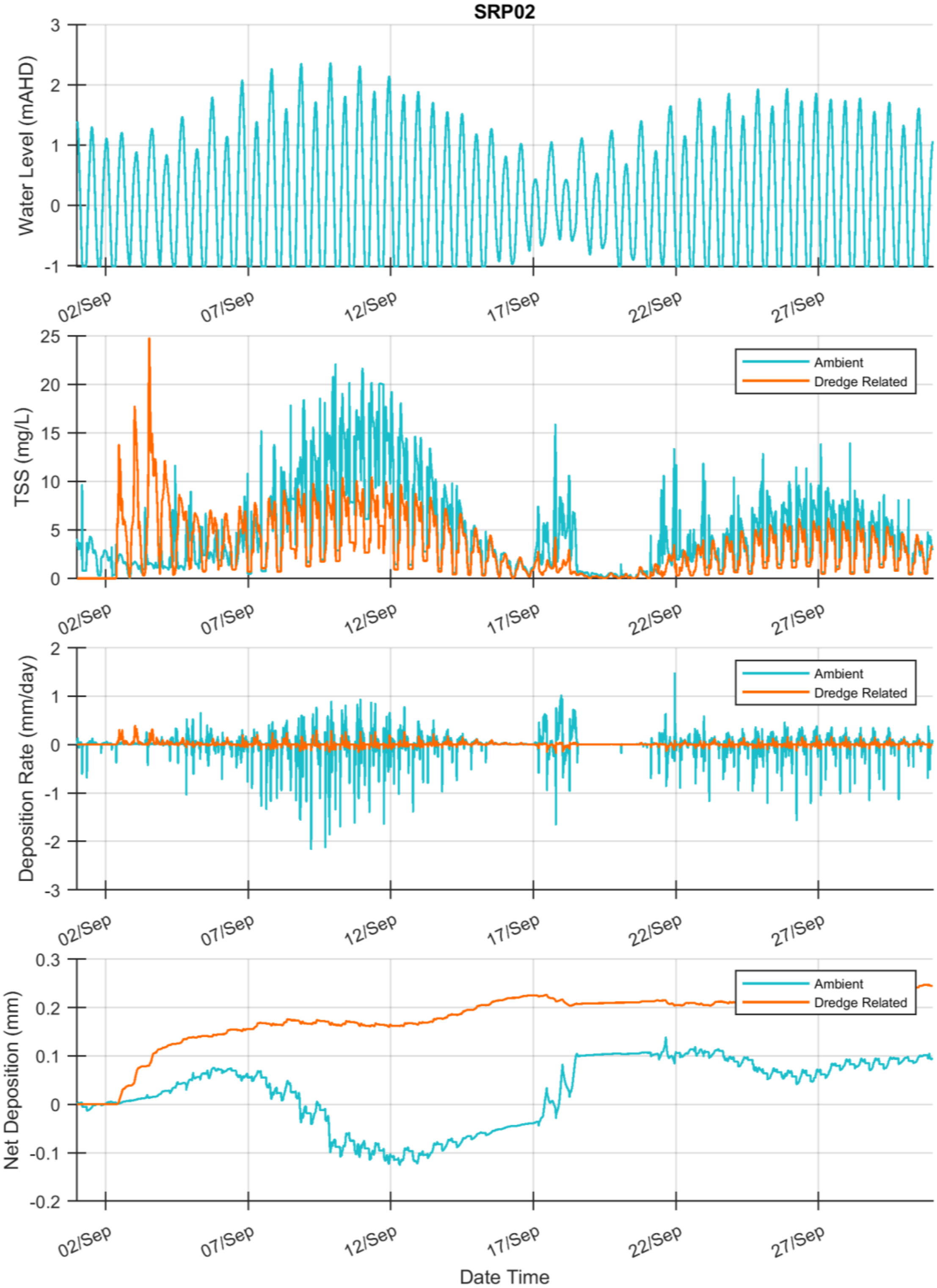

Figure 10. Time series showing natural (ambient) and dredge related SSC and deposition at SRP02 for when sediment is placed at the Tide Island DMPA (BMT, 2020).

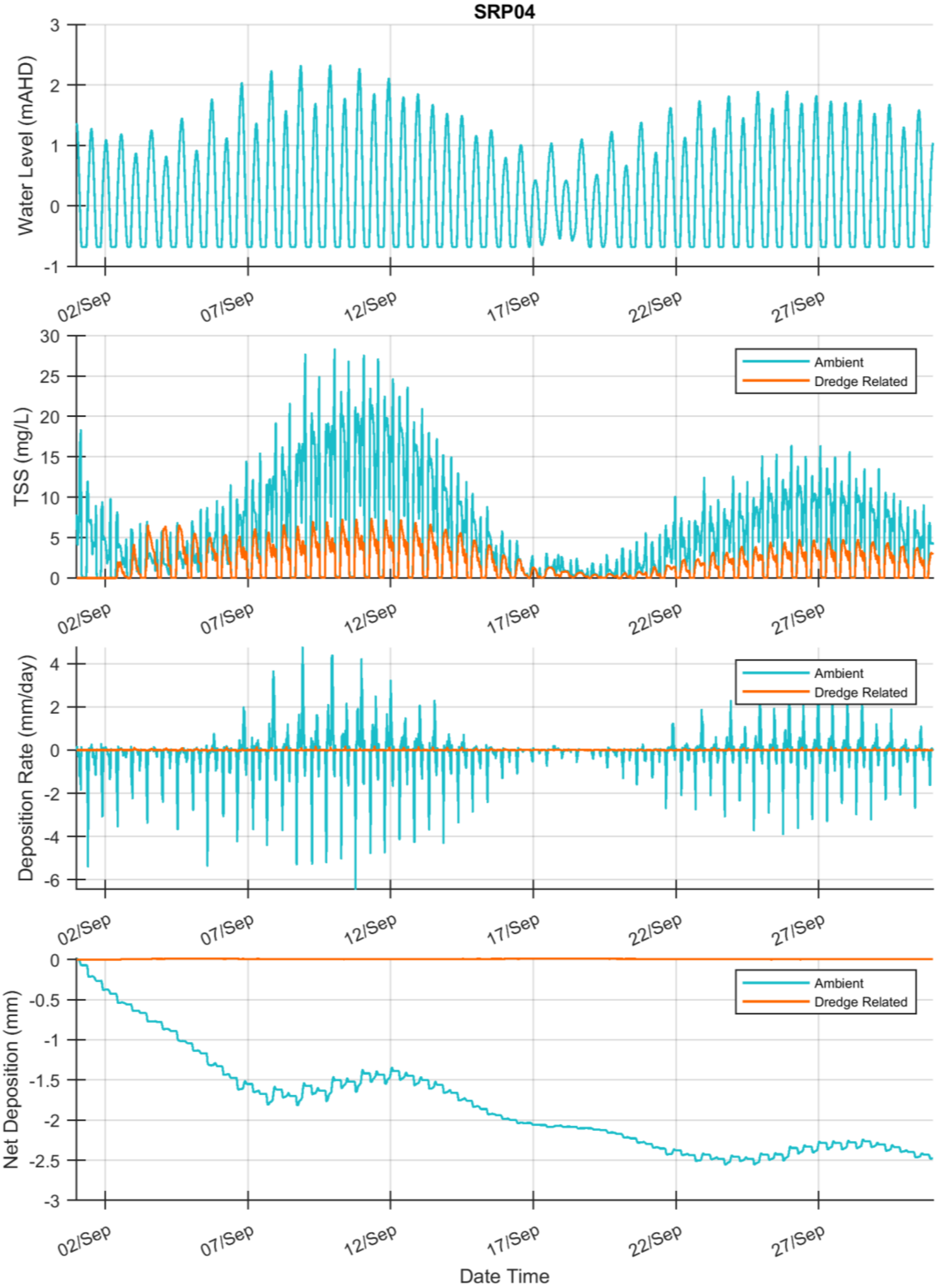

Figure 11. Time series showing natural (ambient) and dredge related SSC and deposition at SRP04 for when sediment is placed at the Tide Island DMPA (BMT, 2020).

