Gladstone Marina Maintenance Dredging Impact Assessment

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BMT Commercial Australia Pty Ltd
Level 5, 348 Edward Street
Brisbane Qld 4000
Australia
PO Box 203, Spring Hill 4004

Tel: + 61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.bmt.org

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Title:	Gladstone Marina Maintenance Dredging Impact Assessment
Project Manager:	Paul Guard
Author:	Darren Richardson, Paul Guard
Client:	GPC
Client Contact:	Gordon Dwane
Client Reference:	
Synopsis:	**Impact assessment for maintenance dredging works in the Gladstone Marina at Port of Gladstone, including an in-channel placement option.**

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Executive Summary

Background

Gladstone Ports Corporation Limited (GPC) is responsible for maintenance dredging of the Port of Gladstone (PoG). GPC is assessing the potential for alternative beneficial reuse of maintenance dredging material. One proposed option involves an alternative in-channel Dredge Material Placement Area (DMPA) option for disposal of predominantly fine dredged sediment from the Gladstone Marina. The proposed dredging activity involves the use of a Cutter Suction Dredge (CSD) working in the Marina, pumping a slurry of dredged sediment to a discharge location on the edge of the Clinton Channel

This report describes the approach and findings of the environmental assessment of the Marina maintenance dredging impacts to marine waters in Port Curtis, including the alternative disposal option. The assessment includes bathymetric changes associated with the CVIP channel footprint, and three alternative Marina dredging campaigns.

The specific objectives of the report are to:

- Identify relevant matters of national and state environmental significance, and the location of sensitive ecological receptors, within the footprint and in adjacent areas potentially affected by maintenance dredging;
- Assess potential changes to water quality and the marine environment associated with the proposed dredging; and
- Assess potential impacts to matters of national and state environmental significance as a result of dredging.

The environmental assessment was based on desktop assessments involving:

- review and analysis of existing information
- hydrodynamic and sediment transport modelling of the generation, advection and dispersion of dredging-related sediment plumes and associated sediment deposition rates.

Findings

Existing Environment

Port Curtis is a macro-tidal estuary that features significant tidal currents. The energetic tidal hydrodynamic conditions play an important role in the context of natural bed remobilisation processes and ambient turbidity. Floods and ‘freshes’ periodically deliver catchment pollutants to estuarine and nearshore coastal waters, exerting a strong control on marine and estuarine water quality and ecosystems. Metal/metalloid concentrations in waters and sediments typically meet ecosystem protection guideline values and are therefore not key ecosystem stressors.

Port Curtis supports a range of intertidal and subtidal habitats that are important in maintaining a range of ecological values. Intertidal habitats (rocky shores, mangroves, saltmarsh, saltpan and mud flats) occur throughout the Port Curtis area, and seagrass meadows and reefs are well developed.

The composition and distribution of biological communities of Port Curtis are controlled in part by water quality properties, especially high ambient turbidity regime and periodic freshwater inputs. In summary:

- Seagrass meadows are restricted to shallow waters. Meadows are comprised of coloniser and opportunistic species that are capable recovery following disturbance.
- Reef building corals have low cover and richness within the turbid, fluvial affected sections of the port, but are more abundant in the

more marine influenced sections of the port. Hard coral communities in Port Curtis are currently in poor condition, having undergone major declines resulting from flood events in in 2011 and 2013.

- Soft sediment benthic community richness and abundance is positively correlated with high levels of turbidity and associated freshwater inflow.

These wetland types support diverse flora and fauna communities and habitat for threatened and listed migratory marine species (e.g. feeding habitat for turtles, dolphins and dugongs), and species of fisheries significance.

Potential Impacts

Maintenance dredging and disposal is expected to result in direct and indirect effects.

Maintenance dredging will result in direct physical disturbance of benthic communities in the Marina, the EBSDS and in the immediate vicinity of the proposed Clinton Channel DMPA. The characteristics of benthic communities at the proposed Clinton Channel DMPA have not been specifically surveyed. Direct impacts to benthic fauna in the Marina and EBSDS will likely be highly localised and short-term, and this would likely be the same at proposed Clinton Channel DMPA assuming this area has similar benthic community types. Correlation analysis found significant positive correlations between benthos abundance/richness and turbidity, on which Currie and Smith (2005) concluded that high turbidity provided favourable conditions for benthic communities.

Modelling results indicate that dredging will result in short-term, low intensity turbidity spikes, typically well within the range of modelled ambient turbidity. Deposition rates will temporarily increase within and immediately adjacent to the dredge and DMPAs (i.e. highly localised effects), however modelled dredging-related deposition rates are predicted to be negligible in the period following the completion of dredging (i.e. only short term effects are expected).

On this basis, no major impacts to sensitive receptor habitats (seagrass meadows, reefs) are expected given the short duration and low intensity of dredge-related turbidity, and the limited spatial extent of significant sediment deposition (mostly restricted to areas within the DMPAs and dredged areas).

Other potential impacting processes include:

- Other water quality impacts – dredged sediments do not contain high pollutant loads, and the dredge area and proposed DMPAs are well flushed. Monitoring of dredge plumes indicates that water quality changes associated with the mobilisation and releases of nutrients (and other substances) are short term and low intensity, and unlikely to result in major impacts to biodiversity values.
- Introduced marine pests - any CSD or TSHD dredger contracted to undertake dredging works will be required to comply with best practices.
- Vessel strike - Given the relatively low numbers of turtles captured by dredgers compared to other activities, and the use of effective management and operational practices to reduce the potential for turtle capture, it is not considered that the proposed dredging will have a significant impact on local turtle populations.

Significant impacts to protected matters (MNES, MSES) are therefore not expected as a result of maintenance dredging and disposal activities.

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1 Introduction

1.1 Background

Gladstone Ports Corporation Limited (GPC) is responsible for maintenance dredging of the Port of Gladstone (PoG). The dredged material is disposed of at sea at the East Banks Sea Disposal Site (EBSDS) in accordance with Sea Dumping Permits issued by the Commonwealth Department of the Agriculture, Water and the Environment (DAWE).

GPC is assessing the potential for alternative beneficial reuse of maintenance dredging material, as part of the Sustainable Sediment Management Project. One proposed option involves an alternative in-channel Dredge Material Placement Area (DMPA) option for disposal of predominantly fine dredged sediment from the Gladstone Marina. The proposed dredging activity involves the use of a Cutter Suction Dredge (CSD) working in the Marina, pumping a slurry of dredged sediment to a discharge location on the edge of the Clinton Channel (see Figure 1-1).

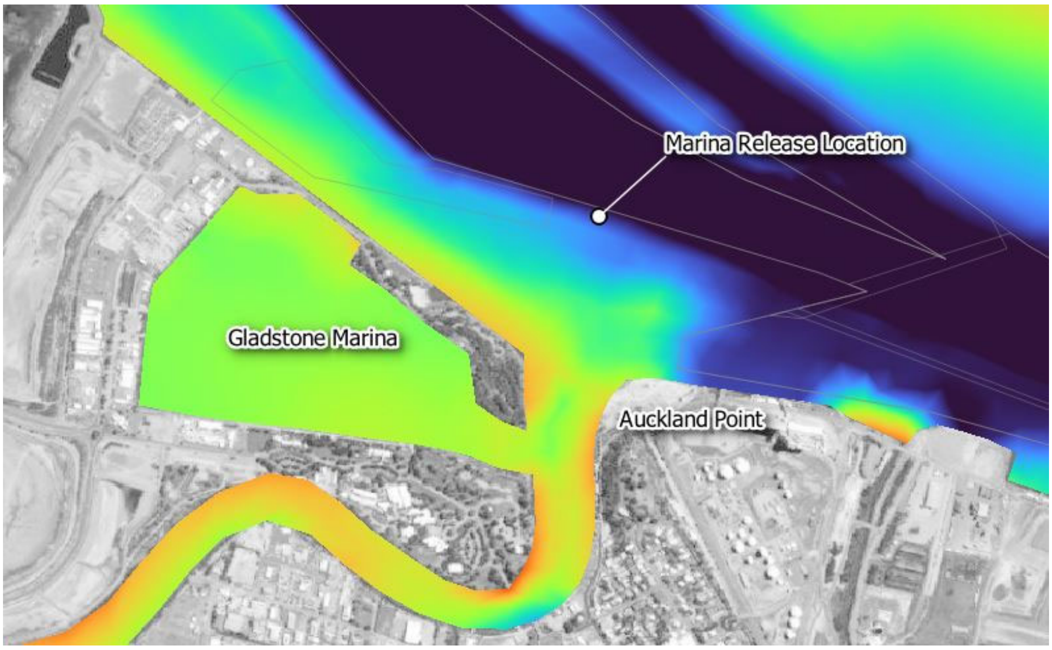


Figure 1-1 Marina Sediment Discharge Location

Three (3) scenarios are assessed in this report:

- 200,000 m^3 dredged from the Marina by a small Trailing Suction Hopper Dredger (TSHD) with placement at the EBSDS DMPA.
- 40,000 m^3 dredged from the Marina by CSD and pumped to the Clinton Channel Placement Area; and
- 150,000 m^3 dredged from the Marina by CSD and pumped to the Clinton Channel Placement Area.

This report describes the approach and findings of the environmental assessment of maintenance dredging impacts to marine waters, incorporating bathymetric changes associated with the Clinton Vessel Interaction Project (CVIP) channel footprint. The environmental assessment was based on desktop assessments involving the review of existing information, and hydrodynamic modelling. This study uses the same methodology as the recently completed revised assessment of regular maintenance dredging activities at the PoG (BMT, 2021a).

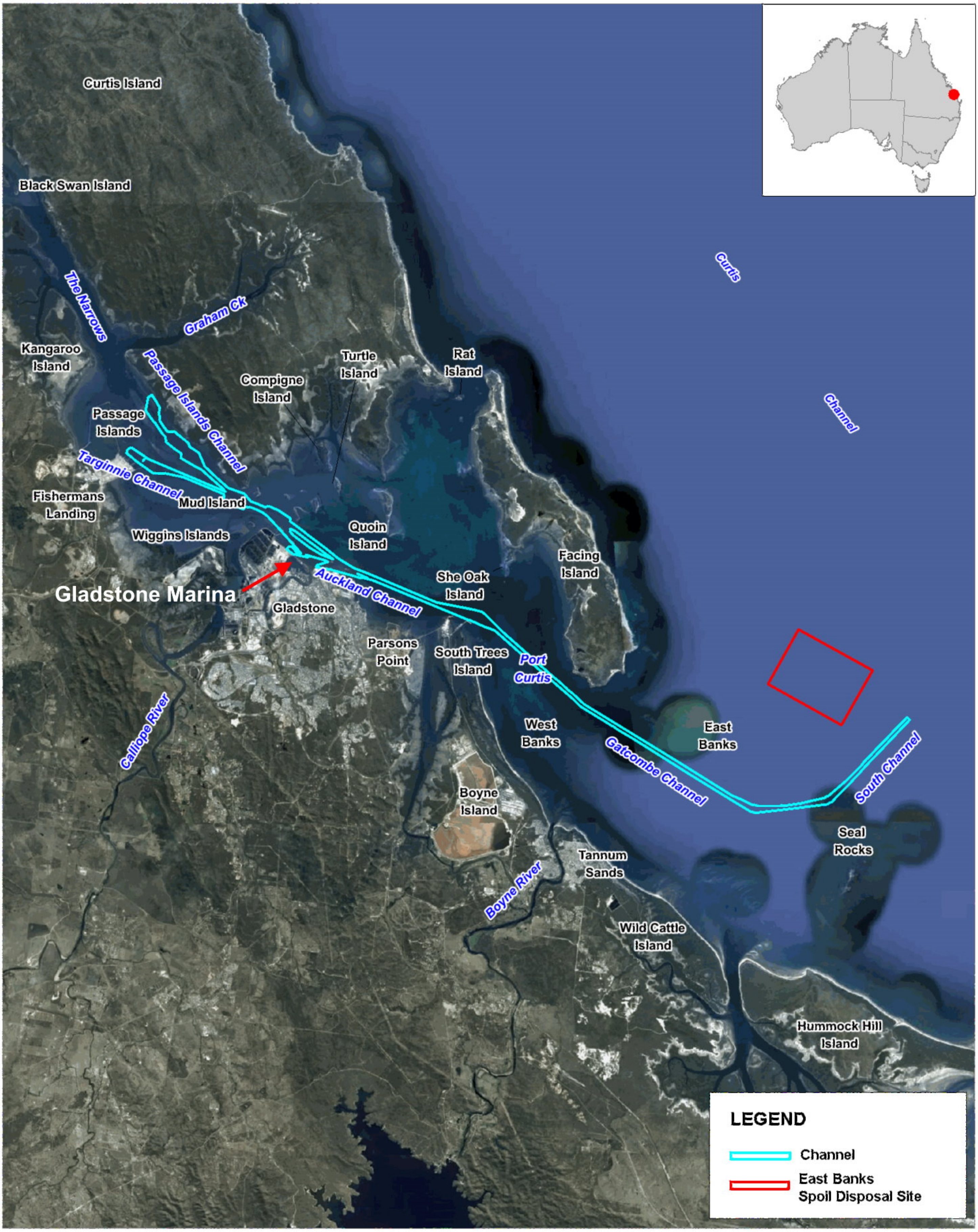
1.2 Study Objectives

The specific objectives of the report is to:

- Identify relevant matters of national and state environmental significance, and the location of sensitive ecological receptors, within the footprint and in adjacent areas potentially affected by maintenance dredging;
- Assess potential changes to water quality and the marine environment associated with the proposed dredging; and
- Assess potential impacts to matters of national and state environmental significance as a result of dredging.

1.3 Study Area

For the purposes of this assessment the study area is defined as all marine waters within Port Curtis. The project area includes the Gladstone Marina area subject to maintenance dredging, the EBSDS, and their immediate surrounds. These features as shown in Figure 1-2.



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Locality Plan

Figure: **1-2**

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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2 Methodology

2.1 Review of Existing Information

2.1.1 Identifying Features of Biodiversity Significance or Sensitivity

This report considers both matters of national and state environmental significance (MNES and MSES, respectively). MNES and MSES that were known or likely to occur within the study area were defined based on searches using the EPBC Protected Matters search tool (PMST), and the State Planning Policy (SPP) Interactive Mapping System. The searches identified: (i) legally defined areas listed under Commonwealth and State Government instruments (i.e. mapped conservation areas and other discrete environmental features; and (ii) in the case of PMST, species listed under the EPBC Act that are known or likely to occur within the study area.

Both the PMST and SPP Interactive Mapping System typically have limited locational precision with regard to defining habitats for listed species. Other information sources were therefore reviewed to determine the known or likely occurrence of species in the project area and/or study area, including academic publications, consultancy reports, and wildlife on-line flora and fauna records. The determination of known or likely occurrences was based on: (i) confirmed records of the species; (ii) an assessment of habitat suitability, based primarily on the online Species Profile and Threats Database (DAWE, 2021).

2.1.2 Other Data Sources

Other data sources used to characterise environmental features and/or inform modelling assessments include:

- Bathymetry and typography – Digital Elevation Models (DEMs) with 10 m resolution for the surrounding area (BMT).
- Latest bathymetry and channel extents within PoG supplied by GPC.
- Reef habitat mapping outlined in BMT (2015; 2018) and WetlandInfo.
- Seagrass mapping data supplied by GPC and contained in seagrass monitoring reports prepared by James Cook University TropWater (and predecessors Department of Primary Industries).
- Boundary condition data from global tidal, wind and atmospheric model outputs (NOAA, 2012).

2.2 Impact Assessment

2.2.1 Numerical Model

The numerical modelling software TUFLOW FV was used to simulate the three-dimensional hydrodynamics of the Port and the advection and dispersion of suspended sediment (both ambient sediment and plumes generated during dredging). The model was used to simulate the dredging campaigns in full so that the potential effect on the turbidity levels and deposition rate within the Port could be estimated. TUFLOW FV carries out calculations on an unstructured mesh, which allows the mesh resolution to be enhanced in the areas of greatest interest.

The coarse regional PoG model mesh and the high-resolution local nested model mesh is presented in Figure 2-1. The model bathymetry was updated to include the most recent survey data collected after completion of the CVIP dredging project.

2.2.2 Model Bathymetry

The model bathymetry is based on a Digital Elevation Model (DEM) of the Port, which has been derived from the following survey components:

- Detailed hydrographic survey data of the dredged channels, swing basins and berths as provided by Maritime Safety Queensland (MSQ) and GPC, together with the progressive inclusion of ongoing surveys to ensure that the model bed levels match the actual bathymetric configuration at the time of the simulation period; and
- Hydrographic survey data and outlines of the edges of the shoreline, mangroves and saltpans used in producing Boating Safety Charts of the area, as provided by MSQ.

Typical levels have been adopted for the edges of the mangroves and saltpan areas for interpolation in those upper inter-tidal zones where no specific survey level data is available. The various data components have been combined and prioritised with respect to date and detail where there is overlap in producing a base DEM. For modelling purposes, all data has been adjusted to a consistent mean sea level datum.

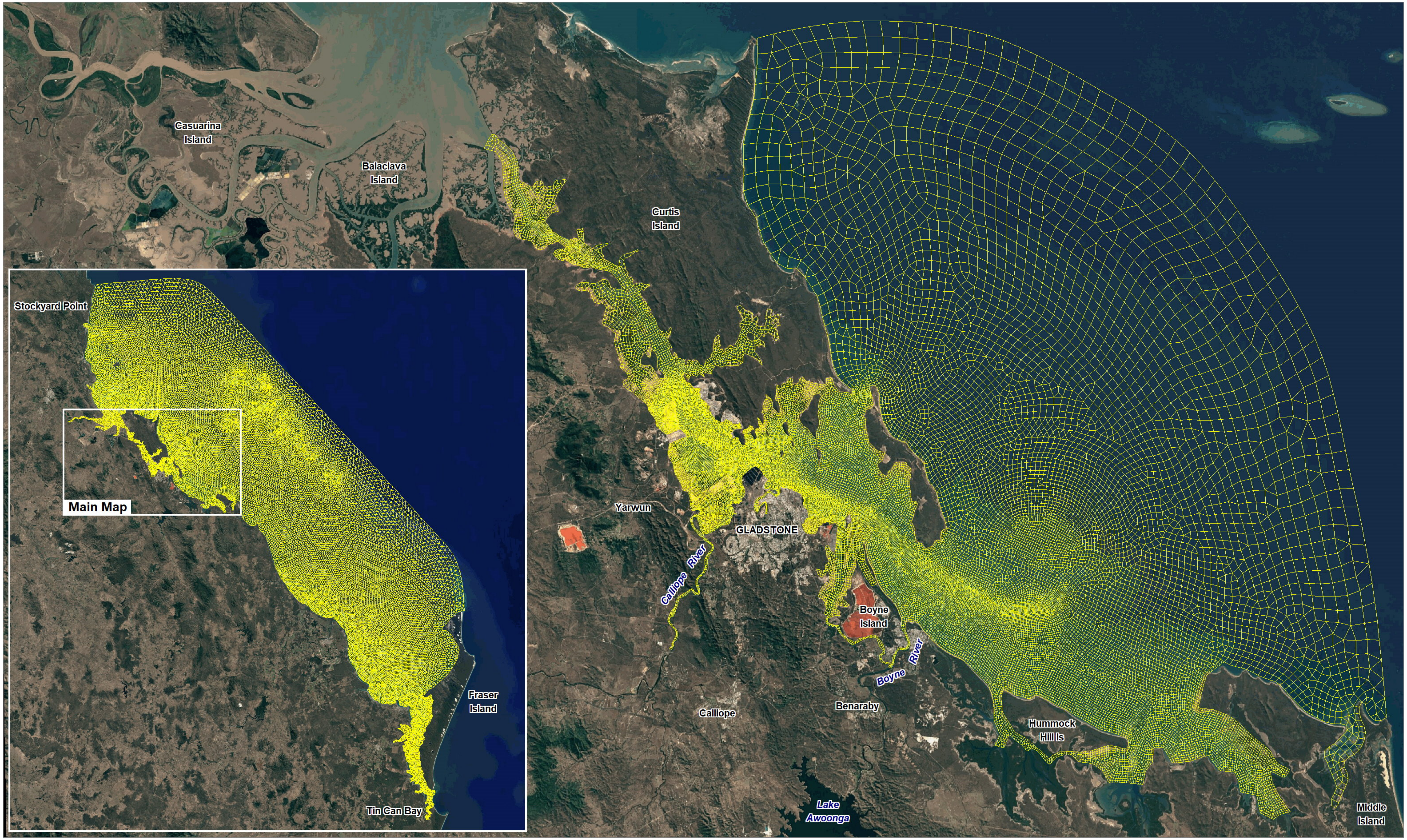
2.2.3 Boundary Conditions

The regional scale model is supplied with external water level boundary conditions from the University of Newcastle Great Barrier Reef Tide Model (Seifi *et al*., 2019). The nested high-resolution local model is coupled with the regional model to provide detailed results within the Port.

A SWAN spectral wave model was developed in order to include the influence of waves on the sediment dynamics (Delft University of Technology, 2006). Wave model outputs were input as a boundary condition for the TUFLOW FV model to enable the calculation of total bed shear stresses.

Due to the large scale of the model, regional oceanic effects needed to be incorporated in the offshore open ocean boundary conditions. This was done using HYCOM global ocean circulation model hindcast outputs (www.hycom.org). This model provided 3D current, salinity and temperature data which was applied on the ocean boundary in combination with the tidal water level variation.

Further boundary conditions were also applied to the model to represent atmospheric influences. These boundary conditions were derived from the National Centers for Environmental Predictions (NCEP) Climate Forecast System Reanalysis (CFSR) (www.ncep.noaa.gov) and included wind, temperature, humidity, short and long wave radiation, which were applied on a spatially varying grid throughout the model domain with a temporal resolution of one (1) hour.



LEGEND

Model mesh

Satellite imagery:
Google Earth December 2016
Image Landsat / Copernicus

Title:

Regional Coarse Model Mesh (Inset) and Local Nested Model Mesh

Figure: **2-1**

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Main Map (km)

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Inset (km)

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2.2.4 Model Validation

The TUFLOW FV numerical model used for the purposes of this study has evolved from previous PoG models which have been progressively updated, refined and calibrated over many years using a large number of recorded water level, wave and current velocity measurements.

The most recent set of model calibration and validation results are available in the report "Post-CVIP Port of Gladstone TUFLOW FV Model Validation" (BMT, 2021b).