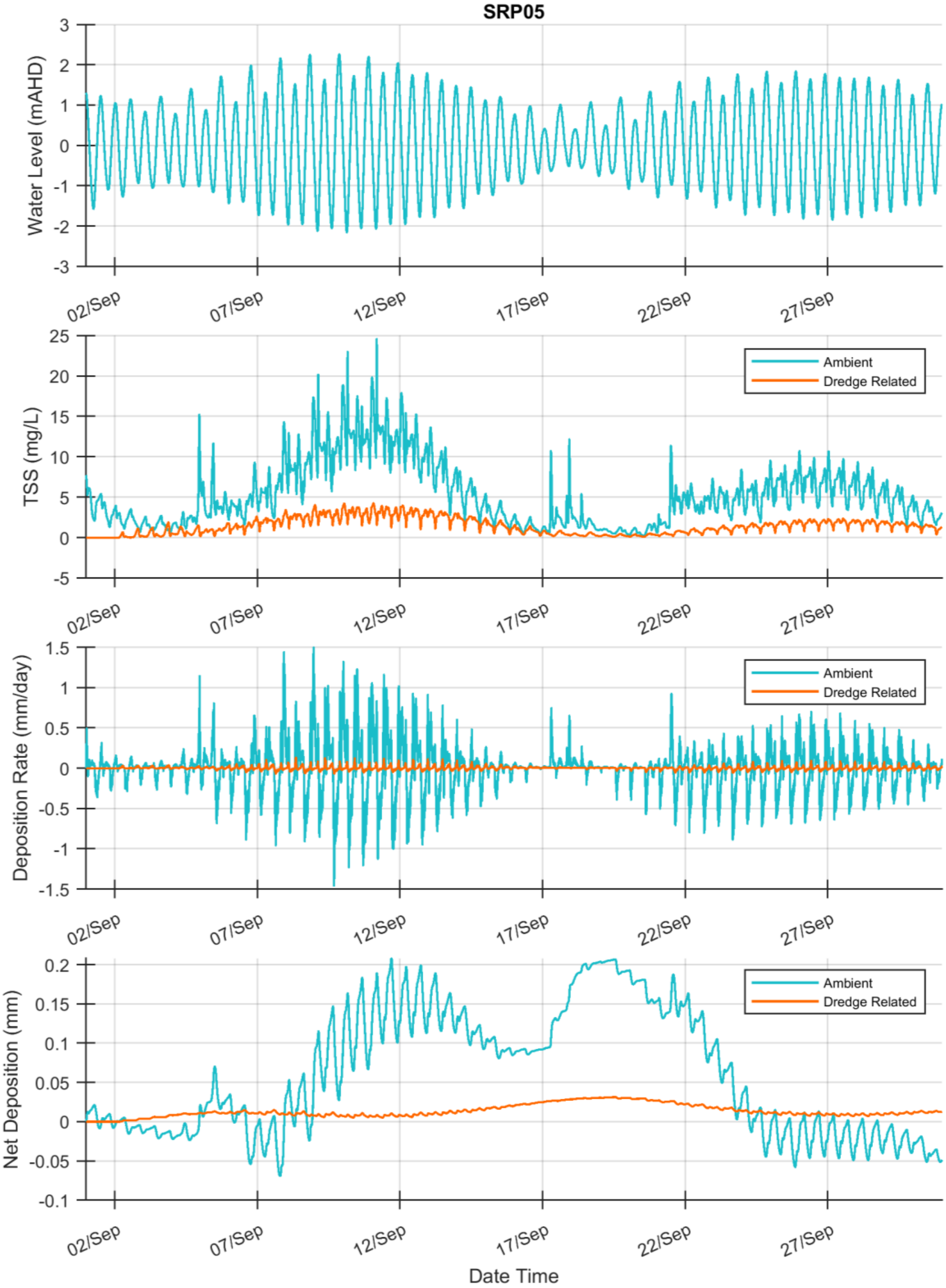

Figure 12. Time series showing natural (ambient) and dredge related SSC and deposition at SRP05 for when sediment is placed at the Tide Island DMPA (BMT, 2020).

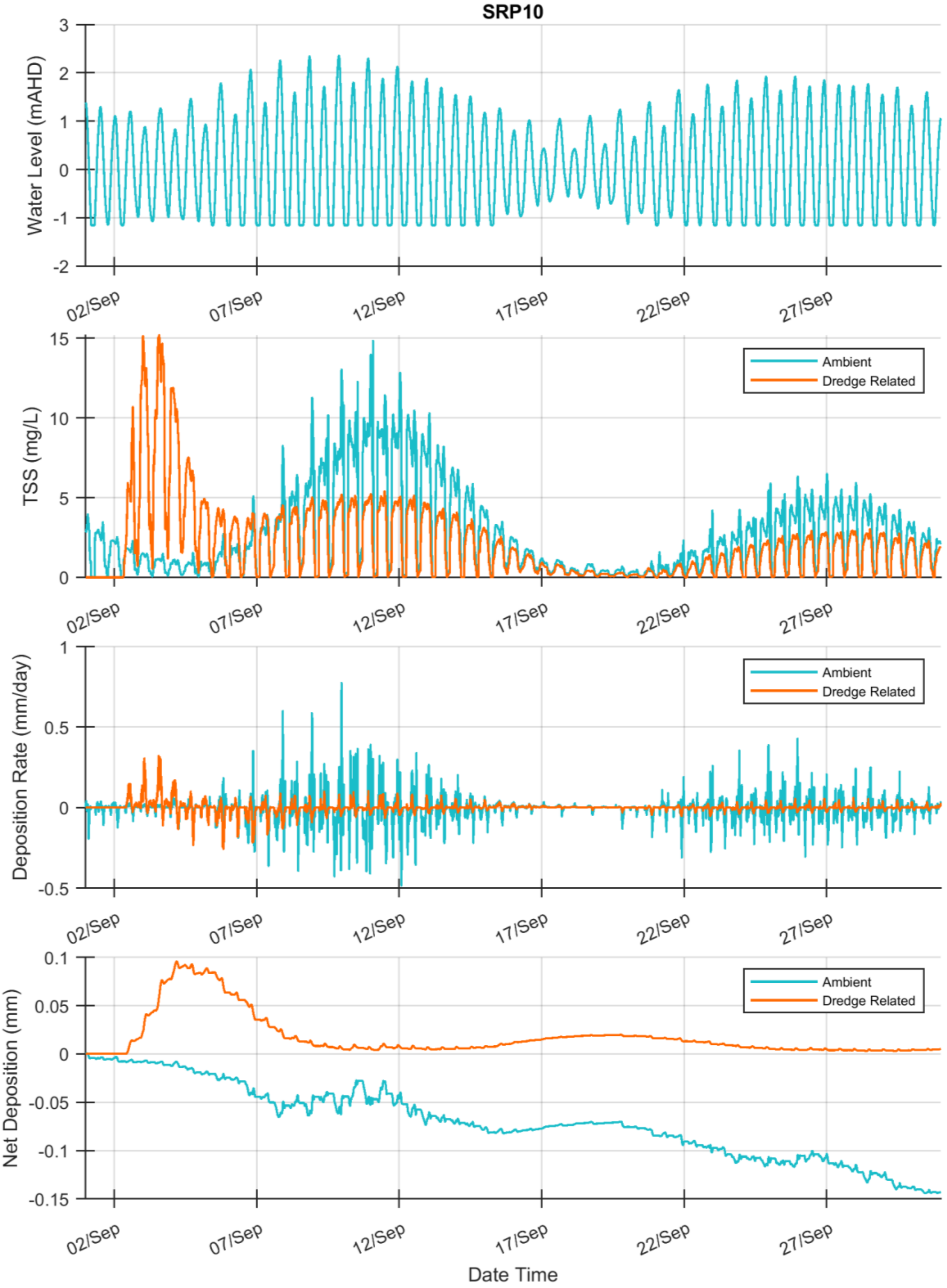

Figure 13. Time series showing natural (ambient) and dredge related SSC and deposition at SRP10 for when sediment is placed at the Tide Island DMPA (BMT, 2020).

4.3.2. EBSDS

The model predicted maximum 95th percentile turbidity calculated over a two-week sliding window within the three-month simulation as well as the predicted final deposition thickness at the end of the three-month simulation are shown in Figure 14 and Figure 15, respectively. The predicted deposited sediment present in various areas at the end of the three-month simulation is summarised in Table 6.

The turbidity plot shows that the turbidity is not predicted to exceed 6 NTU for more than 5% of the time anywhere due to the placement at EBSDS. The plot shows that turbidity is predicted to be increased in two areas, where the dredging occurs within the LNG Terminals region and where the placement occurs in EBSDS and the adjacent areas to the north-west and south-west of EBSDS where some of suspended sediment is transported to. Away from these two (2) areas with increased turbidity, the turbidity is predicted to remain low, with 95th percentile values of less than 2 NTU present throughout the remainder of Port Curtis.

The final deposition plot shows that there is predicted to be widespread deposition within Port Curtis as well as deposition at EBSDS and to the north-west of EBSDS offshore of Facing Island. Based on the spatial area and the deposition depths, it can be seen that the majority of sediment from the dredging and placement is located offshore of Port Curtis at the end of the three-month simulation. The summary of deposited sediment shows that just under 6% of the sediment is predicted to be deposited in the dredged channels of the PoG, with the majority of this (5%) predicted to be in the Jacobs Channel region (including LNG Terminal berths and aprons). Just under 4% is predicted to be deposited in the historic intertidal seagrass regions and a very small amount of the sediment (0.1%) is predicted to be deposited at the coral reefs in Port Curtis, with two (2) areas of coral reef at risk of increased deposition being the coral surrounding Turtle Island and at the southern tip of Facing Island (at Gatcombe Head).

Table 6. Deposited sediment in different areas at the end of the EBSDS model simulation.

Area	Mass (t)	% of Total Mass
Seagrass in Port Curtis	1,203	4
Coral in Port Curtis	27	0.1
Coral offshore of Port Curtis	0	0
PoG Dredged Areas	1,903	6

Note: total mass released as part of the simulation = 32,500 tonnes.

Time series plots of the model predicted SSC and deposition resulting from natural conditions and the dredging and associated placement at EBSDS are shown at the same sites as for the Tide Island DMPA in Figure 16 to Figure 19. When the plots are compared with the time series plots for the Tide Island DMPA option (Figure 10 to Figure 13) and the limitations and uncertainties with the model are considered (see Section 4), the model results suggest the following:

- the turbidity resulting from the dredging and placement at the Tide Island DMPA is higher and continues for a longer duration at the three (3) seagrass sensitive receptor sites close to the LNG Terminal region compared to the placement at EBSDS. The deposition is predicted to be similar for both placement options at most sensitive receptor sites, except at the seagrass site SRP02, where the Tide Island DMPA placement results in more deposition after one (1) month compared to placement at EBSDS (0.2 mm compared to 0.05 mm). The reason that the model predicts that the option of placement at the Tide Island DMPA results in higher turbidity for a longer duration at these sites compared to placement at EBSDS is because the areas are influenced by turbidity and deposition (at SRP02) from sediment suspended as part of the initial dredging and placement activity (over the first two (2) weeks) as well placed sediment which is resuspended from the seabed at the Tide Island DMPA over the month following placement; and

- at the closest coral reef to the Tide Island DMPA (SRP05) there are predicted to be higher peaks in turbidity (4 mg/l compared to 2 mg/l) due to the dredging and the duration of increased turbidity is predicted to last for a longer duration for the placement at the Tide Island DMPA compared to placement at EBSDS. In addition, the placement at the Tide Island DMPA is predicted to result in deposition of approximately double (up to 0.03 mm) that predicted for placement at EBSDS at SRP05, although in both cases the sediment is subsequently eroded during the following spring tides.

As noted in Section 4, there are limitations and uncertainties associated with the model results which must be considered when interpreting the results. As expected, the model results show higher turbidity and deposition at the closest sensitive receptor locations to the LNG Terminals region and the Tide Island DMPA for when sediment is placed at the Tide Island DMPA compared to at EBSDS. The increases in turbidity due to the dredging and placement at the Tide Island DMPA were comparable to the natural range in turbidity during the initial dredging and placement period (two (2) days) and then gradually reduced so the dredging related turbidity is lower than the natural turbidity. This shows that the approach is behaving as intended, with the sediment placed at the Tide Island DMPA being resuspended over time and then transported within Port Curtis so that the sediment remains part of the active sediment system.

To assess potential impacts to water quality and sensitive receptors, threshold values were developed for the Gladstone region as part of the Gatcombe and Golding Cutting Channel Duplication Project Environmental Impact Statement (EIS) (BMT, 2019b). The impact predictions are presented as 'zones of impact' as per the Commonwealth EIS Guidelines and were derived using percentile exceedance values (see BMT (2020) for further details). Plots of the zones of impact for the two (2) placement options are shown in Figure 20 and Figure 21. The plots show the following:

- both placement options result in a large zone of influence which covers the main channels of the Port and extends to the southern entrance for the Tide Island DMPA option and further south of the southern entrance for the EBSDS option. The zone of influence is defined by BMT (2020) as the extent of the detectable plume that could be measured by instrumentation, but with no predicted ecological impacts; and
- only the Tide Island DMPA results in a zone of low impact which is defined by BMT (2020) as the zone where excess turbidity from dredging activities may cause water quality to deteriorate beyond natural variation. This zone is predicted to be centred around the Tide Island DMPA and extends 5 km from the DMPA to the north-west and 6 km to the south-east from the DMPA. The zone is predicted to predominantly cover the designated channels (Jacobs Channel, Clinton Channel and Auckland Channel) as opposed to locations of sensitive receptors.

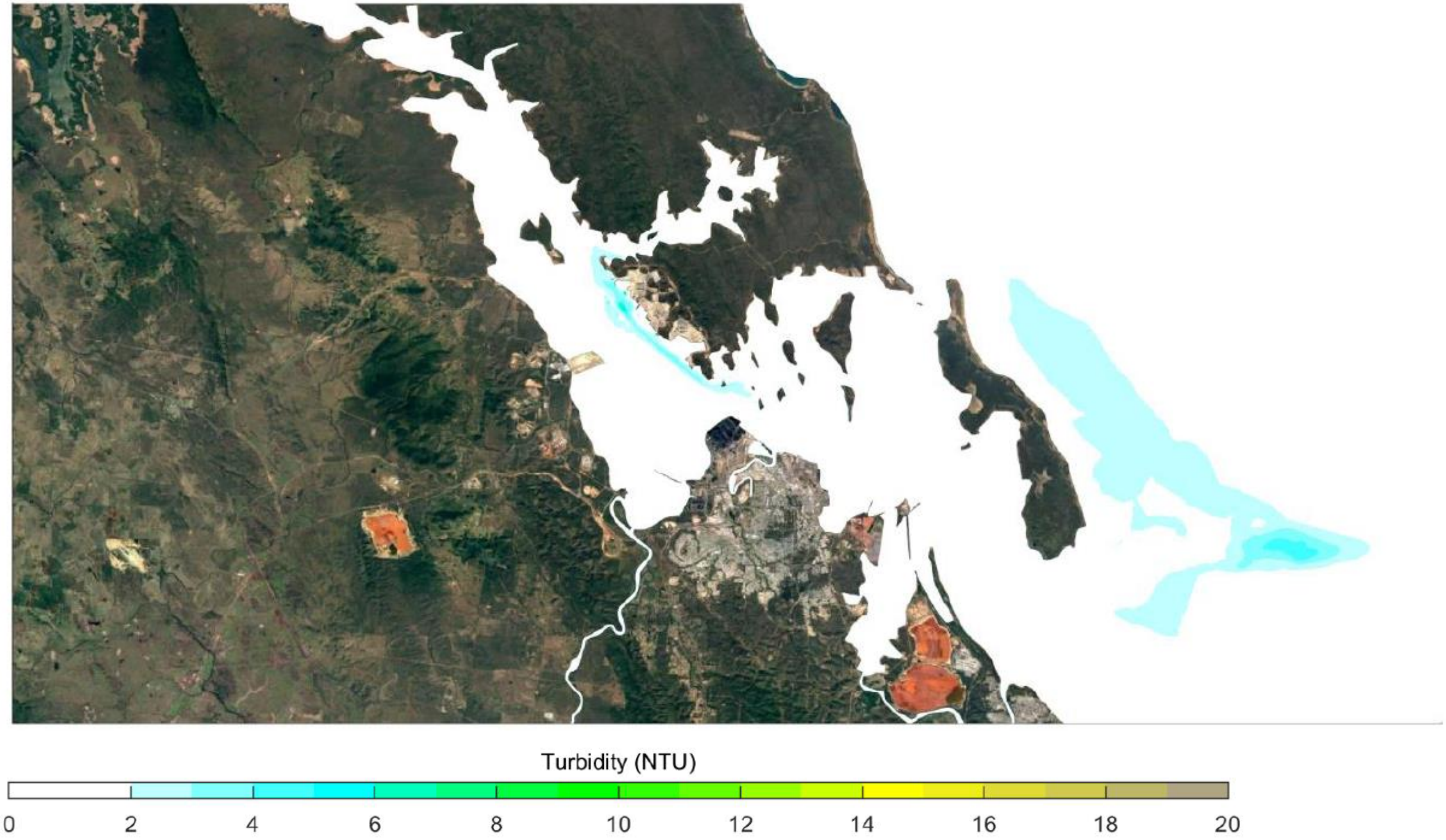

Figure 14. Maximum 95th percentile turbidity over two weeks for the placement activity at the EBSDS (BMT, 2020).