2.2.5 Impact Assessment Methodology

The effects of dredging were assessed based on modelled increases in turbidity and deposition rate above natural or ambient levels, consistent with the methodology used for the PoG Gatcombe and Golding Cutting Channel Duplication Project EIS (BMT, 2019b). Both ambient and dredge related signals were resolved in the numerical model, which allows for an understanding of how significant the dredge contribution is in relation to ambient conditions.

Depth-averaged turbidity values (in NTU) are presented since they are most relevant to assessing ecological impacts due to the reduction in Benthic Photosynthetically Active Radiation (BPAR). Deposition rate impacts were derived from the daily rate of change in bed sediment mass. The deposition rate was calculated in units of $mg/cm^2/day$.

The anticipated effects of dredging were assessed by analysing:

- Time series of turbidity and deposition rate at representative sensitive receptor sites; and
- Spatial plots of the change in the percentiles of the turbidity and deposition rate due to dredging.

The impacts of dredging on the modelled turbidity and deposition rate were then compared to biologically-relevant thresholds to determine potential Zones of Influence (where plumes are detectable but cause no ecological impact) and Zones of Impact (where some temporary ecological effects are anticipated to occur).

Further methodological details and results are provided in Section 5.

3 Dredging Project Description

3.1 Maintenance Dredging Volumes and Locations

3.1.1 200,000 m^3 dredged from the Marina by a small TSHD with placement at the EBSDS DMPA

The source rates for the plumes produced by the TSHD during dredging and during placement of material were derived from the rates developed for the TSHD Brisbane, but with the dredging time per cycle reduced in proportion to the smaller size of the dredge (it was assumed that the small TSHD would remove 1,000 m^3 per trip and require 200 trips to complete the campaign). The adopted assumptions for the small TSHD plume source rates are provided in Table 3-1.

Table 3-1 Small TSHD Plume Source Rate Assumptions

Dredging Parameter	Adopted Value
Amount of in-situ material removed per trip	1,000 m^3 per trip (200 trips total)
Time to overflow	15 minutes
Time overflowing	60 minutes
Time sailing to EBSDS	1.9 hours, 10 minutes placing material
Estimated material composition	5% sand, 40% silt, 55% clay
Pre-overflow plume source rate (draghead)	5.1 kg/s silt, 7.0 kg/s clay
Plume source rate during overflow	1.2 kg/s sand, 30.7 kg/s silt, 42.2 kg/s clay
Placement plume source rate	3.8 kg/s sand, 68.5 kg/s silt, 94.2 kg/s clay
Placement on sea bed at EBSDS (10 minutes)	188.1 kg/s sand, 616.5 kg/s silt, 847.6 kg/s clay

3.1.2 40,000 m^3 dredged from the Marina by Cutter Suction Dredger (CSD) and pumped to the Clinton Channel Placement Area

A 40,000 m^3 Marina dredge campaign was simulated in the numerical model, involving a CSD working in the Marina pumping to a near bed discharge location on the edge of the Clinton Channel (see Figure 1-1). The simulation assumed 12 hours of discharge per day at a rate of 0.3 m^3/s of slurry with 10% sediment (0.03m^3/s in-situ sediment), with discharge beginning at 6am and ending at 6pm each day (this is an upper-bound estimate for the number of hours of operation per day). An average dry density for the sediment of 300 kg/m^3 was assumed (medium consolidated based on Van Rijn), so the dry mass of sediment released during discharge was 9 kg/s. The composition of the discharge material was assumed to be 5% sand, 40% silt and 55% clay. The simulation durations were 31 days for the 40,000 m^3 campaign. The plume sources included the CSD cutter head producing a plume within the Marina (at a rate of 3% of the pipe discharge).

3.1.3 150,000 m^3 dredged from the Marina by Cutter Suction Dredger (CSD) and pumped to the Clinton Channel Placement Area

This simulation was similar to the 40,000m^3 campaign described above, but assuming a 24hr operation with 30% downtime. The downtime was simulated as 6 hours' continuous discharge followed by 2 hours with no discharge. The rate of discharge, as per previous simulation, was 0.3 m^3/s of slurry with 10% sediment (0.03m^3/s in-situ sediment). An average dry density for the sediment of 300 kg/m^3 was assumed as before (medium consolidated based on Van Rijn), so the dry mass of sediment released during discharge was 9 kg/s. The composition of the discharge material was assumed to be 5% sand, 40% silt and 55% clay (unchanged from previous simulation). The simulation duration was 82.5 days for the 150,000 m^3 campaign. The plume sources included the CSD cutter head producing a plume within the Marina at a rate of 3% of the pipe discharge.

4 Existing Conditions

4.1 Sedimentary and Hydrodynamic Environment

The PoG is located within a macro-tidal estuary that features significant tidal currents. The energetic tidal hydrodynamic conditions play an important role in the context of natural bed remobilisation processes. The surface sediments in the main channels where tidal velocities are high are typically dominated by coarser fractions with the finer particles swept away. The shallower areas are a mixture of sands and silts with fine sediment dominating lower current/wave energy areas.

The dredged channels in Port are effective sediment traps, due to their increased depth relative to the surrounding seabed. Maintenance dredging is carried out on an annual basis. The composition of the dredged material is variable, with sediments in the main navigation channels dominated by sands and gravels (where tidal currents are strong) and sediments in the berth pockets and closed-ended channels having a higher fines content (BMT, 2014). The material in the Gladstone Marina is dominated by fines (estimated to be around 95% silts and clays).

GPC is undertaking the Sustainable Sediment Management Project (SSM Project) to help obtain a robust, well considered, long term solution for the management of maintenance dredging sediment. As part of this project, a quantitative sediment budget was developed that estimated the sediment fluxes, sources and sinks in the Port (P&CS, 2019).

The EBSDS is located in an exposed coastal environment at the entrance to the PoG. The EBSDS is partially retentive, with sediments consisting of sands with low proportion of silts and gravel, due to winnowing by wave/current resuspension (BMT, 2012a). Recent analysis undertaken to develop the quantitative sediment budget for the Port indicates that between 5-40% of sediment placed at the EBSDS could be moved on by natural wind/wave events (P&CS, 2019).

The Calliope River discharges sediment directly into the Port, as do smaller catchments on Curtis Island. The Boyne River also discharges into the Port but sediment discharge is relatively minor due to sediment trapping and flow attenuation by the Awoonga Dam. Overall, the sediment fluxes contributed by these catchments are very small compared to the channel infilling that is driven by energetic spring tide currents (within the Port) and wave activity (outside the Port). Connectivity between new fluvial inputs and maintenance dredging requirements is weak.

4.2 Water and Sediment Quality

The Port Curtis Integrated Monitoring Program (PCIMP) is a long term water quality and ecosystem health monitoring program encompassing the estuarine and marine waters of Port Curtis. PCIMP undertakes quarterly water quality sampling at 54 sites in 15 zones (refer to Figure 4-1). Surface sediment is sampled annually at each of the 54 water sites. PCIMP data are used to produce the Gladstone Healthy Harbour Partnership (GHHP) Gladstone Harbour annual report card.

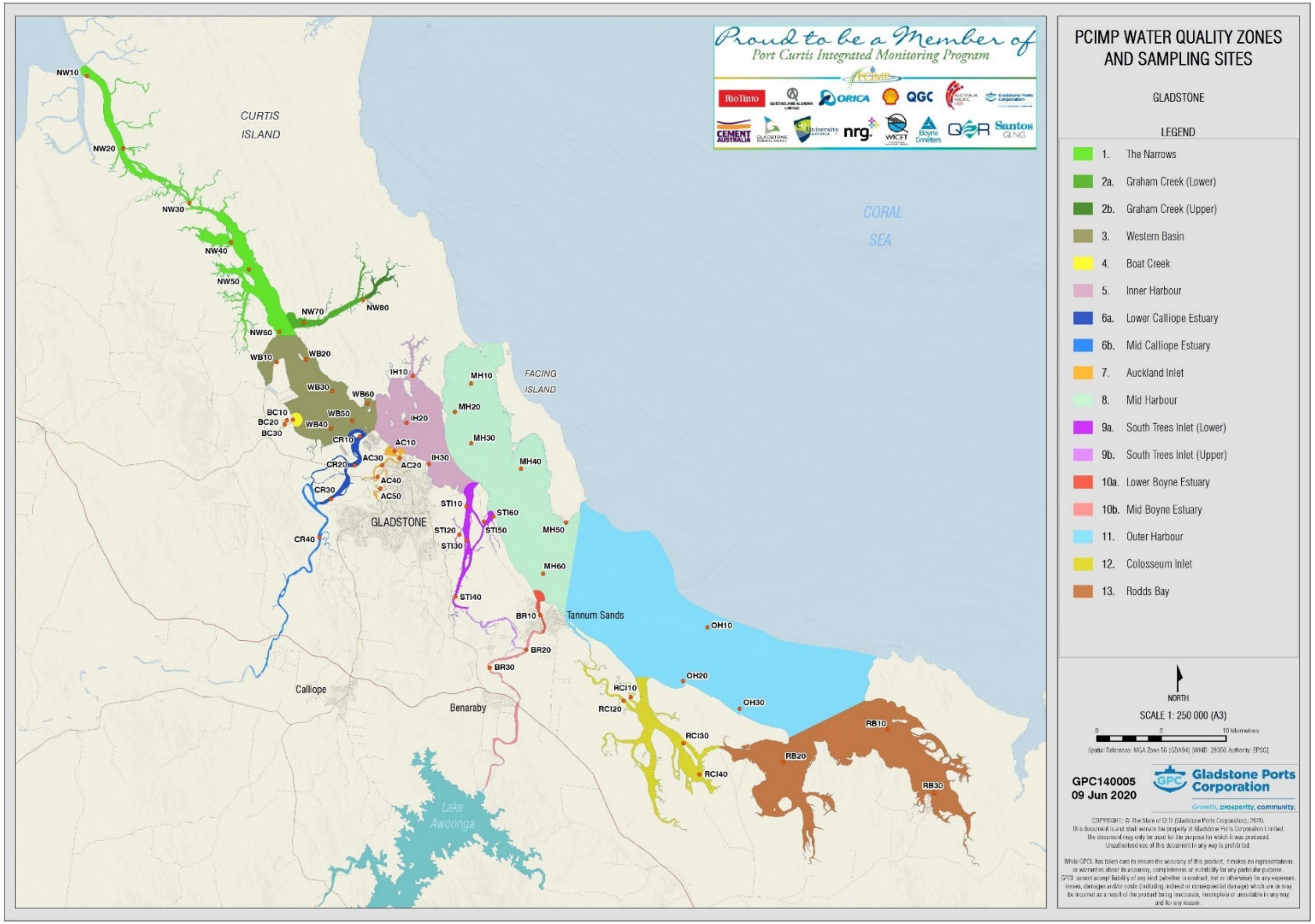


Figure 4-1 Gladstone Harbour Monitoring Regions (Gladstone Ports Corporation 2020)

4.2.1 Water Quality

The study area (see Section 1.3) extends across several water types within the Port Curtis, all of which are classified as *Moderately Disturbed* waters under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity). Water Quality Objectives (WQOs) have been defined for the protection of scheduled aquatic ecosystem and human use environmental values (EVs[1]) shown in Table 4-1. PCIMP data (mean and standard error[2]) for key water quality variables and scheduled WQOs are presented in Figure 4-2 and Figure 4-3 for sites from the Inner Harbour zone[3]. GHHP report card ratings developed from PCIMP data are summarised in Table 4-2 for all zones.

Table 4-1 Scheduled environmental values for Gladstone Harbour and adjacent coastal waters, mainland estuaries (Source: EPP Water and Wetland Biodiversity)

GLADSTONE HARBOUR, ADJACENT COASTAL WATERS, MAINLAND ESTUARIES THE NARROWS FITZROY DELTA	Environmental values[1–7]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation [5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
GLADSTONE HARBOUR (listed west to east)[7] AND ADJACENT COASTAL WATERS												
Western Basin	✓					✓		✓[5]	✓		✓	✓
Inner Harbour (including waters adjacent to Spinnaker Park beach, Barney Point)	✓					✓	✓[5]	✓[5]	✓	✓[6]	✓	✓
Mid Harbour	✓					✓	✓[5]	✓[5]	✓	✓[6]	✓	✓
Outer Harbour	✓					✓	✓[5]	✓[5]	✓	✓[6]	✓	✓
Coastal waters outside Gladstone Harbour east and south of Facing Island (to southern limits of Port)	✓					✓	✓[5]	✓[5]	✓	✓[6]	✓	✓

[1] referred to as community values in ANZG (2018)
[2] note that comparisons of WQOs to measured data should be based on median values rather than means. The comparisons shown herein should be considered indicative
[3] Inner Harbour waters are representative of water quality characteristics of dredged areas within Gladstone Harbour (see Table 4-2)

Table 4-2 Water quality sub-indicator, zone and harbour scores for the 2020 GHHP report card. Overall water quality scores 2019 and 2018 are also shown (Source: GHHP 2020)

Water quality	Physico-chemical	Nutrients	Dissolved metals	2020	*2019*	*2018*
1. The Narrows	0.93	0.63	1.00	0.85	*0.74*	*0.71*
2. Graham Creek	0.98	0.76	1.00	0.91	*0.79*	*0.78*
3. Western Basin	0.97	0.75	0.96	0.89	*0.77*	*0.72*
4. Boat Creek	0.89	0.69	0.98	0.85	*0.68*	*0.63*
5. Inner Harbour	0.94	0.68	0.95	0.85	*0.82*	*0.80*
6. Calliope Estuary	1.00	0.84	0.99	0.94	*0.80*	*0.76*
7. Auckland Inlet	0.83	0.66	0.97	0.82	*0.77*	*0.74*
8. Mid Harbour	0.87	0.75	1.00	0.87	*0.86*	*0.81*
9. South Trees Inlet	0.96	0.67	1.00	0.87	*0.83*	*0.76*
10. Boyne Estuary	0.98	0.72	1.00	0.90	*0.88*	*0.79*
11. Outer Harbour	1.00	0.89	1.00	0.96	*0.93*	*0.92*
12. Colosseum Inlet	0.99	0.69	1.00	0.89	*0.88*	*0.83*
13. Rodds Bay	0.93	0.73	1.00	0.89	*0.83*	*0.74*
Harbour score	**0.94**	**0.73**	**0.99**	**0.89**	***0.81***	***0.76***

Score card ratings: A = Dark green; B = light green; C = yellow; D = red

In summary:

- Water quality grade improved between 2018 to 2020, and was rated as ‘A’ (Very Good) in most zones (previously a ‘B’ in most zones). The overall Very Good grade in 2020 was the highest recorded score since the program commencement in 2015. The Very Good water quality in 2020 was mostly a consequence of low rainfall/catchment inflows.
- In 2020, Inner Harbour and Western Basin zones were rated as ‘A’ for physio-chemical stressors (turbidity, pH) and dissolved metals/metalloids, and ‘B’ for nutrients.
- Turbidity displays great variability over time, mostly in response to variations in tidal and rainfall conditions. Quarterly grab-based turbidity measurements exceeded the Queensland WQO median range (Figure 4-2) and logging instruments have recorded turbidity peaks >50 NTU in the Inner Harbour.
- Mean total nitrogen has remained below the WQO since the 2018-19 wet season (Figure 4-2). Mean ammonia concentrations were generally less than or at the WQO in the period 2016-21. (Note that ammonia data collected prior to July 2015 are erroneous and have been disregarded.) NOx displayed great variability over time and among sites, with the mean concentration exceeding the WQO on three of 17 sampling occasions.
- Mean total phosphorus concentrations were generally below the WQO, except wet season 2012-13 when the harbour experienced major flooding.
- Chlorophyll *a* (a surrogate for phytoplankton biomass) was generally less than the WQO in the period 2016-21, except wet season 2017-18. The period prior had chlorophyll *a* concentrations near the WQO.

- Mean concentrations of dissolved metals/metalloids were generally less than WQOs. The exception was aluminium (exceeded in Feb 2020) and zinc (exceeded in May and August 2014).

GHHP (2020) suggested that the key water quality drivers operating in the harbour are: (i) nutrient (and other contaminant) inputs from point and diffuse (pulsed, rainfall driven events) sources; (ii) sediment (and associated nutrients and other compounds) resuspension by tides and (iii) oceanic inputs of low nutrient and turbidity waters. The relative influence of these drivers, and the spatial and temporal scales at which they operate, has not been examined in detail in Port Curtis. Port Curtis is a highly dynamic system that is generally well mixed, with areas of greatest turbidity occurring between Wiggins Island and Graham Creek, in the upper reaches of the Narrows, and within South Trees Inlet (areas where fine sediment has accumulated). These processes have implications for the distribution of seagrasses and reef-associated benthos within the broader Port Curtis area; both communities typically occur in shallow waters and/or are remote from areas that experience the greatest tidally-driven sediment resuspension.

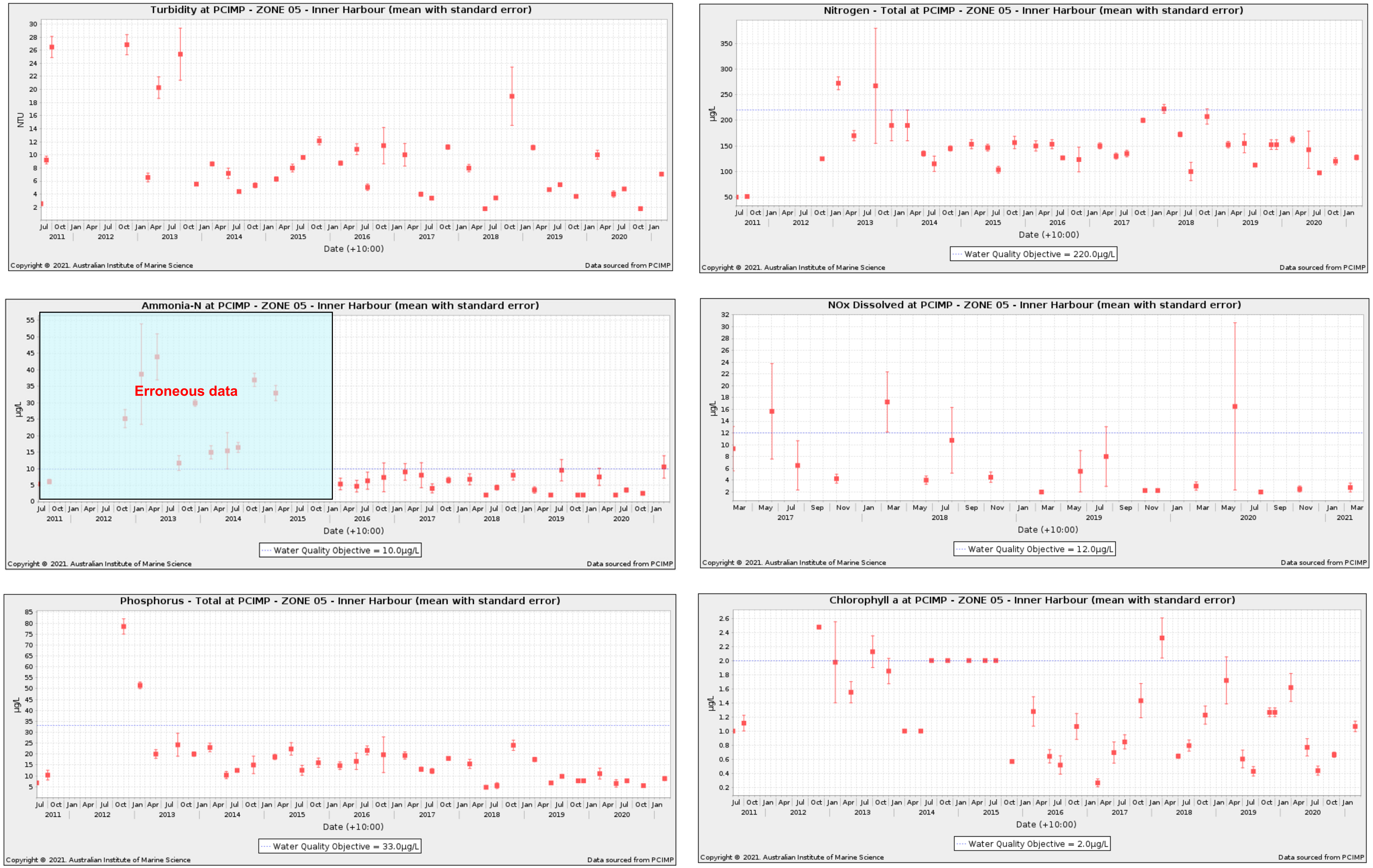


Figure 4-2 Mean (error bars ± SE) turbidity (NTU), TN, ammonia, NOx, TP, chlorophyll *a* (µg/L) - Inner Harbour water quality monitoring sites 2011-2021 (Source: PCIMP, 2021)

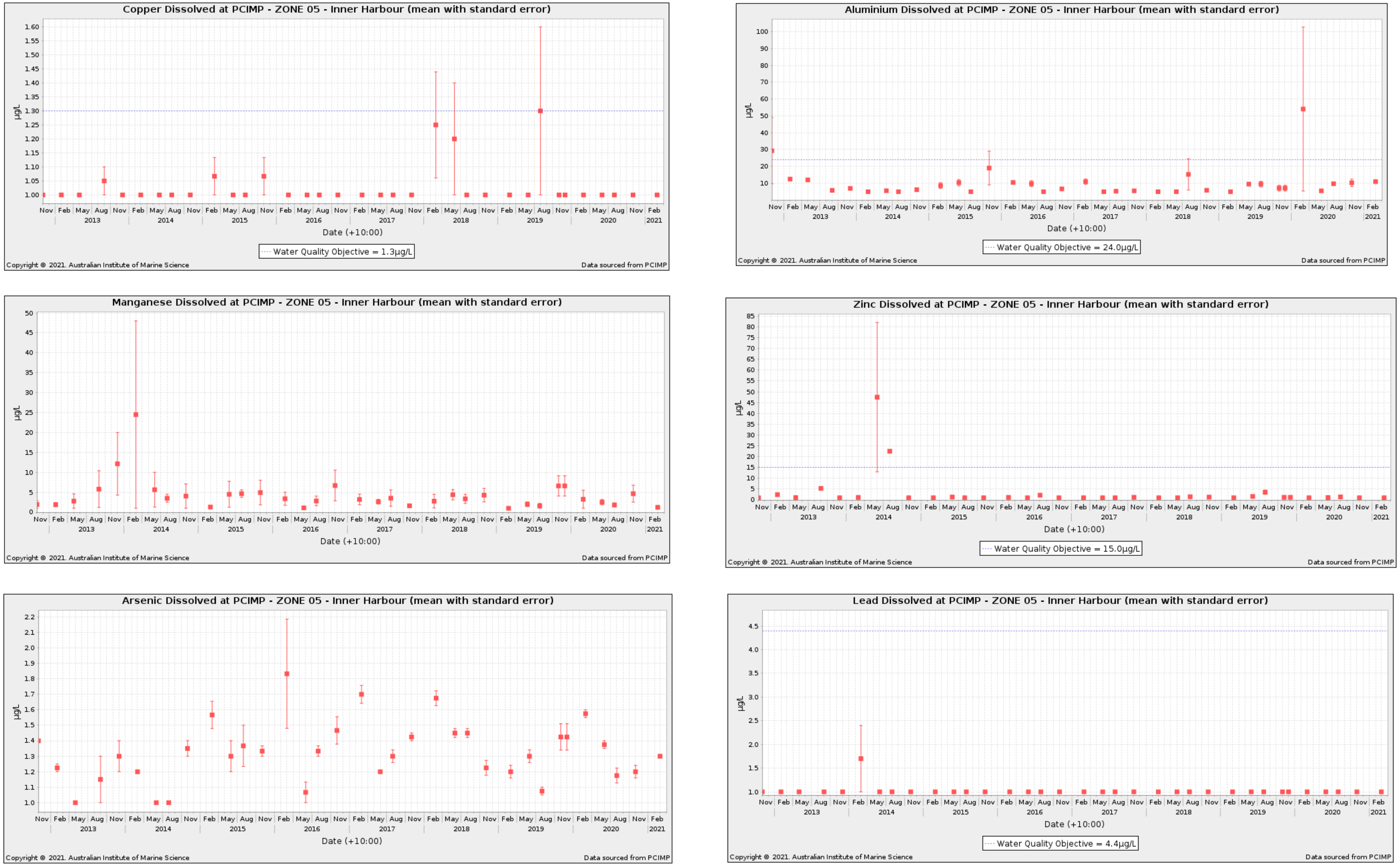


Figure 4-3 Mean (error bars ± SE) dissolved copper, aluminium, manganese, zinc - Inner Harbour water quality monitoring sites 2011 -2021 (Source: PCIMP, 2021)

4.2.2 Sediment Quality

The catchments that drain into the port are mostly agricultural lands, with urban and industrial areas on the coastal fringe. Dredged sediments consist of sand/gravel in the channel, and mostly silts and clays in berths.