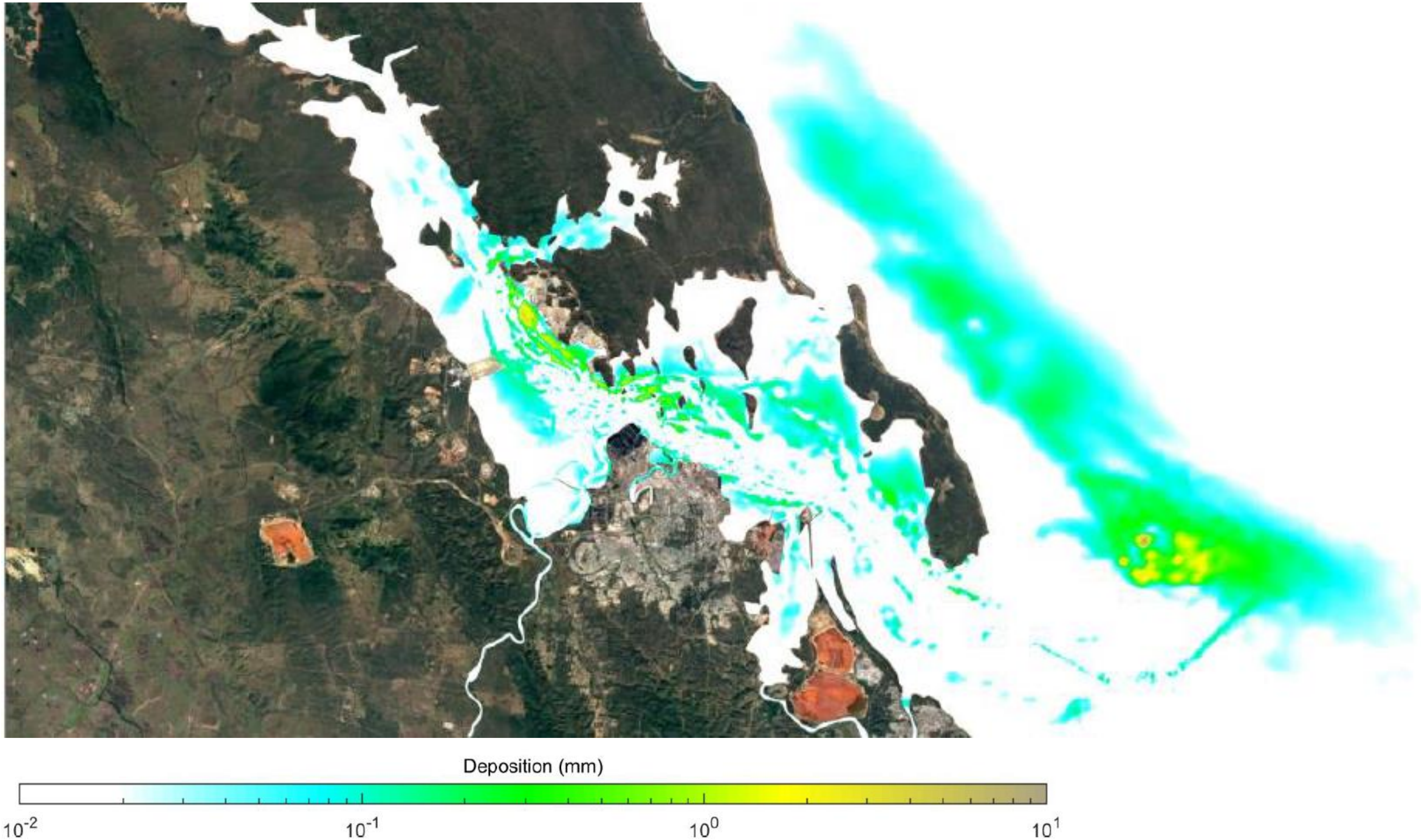

Figure 15. Final deposition of the sediment placed at EBSDS after three months (BMT, 2020).

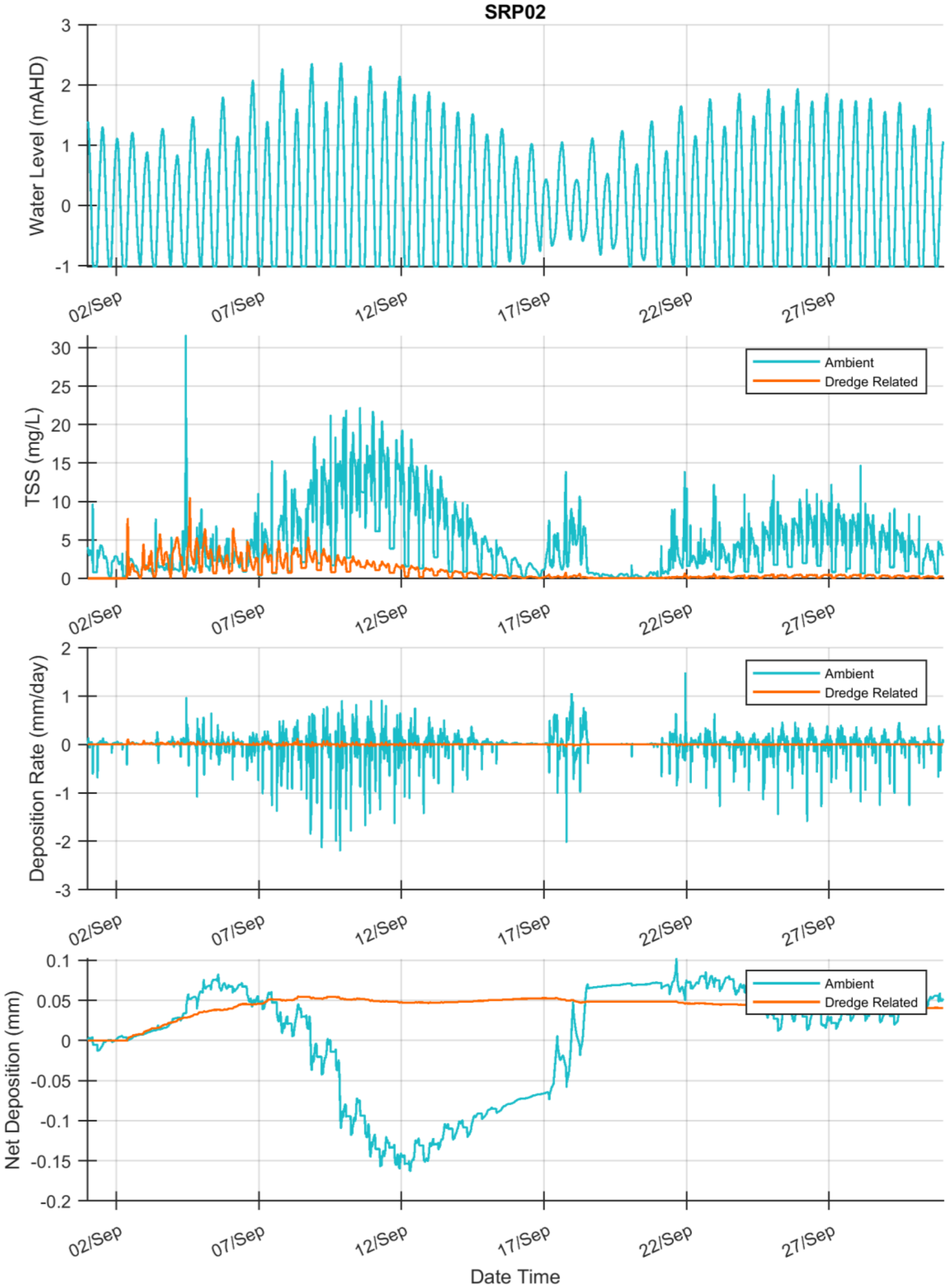

Figure 16. Time series showing natural (ambient) and dredge related SSC and deposition at SRP02 for when sediment is placed at EBSDS (BMT, 2020).

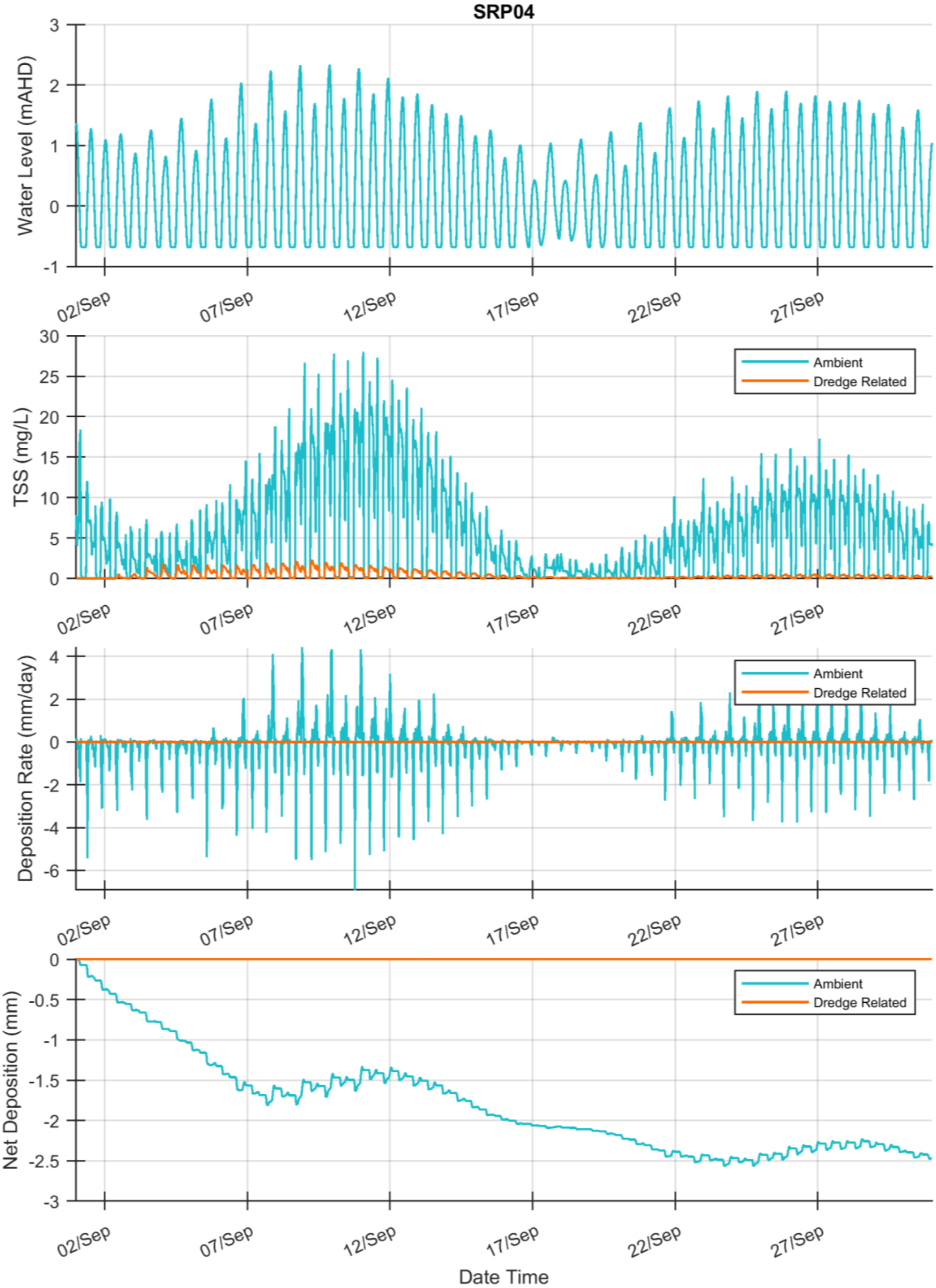

Figure 17. Time series showing natural (ambient) and dredge related SSC and deposition at SRP04 for when sediment is placed at EBSDS (BMT, 2020).

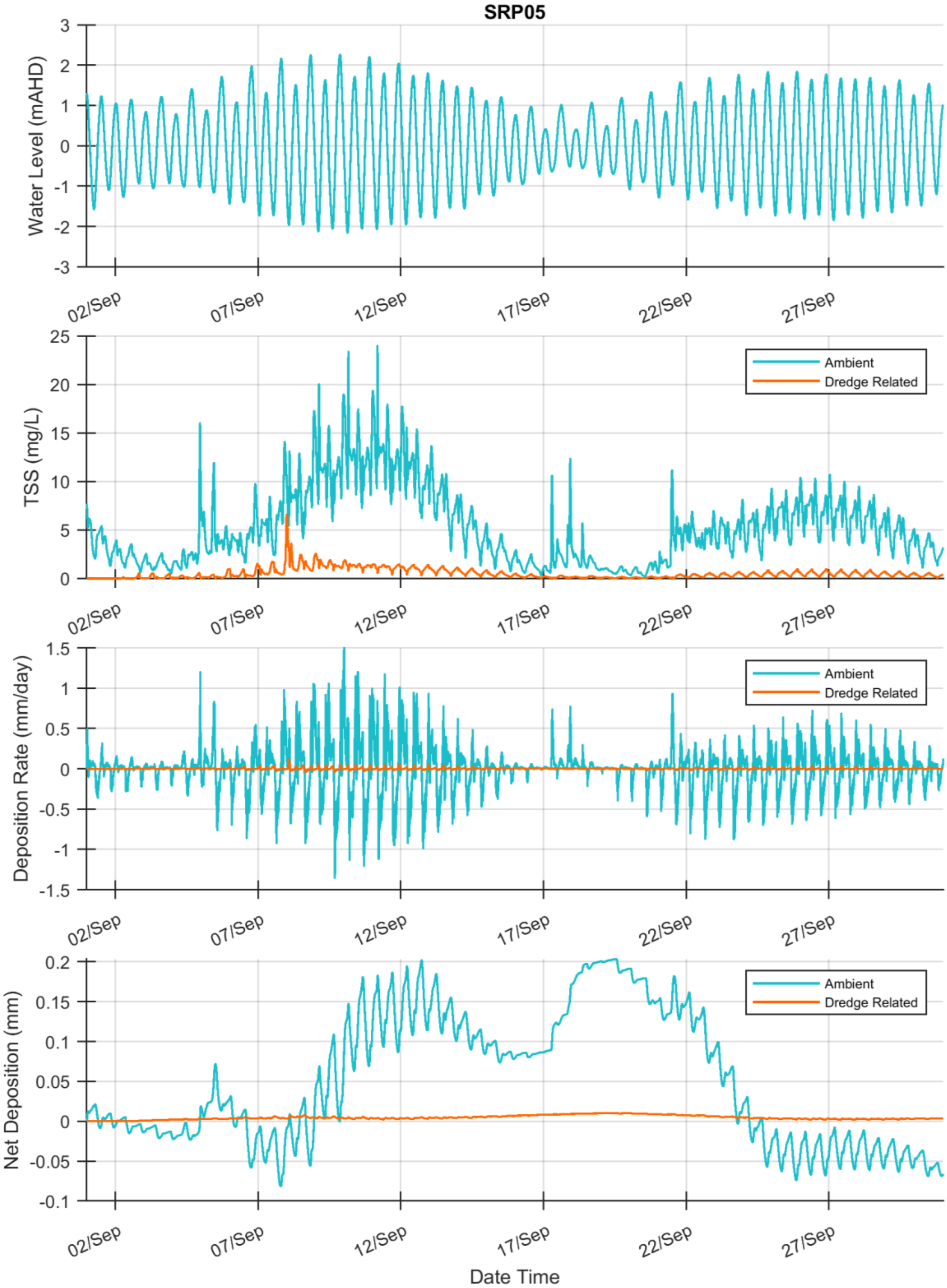

Figure 18. Time series showing natural (ambient) and dredge related SSC and deposition at SRP05 for when sediment is placed at EBSDS (BMT, 2020).

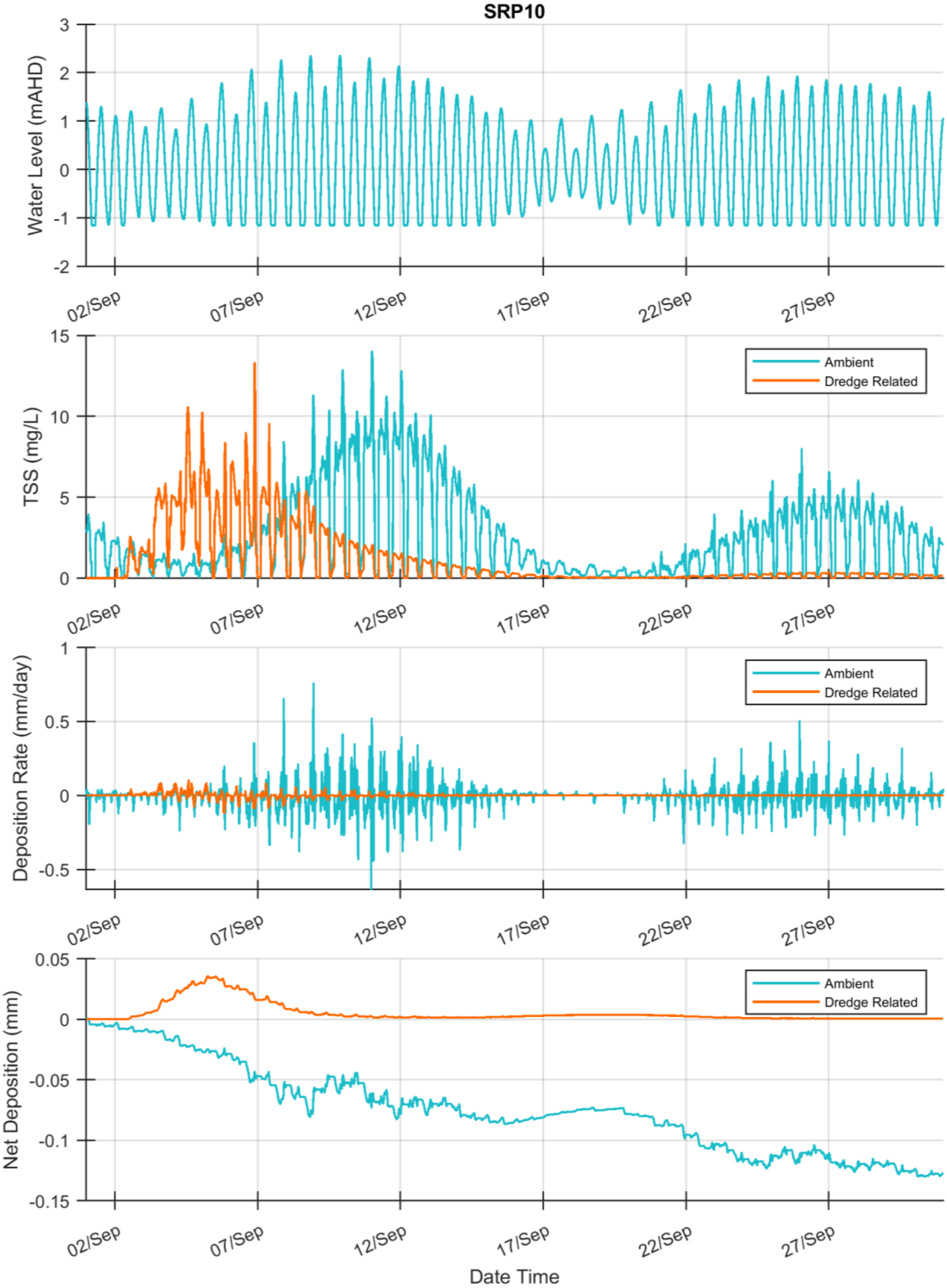

Figure 19. Time series showing natural (ambient) and dredge related SSC and deposition at SRP10 for when sediment is placed at EBSDS (BMT, 2020).