BMT (2017a) reviewed sediment SAP reports for dredged areas in Port Curtis. The review found that several metals/metalloids and organic pollutants (PAHs, and occasionally TPH) were detected in dredged sediments, but all had average concentrations below the screening level or background (BMT, 2017a). On occasions, arsenic was elevated in places, however the average was well below screening level. Other contaminants, including TBT and pesticides were not detected or well below screening levels. The sediment SAP for the Western Basin Project (BMT, 2014) detected potential ASS in surficial layers, but at concentrations where minor or no treatment would be required if placed on land. In the 2017 maintenance dredging SAP, sediment samples from Upper Auckland Inlet, Gladstone Marina, and Gatcombe Head Harbour were the subject of acid sulfate soil analytical testing. All of the Gladstone Marina and Gatcombe Head samples returned net acidity <0.02% S, which indicates that no further consideration of PASS is required at these locations (AMA, 2018).

PCIMP data indicated that overall sediment quality scores were Very Good ('A') across all zones of Gladstone Harbour in the period 2018-20 (Table 4-3). Scores for individual parameters were typically also rated as 'A', except arsenic and nickel were occasionally good ('B') or satisfactory ('C'). The source of arsenic and nickel was likely natural (geological formation on the area) and not associated with anthropogenic inputs (Angel *et al*., 2012; GHHP, 2020).

Table 4-3 Scores for sediment quality measures for each zone – 2020 (Source: GHHP, 2020)

Zone	Metals and metalloid					
	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc
1. The Narrows	0.79	1.00	1.00	1.00	0.66	1.00
2. Graham Creek	0.60	1.00	1.00	1.00	0.81	1.00
3. Western Basin	0.92	1.00	1.00	1.00	0.94	1.00
4. Boat Creek	0.76	1.00	1.00	1.00	0.61	1.00
5. Inner Harbour	0.63	1.00	1.00	1.00	0.97	1.00
6. Calliope Estuary	0.91	1.00	1.00	1.00	0.82	1.00
7. Auckland Inlet	0.96	1.00	0.96	1.00	0.80	1.00
8. Mid Harbour	0.83	1.00	1.00	1.00	1.00	1.00
9. South Trees Inlet	0.85	1.00	1.00	1.00	0.93	1.00
10. Boyne Estuary	1.00	1.00	1.00	1.00	1.00	1.00
11. Outer Harbour	0.93	1.00	1.00	1.00	1.00	1.00
12. Colosseum Inlet	0.85	1.00	1.00	1.00	1.00	1.00
13. Rodds Bay	0.83	1.00	1.00	1.00	0.95	1.00
Harbour score	**0.84**	**1.00**	**1.00**	**1.00**	**0.88**	**1.00**

4.3 Marine Habitats and Communities

4.3.1 Marine Habitats

Port Curtis supports a range of intertidal and subtidal habitats that are important in maintaining a range of ecological values. Intertidal habitats (rocky shores, mangroves, saltmarsh, saltpan and mud flats) occur throughout the Port Curtis area, and seagrass meadows and reefs are well developed.

The following provides a summary of the marine habitats located within or adjacent to dredge areas, namely seagrass meadows, reefs and soft sediment habitats. Although extensive areas of intertidal habitat (mangroves, saltmarsh, saltpan and mud flats) occur throughout Port Cutis, these are outside of the zone of impact from dredging (see Section 5) and are not considered further.

4.3.1.1 Seagrass Meadows

Seagrass Species and Meadow Types

Six (6) species of seagrass have been identified in Port Curtis by James Cook University TropWater (formerly Department of Agriculture Forestry and Fisheries DAFF), namely: *Zostera muelleri*[4], *Halodule uninervis*, *Cymodocea serrulata, Halophila spinulosa*, *Halophila ovalis* and *Halophila decipiens*. *Cymodocea serrulata* is uncommon and has not been recorded in the study area in the last three years (Smith *et al*., 2021).

Figure 4-4 shows two (2) broad types of seagrass meadow:

- Permanent/ semi-permanent coastal meadows. This meadow type occurs on the tidal flats of Port Curtis, and was numerically dominated by *Zostera* and a mix of *Halophila* species; and
- Deep water meadows (>5 m deep), which are typically sparser than coastal meadows and are typically dominated by *Halophila* species. This meadow type occurs in offshore coastal waters, which have higher water clarity than the enclosed waters of Port Curtis. These are ephemeral meadows, varying in response to temporal changes in water clarity and disturbance.

Temporal Trends

The results of monitoring studies indicate that the distribution, extent and density of seagrass meadows within Port Curtis and surrounds can show great variation over a range of temporal scales. At inter-annual timescales, there was a major reduction in seagrass meadow extent in the period 2009-2013, and a period of recovery in subsequent years (Figure 4-5). Between 2009 and 2011, seagrass cover and biomass at Fisherman's Landing, Wiggins Island, and Rodds Bay had almost disappeared with average percent cover less than 1% (Sankey and Rasheed, 2011) and *H. ovalis* was no longer observed at the study area. The disappearance of seagrass from these areas was thought to be related to heavy rainfall associated with strong Southern Oscillation Index values for 2010 and 2011 (Sankey and Rasheed, 2011). Heavy rainfall associated with Cyclone Oswald resulted in further reductions in seagrass meadow extent between 2012 and March 2013 at Fisherman's Landing, Wiggins Island and Rodds Bay (Amies *et al.*, 2013).

[4] *Zostera muelleri* subspecies *capricorni* (Ascherson) 1876 afterwards referred to as *Zostera muelleri*

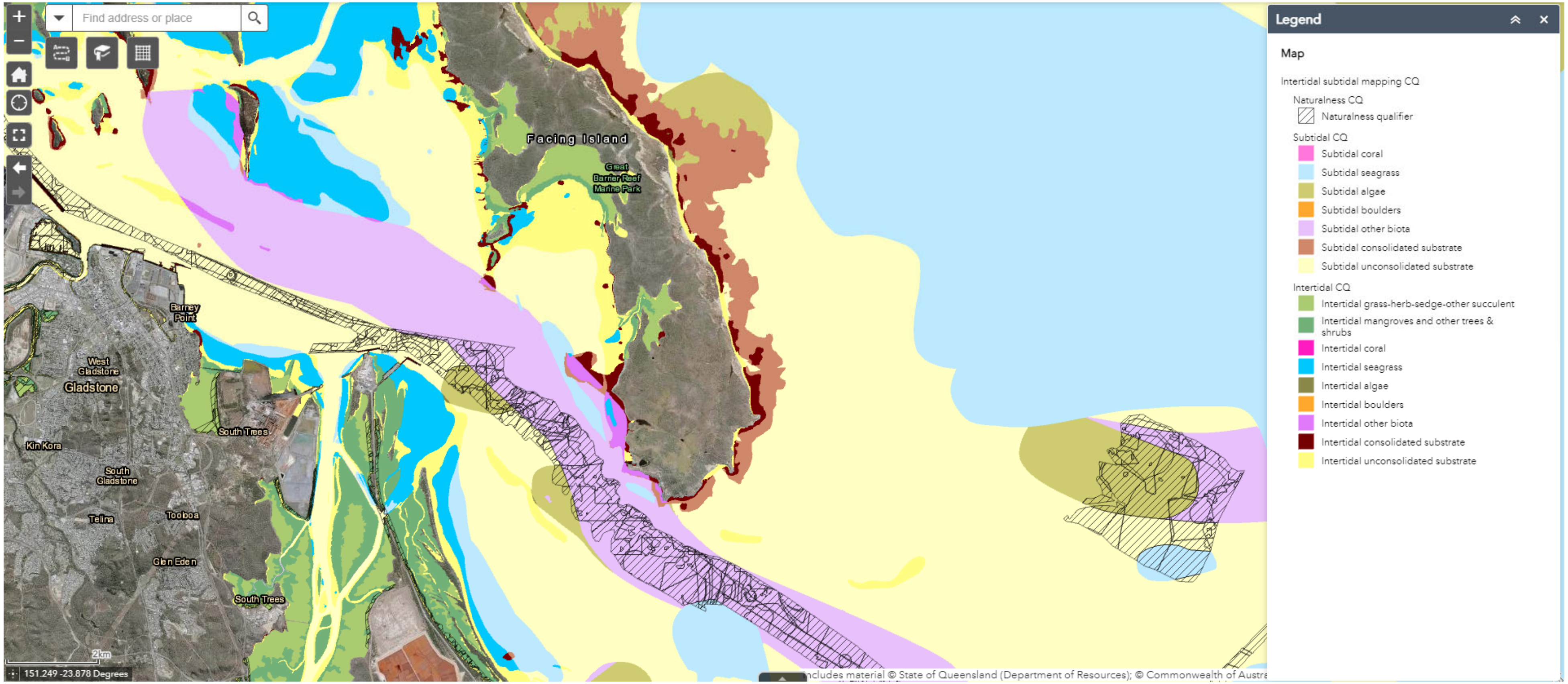


Figure 4-4 Intertidal and subtidal habitats of Port Curtis, including modified habitats (naturalness qualifier). Source: Wetlandinfo Wetland Maps

The GPC monitoring program results reported by the GHHP provide a composite seagrass condition grading for the period 2015-2020 (Figure 4-5). Key indicators within each of the monitoring meadows include:

- Biomass: changes in average above-ground biomass.
- Percent cover.
- Species composition: relative abundance of species.

Seagrass meadow condition remained in poor condition between 2015-2018. There was an improvement to seagrass meadow condition between 2018 and 2020 (Figure 4-5). GHHP (2020) classified seagrass condition in 2020 as better than 2019, whereas JCU (Smith *et al*., 2021) found seagrass was in good condition in both years (the difference was due to the use of different metrics and sample set). The 2020 sampling period occurred following a major capital dredging campaign in the inner harbour and maintenance dredging of navigation channels. Antecedent rainfall and runoff, and therefore turbidity, was low in the two (2) years of seagrass meadow improvement. At a GBR scale, there has been a general improvement in seagrass meadow condition along the GBR coast since flood-generated seagrass losses during 2009-10 (Smith *et al*., 2020).

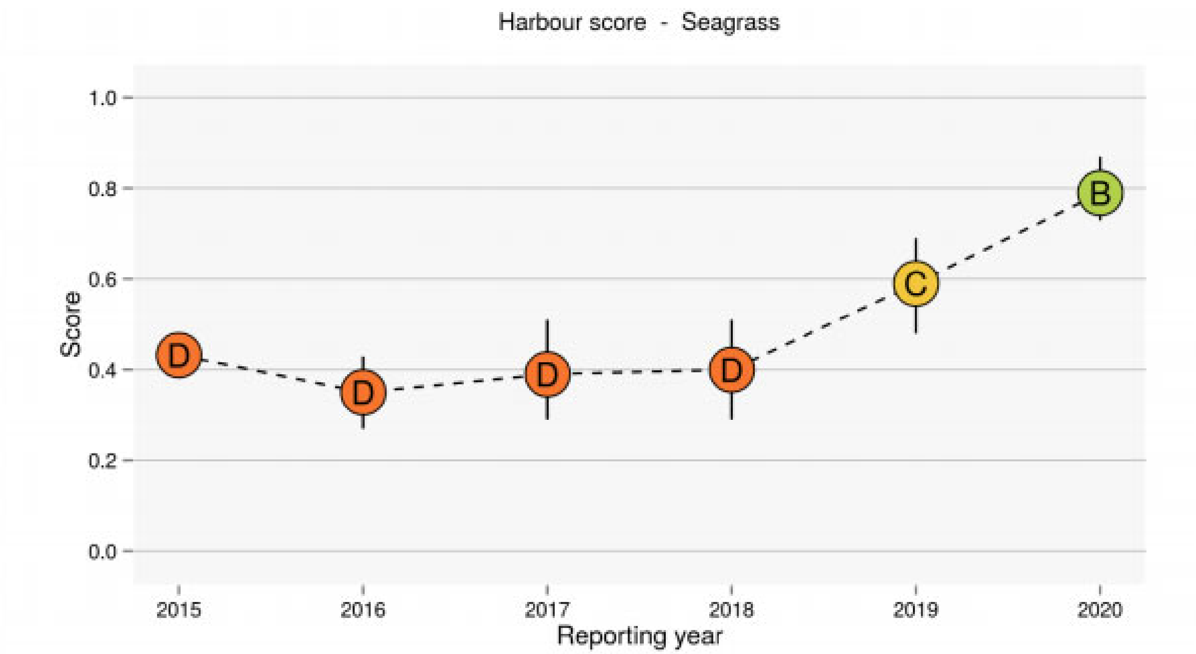


Figure 4-5 GHHP seagrass condition scores for Port Curtis (GHHP, 2020)

4.3.1.2 Hard Substrate Habitats

Hard substrate habitats in Port Curtis are comprised of intertidal rocky shores, shallow water reefs, deep water cobble/bedrock reefs and artificial hard structures (rock walls, pylons etc.). Several studies have mapped the extent of hard substrate habitats within Port Curtis (Rasheed *et al*., 2003; Connolly *et al*., 2005; BMT, 2009, 2015; DES, 2021).

Inter-tidal Rocky Shores

The natural rocky shores along the south-west coast of Curtis Island consist of terrigenous fringing reefs (see Figure 4-4). The supra-littoral and upper intertidal zone of these rocky shores was typically comprised of unconsolidated soft sediment (mud, sand and gravel), and the mid to lower intertidal zone was comprised of either massive/bedrock platform reef, boulder fields or rubble fields (BMT, 2009). All rocky shores in this area were dominated by oysters in the intertidal zone (BMT, 2009), and sponges, soft coral, hydroids, gorgonians and algae in the subtidal zone (URS, 2009).

Shallow-water Reefs

BMT (2009) recorded high hard coral cover at several shallow (<2 m deep) subtidal reefs in the study area including Bushy Island, Manning Reef and surrounding Facing Island. Follow-up surveys in 2014 indicate that reef communities within the study area experienced a major change in structure since the 2009 baseline surveys (BMT, 2015). In contrast to 2009 surveys, reefs at Port Curtis in 2014 had minimal living hard coral cover, and were dominated by bare substrate, turfing algae and macroalgae. Reef communities between Port Curtis and Rodds Bay also had low hard coral cover, however, limited baseline data make changes through time difficult to determine. Nearshore reefs along the eastern coastline of Facing Island, which are less affected by floods, had diverse and abundant hard coral cover in 2014, similar to 2010 survey results (BMT, 2015). Water quality modelling and measurements indicate that reefs within the PoG were strongly affected by flood events in 2010 and 2013, with reduced salinities and high turbidity likely to be a major driver of change in coral cover (BMT, 2015).

Coral monitoring undertaken in 2015 revisited a small selection of the previously surveyed sites within Port Curtis (Thompson *et al.*, 2015), all of which were noted by BMT (2015) as having experienced coral loss. Thompson *et al.* (2015) found that the surveyed reefs had not recovered to pre-2010 levels of coral cover.

GHHP (2020) undertakes annual monitoring of coral condition. Four (4) sub-indicators of coral health were measured to calculate the Gladstone Harbour Report Card coral score:

(1) Coral cover (%): the combined cover of hard and soft corals observed at the monitored reefs

(2) Macroalgal cover (%): the cover of macroalgae observed at the monitored reefs

(3) Juvenile coral density (no. m^{-2}): the density of juvenile corals observed at the monitored reefs

(4) Change in hard coral cover (%): averaged over a three-year period to give the rate at which hard coral cover increases or decreases.

Coral condition grades for the 2015-2020 period are shown in Figure 4-6. Coral condition grade has remained very poor (‘E’) in most years except 2017 (poor ‘D’). This indicates that reefs had low living coral cover, low numbers of juveniles, and that macroalgae numerically dominated reefs. This suggests that corals display little evidence of recovery, and a phase shift from coral to macroalgae dominance. A combination of factors appears to be restricting coral recovery, including interactions with macroalgae (shading, competition), interactions with bio-eroding sponge *Cliona orientalis*, and high water temperatures resulting in coral bleaching in some areas.

Given the poor condition of coral assemblages, it is expected that:

- recovery will be dependent on inputs from areas outside Port Curtis;
- recovery timeframes, if it occurs, are expected to be measured in years to decades; and
- coral assemblages will continue to have low resilience and capacity to cope with additional stressors (e.g. increased sediment concentrations, low salinity due to rainfall) during this recovery period.

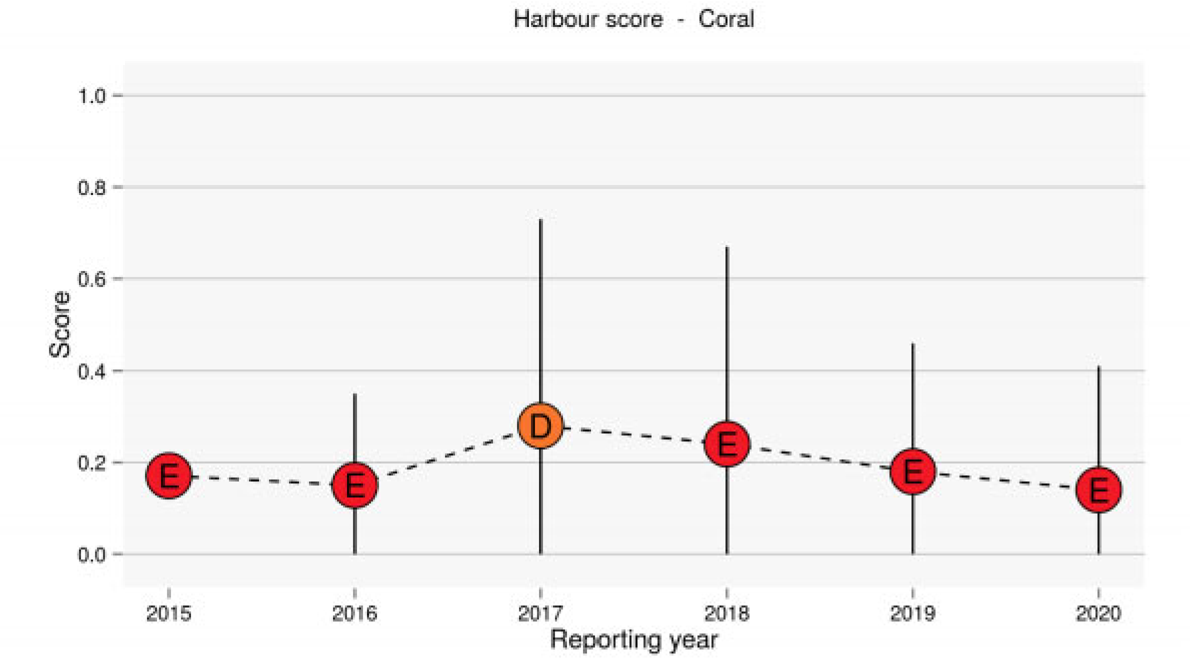


Figure 4-6 GHHP coral condition scores for Port Curtis (GHHP 2020)

Deep Water Communities

Rasheed *et al*. (2002) mapped deep water benthic communities in 2002 where a large number of remote camera deployments were used to map benthic community types throughout Port Curtis and Rodd's Bay. The spacing of points within each habitat class polygon is relatively sparse, varying between 1.2 and 4 km. Rasheed *et al*. (2002) used four-minute camera tows at drift speeds less than one (1) knot to classify communities into density categories consisting of:

- open substrate - dominant feature was bare substrate with occasional isolated benthic macro-invertebrate individuals
- low density - benthic macro-invertebrates present on the screen for < 10% of the site video record
- medium density - benthic macro-invertebrates present in 10 - 80% of the site video record
- high density - benthic macro-invertebrates present on the screen for > 80% of the site video record.

The distribution of benthic communities and the intensity of sampling used to make these classifications are shown in Figure 4-7. This work demonstrated that the deep inner harbour section of Port Curtis (Benthic community region 9 in Figure 4-7) was composed of moderate density rubble reef communities dominated by bivalves, ascidians, bryozoans and hard corals. From Fisherman's Landing to South Trees, the deep water benthos consisted of scallop and rubble reef along the most of the natural channel (Figure 4-7 region 18), while channel arm near Curtis Island (Figure 4-7 region 8) was mostly open substrate. Downstream from South Trees to East Banks epibenthic communities (Figure 4-7 regions 16, 22, 23) were also classified as high density rubble reefs, with dominant taxa including scallops, bryozoans, sponges, ascidians, bivalves, soft and hard corals. The relatively high densities of epibiota were a significant finding and believed to be the result of strong tidal currents acting as a food supply for filter feeders. Another significant finding from this study was the presence of hard corals at several community regions. Moderately dense hard coral colonies were observed at benthic community regions 16, 17, and 23; south and west of Facing Island and surrounding Seal Rocks.

These deep-water rubble/soft sediment substrates do not represent habitats for reef building (hermatypic) corals. There are knowledge gaps regarding the distribution, extent and ecology of these deep water systems (see BMT, 2014), but it can be reasonably inferred that species in these environments have adaptations that allow them to cope with a range of stressors including high turbidity, high sediment deposition, no to low light, and periodic low salinity conditions.

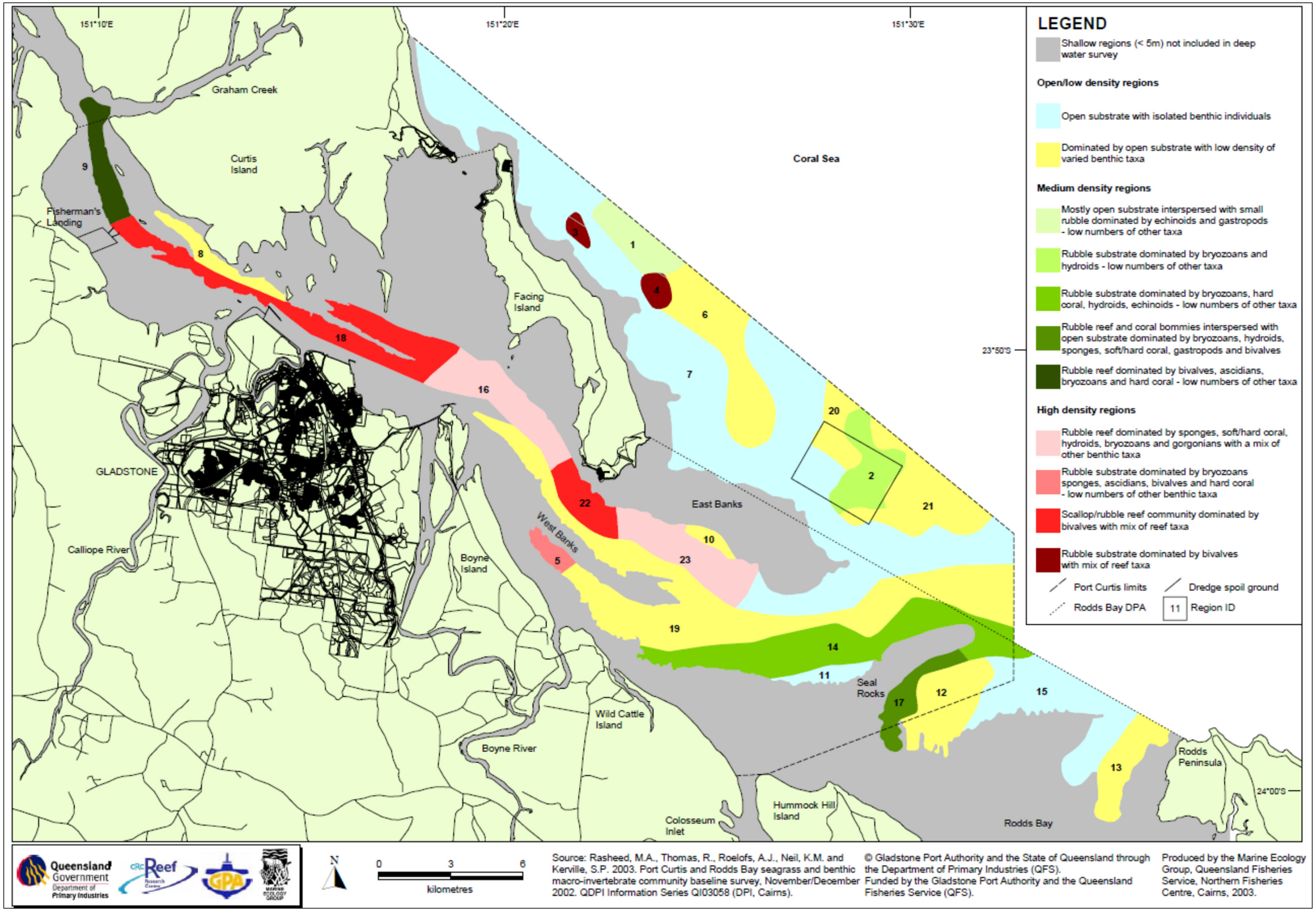


Figure 4-7 Deep Water Benthic Macro-Invertebrate Regions in Port Curtis, November/December 2002 (Source: Rasheed *et al.,* 2003)

4.3.1.3 Soft Sediment Habitats and Communities

Soft sediment invertebrate communities within Port Curtis were comprehensively described by Currie and Small (2005) and have been described in lesser detail by LNG project proponents. Soft sediment communities within and adjacent to the EBSDS have also been described as a part of dredge monitoring conducted by BMT (2012a) and Vision Environment (2017).

Currie and Small investigated changes in macroinvertebrates at 30 sites in Port Curtis, twice yearly, over six (6) years between 1995 and 2001. Currie and Small (2005) found that the bivalve *Carditella torresi* and to a lesser extent the sea-squirt *Ascidia sydneiensis* were the most abundant taxa, particularly in subtidal waters. Great variability in community structure was observed. Gradients in abundance and species richness were principally driven by depth and sediment grain size, with extremely fine, or extremely coarse sediments having the lowest richness and abundance. Species richness and abundance were lowest on intertidal muddy substrates, and greatest in coarse, sandy-sediments predominantly occurring in the deeper channels of the estuary. Bivalve molluscs, ascidians, polychaetes and pistol shrimp (*Alpheus* sp.) were among the most important taxa defining the difference between intertidal and subtidal sediments.

Nearshore tropical and sub-tropical benthic fauna communities are dynamic, varying across multiple temporal scales (Stephenson, 1980; Alongi, 1989; Currie and Small, 2005; BMT, 2012a). Currie and Small (2005) found that benthic communities in Port Curtis did not show predictable seasonal trends, unlike in higher latitudes where seasonal changes in water temperature and other processes can lead to changes in community structure. Instead, Currie and Smith (2005) found that temporal changes in communities were more closely aligned with the Southern Oscillation Index (SOI), with the most significant El Nińo (drought) episode during the measurement period coincident with a halving of taxa richness and abundance. Correlation analysis found significant positive correlations between benthos abundance/richness and turbidity, on which Currie and Smith (2005) concluded that high turbidity provided favourable conditions for benthic communities.

It is possible that Cyclone Yasi and associated flooding in 2011 had resulted in changes to benthic communities since the Currie and Smith (2005) study. For example, BMT (2012a) examined temporal patterns in benthic communities at and near the EBSDS. No strong seasonality was observed, however benthic abundance and to a lesser extent richness was observed to significantly decline at most locations immediately before and one month after Cyclone Yasi. Other case studies demonstrate that river flows and associated nutrient inputs can promote benthic abundance in the longer term (e.g. review by Gillanders and Kingsford, 2002). No significant changes in communities were observed over the EDSDS and surrounding environments between the 2016 and 2017 wet season and the 2017 dry season (Vision Environment, 2017).

Table 4-4 Abundance (per 0.1 m²) and richness measures measured by Currie and Small (2005)

Parameter	Currie and Small (2005)
Dominant taxa	*Carditella torresi* (14% of individuals), *Ascidia sydneiensis* (4% of individuals)
Proportion of uncommon taxa (accounting for <2% of individuals)	98% of species
Mean (± s.e.) no. individuals per 0.1 m^2	5.9 ± 0.40 to 24.4 ± 1.25
Mean (± s.e.) no. taxa	3.6 ± 0.20 to 11.6 ± 0.48 per 0.1 m^2
Mean (± s.e.) no. polychaetes per 0.1 m^2	1.0 ± 0.09 to 8.0 ± 0.59
Mean (± s.e.) no. molluscs per 0.1 m^2	4.0 ± 0.32 to 10.3 ± 0.71
Mean (± s.e.) no. crustaceans per 0.1 m^2	0.6 ± 0.09 to 2.7 ± 0.28

Vision Environment (2017) undertook an assessment of benthic macroinvertebrate abundance and richness assemblages within the maintenance dredge footprint and adjacent non-dredged areas. The results of this study are difficult to compare with those recorded in Currie and Small (2005) or BMT (2012a) due to the different authors reporting grab volume versus grab area. Notwithstanding this, Vision Environment (2017) found no significant difference in macroinvertebrate communities in areas that had been dredged and undredged areas (Vision Environment, 2016). This suggests that benthic assemblages may have a high capacity to recover from disturbance due to maintenance dredging.

4.3.1.4 Fish Communities from Soft Sediments

Port Curtis contains a broad range of habitats for marine and estuarine fish. Connolly *et al.* (2006) undertook the most detailed fish surveys in Port Curtis, where 105 intertidal and shallow subtidal sites were surveyed using a 5 m wide beam trawl.

The survey recorded 88 fish species and 2294 individuals from 315 replicate trawl shots. Small schooling fish dominated the samples as is typical of similar environments elsewhere in Queensland (Blaber *et al.*, 1989). Approximately 30 species of the fish species recorded were of direct or indirect economic importance.

Sites located on mud flats and seagrass meadows in the study area had the richest (i.e. highest number of species) and most abundant fish assemblages on a Port Curtis wide scale (Figure 4-8). Connolly *et al.* (2006) also found that seagrass meadows had a distinctive fish fauna that differed from assemblages on 'unvegetated' habitats, emphasizing the importance of seagrass in maintaining biodiversity values.

Connolly *et al.* (2006) also undertook studies using stable isotope analysis to trace energy pathways and nutrient cycling in Port Curtis. They found that seagrass was an important component at the base of food webs, including in areas beyond the seagrass meadows themselves. The analysis suggested that the food webs that sustain many economically important fisheries species caught over mudflats (e.g. whiting) and in mangrove-lined creeks (e.g. mud crabs) rely largely on organic matter produced in seagrass meadows.

A) Abundance B) Species Richness

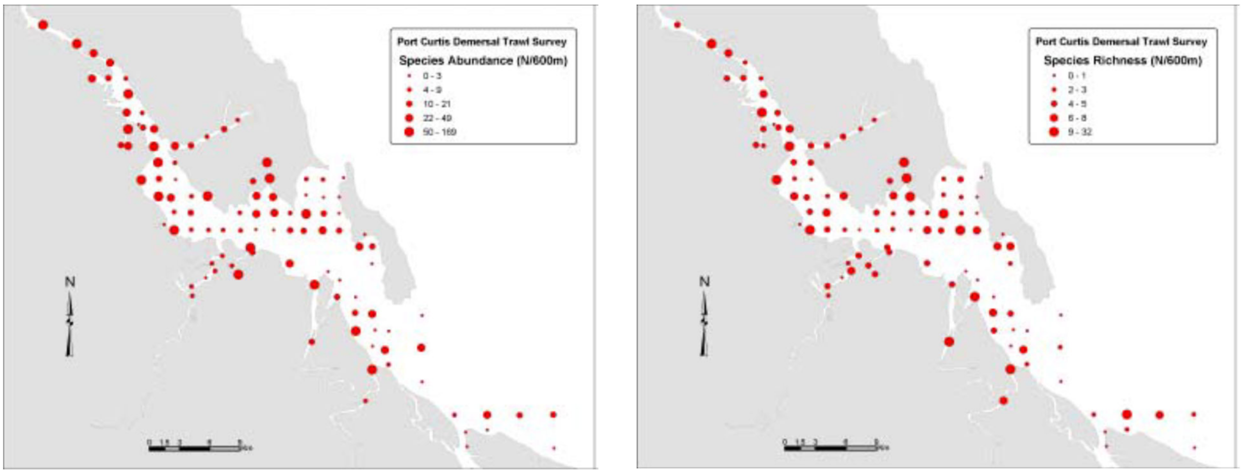


Figure 4-8 Map of Port Curtis showing a) Total Species Abundance and b) Total Species Richness of Demersal Fish Collected from Three Replicate Beam Trawl Samples (200 m Length) at 105 Sampling Stations (Source: Connolly *et al.,* 2006)

4.4 Matters of National Environmental Significance (MNES)

Table 4-5 summarises EPBC Act Protected Matters Search Tool (PMST) results for PoG and immediate surrounds, and an assessment of known/potential occurrence of protected matters in areas directly and indirectly influenced by dredging and disposal. MNES relevant to areas influenced by dredging and disposal are Threatened Species, Listed Migratory Species, World Heritage Area, Natural Heritage Property and Great Reef Marine Park. These MNES are considered further below. Refer to Appendix A for the PMST report.

Table 4-5 Summary of MNES Protected Matters Search Tool Results

MNES	Search Area (PMST)	Areas Influenced by Dredging and Offshore Disposal
Threatened Ecological Communities	Seven TECs	None - does not occur in subtidal waters
Threatened Species	67 species (turtles, cetaceans, sharks, birds, terrestrial fauna)	Likely – multiple marine species
Listed Migratory Species	68 species (turtles, cetaceans, sharks, birds, terrestrial fauna)	Likely – multiple marine species
World Heritage Area	Present – GBRWHA	Present – GBRWHA
Natural Heritage Property	Present - GBRNHP	Present - GBRNHP
Great Barrier Reef Marine Park	Present	Outside dredging and disposal sites. Marine Park (General Use zone) adjacent to East Banks Spoil Disposal Site
Wetlands of International Importance	None	None
Commonwealth Marine Area	None	None

4.4.1 Threatened Ecological Communities (TECs)

TECs occur in the Gladstone region (Table 4-6). AECOM (2016) identified five (5) TECs in the Gladstone Port master plan area, which encompasses PoG and adjacent lands beyond the port. The PMST report identifies three (3) additional TECs as potentially occurring in the search area: Weeping Myall Woodlands; Poplar Box Grassy Woodland on Alluvial Plains; Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland. All TECs are restricted to lands above high water, outside the area of influence of maintenance dredging or dredged material disposal.

Table 4-6 EPBC Listed Threatened Ecological Communities

TEC	EPBC Status	Occurrence in Search Area (PMST)	Occurrence in Areas Influenced by Dredging and Offshore Disposal
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area	No - does not occur in subtidal waters
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area	No - does not occur in subtidal waters
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community may occur within area	No - does not occur in subtidal waters
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community may occur within area	No - does not occur in subtidal waters
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community may occur within area	No - does not occur in subtidal waters
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community may occur within area	No - does not occur in subtidal waters
Weeping Myall Woodlands	Endangered	Community may occur within area	No - does not occur in subtidal waters

4.4.2 Threatened and Listed Migratory Species

Table 4-7 lists threatened and listed migratory species known or possibly occurring in the search area, as defined in the PMST report.

Bony Fish

Atlas of Living Australia (ALA, 2021) has historical records of the endangered White's seahorse in Port Curtis and other locations in central Queensland, all of which pre-date 1940. This species is highly sensitive to habitat disturbance and has declined in abundance in estuarine areas in NSW. It is unknown whether species is still supported in central Queensland (Short *et al*., 2019), especially given the high degree of habitat modification since the time of last record. Suitable habitat for this species occurs near the dredge site (soft corals/hard substrate).

Sharks and Rays

Several threatened and/or listed migratory pelagic shark and ray species have the potential to occur in Port Curtis. The dredge and disposal sites are unlikely to represent high quality or otherwise important habitat for these species.

Green sawfish is a demersal species that utilises habitats similar to those occurring in the dredge area and surrounds. This species is now thought to be restricted to waters north of Cairns. Based on the analysis of Queensland Beach Control Program catch records for the Cairns, Townsville and Rockhampton regions (Stevens *et al*., 2005), a major decline in sawfish catches was observed in the 1970's and 1980's, and no sawfish have been recorded by the netting program in the Rockhampton region since the early 1990's. On the basis of the range retraction and its sensitivity to disturbance, it is considered unlikely that the nearshore waters of Port Curtis currently represent important habitat for green sawfish.

Marine Mammals

Both the Australian snubfin dolphin and Australian humpback dolphin occur in Port Curtis (Parra, 2006; Parra *et al.,* 2006). These species form small metapopulations across the north of Australia and undertake regular migrations within and outside Port Curtis (Cagnazzi *et al*., 2011). Cagnazzi (2017) derived population estimates of approximately 140–162 adult Australian humpback dolphins and 100–163 adult Australian snubfin dolphins for the Port Curtis area between May and September each year.

All nearshore waters (<20 m depth) in Queensland north (and inclusive) of Rodd's Bay are mapped as Biologically Important Areas (BIAs) for Australian humpback dolphins (calving and foraging), but not for Australian snubfin dolphin. The BIA approximates the known distribution of humpback dolphins (Brooks *et al*., 2014). Within Port Curtis, Australian snubfin dolphins has been observed within channels and in close association with sand/mud banks near creek mouths (GHD, 2009). It was recorded around Fisherman's Landing in moderate numbers. Calves were observed among groups for many of these sightings, suggesting that Port Curtis is in an important calving area GHD (2009). Cagnazzi (2017) suggests that "Australian snubfin dolphins typically forage in more inshore, benthic habitats than humpback dolphins", and that Australian humpback dolphins may have a broader trophic niche width and may feed in a wider range of habitat types.

Dugong is common in Port Curtis, especially in seagrass meadows throughout the harbour (Rasheed *et al*., 2017). There are no seagrass meadows at and immediately adjacent to dredge and disposal sites. Dugong may transit through the Project area when moving between seagrass meadows. The dredge/disposal sites are not located at or near dugong protection areas (DPAs) under the *Fisheries Act 1994* nor is it mapped as part of a BIA for dugong on the NCVA.

Several whale species occur in the Gladstone region. Humpback whale may occasionally utilise Port Curtis during their annual migration, but are more common in offshore waters. There is limited information on the occurrence of other whale species in Port Curtis, and it is likely that usage is infrequent.

Marine Reptiles

All six (6) marine turtle species found in Australian waters are known or possibly occur in the Gladstone region. These species use a variety of habitats as part of their life cycle. In conceptual terms (Musick and Limpus, 1997):

- All species nest on beaches (islands and mainland), with mating typically occurring close to nesting beaches.
- Early juvenile nursery habitat is usually pelagic/oceanic, and later juvenile habitat is usually demersal and neritic (shallow waters).
- Adult foraging habitat varies among species and includes both pelagic and demersal habitats, depending on species.

Based on habitat requirements of each species, suitable foraging habitats for older juveniles and adults of most species occurs in the Gladstone area, but key foraging habitat (IBA, Critical Habitat) critical to supporting species populations is not present. Based on ALA records, the most frequently recorded species in PoG was green turtle. Most green turtle records were in Western Basin and Pelican Banks. The seaward sandy beaches of Facing and Curtis Island provide turtle nesting habitat – an area 60 km surrounding Curtis Island represents a BIA (inter-nesting) for flatback turtle. Critical habitat and BIA for loggerhead and leathery turtles also occur south of PoG, remote from dredging and disposal sites.

In addition to marine turtles, Port Curtis provides potential foraging habitat for saltwater crocodile. There are no records of this species in ALA, but it is known to occur.

Other Marine Species

The EPBC Protected Matters database search results also identified that numerous species of sea snake, pipefish, and sea horses occur or could occur in Port Curtis. These species are listed marine species and are protected under the EPBC Act, but are not considered to be threatened or listed migratory species under EPBC or state legislation. These species could occur across a wide range of habitats found within Port Curtis.