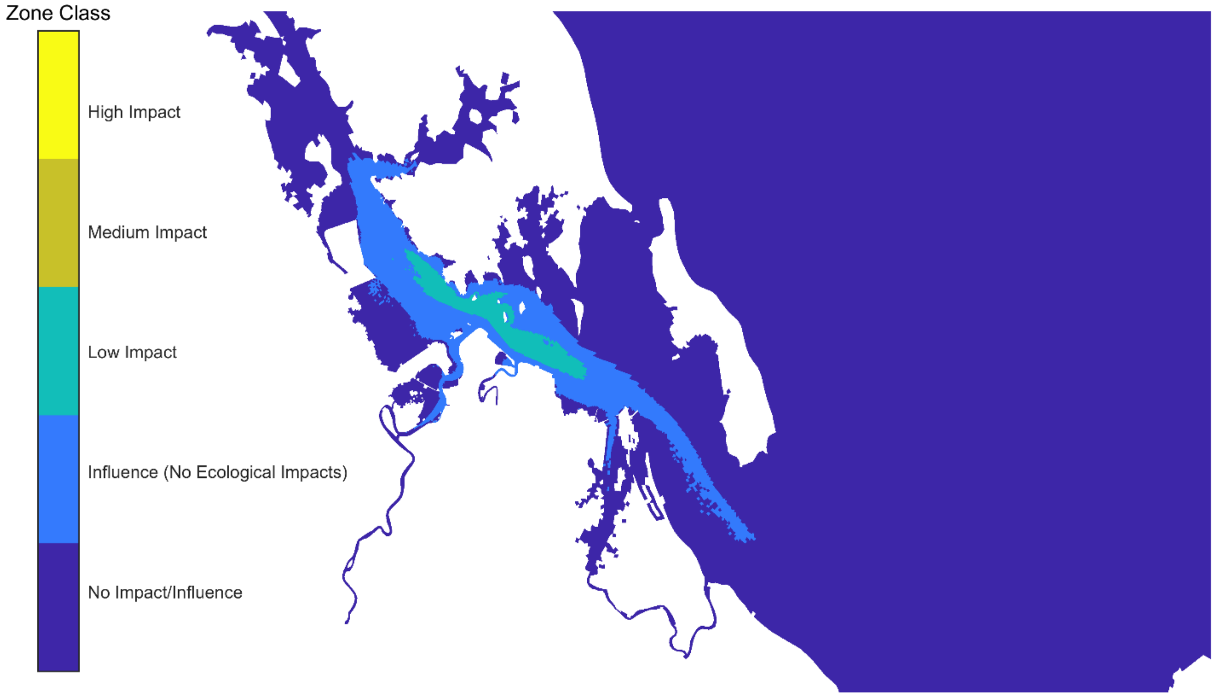

Figure 20. Zone of influence and impact due to dredging related turbidity for placement at Tide Island DMPA (BMT, 2020).

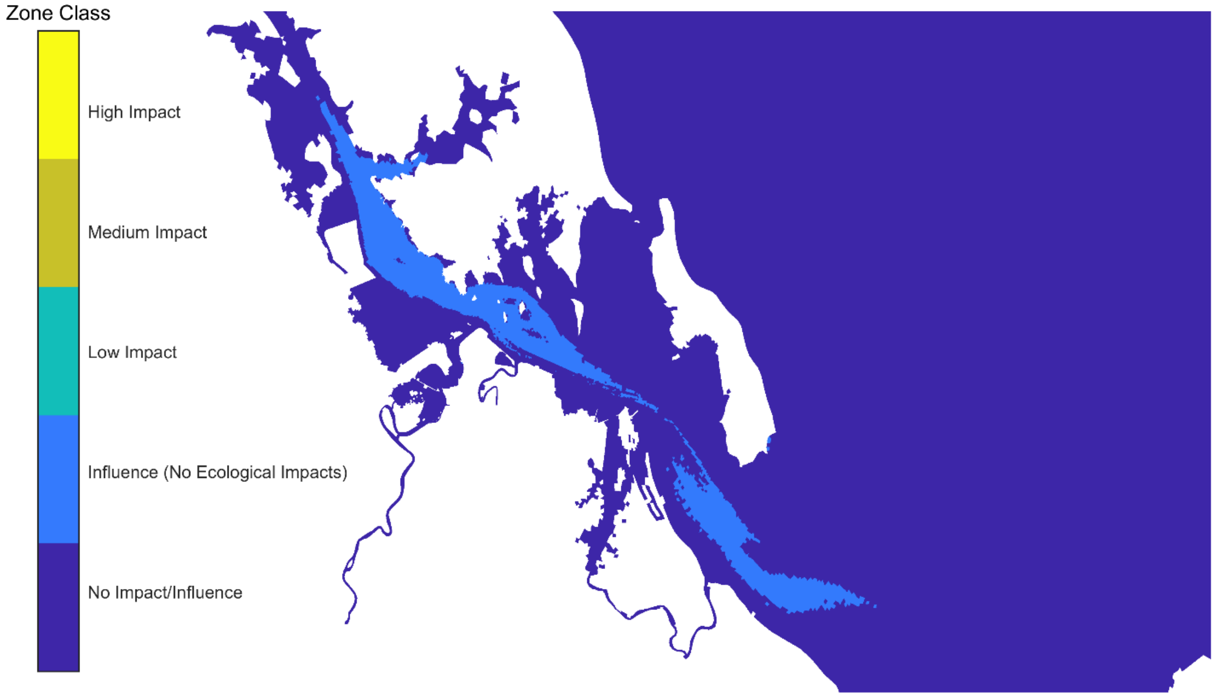

Figure 21. Zone of influence and impact due to dredging related turbidity for placement at EBSDS (BMT, 2020).

5. Feasibility

This section provides a summary of the feasibility assessment for the sustainable relocation approach for the LNG terminal region and based on the results provides recommendations for further work.

5.1. Likelihood of Success

While considering the limitations and uncertainties associated with the model, the model predictions, along with other evidence and information, suggest that the proposed sustainable relocation approach using the Tide Island DMPA has the potential to be successful for the following reasons:

- the majority of the placed sediment is predicted by the model to be transported away from the Tide Island DMPA (i.e. the placement site is dispersive as was intended). This finding is in agreement with evidence from the natural bathymetry, with the naturally deep bathymetry at the Tide Island DMPA suggesting that high current speeds occur and therefore any loosely consolidated fine-grained sediment placed there would be removed;
- the model predicts that at the nearby sensitive receptors, the SSC of the sediment transported away from the Tide Island DMPA is of a comparable concentration to the natural SSC during the dredging activity, after the initial two (2) days of dredging the SSC gradually reduces with peaks in SSC due to the reworking and transport of placed sediment reducing to approximately half the natural variability;
- the placement of 40,000 m^3 at the Tide Island DMPA is predicted to result in a zone of low impact, where the excess turbidity from the dredging activities may cause water quality to deteriorate beyond natural variation. However, the zone of low impact is predicted to predominantly cover designated channels (Jacobs Channel, Clinton Channel and Auckland Channel) as opposed to areas with sensitive receptors indicating the risk of impacts to sensitive receptors is low;
- the model predicts that the majority of the sediment will remain within the active sediment system within Port Curtis;
- the model predicts that the approach behaves as it was intended, with a widespread thin layer of sediment deposition throughout much of Port Curtis. The deposition is predicted to occur in many intertidal and adjacent subtidal areas as was intended. However, it is important to note that the numerical model is a tool which helps to inform the feasibility of the approach but that there are inherent limitations of the model in reliably predicting sedimentation; and
- although some of the sediment placed at the Tide Island DMPA is predicted by the model to subsequently be redeposited in the LNG Terminals region, this is considered to be a relatively small amount (approximately 10%, which is a 4% increase compared to placement at EBSDS) and the majority of this would be expected to be removed by subsequent dredge loads removed from this region during the dredge campaign. However, given the limitations of the model in reliably predicting sedimentation, a pilot study would be required to confirm this.

5.2. Impacts, Costs and Limitations

Based on a number of assumptions, and considering the limitations of the numerical model, the results have predicted that the placement of 40,000 m^3 of dredged sediment at the Tide Island DMPA results in increases in SSC and deposition within Port Curtis relative to placement at EBSDS. The potential impact of the proposed dredging on water quality and sensitive receptors was predicted using the modelling results and based on this it was found that the placement at the Tide Island DMPA results in a zone of low impact, where the excess turbidity from the dredging activities may cause water quality to deteriorate beyond natural variation, while the placement at EBSDS does not result in a zone of low impact. The zone of low impact for the Tide Island DMPA placement is predicted to predominantly cover designated channels (Jacobs Channel, Clinton Channel and Auckland Channel) as opposed to areas with sensitive receptors. The approach is not predicted to result in any zones of moderate or high impact where excess turbidity from dredging is either likely or most likely to cause water quality to deteriorate beyond natural variation. Based on these results, the risk of any impacts to nearby sensitive receptors is considered to be low.

When the dredge duration and cost of placement at the Tide Island DMPA are compared to ongoing placement at EBSDS, placement at the Tide Island DMPA results in a reduction in both time and cost of more than half. For example, if it is assumed that 75,000 m^3 of sediment is dredged from the LNG Terminal region and placed at the Tide Island DMPA instead of at EBSDS, this would reduce the dredge duration from 10 days to 4.3 days and the cost from $990,000 to $430,000. The reduction in dredging time would also result in a comparable percentage reduction in greenhouse gas (GHG) emissions.

It is likely that the Tide Island DMPA sustainable relocation site could be used as a long-term placement option given the volume capacity of the site below declared depths (1 million m^3) and the dispersive nature predicted by the numerical modelling. However, there remains uncertainty and a potential limitation with the approach relates to how much sediment can be placed at the Tide Island DMPA during each annual maintenance dredging campaign. As the results from the numerical modelling indicate that placing sediment at the Tide Island DMPA results in some SSC and deposition increases at the nearby sensitive receptors compared to placement at EBSDS, there is a risk that if too large a volume of sediment is placed at the Tide Island DMPA there could be impacts to these nearby sensitive receptors. Therefore, it is recommended that an initial pilot study is required to confirm whether or not there is a significant build-up of sediment at the Tide Island DMPA and whether the approach has the potential to result in impacts to any sensitive receptors.