Table 4-7 Threatened and listed migratory species (marine species) defined in the PMST report, and likelihood of occurrence in dredge/disposal site and surrounds

Common Name	Species Name	EPBC Status	NCA Status	Type of Presence (PMST)	Records (ALA+Wildnet)	Habitat (SPRAT) Potential Occurrence in Dredge/Disposal Sites	Important Areas (BIA, CH, Recovery Plans) in Region
Bony Fish							
White's Seahorse	*Hippocampus whitei*	Endangered	Endangered	Species or species habitat may occur within area	Historical ALA record in the PoG and other locations in central Qld (all pre-date 1940). No nearby Wildnet sightings.	Depth 1-15m; inhabits seagrass, soft coral, macroalgae, sponges and artificial structures, which are represented at and adjacent to dredge/disposal sites. Highly sensitive to habitat disturbance, unknown whether species still supported in central Qld (Short *et al.* 2019).	None
Mammals							
Blue Whale	*Balaenoptera musculus*	Endangered, Mig	-	Species or species habitat may occur within area	No ALA records in the PoG, historical and contemporary records from Port Alma area. Historical Wildnet sighting off Saint Laurence.	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites. Seasonal migrations (summer)	None
Humpback Whale	*Megaptera novaeangliae*	Vulnerable, Mig	Vulnerable	Species or species habitat known to occur within area	Historical ALA and Wildnet records in the PoG, multiple contemporary records in offshore waters	Pelagic, coastal and offshore waters. Transient visitor to Port Curtis, unlikely to regularly use dredge/disposal sites.	All Qld coastal waters represent BIA (breeding/calving)
Australian Snubfin Dolphin	*Orcaella heinsohni*	Mig	Vulnerable	Species or species habitat known to occur within area	No ALA records in the PoG, historical and contemporary ALA records in the wider region. Historical Wildnet sighting in the PoG and contemporary sightings off Yeppoon.	Coastal and estuarine water – close to river mouths and seagrass meadows. This species is abundant in Gladstone Harbor (Cagnazzi, 2017) and likely feeds in dredge/disposal sites.	None
Australian Humpback Dolphin	*Sousa sahulensis (=chinensis)*	Mig	Vulnerable	Breeding known to occur within area	Numerous contemporary ALA and Wildnet records in Port Curtis. This species is abundant in Gladstone Harbor (Cagnazzi, 2017).	Inlets, estuaries, major tidal rivers, shallow bays, inshore reefs and coastal archipelagos. This species is abundant in Gladstone Harbor (Cagnazzi, 2017) and likely feeds in dredge/disposal sites.	BIA (feeding, calving) - coastal waters south of Shoalwater Bay to Rodds Bay (particularly Port Alma and the PoG), within the 20m depth contour
Dugong	*Dugong dugon*	Mig	Vulnerable	Species or species habitat known to occur within area	Two ALA records from Port Curtis. Historic Wildnet sightings in the PoG.	Seagrass meadows (foraging). Known to be common, especially in seagrass meadows throughout the harbour (Rasheed *et al*., 2017). May occasionally transit through dredge/disposal sites.	None
Bryde's Whale	*Balaenoptera edeni*	Mig	-	Species or species habitat may occur within area	No ALA or Wildnet records for Port Curtis, but recorded elsewhere in the central Qld coastal region	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None
Killer Whale	*Orcinus orca*	Mig	-	Species or species habitat may occur within area	No ALA records for Port Curtis, but recorded elsewhere in the central Qld coastal region. No nearby Wildnet records.	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None
Reptiles							
Loggerhead Turtle	*Caretta caretta*	Endangered	Endangered	Breeding known to occur within area	Two ALA and Wilnet records in Port Curtis (1989, 1997) - Boyne Island and Calliope River.	Nesting sandy beaches (including central Qld), foraging mainly in open waters. Most sightings of this species in the region have been in close proximity to channels where they are thought to feed (Pers. Comm. C. Limpus,15-11-13).	Critical Habitat (nesting) - adjacent to Gladstone (beaches south of Elliot Heads and offshore islands of Capricorn Bunker group), remote from dredging/disposal BIA (inter-nesting) - waters extending from Turkey Beach around past Agnes Water, remote from dredging/disposal

Common Name	Species Name	EPBC Status	NCA Status	Type of Presence (PMST)	Records (ALA+Wildnet)	Habitat (SPRAT) Potential Occurrence in Dredge/Disposal Sites	Important Areas (BIA, CH, Recovery Plans) in Region
Green Turtle	*Chelonia mydas*	Vulnerable	Vulnerable	Breeding known to occur within area	Numerous records throughout harbor, especially Pelican Banks and Western Basin. Historic Wildnet records in Calliope River.	Nesting sandy beaches (Gladstone is not a key area), foraging in seagrass meadows, macroalgae, mangroves. The Project area has soft substrates which do not represent foraging habitat for this species. Likely to transit through the Project area. Important foraging areas include seagrass meadows in Rodds Bay, Shoal Bay, Pelican Banks and the Narrows (GHD 2009, 2011), coral and rocky reefs throughout the region and along the mangrove fringes (DEHP 2013, Pers. Comm. C. Limpus,15-11-13).	None
Leatherback Turtle	*Dermochelys coriacea*	Endangered	Endangered	Species or species habitat known to occur within area	No records in ALA, but likely to occur. Historical Wildnet records off Agnes Waters and Heron Island.	Nesting sandy beaches (Gladstone is not a key area), foraging in open waters. Transient visitor to Port Curtis, unlikely to regularly use dredge/disposal sites.	BIA (inter-nesting) - Mon Repos to Agnes Water, remote from dredging/disposal
Hawksbill Turtle	*Eretmochelys imbricata*	Vulnerable	Endangered	Species or species habitat known to occur within area	Most records in ALA from sandy beaches on Facing Island, but also Boyne Island and mouth of Calliope River. Historic Wildnet record off Tannum Sands.	Nesting sandy beaches (Gladstone is not a key area), foraging in open waters, seagrass meadows and reefs. GHD (2009) reported this species in low abundance around North Passage. Incidental sightings of hawksbill turtles in Port Alma and Port Curtis are predominantly associated with foraging habitats, including seagrass meadows, reefs and soft-bottomed subtidal areas (Pers. Comm. C. Limpus,15-11-13).	None
Olive Ridley Turtle	*Lepidochelys olivacea*	Endangered	Endangered	Breeding likely to occur within area	Several ALA records on the beaches particularly at South Trees Island, Facing Island and Curtis Island. No nearby Wildnet records.	Nesting occurs on sandy beaches, mostly outside Central Qld (key nesting sites located in Gulf of Carpentaria). Forages in open waters. Possible transient visitor to Port Curtis, unlikely to regularly use dredge/disposal sites.	None
Flatback Turtle	*Natator depressus*	Vulnerable	Vulnerable	Breeding known to occur within area	Numerous ALA sightings on the beaches particularly at South Trees Island, Facing Island, Wild Cattle Island and Curtis Island. Historic Wildnet records in the PoG and surrounding islands.	Nesting sandy beaches (inc. Curtis and Facing Island). Flatback turtles are carnivorous and forage predominantly on soft-bottomed inter-tidal and sub-tidal habitats, typically at depths ranging from 6 to 35 meters (DEHP 2013), as occurs throughout Port Curtis including the Project area. Nesting flatback turtles return to nesting beaches approximately every 15 days throughout the season and are dispersed throughout the region during the inter-nesting period (Limpus 1971, Pers. Comm. C. Limpus,15-11-13). Possible transient visitor to Port Curtis, unlikely to regularly use dredge/disposal sites.	Critical Habitat (nesting) - Curtis Island, includes seaward beaches. Inter-nesting buffer of 60km around Curtis Island
Salt-water Crocodile	*Crocodylus porosus*	Mig	Vulnerable	Species or species habitat likely to occur within area	No Port Curtis records in ALA, but known to occur. Historic Wildnet record in Calliope River.	Nesting wetlands; feeding rivers, estuaries, and occasionally coastal waters. Transient visitor to Port Curtis, unlikely to regularly use dredge/disposal sites.	None
Sharks and Rays							

Common Name	Species Name	EPBC Status	NCA Status	Type of Presence (PMST)	Records (ALA+Wildnet)	Habitat (SPRAT) Potential Occurrence in Dredge/Disposal Sites	Important Areas (BIA, CH, Recovery Plans) in Region
Great White Shark	*Carcharodon carcharias*	Vulnerable	-	Species or species habitat known to occur within area	No Port Curtis records in ALA or Wildnet, but could occur.	Pelagic, coastal and offshore waters. Occasionally reported from Capricorn Bunker region, possible occasional visitor to Port Curtis.	None
Green Sawfish	*Pristis zijsron*	Vulnerable	-	Breeding may occur within area	No Port Curtis records in ALA or Wildnet. Contemporary records for this species north of Cairns only.	Demersal, riverine and coastal waters. While suitable habitat is present in Port Curtis, the region is outside known geographic range.	None
Whale Shark	*Rhincodon typus*	Vulnerable	-	Species or species habitat may occur within area	No Port Curtis records in ALA. Nearest sighting Fraser Island therefore, unlikely to occur. No nearby Wildnet records, closest record off Lady Musgrave Island.	Pelagic, coastal and offshore waters. Occasionally reported from Capricorn Bunker region. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Mig	-	Species or species habitat may occur within area	No Port Curtis records in ALA or Wildnet. Nearest sighting offshore of Fraser Island therefore, unlikely to occur.	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None
Porbeagle Shark	*Lamna nasus*	Mig	-	Species or species habitat may occur within area	No Port Curtis records in ALA or Wildnet. Nearest sighting offshore of Fraser Island therefore, unlikely to occur.	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None
Reef Manta Ray	*Mobula alfredi*	Mig	-	Species or species habitat likely to occur within area	No Port Curtis records in ALA or Wildnet. Nearest sighting near Heron Island, but may occur.	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None
Giant Manta Ray	*Mobula birostris*	Mig	-	Species or species habitat likely to occur within area	No Port Curtis records in ALA or Wildnet. Nearest sighting offshore of Rainbow Beach therefore, unlikely to occur.	Pelagic, coastal and offshore waters. Possible (but highly unlikely) transient visitor to Port Curtis, and highly unlikely to regularly use dredge/disposal sites.	None

4.4.3 World Heritage Area and Natural Heritage Property

The dredging and disposal sites occur in the Great Barrier Reef World Heritage Area (GBRWHA) and Natural Heritage Property (GBRNHP). Both MNES share the same boundaries, which in the context of the PoG encompass all waters seaward of low water mark, and all islands within the boundaries shown in Figure 4-9.

World Heritage properties are recognised for their Outstanding Universal Value (OUV). A Statement of OUV provides a summary of the rationale for including a property on the World Heritage List. The GBRWHA was listed as meeting four World Heritage criteria for OUV, which are summarised in Table 4-8. The Statement of OUV is, by necessity, a high-level summary, and does not characterise the OUV attributes represented at individual locations within the property.

The *EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area* (DoE, 2014) set out examples of the attributes of the GBR that contribute to its listing under the criteria of the World Heritage Convention. The GBR Marine Park Authority also identified the series of values, attributes and processes of the GBR that contribute to world heritage and national heritage property values as part of the GBR Strategic Assessment (GBRMPA, 2014).

Building on this, AECOM (2016) describes the OUV attributes of the GBRWHA represented within the Gladstone port master planned area, which includes all waters in Port Curtis including dredging and disposal sites. Table 4-8 summarises OUV attributes expressed in the Gladstone region as determined by AECOM (2016), and OUV attributes potentially relevant to marine areas at and adjacent to dredging and disposal sites (blue shaded). Within and adjacent to dredge and disposal sites, relevant OUV attributes include: contributing to habitat connectivity; corals and reef environments (see Section 4.3.1.2); fauna species and species diversity; seagrass meadows (see Section 4.3.1.1), marine megafauna species (see Section 4.4.1 and 4.4.2); and traditional owner interaction with the environment (e.g. fishing, recreation, scenic, spiritual).

Table 4-8 OUV attributes expressed in the proposed Gladstone region from AECOM (2016)(✓) and attributes relevant to waters at and directly adjacent to dredging and disposal sites (blue shaded)

Overview of attributes	Criterion vii – aesthetic values and superlative natural phenomena	Criterion vii – ongoing geological processes	Criterion ix – ecological and biological processes	Criterion x – biodiversity conservation
Connectivity: cross-shelf, longshore & vertical		✓	✓	✓
Continental islands	✓	✓	✓	✓
Beaches	✓			
Dune systems	✓	✓		
Fringing reefs	✓	✓	✓	✓
Inshore turbid reefs		✓	✓	✓
River deltas	✓	✓	✓	✓

Overview of attributes	Criterion vii – aesthetic values and superlative natural phenomena	Criterion vii – ongoing geological processes	Criterion ix – ecological and biological processes	Criterion x – biodiversity conservation
Marine faunal groups diversity	✓		✓	✓
Coral species – diversity & extent	✓	✓	✓	✓
Total species diversity	✓		✓	✓
Island plant species diversity	✓		✓	✓
Seagrass	✓	✓	✓	✓
Mangroves	✓	✓	✓	✓
Marine turtles	✓			✓
Whales	✓			✓
Threatened & endangered species				✓
Dolphins	✓			✓
Seabirds	✓		✓	✓
Traditional Owner interaction with the natural environment			✓	

4.4.4 Great Barrier Reef Marine Park

Great Barrier Reef Marine Park (GBRMP) is managed under *the Great Barrier Reef Marine Park Act 1975*. Under the existing zoning plan, waters along the east coast of Facing Island adjacent to East Banks Spoil Disposal Site (EBSDS) are zoned Habitat Protection, whereas waters further offshore are zoned General Use (Figure 4-9). The GBRMP sits outside the PoG and does not include the dredged channels and EBSDS.

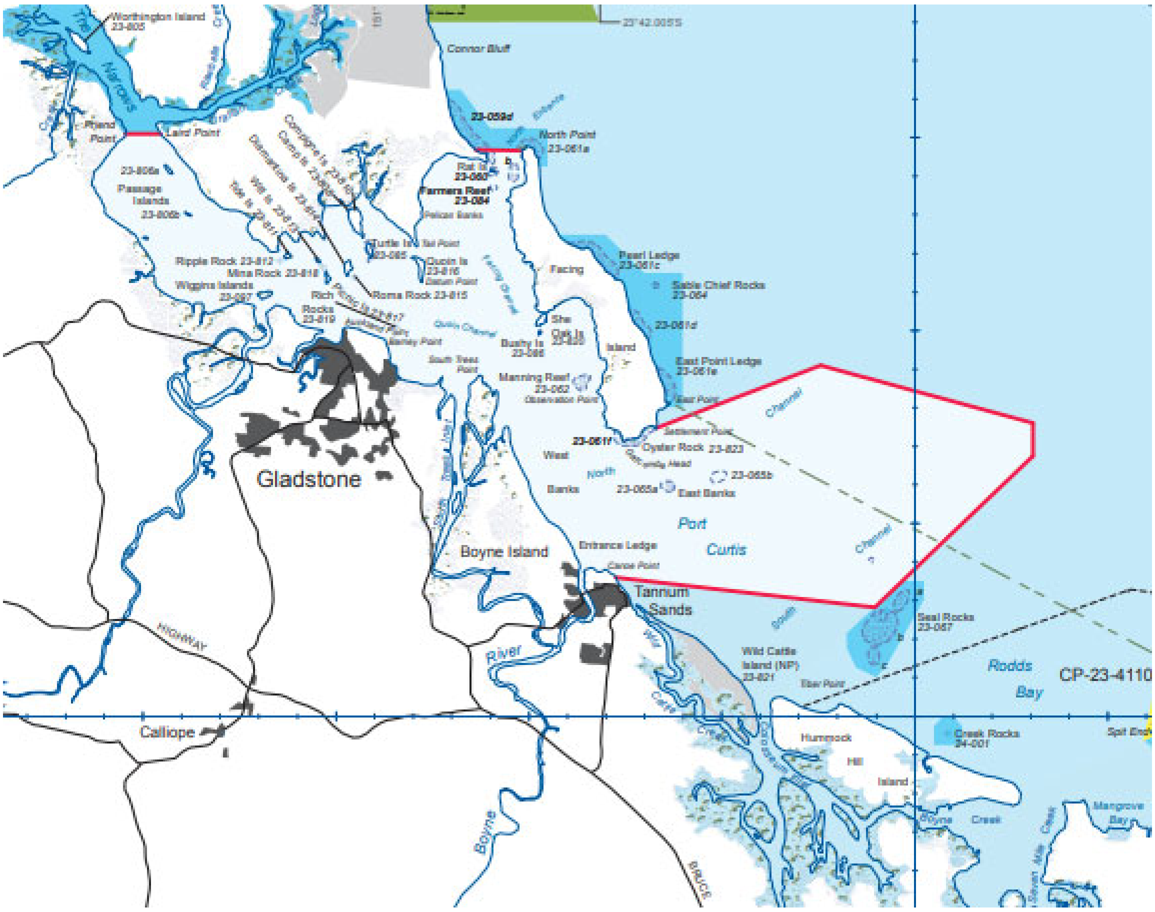


Figure 4-9 Great Barrier Reef Marine Park Zones, WHA and NHP Boundaries

4.5 Queensland

4.5.1 Matters of State Environmental Significance

Matters of state environmental significance (MSES), referenced under the State Planning Policy (SPP) 2017, are environmental values that are protected under Queensland legislation including the *Nature Conservation Act* 1992 (NC Act), *Marine Parks Act* 2004 (MP Act), the *Fisheries Act* 1994, *Environmental Protection Act* 1992, the *Regional Planning Interests Act* 2014, and the *Vegetation Management Act* 1999. MSES have been defined by the Queensland Government as the following natural values and areas:

- Protected areas under the NC Act.
- Marine parks and land within a ‘marine national park’, ‘conservation park’, scientific research’, ‘preservation’ or ‘buffer’ zone under the MP Act.
- Areas within declared fish habitat areas (FHAs).
- Endangered, vulnerable and near threatened (EVNT) and special least concern species.
- Regulated vegetation, including:
    - Category B, C and R areas.

  - Areas of essential habitat for wildlife prescribed as endangered or vulnerable under the NC Act.
  - Regional ecosystems (REs) that intersect with watercourses/wetlands.
- Wetland/watercourse features that are:
  - Wetlands in a wetland protection area.
  - Wetlands of high ecological significance (HES).
  - Wetlands/watercourses in high ecological value (HEV) waters.
- Designate precincts in a Strategic Environmental Area.
- Legally secured offset areas.

With the exception of ENVT and special least concern species, all of these features are spatially defined based on mapping and regulations. For species, the Queensland Government *Method for mapping: Matters of State environmental significance for use in land use planning and development assessment* (v1.4, DEHP 2014) uses several mapping layers as a 'surrogate' for species occurrence. This includes essential habitat mapping, peer-reviewed modelled habitat distributions, mapped distributions based on known habitat factors, and point records within remnant or regrowth REs. In addition, this mapping methodology adopts dugong protection areas (relevant to Project), southeast Queensland koala habitat value areas (not relevant), and Ramsar sites (not relevant) as specific surrogates for the occurrence of dugongs, koalas and migratory shorebirds (respectively).

MSES relevant to the PoG are provided in Table 4-9 and Figure 4-10.

Table 4-9 Matters of State Environmental Significance and Relevance to Port Curtis

MSES*	Description
Protected areas under the NC Act	There are no marine areas within Port Curtis classified as a protected area for the purpose of the NC Act. Garden Island Regional Park is located in Port Curtis outside the dredge footprint and disposal sites.
Marine parks and land within a 'marine national park', 'conservation park', scientific research', 'preservation' or 'buffer' zone under the Marine Parks Act 2004 (MP Act) – highly protected features	The Great Barrier Reef Coast Marine Park (GBRCMP) is located offshore of Port Curtis and extends into the southern part of Rodds Bay, and the Narrows. The dredge footprint and disposal sites are located outside the GBRCMP. The closest 'highly protected' GBRCMP feature listed as a MSES is the marine national park zone located on the eastern coast of Curtis Island, outside Port Curtis.
Areas within declared fish habitat areas (FHAs)	The Colosseum Inlet Fish Habitat Area is located approximately 30 km from dredge and disposal sites. De-ral-li FHA is located in the Calliope River, >5 km from dredging and disposal sites.
EVNT and special least concern species	Islands and mainland areas surrounding Port Curtis are mapped as habitat for threatened wildlife and/or iconic species listed under NC Act.

MSES*	Description
	Dredge and disposal sites are within the Port Curtis - Rodds Bay Dugong Protection Area, which is a surrogate for known/potential dugong habitat. Refer to Table 4-7 for summary of habitat values for threatened and special least concern species
HES wetlands protected under EP Act	Many of the seagrass meadows present in Port Curtis are considered HES wetlands
Wetlands and watercourses in HEV waters	No HEV areas present
Regulated vegetation	None in marine waters potentially affected by maintenance dredging
Strategic Environmental Area	None present in Port Curtis
Legally secured offset areas	None present in Port Curtis

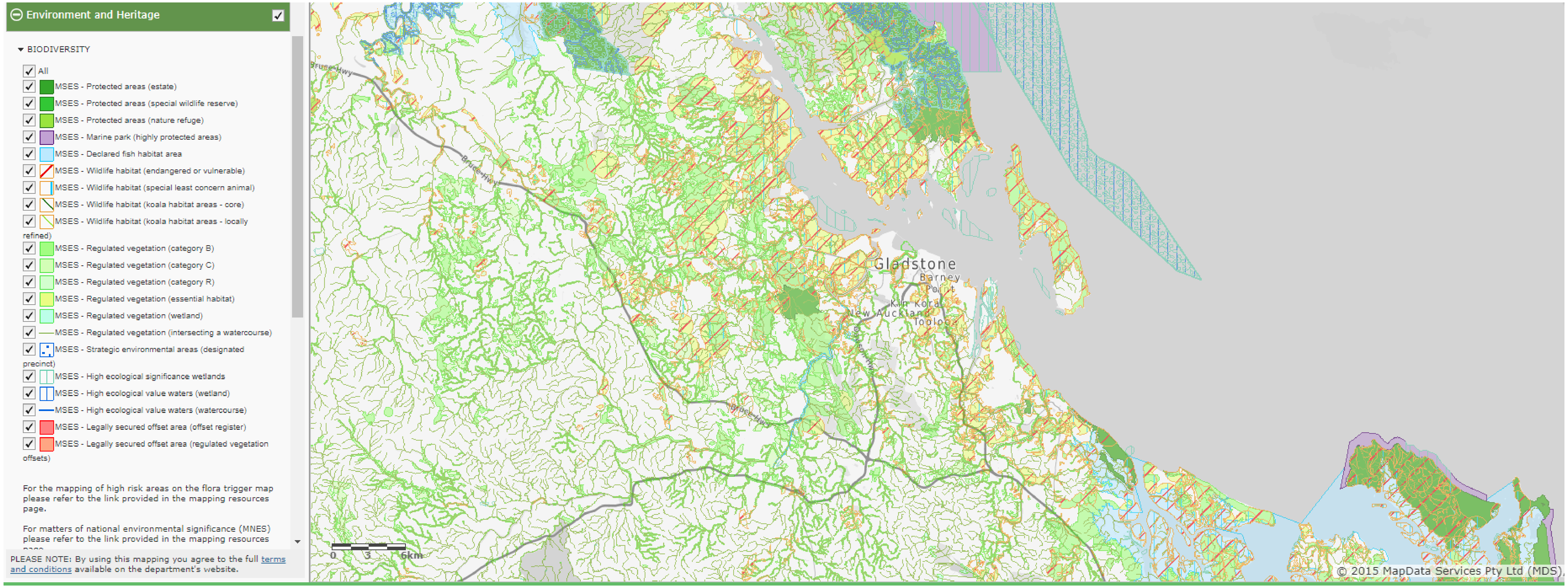


Figure 4-10 MSES in the Gladstone region

4.5.2 State Code 8 Coastal Development and Tidal Works

State Code 8 Coastal Development and Tidal Works sets out performance outcomes to "…e*nsure that developments are designed and located to:*

(1) protect life, buildings and infrastructure from the impacts of coastal erosion

(2) maintain coastal processes

(3) conserve coastal resources

(4) maintain appropriate public use of, and access to and along, state coastal land

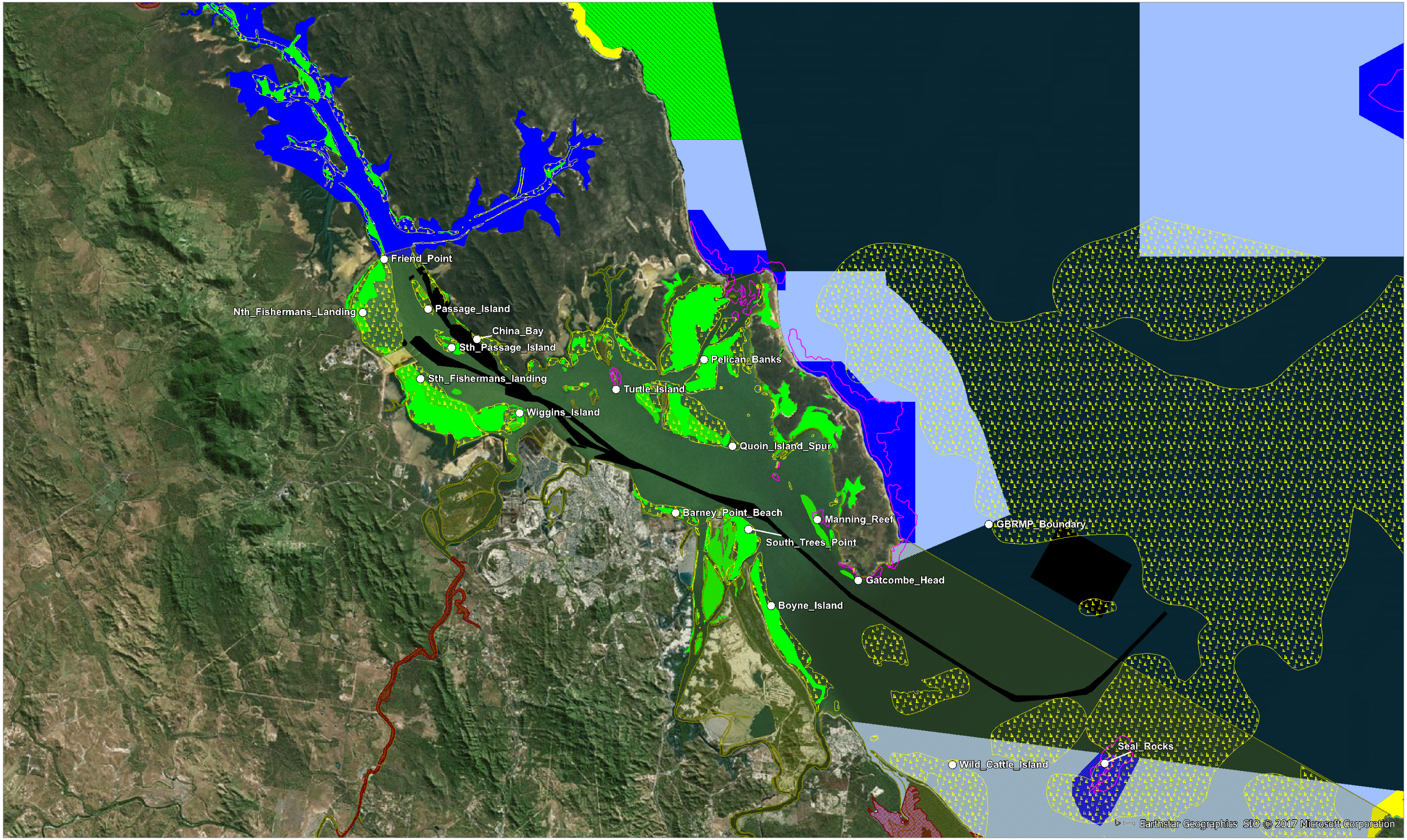
(5) account for the projected impacts of climate change; and

(6) avoid impacts on matters of state environmental significance and, where avoidance is not reasonably possible, minimise and mitigate impacts, and provide an offset for significant residual impacts where appropriate.

In addition to the above, the purpose of this code is to ensure that development involving operational works which is not assessed by local government is designed and located to protect life and property from the impacts of storm tide inundation."

State Code 8 applies in circumstances where coastal development and tidal works are assessable under the Planning Regulation 2017. The Department of Development, Infrastructure, Local Government and Planning (DILGP) as the assessment manager (or concurrence agency) uses the State Development Assessment Provisions (SDAP) to inform their assessment of a Development Application (DA). The SDAP incorporates 'state codes' in a module for each of the 'matters of interest' to SARA. Dredging and disposal of dredge material in tidal waters triggers assessment against State Code 8.

Assessment of the project against relevant sections of State Code 8 are shown in Section 5.



LEGEND

- Dredge Footprint and EBSDS
- Seagrass composite distribution (2002-2014)
- Coral Reefs (BMT WBM 2014)
- Rodds Bay Dugong Protection Zone
- High Ecological Significance Wetlands
- Calliope River and Colosseum Inlet Fish Habitat Areas

Great Barrier Reef Coastal Marine Park Zoning

- General Use Zone
- Habitat Protection Zone
- Marine National Park Zone
- Conservation Park Zone

** Great Barrier Reef Marine Park Authority 2006*

Title:

Features Listed as Matters of State Environmental Significance and Model Output Points

Figure: **4-11**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx.Scale

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5 Impact Assessment

5.1 Modelling Results

5.1.1 Modelled Changes to the Turbidity and Deposition Rate Percentiles

Spatial representations of the dredging impacts were based on percentile analysis of the model results and were derived by applying a moving 14-day analysis window over each simulation period. The 14-day window in a physical hydrodynamic context represents the approximate duration of one (1) spring-neap tidal cycle, while in an ecological context it provides meaningful timescales (i.e. exposure measured in hours and days) for assessing impacts to key sensitive receptors in the area (e.g. intertidal seagrass meadows). The 14-day analysis window was moved forward by 5-day increments from the start to the finish of each simulation period, to ensure full coverage of the simulation.

The percentile impact plots correspond to the modelled increase in turbidity and deposition rate above ambient conditions that are attributable to the dredging. Impacts at each percentile level were calculated for every 14-day window during the simulation, and the maximum increase for any window at each location in the model domain is presented. Different locations within the model will have experienced their highest turbidity at different times during the simulation.

The 95th percentile of the turbidity or deposition rate is the level that is exceeded for approximately 17 hours over the 14-day window. The 50th percentile of the turbidity or deposition rate is the level that is exceeded for approximately seven (7) days in total over the 14-day window. An increase in the highest percentiles correspond to relatively short-lived increases in turbidity/deposition while an increase in the lower percentiles correspond to sustained (but temporary) increases.

Key features of the moving window percentile analysis include:

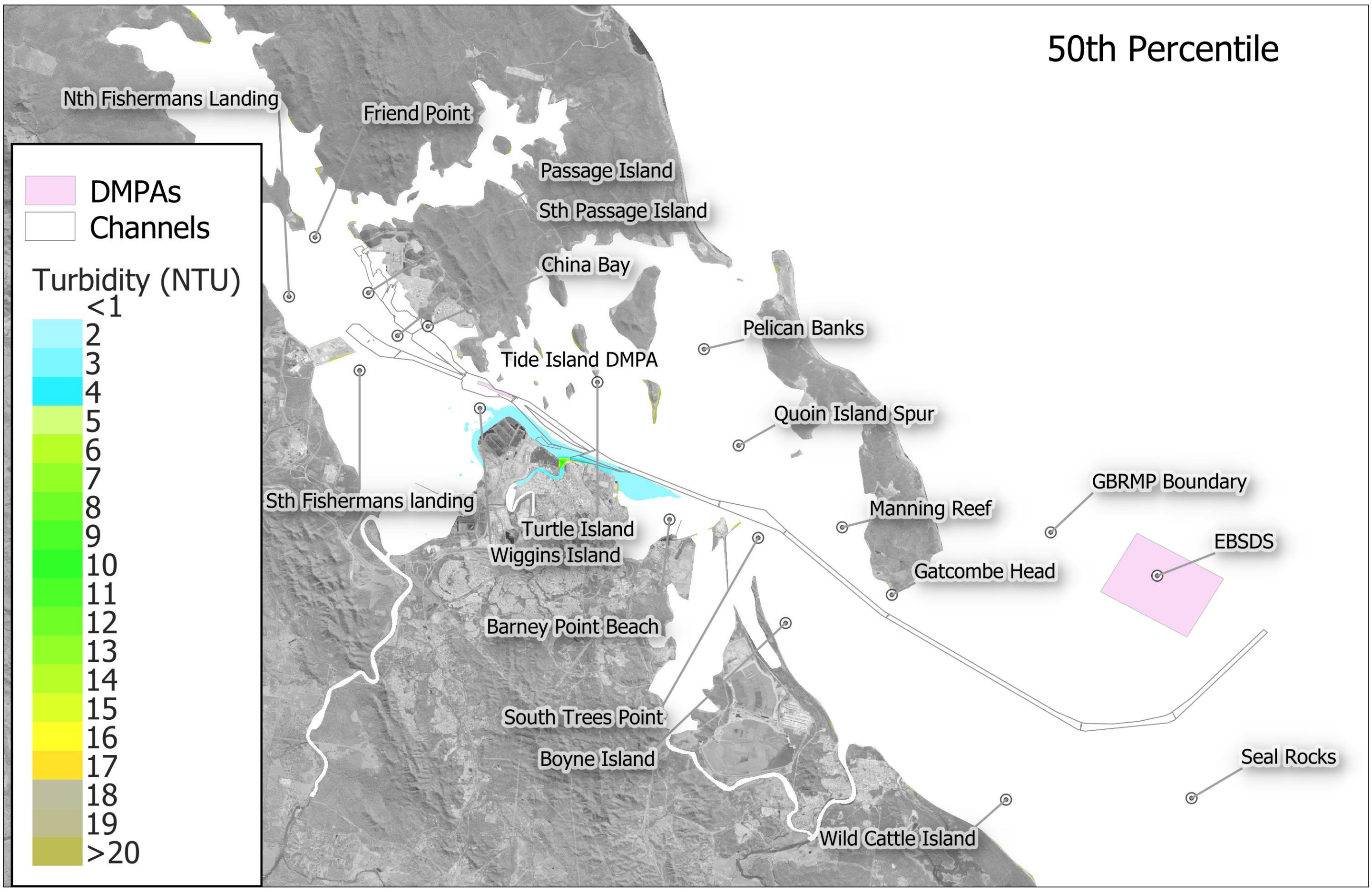
- Consideration of a range of impact durations from short to long term;
- Can be applied to a long term program and capture periods of high intensity versus low intensity impacts.

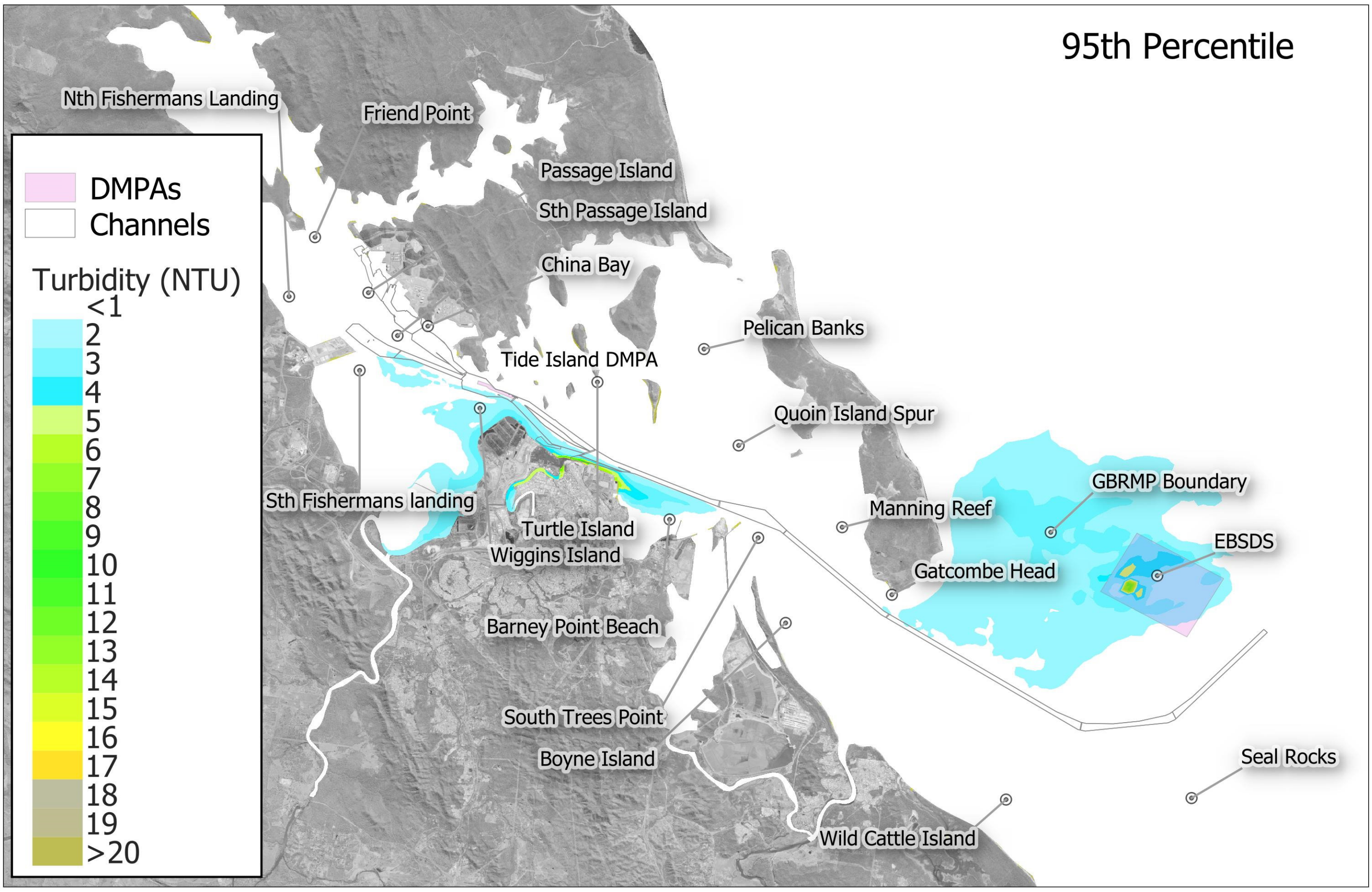
It is important to note that the percentile plots presented in this report are not ‘snapshots’ of the levels of turbidity or deposition rate, and the impact plots do not represent what the visible plume might look like at any one time. They are representations of turbidity and deposition rate statistics over long periods of time, and the impact plots show the potential changes to those statistics.

5.1.2 200,000 m^3 dredged from the Marina by small TSHD with placement at EBSDS

The modelled impacts to the 50th and 95th percentile of the turbidity for a 200,000 m^3 maintenance dredging campaign with placement at the EBSDS are shown in Figure 5-1. Sustained increases to the turbidity (50th percentile) are only significant in the vicinity of the Gladstone Marina and Auckland Point. There are significant increases to the short-term turbidity levels (95th percentile) between Auckland Point and Barney Point, within the Marina, and near the EBSDS.

The modelled impacts to the deposition rate percentiles are shown in Figure 5-2. The modelled increases most significant with the Marina and within the EBSDS, with only minor increases at other locations.





Title:

200,000m³ Marina Campaign with Placement at the EBSDS - Change to the 50th & 95th Percentiles of the Modelled Depth Averaged Turbidity due to Dredging

Figure: **5-1**

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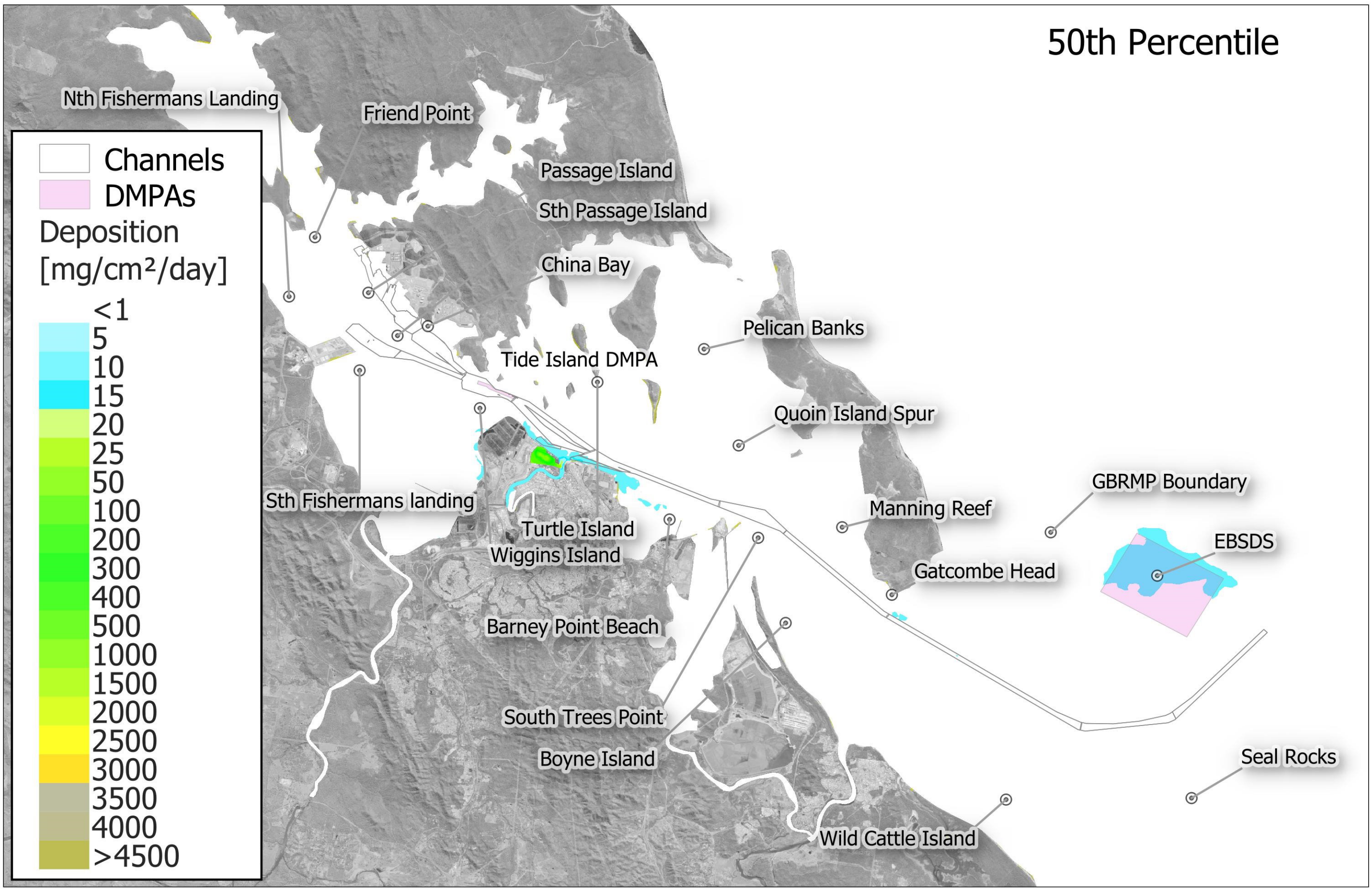

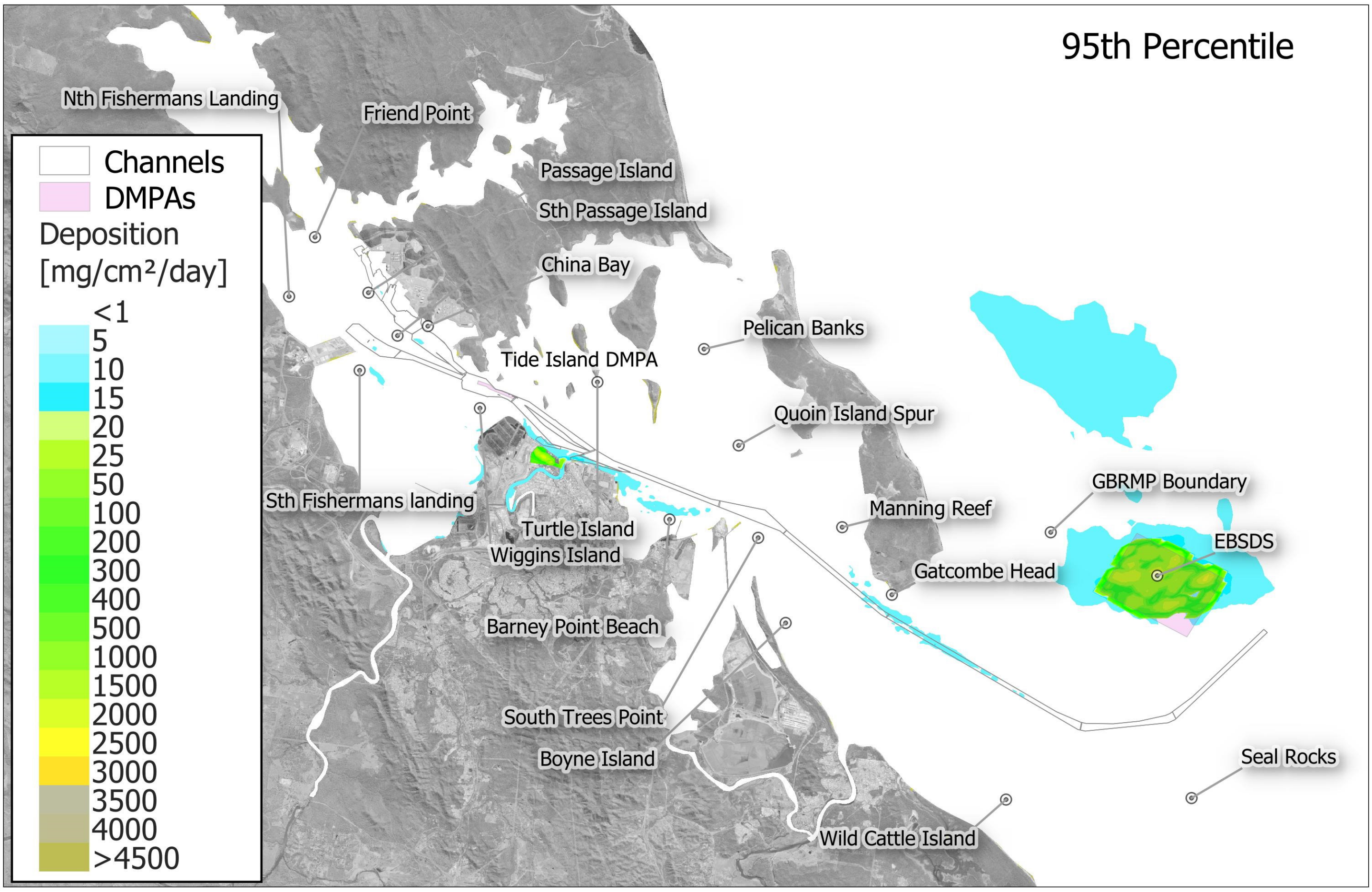

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200,000m³ Marina Campaign with Placement at the EBSDS - Change in the 50th & 95th Percentile of the Modelled Deposition Rate due to Dredging

Figure: **5-2**

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5.1.3 40,000 m^3 dredged from the Marina by Cutter Suction Dredger (CSD) and pumped to the Clinton Channel Placement Area

The modelled impacts to the 50th and 95th percentile of the turbidity for the 40,000 m^3 CSD campaign with in-channel placement are shown in Figure 5-3. Both the sustained and short-term increases to the turbidity (50th and 95th percentiles) are only significant in the vicinity of the Gladstone Marina and the pipe discharge location (the Clinton Channel Placement Area).