5.3. Recommendations

Based on the findings of this feasibility assessment, the approach of sustainable in-channel relocation of sediment from the LNG Terminals and Fishermans Landing regions to the Tide Island DMPA is considered feasible. However, in support of the SSM project, it is important to carry out direct monitoring of the sediment placed in the Tide Island DMPA to understand the behaviour, processes and fate of the material, both in terms of having a positive beneficial use and confirming it does not return to and lead to sedimentation in the navigation channel and berths. It is also critical to confirm that there are no detrimental impacts on sensitive receptors or the wider environment. In addition, direct monitoring will provide calibration data for future modelling and a validation dataset to compare with the model predictions.

To date, assuming the model predictions are accurate, the findings suggest that the approach has the potential to provide the following benefits:

- it would help to keep existing natural sediment within Port Curtis and assist in distributing the sediment throughout the region. This in turn has the potential to help habitats accrete at a comparable rate to sea level rise which would reduce the risk of any changes in habitat due to increased water depths;
- the majority of the sediment placed at the Tide Island DMPA is predicted to be transported away from the DMPA and distributed throughout much of Port Curtis. This is what the approach was designed to do, redistributing the sediment within Port Curtis and providing an ongoing sediment supply;
- a low risk of impacts to any other sensitive receptors due to the placement as well as a low risk of any significant increased sedimentation in the dredged channels;
- the dredging can be undertaken by the TSHD Brisbane as part of any annual maintenance dredging campaign, with the potential for all of the sedimentation from the LNG Terminals and Fishermans Landing regions being placed there; and

- the option represents a significant time and cost saving to the annual maintenance dredging campaign for the PoG, and it also results in a significant reduction of GHG emissions due to the reduced dredge vessel time.

5.3.1. Pilot Study

As this feasibility assessment has found that the sustainable in-channel relocation of sediment from the LNG Terminals and Fishermans Landing regions to the Tide Island DMPA to be potentially feasible, it is suggested that a pilot study should be undertaken. This will give the opportunity to further assess the feasibility of the approach through monitoring of the pilot study and will also act to reduce any uncertainties prior to making a decision as to whether this approach could be adopted as a long-term solution. Undertaking a pilot study along with monitoring is an important requirement prior to adopting long-term solutions as it provides physical measurements which, as noted by the analogue of the Mud Motor, can differ from numerical modelling results (see Section 2.3).

For the approach to be considered a success, in addition to other success criteria, it is necessary for the majority of sediment to be transported away from the Tide Island DMPA and for the sediment to be distributed within Port Curtis without resulting in significant sedimentation in the dredged channels, berths as well as sensitive receptors and the wider environment. Therefore, to be able to assess whether a pilot study can be considered successful, the following is necessary:

- sufficient sediment has to be placed at the Tide Island DMPA so that it is possible to determine whether the majority of the sediment has been transported away; and
- sediment needs to be placed during all stages of the tidal cycle to allow sediment to be transported in all directions due to the changing tidal currents over a tidal cycle.

Based on the above, it is recommended that approximately 10,000 m^3 of predominantly fine-grained sediment from the LNG Terminals region is placed at the Tide Island DMPA over a continuous 12-hour period, to cover a complete flood-ebb tidal cycle, as part of the pilot study. The sediment should be placed within a 500 m length in the middle of the DMPA along its centreline so that any build-up of sediment should be measurable during the post-dredge bathymetric survey (the survey should be undertaken using a dual frequency echosounder so that the depth of any unconsolidated silt/clay can be recorded). The pilot study could be undertaken as part of any annual maintenance dredging campaign, with no additional requirements in order for the TSHD Brisbane to be able to undertake the dredging and placement.

5.3.2. Monitoring

In order to determine the success of the option, monitoring will be required as part of the pilot study. The monitoring would have the following key aims:

- to determine whether the Tide Island DMPA acts as a dispersive placement site when fine-grained sediment in placed there;
- to determine where sediment transported away from the placement area is transported to within Port Curtis; and
- to identify whether the placement of sediment has the potential to result in any negative impacts to sensitive receptors in Port Curtis.

If it is shown that the Tide Island DMPA is a dispersive placement site and does not lead to increased sedimentation in the navigation channel, berths and/or sensitive receptor sites, a key part of the study will be to estimate the transport rates for dispersal and potentially the future capacity of the placement site. If, following the results from the monitoring, the pilot study is deemed to have been a success, then there is the potential that a gradual increase in volume of sediment could be placed in the area during subsequent annual maintenance dredging campaigns along with ongoing monitoring of the build-up of sediment at the DMPA and monitoring at any sensitive receptors which the pilot study identified as potentially being at risk.

To achieve these aims, two (2) complimentary and discrete monitoring campaigns will be required, these are detailed in the following sub-sections. It has been assumed that ongoing monitoring of the key sensitive receptors within Port Curtis (seagrass and coral reefs) will continue to be undertaken by GPC, including samples which can be analysed for sediment tracers released and will not therefore require specific focused monitoring as part of this pilot study.

The cost of the detailed monitoring proposed as part of the pilot study are expected to be in the order of $400,000 to $500,000 and so is important to consider as it could influence the feasibility of the approach for GPC. The detailed monitoring outlined in the following sections would only be required for the initial pilot study. It is not expected that any subsequent dredge campaigns when placement occurs in the Tide Island DMPA would require such detailed monitoring. The scale of ongoing monitoring required would be dependent on the results of the pilot study monitoring, but it is possible that an ongoing monitoring site in the area would be required with monitoring costs likely to be in the order of thousands to tens of thousands of dollars per year.

If, following the results from the monitoring, the pilot study is deemed to have been a success, then there is the potential that a gradual increase in volume of sediment could be placed in the area during subsequent annual maintenance dredging campaigns along with monitoring of the build up of sediment at the DMPA and ongoing monitoring at any site(s) which the pilot study identified as being required.

5.3.2.1. Bathymetric Analysis

To assess whether the Tide Island DMPA acts as a dispersive placement site, the DMPA and immediate surrounding area (approximately 250 m in all directions) should be included in the pre- and post-maintenance dredging surveys. A dual frequency echosounder should be used for the surveys to ensure that the depth of any loosely consolidated silt and clay is measured. Any changes in bathymetry should be analysed to determine whether there has been an increase in sediment over the maintenance dredging period and if so the increase in volume of sediment can be estimated. If the post-dredge survey does show that the majority of sediment placed at the Tide Island DMPA is still within the DMPA after the end of dredging, then an additional bathymetric survey should be undertaken approximately three-months later to determine whether further sediment dispersion has occurred.

5.3.2.2. Tracer Investigation

An optimal way to provide evidence on the fate of the dredged sediment released at the Tide Island DMPA and also build a better understanding of sediment transport processes is using sediment tracers to label and track the material spatially and temporally. Sediment tracers assimilate all of the hydrodynamics and sediment transport processes including tidal currents, waves, wind-driven circulation, bedform, erosion-resuspension, transport and settling-deposition. In addition, sediment tracers can be introduced directly into a dredge hopper load to mimic the initial mixing and dispersal during dredge discharge and entrainment allowing both the near-field and mid- to far-field transport to be monitored.

Sediment tracers provide a direct, quantitative and unequivocal way of measuring whether movement of the sediment takes place (or not), how fast it is transported, where the material ends up over time and how long it remains in the target area, in this case within the wider area of Port Curtis including the navigation channel, berths, sensitive receptors and the wider environment.

Accurately modelling sediment transport, in particular fine-grained sediment (silt and clay), is extremely difficult within nearshore embayments and tidal estuaries especially deep-water ports where rapid changes in water depth, circulation and current velocities can occur along with natural intertidal and shallow subtidal environments. Models assume that fine-grained sediment are permanently in suspension once eroded or introduced from a dredge hopper. However, accurately predicting initial mixing and dispersal correctly during dredge dumping and subsequent secondary transport are extremely difficult. Erosion-resuspension of fine-grained sediment from the bed in deep navigation channels versus adjacent shallow intertidal/subtidal areas requires very different approaches particularly with regard to turbulence functions. This is also the case for dredge plumes where models have to assume and balance horizontal and vertical dispersion coefficients as dredge plumes dilute and disperse with assumptions on flocculation, settling and deposition parameters. Flocculation processes, and as a result settling and deposition, are affected by turbidity (along with turbulence) meaning that spatial or temporal changes in both can lead to further variations. Therefore, subtle changes in the model for turbulence, turbidity, dispersion coefficients, erosion-resuspension, flocculation and settling-deposition functions can make a significant difference to the predictions made.