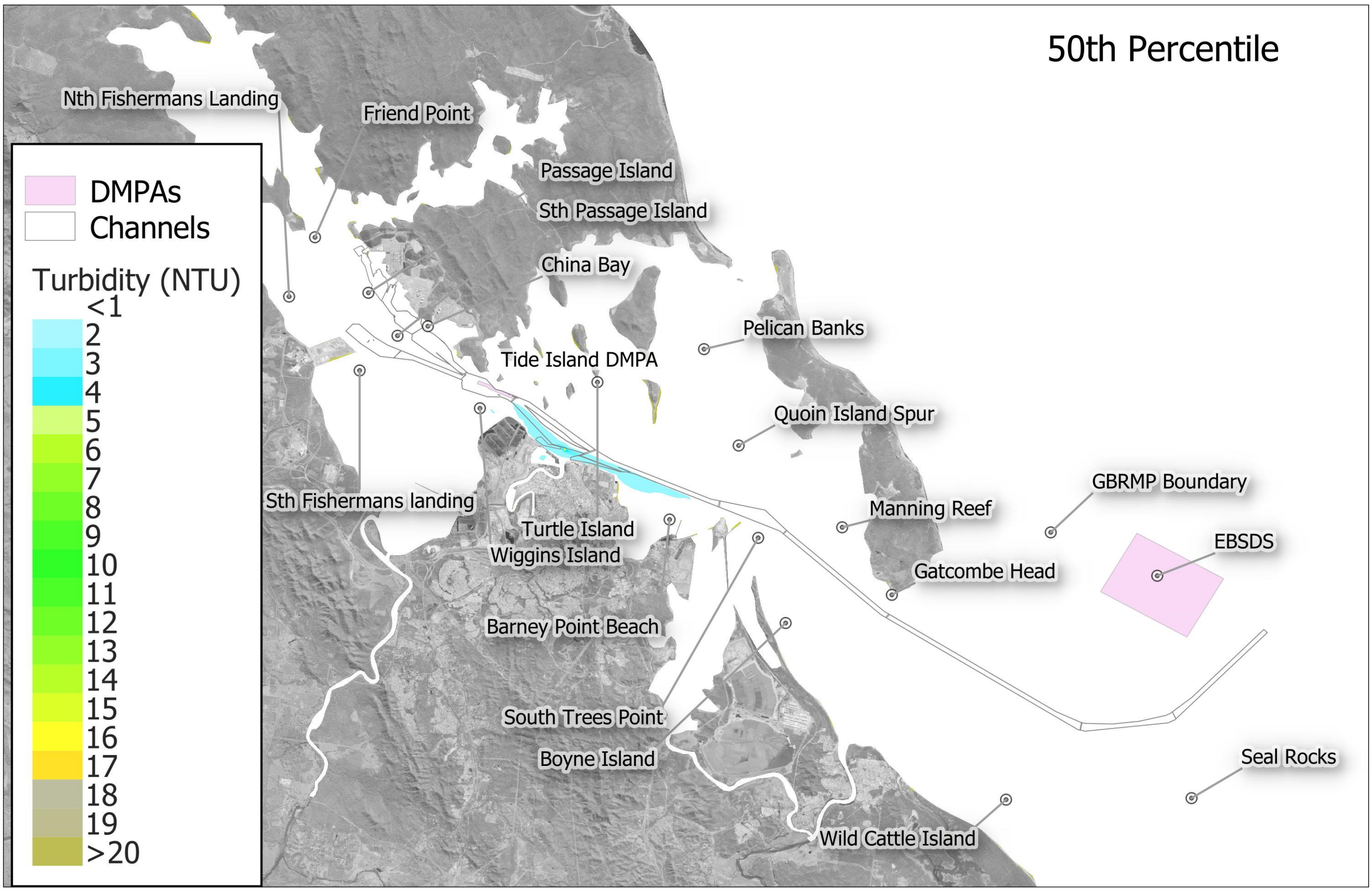
The modelled impacts to the deposition rate percentiles are shown in Figure 5-4. The largest increases in deposition rate occur in the vicinity of the pipe discharge location (the Clinton Channel Placement Area), as expected.

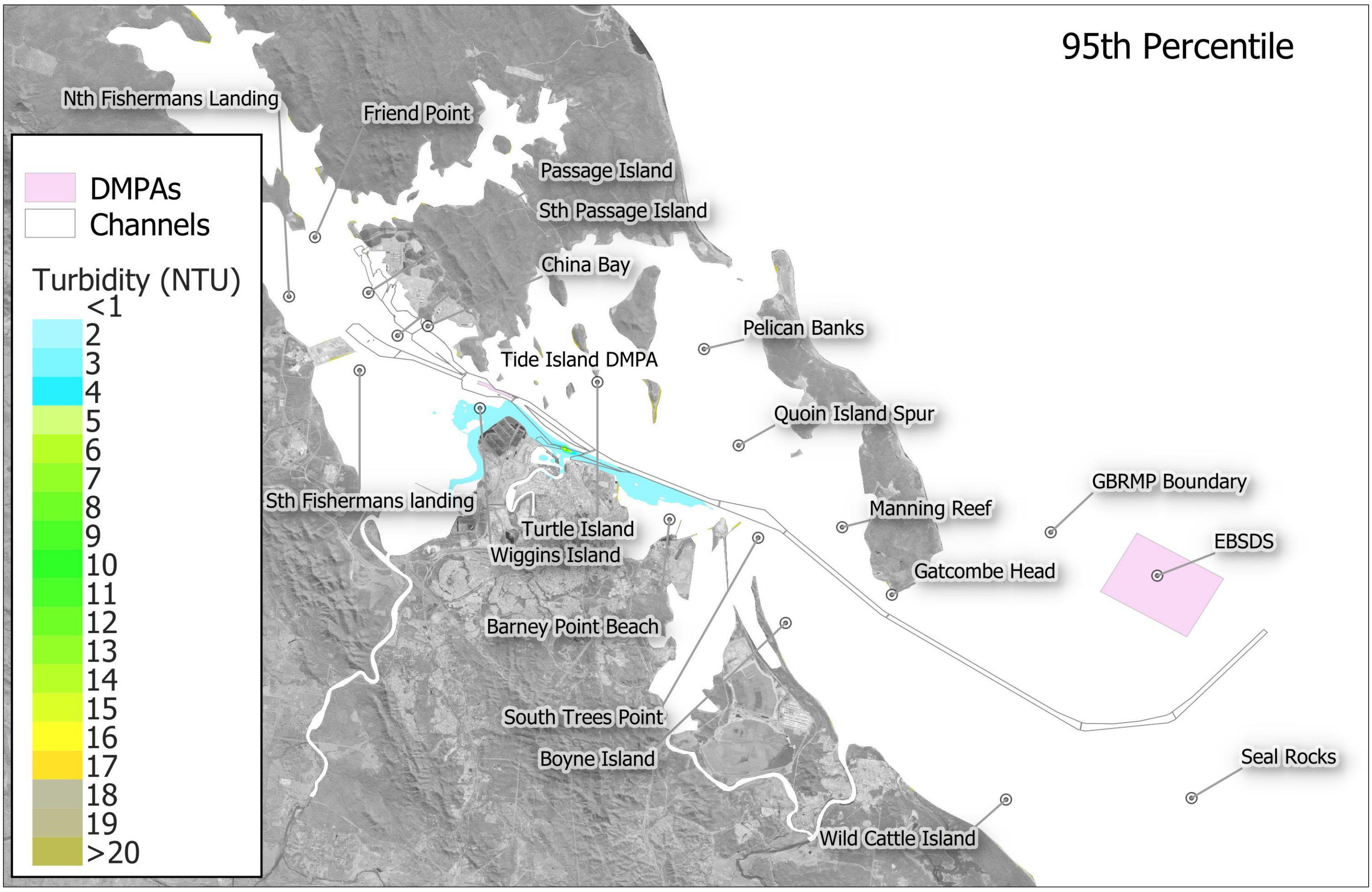
5.1.4 150,000 m^3 dredged from the Marina by Cutter Suction Dredger (CSD) and pumped to the Clinton Channel Placement Area

The modelled impacts to the 50th and 95th percentile of the turbidity for the 150,000 m^3 CSD campaign with in-channel placement are shown in Figure 5-5. Both the sustained and short-term increases to the turbidity (50th and 95th percentiles) are only significant in the vicinity of the Gladstone Marina and the pipe discharge location (the Clinton Channel Placement Area).

The modelled impacts to the deposition rate percentiles are shown in Figure 5-6. The largest increases in deposition rate occur in the vicinity of the pipe discharge location (the Clinton Channel Placement Area), as expected.

The net deposition of sediment at the end of the simulation is shown in Figure 5-7. The net deposition is highest in the vicinity of the pipeline discharge location. The model indicates that very little net deposition of dredged sediment is expected outside of the Marina and the pipe discharge location.





Title:	Figure:	Rev:
40,000m³ Marina Campaign with Placement in the Clinton Channel - Change to the 50th & 95th Percentiles of the Modelled Depth Averaged Turbidity due to Dredging	**5-3**	**A**

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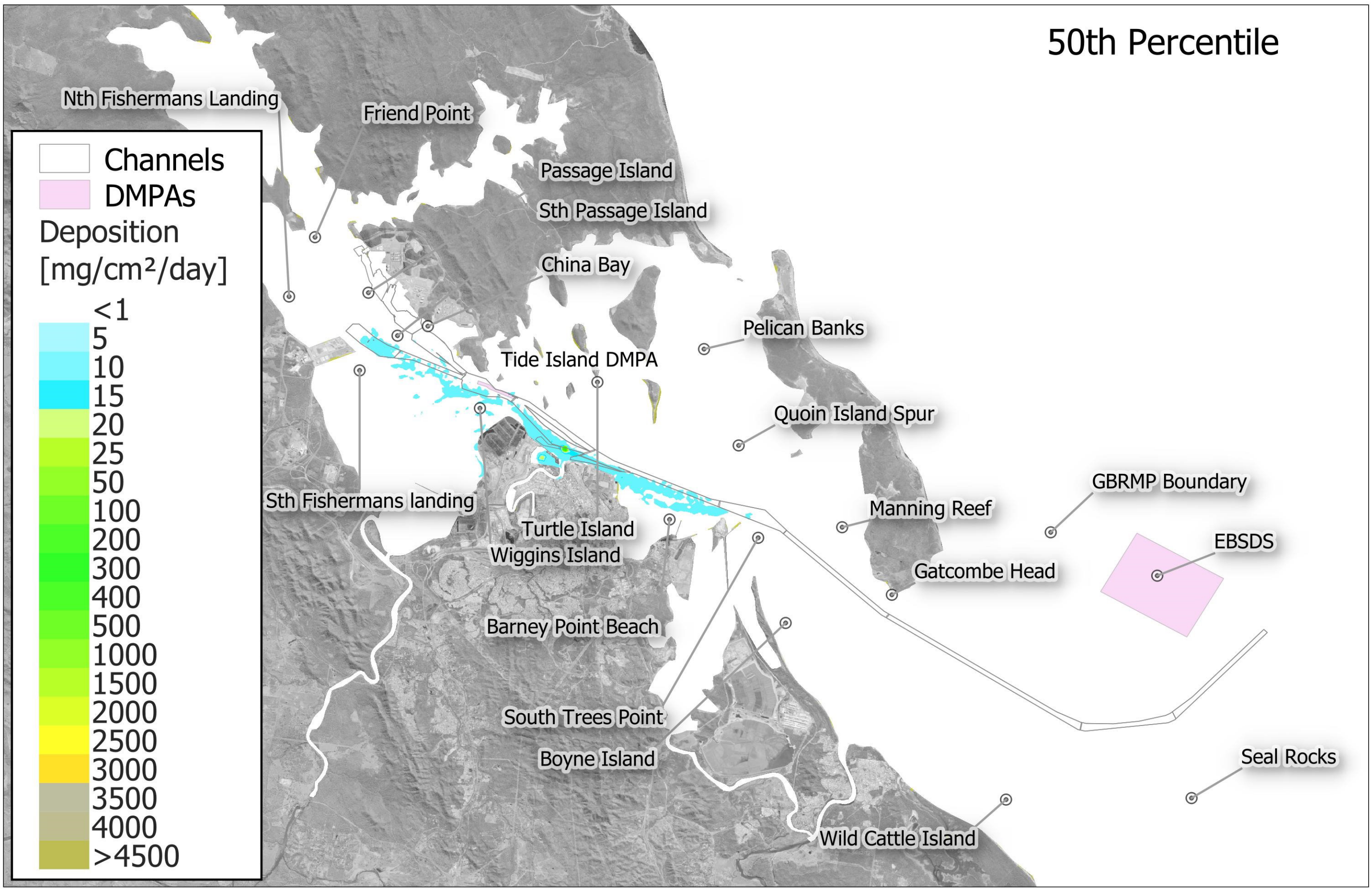

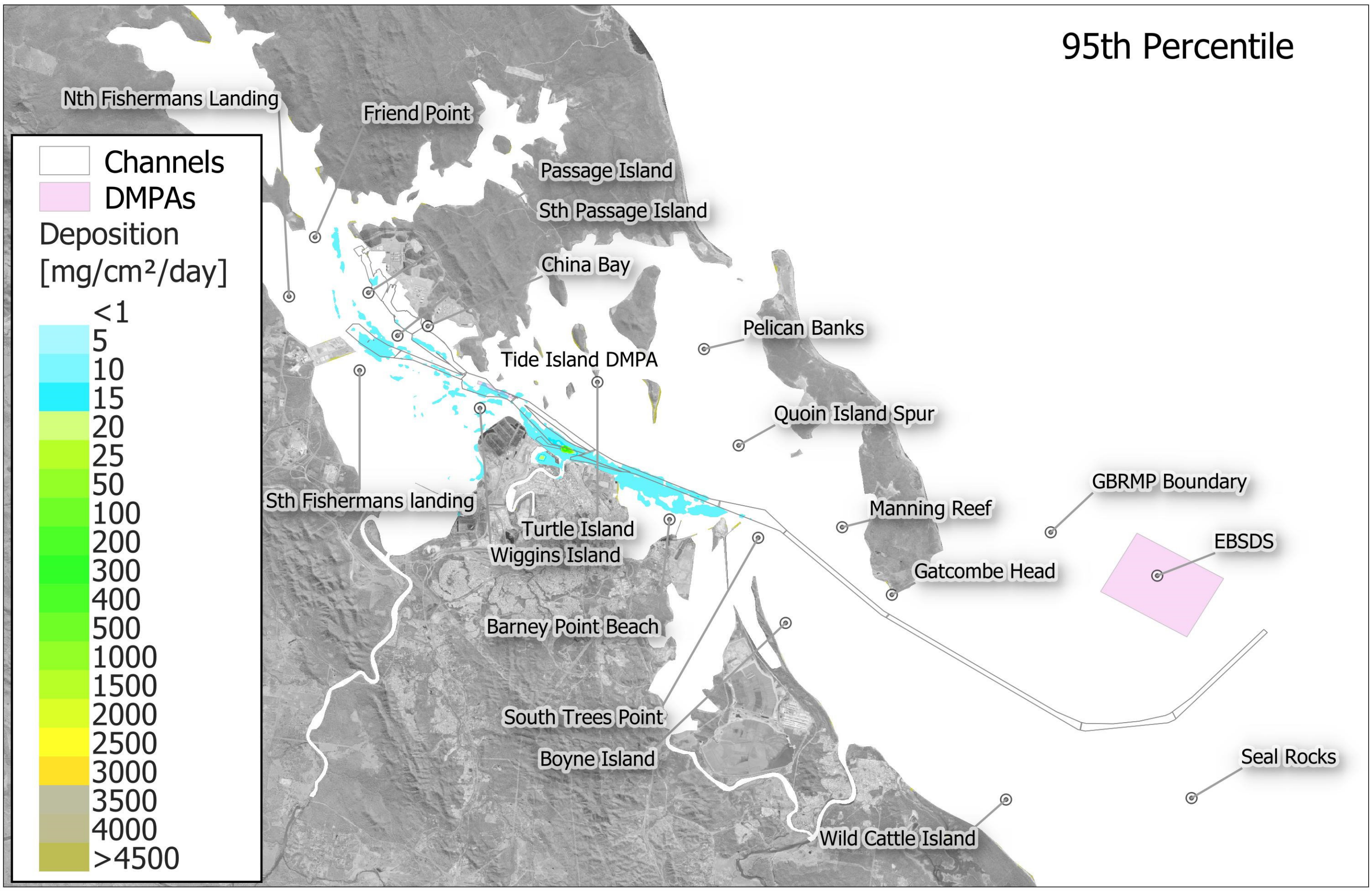

Title:

40,000m³ Marina Campaign with Placement in the Clinton Channel - Change in the 50th & 95th Percentile of the Modelled Deposition Rate due to Dredging

Figure: **5-4**

Rev: **A**

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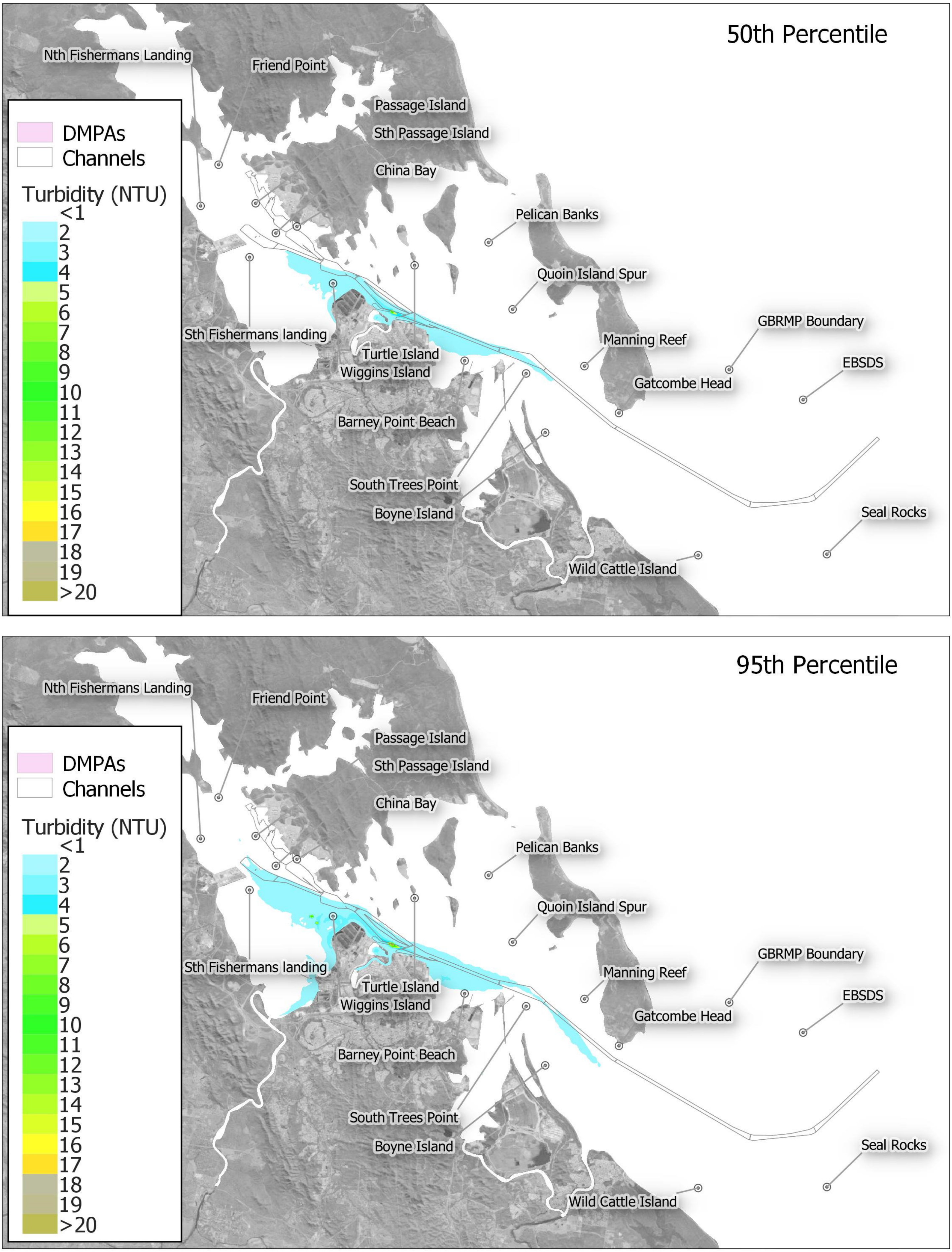

Title:

150,000m³ Campaign with Placement in the Clinton Channel - Change to the 50th & 95th Percentiles of the Modelled Depth Averaged Turbidity due to Dredging

Figure: **5-5**

Rev: **A**

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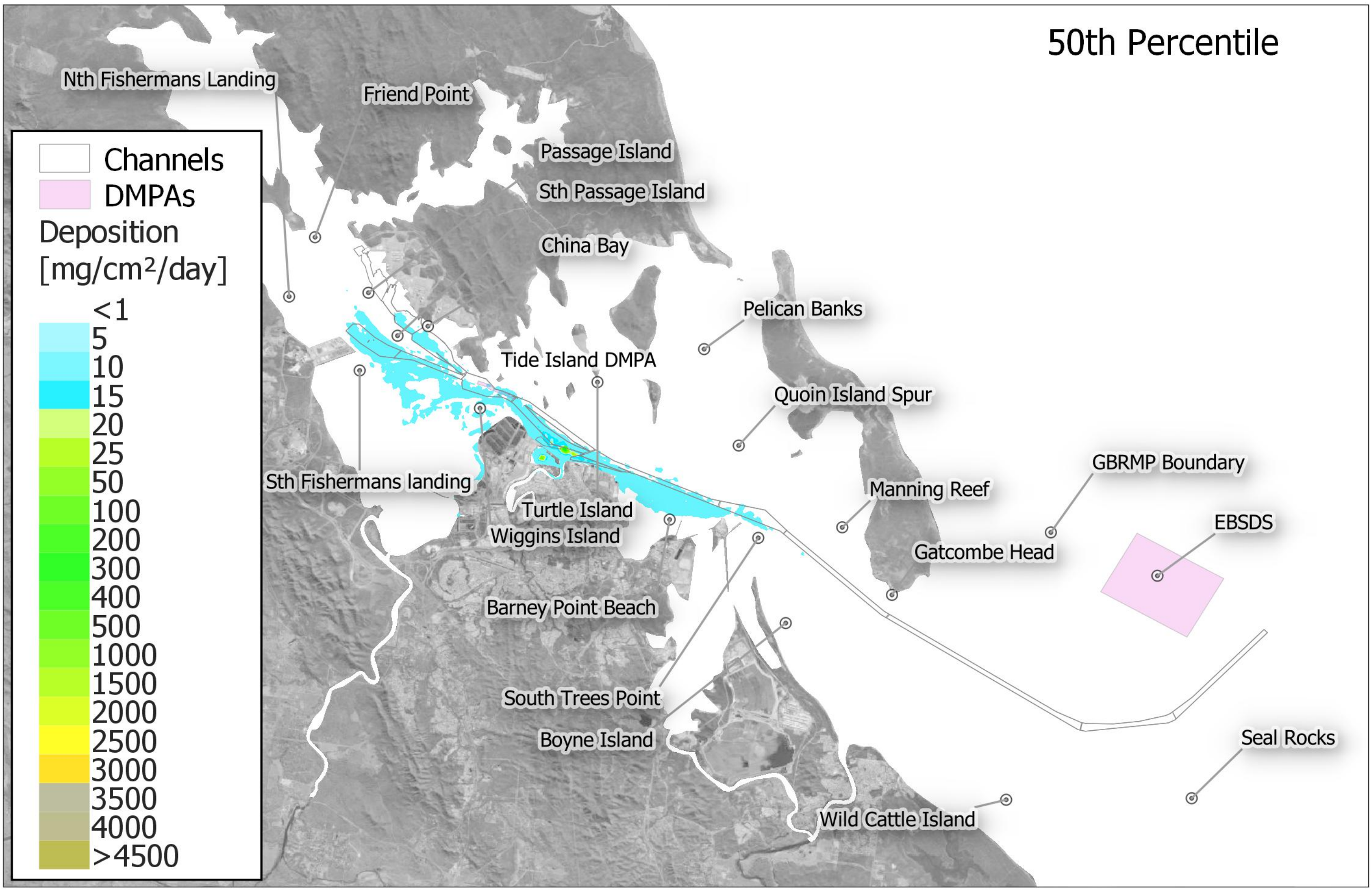