To assess both whether the Tide Island DMPA acts as a dispersive placement site, as well as where sediment which is transported away from the placement area is deposited, the use of sediment tracers is proposed. The tracers would have comparable properties to the sediment being placed, with silt/clay sized tracers being used. The tracers would be manually added to the hopper of the TSHD Brisbane when it has a full load of sediment from the LNG Terminals region. It is proposed that two (2) separate tracer colours should be used, one (1) for sediment placed at low water and peak flood (tracer placed in two (2) hopper loads) and one (1) for sediment placed at high water and peak ebb (tracer placed in two (2) hopper loads). The tracer would then be bottom dumped along with all the sediment in the hopper at the Tide Island DMPA. Prior to the release of the sediment tracers, two (2) or three (3) hopper loads should be released within the Tide Island DMPA to increase the volume placed up to approximately 10,000 m^3 to enable detection by bathymetric survey, to create a more 'typical' unconsolidated seabed and also to provide additional field measurements to be collected of the dredge plume.

It is proposed that during the release of the six (6) or seven (7) dredge hopper loads, both unlabelled and labelled with sediment tracers as above, vessel-mounted ADCP data (current velocity and backscatter), vertical profiling of salinity, temperature, depth and turbidity in addition to gated sampling for turbidity and sediment tracers is carried out. These measurements will provide calibration data for modelling and allow comparison of model predictions with measured field data and will also provide an initial indication of the dispersal and dilution of the dredge plumes, which in turn may help focus or streamline bathymetric survey and also future sampling.

Ongoing sediment sampling and analysis after the placement activity would be required to assess the transport and fate of the placed sediment. It is expected that this would involve the following:

- collection of background samples from the study area to determine if any coloured or fluorescent material is present that may interfere with the sediment tracers to be used. Approximately 100 sediment samples from the area should be collected and analysed; ideally this would be done in advance of deciding on which sediment tracers and colours will be used;
- once the sediment tracers are released, it is proposed to collect approximately 350-400 sediment grab samples per single sampling campaign from the Tide Island DMPA, adjacent areas to the placement site, navigation channels and berths, sensitive receptor sites both upstream and downstream of the DMPA and other areas which the modelling predicted high sedimentation;
- four (4) or five (5) separate sediment sampling campaigns will be undertaken two (2), four (4), eight (8), 16 and 26 weeks after the completion of the placement activity (and completion of the annual maintenance dredging campaign) subject to the initial results;

- laboratory analysis of the background, dredge plume and seabed grab sediment samples to determine the colour and amount of tracer present for each release; and
- interpretation of the tracer results to estimate the retention of placed sediment at the site and the fate of any of the placed sediment which was transported away from the site.

A third sediment tracer colour could also be added to maintenance dredge hopper loads discharged at EBSDS, followed by sampling within the port area outlined above. The purpose of this tracer would be to provide a direct comparison between the dispersion within Port Curtis of sediment placement at Tide Island DMPA and EBSDS; it is not proposed to sample around EBSDS or adjacent areas outside of Port Curtis. The purpose of this would be to determine if fine sediment released there makes it back into the channel, berths or sensitive receptors and compare these with the tracers released at the Tide Island DMPA. All the samples collected as outlined above could be analysed for two (2) sediment tracers released at Tide Island DMPA and one (1) sediment tracer at EBSDS. These data may indicate there are other benefits to beneficial use not previously considered or that placing material at EBSDS leads to a similar return of material back into the port areas.

It would also be beneficial to deploy a current meter and turbidity logger close to the Tide Island DMPA to gain a better understanding of the water column velocities and near-bed turbidity at this site for the first two (2) to four (4) weeks as placement of dredge material commences. These instruments would measure the ambient metocean conditions and turbidity and the data could be used to calibrate any modelling and help understand and interpret dredged sediment and sediment tracer transport at the site.

There are a number of different sediment tracers that could be adopted for the monitoring, these are detailed below:

- artificial fluorescent silt and sand tracers, EcoTrace particles[4], that can be adjusted in terms of size and density to match the ambient sediment. EcoTrace particles have been used in the vast majority of tracer studies to date (including all previous projects in Australia) with material being tracked from multiple sources using different fluorescent colours for up to 5 years in very high energy environments. Scientifically, EcoTrace particles represent the optimal sediment tracer in terms of being robust for tracking over months/years, minimal product needed per release and highest detectability. In the case of EcoTrace silt tracer particles, they form as part of natural fine sediment flocs and therefore move, settle and deposit mixed in with natural fine sediment. This is critical to ensure the same behaviour, processes and fate and has been studied, tried and tested over more than 30 years including more than 75 silt particle tracing studies and related laboratory analysis;
- stained or marked natural silt and sand grains, GeoTrace particles, that use material from the study site. However, these particles are only suitable for studies of a few days due to the marker being abraded and washing off the particles making them very difficult to detect over time. Therefore, this type of tracer is not considered suitable in this case; and

[4] It should be noted that EcoTrace particles contain polymer as part of the manufacturing process and even though the polymer content can be reduced to <15%, with the remaining >85% comprising all-natural occurring materials, use of polymer in some cases is less acceptable in the marine environment. Use of both recycled polymer and biopolymer (made solely from plant-based material) have been actively researched, however some parties/groups feel that anything 'polymer' even recycled polymer or plant-based should not be used. In addition to reducing the percentage of polymer used, detection limits have been improved for the EcoTrace particles by 150-200% which in turn has reduced the quantity of tracer needed to be released into the environment for each study or site. In terms of sediment tracers, EcoTrace offer by far the most cost-effective, accurate and tried and tested sediment tracer option and represents significant research and development carried out over 20 years to successfully manufacture, test and analyse the particles. However, non-polymer options are becoming available. However, these require a greater volume of particles to be released versus EcoTrace particles (increasing manufacturing, shipping, handling and release requirements) and have a lower detection limit.

- non-polymer coloured silt and sand tracers, that have a fixed density of 2,650 kg/m^3 and available in a limited number of colours. Given they are not fluorescent, the detection limits are lower than the EcoTrace fluorescent particles requiring more material to be released and lower detection limits. To date, the non-polymer tracers have only had lab-scale trials, however they are proposed to be used in small-scale field studies during 2020.

6. Summary

This assessment has considered the feasibility of an alternative option to manage sediment from maintenance dredging for the PoG. The option is the sustainable relocation of sediment from the LNG Terminals region of the PoG. It involves the release of fine-grained sediment in a naturally deep area close to Tide Island, with the aim of the sediment subsequently being transported within the Inner Harbour and providing additional sediment input to intertidal regions whilst not resulting in an increase in sedimentation in any dredged areas. The option was identified as part of the SSM Project Reduce assessment and subsequently assessed by stakeholders and based on this it was considered a preferred option and considered in a feasibility assessment.

An option development was undertaken and as part of this it was concluded that the previously proposed Tide Island DMPA is the most suitable location and that the placed sediment should be predominantly fine-grained silt and clay which could either be from the LNG Terminals region or the Fishermans Landing region. The sediment could be placed by bottom dumping and the total volume of sediment which could potentially be placed there from the two (2) regions could be in the order of 150,000 m^3/yr. Numerical modelling was undertaken as part of the feasibility assessment and the results have predicted that the placement of 40,000 m^3 of dredged sediment at the Tide Island DMPA results in increases in SSC and deposition within Port Curtis relative to placement at EBSDS. The potential impact of the proposed dredging on water quality and sensitive receptors was predicted using the modelling results and based on this it was found that the placement at the Tide Island DMPA results in a zone of low impact, where the excess turbidity from the dredging activities may cause water quality to deteriorate beyond natural variation, while the placement at EBSDS does not result in a zone of low impact. The zone of low impact for the Tide Island DMPA placement is predicted to predominantly cover designated channels (Jacobs Channel, Clinton Channel and Auckland Channel) as opposed to areas with sensitive receptors. The approach is not predicted to result in any zones of moderate or high impact where excess turbidity from dredging is either likely or most likely to cause water quality to deteriorate beyond natural variation. Based on these results, the risk of any impacts to nearby sensitive receptors is considered to be low.

When the dredge duration and cost of placement at the Tide Island DMPA are compared to ongoing placement at EBSDS, placement at the Tide Island DMPA results in a reduction in both time and cost of more than half. For example, if it is assumed that 75,000 m^3 of sediment is dredged from the LNG Terminal region and placed at the Tide Island DMPA instead of at EBSDS, this would reduce the dredge duration from 10 days to 4.3 days and the cost from $990,000 to $430,000. The reduction in dredging time would also result in a comparable percentage reduction in greenhouse gas (GHG) emissions.

Based on the findings of this feasibility assessment the approach of sustainable in-channel relocation of sediment from the LNG Terminals and Fishermans Landing regions to the Tide Island DMPA is considered feasible. The Tide Island DMPA has been found to have the potential to be used as a long-term placement option given the volume capacity of the site below declared depths (1 million m^3) and the dispersive nature of the site predicted by the numerical modelling. However, there remains uncertainty as to how much sediment can be placed at the Tide Island DMPA during each annual maintenance dredging campaign. As the results from the numerical modelling indicate that placing sediment at the Tide Island DMPA results in some SSC and deposition increases at the nearby sensitive receptors compared to placement at EBSDS, there is a risk that if too large a volume of sediment is placed at the Tide Island DMPA there could be impacts to these nearby sensitive receptors. Therefore, it is recommended that an initial pilot study is required to confirm whether or not there is a significant build-up of sediment at the Tide Island DMPA and whether the approach has the potential to result in impacts to any sensitive receptors. Details of the pilot study, which proposes that 10,000 m^3 of sediment is placed at the Tide Island DMPA, and the associated monitoring have been provided within this report.

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