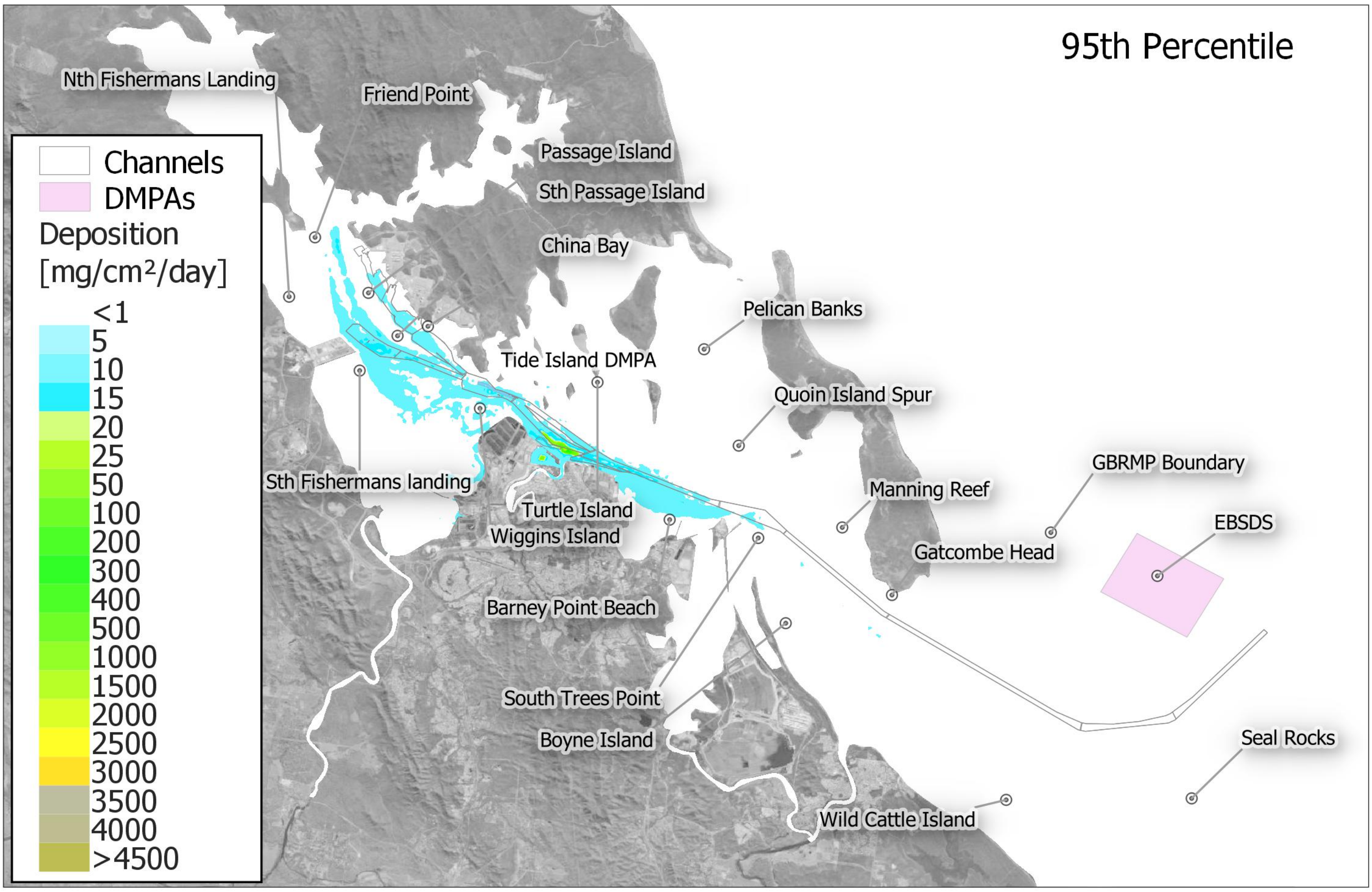

Title:

150,000m³ Marina Campaign with Placement in the Clinton Channel - Change in the 50th & 95th Percentile of the Modelled Deposition Rate due to Dredging

Figure: **5-6**

Rev: **A**

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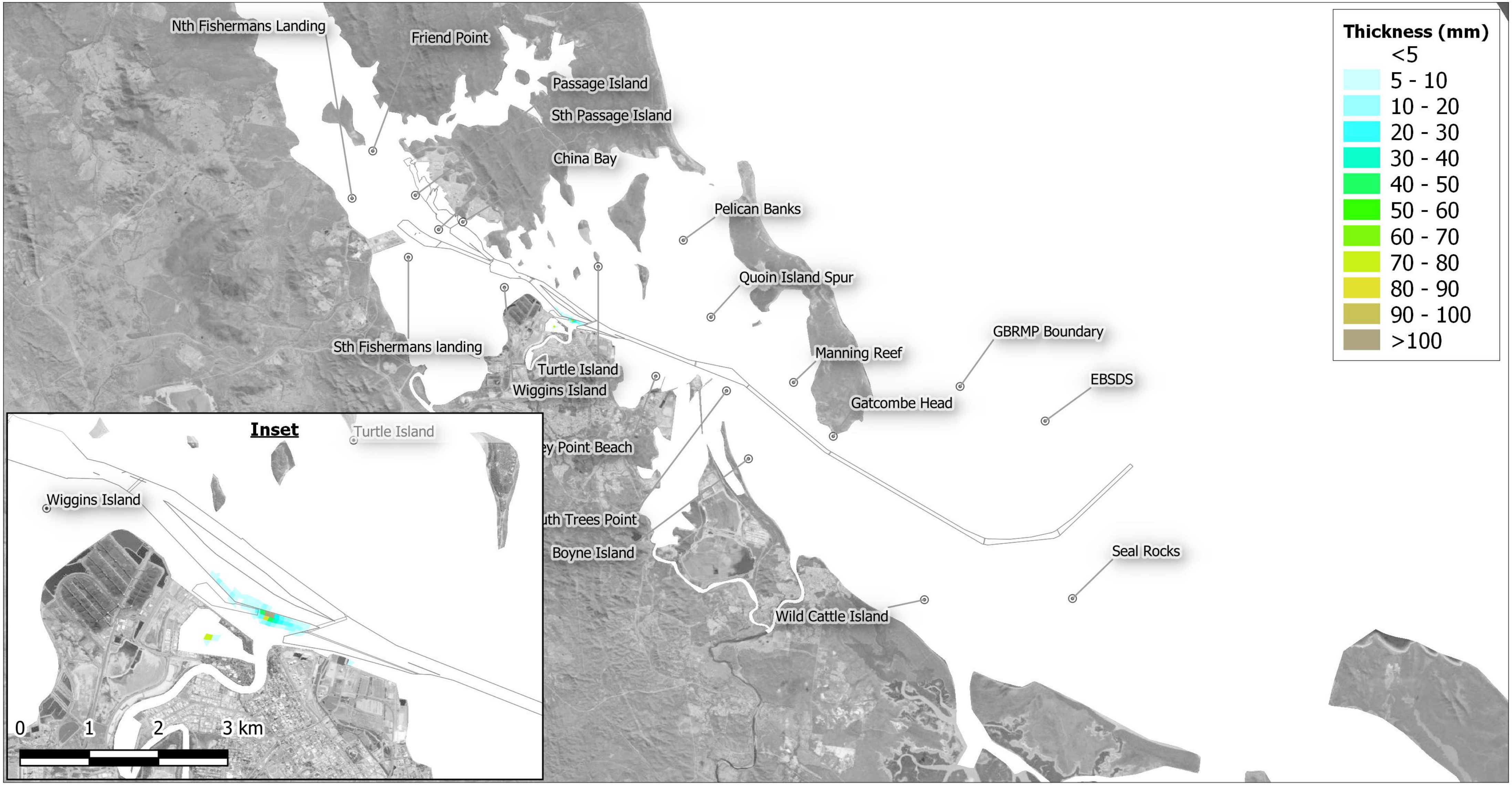

Legend

⊙ Time Series Output Locations

Channels

Title:

Dredge Deposition Thickness -
150,000m³ Marina Campaign with Placement in the Clinton Channel

Figure: **5-7**

Rev: **A**

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5.1.5 Zones of Influence and Impact

The modelled impacts to the turbidity were compared to threshold values derived from measured data to assess the potential impacts to marine water quality and ecologically sensitive areas. These are presented as 'Zones of Impact', in accordance with standard industry practice such as the WA EPA (2016) dredging environmental assessment guidelines. Four zones were defined in accordance with WA EPA (2016):

- Zone of High Impact = Excess turbidity from dredging most likely to cause water quality to deteriorate beyond natural variation;
- Zone of Moderate Impact = Excess turbidity from dredging likely to cause water quality to deteriorate beyond natural variation;
- Zone of Low Impact = Excess turbidity from dredging may cause water quality to deteriorate beyond natural variation; and
- Zone of Influence = Extent of detectable plume (as measured by instrumentation) but no predicted ecological impacts.

To determine the threshold values to delineate the Zones of Impact, a combination of referential and biological tolerances methods was used. This entailed using baseline water quality monitoring data to set initial threshold values (referential method). These values were then compared to biological tolerances from literature values as a 'reality check' to see if the threshold values are biologically meaningful.

5.1.5.1 13-Month Baseline Water Quality Data

As part of the Gatcombe and Golding Cutting Channel Duplication Project EIS (BMT, 2019b), continuous turbidity data (and other parameters) were collected over a 13-month period (May 2014 to June 2015) at eight (8) sites within the Port area. The monitoring data set underwent a quality control process to remove invalid data (outliers resulting from fouling or malfunction).

5.1.5.2 Threshold Values

As the long term data shows variability in turbidity among sites during the same time period, site-specific thresholds were derived which reflect the natural variability of the turbidity in that location. To determine initial impact threshold values, the 13-month baseline water quality monitoring dataset was analysed and percentile curves were produced. These percentile curves provide an indication of magnitude of turbidity and combined duration/frequency metrics for a range of conditions.

The 13-month baseline data were analysed over a moving 14-day window period to give a range of percentile values over different periods. The 14-day moving window analysis was undertaken by moving the 14-day window by 5-day increments over the entire monitoring period (approximately 77 different 14-day periods). This method provides an indication of natural variability around each percentile value and provides context for excess turbidity from dredging.

As an example, Figure 5-8 shows the percentile curves for data collected at Site WB50. This shows the natural variability measured around the median (50^{th} percentile) and other percentile values. The x-axis in Figure 5-8 represents the different percentile values extracted from the moving 14-day window analysis from frequently exceeded on the left to rarely exceeded on the right. The different curves are statistics representing the variability of the turbidity percentiles across the different 14-day periods (making up the 13-month baseline monitoring period). The lower curve represents the least turbid conditions during any window within the 13-month period, while the upper limit is the result for the windows with the most turbid conditions. The solid red line is the mean of the different 14-day window conditions.

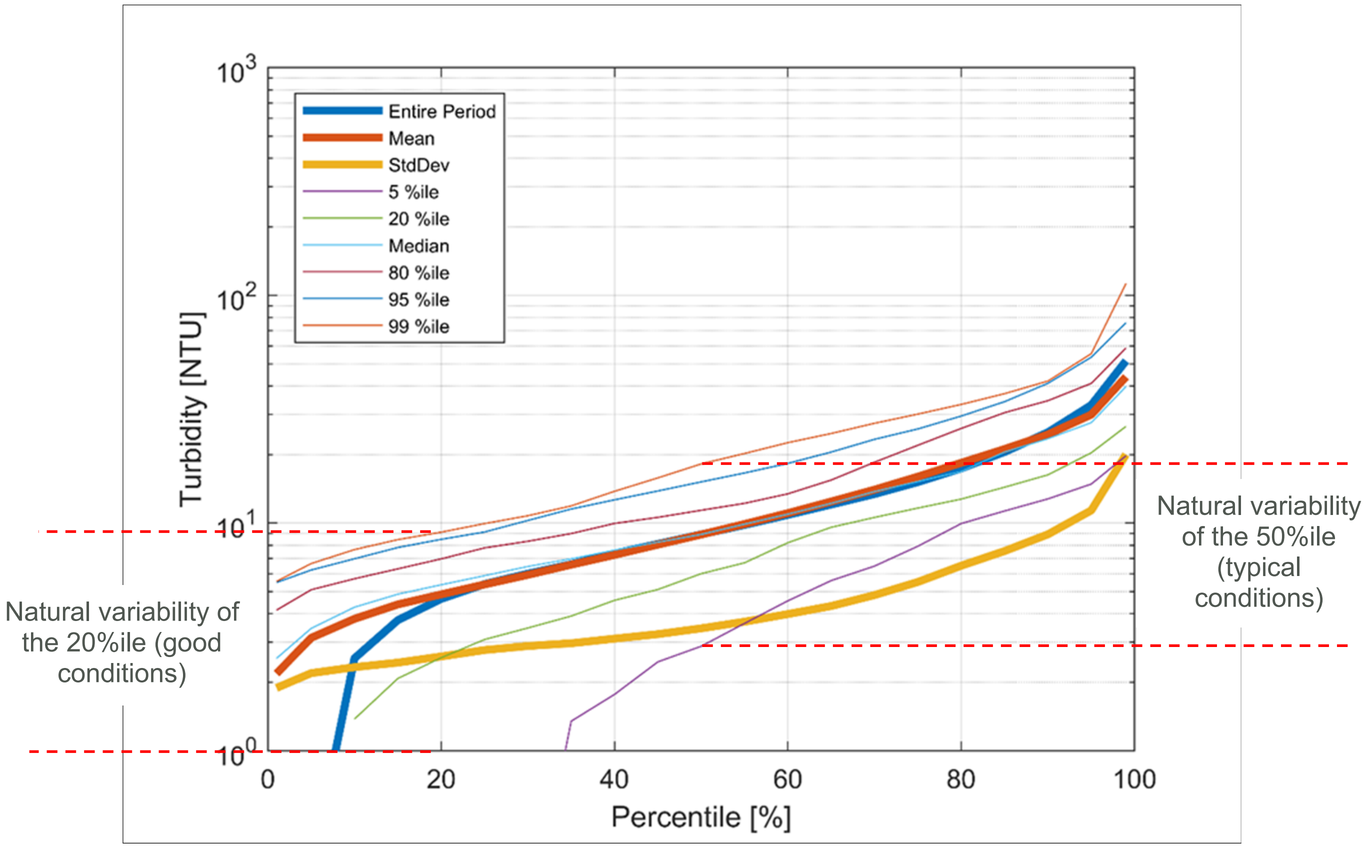


Figure 5-8 Example Summary Analysis of Baseline Data for Site WB50

Threshold values were derived from these percentile curves based on the natural variability around the 50th percentile (average conditions), 20th percentile (good conditions – neap tides / low winds and waves) and the 80th percentile (poor conditions – spring tides / moderate to high wind and waves). Therefore, this method considers both short term and sustained impacts.

A description of the threshold values for the three zones of impact and how they relate to the natural variability is provided in Table 5-1. The approach used to determine the threshold levels involved using the standard deviation from the natural background mean of each percentile over all of the 14-day windows (i.e. 20th, 50th and 80th percentiles). This is a similar approach to the one developed by Orpin *et al.* (2004) to assess impacts from construction-related turbidity increases in Townsville. Orpin *et al.* (2004) suggested that one standard deviation from ambient conditions could be used as a possible conservative upper limit of an acceptable increase in turbidity. Orpin *et al.* (2004) noted that the standard deviation of natural turbidity levels was considered to be a reasonable and convenient envelope within which an allowable construction-related increase could occur. If construction-related turbidity remained within one standard deviation of natural variation, Orpin *et al.* (2004) suggested it would not be detectable over and above the natural variability. Extending this method out, threshold levels for the 'zone of medium impact' and the 'zone of high impact' were determined using two and three standard deviations from the mean, respectively. These levels were also tested against biological tolerance literature values (refer BMT, 2019b).

The 'zone of influence' was defined as the probable maximum extent of detectable plumes due to the proposed dredging. Turbid plumes were assumed to become detectable by instrumentation once they were approximately 20-30% above background conditions. To determine the extent of this zone, the following criteria were used (with any one (1) criterion to be satisfied):

- 0.5 NTU above 50th percentile conditions;
- 2 NTU above 80th percentile conditions;
- 5 NTU above 95th percentile conditions; or
- 10 NTU above 99th percentile conditions.

Included in Table 5-1 are biological tolerance literature values for seagrass in other regions. Only biological tolerances for seagrass are included as corals are too variable among species and sites to define at this stage. As the seagrass tolerances are expressed as light requirements, a relationship between BPAR and turbidity was used to convert light requirements to turbidity.

Further to the conservative nature of the literature values, it is acknowledged (including by regulators and scientists) that there are uncertainties regarding the responses of seagrass to high turbidity values, which is used here as a proxy for light. Therefore, the biological tolerance literature values are only used as a means for cross-checking potential ecological relevance of changes to turbidity values.

For full details of the derivation and testing of the impact zone threshold values, refer to the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS, Appendix D (BMT, 2019b). The threshold values for each zone at each monitoring site are provided in Table 5-2.

The threshold values at each site in Table 5-2 for each percentile were used to derive an interpolated grid of threshold values for the entire Port. The modelled increases in the 20^{th}, 50^{th} and 80^{th} percentiles of the turbidity in each cell of the model were then compared to the local threshold values, and the cell was included in an impact zone if any of the threshold values for that zone at that location were exceeded.

Table 5-1 Description of Threshold Values

Impact Zone	Referential (Water Quality)	Biological Tolerances (Seagrass)*
Zone of High Impact	Excess turbidity *most likely* to cause total turbidity to go beyond natural variation Threshold value = excess turbidity greater than three standard deviations from the natural background mean	*Zostera muelleri* subsp. *capricorni* – 14 day rolling average of <6 mol photons m^{-2} day^{-1} over 28 days *Halodule uninervis* – 14 day rolling average of <5 mol photons m^{-2} day^{-1} over 40 days **Halophila* spp. – 7 day rolling average of <2 mol photons m^{-2} day^{-1} over 14 days
Zone of Moderate Impact	Excess turbidity *likely* to push total turbidity beyond natural variation Threshold value = excess turbidity greater than two standard deviations from the natural background mean	*Zostera muelleri* subsp. *capricorni* – 14 day rolling average of <6 mol photons m^{-2} day^{-1} over 21 days *Halodule uninervis* – 14 day rolling average of <5 mol photons m^{-2} day^{-1} over 21 days **Halophila* spp. – 7 day rolling average of <2 mol photons m^{-2} day^{-1} over 10 days
Zone of Low Impact	Excess turbidity *may* push total turbidity beyond natural variation Threshold value = excess turbidity greater than one standard deviation from the natural background mean	*Zostera muelleri* subsp. *capricorni* – 14 day rolling average of <6 mol photons m^{-2} day^{-1} *Halodule uninervis* – 14 day rolling average of <5 mol photons m^{-2} day^{-1} **Halophila* spp. – 7 day rolling average of <2 mol photons m^{-2} day^{-1}
Zone of Influence	Extent of detectable plume (as measured by instrumentation) but no predicted ecological impacts Turbidity related to dredging activities exceeds: - 0.5 NTU above 50th percentile conditions - 2 NTU above 80th percentile conditions - 5 NTU above 95th percentile conditions - 10 NTU above 99th percentile conditions	*Zostera muelleri* subsp. *capricorni* – 14 day rolling average of >6 mol photons m^{-2} day^{-1}, however less than ambient *Halodule uninervis* – 14 day rolling average of >5 mol photons m^{-2} day^{-1}, however less than ambient **Halophila* spp. – 7 day rolling average of >2 mol photons m^{-2} day^{-1}, however less than ambient

*As per Collier *et al.* (2016), *Halophila ovalis* has different light thresholds for intertidal and deepwater environments. The above thresholds apply to *Halophila ovalis* in deepwater environments, whereas intertidal *Halophila ovalis* has broadly similar light requirements to *Zostera*

Table 5-2 Impact Threshold Values (Above Background) for each Monitoring Site

Impact Zone	Description	Method	Percentile	Descriptor	CD1	CD2	CD3	CD4	CD5	WB50	MH30	QE3
					Turbidity Threshold Values (NTU) - *above background*							
Zone of High Impact	Excess turbidity *most likely* pushes total turbidity beyond natural variation	3 x standard deviations from 20%ile mean	20%ile	Exceeded 80% of the time	4	5	6	4	2	8	3	12
		3 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	7	7	9	5	4	10	5	13
		3 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	12	12	16	8	8	20	13	20
Zone of Moderate Impact	Excess turbidity *likely* pushes total turbidity beyond natural variation	2 x standard deviations from 20%ile mean	20%ile	Exceeded 80% of the time	3	3	4	3	2	5	2	8
		2 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	5	5	6	4	3	7	4	9
		2 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	8	8	10	5	6	13	8	13
Zone of Low Impact	Excess turbidity *may* push total turbidity beyond natural variation	1 x standard deviation from 20%ile mean	20%ile	Exceeded 80% of the time	1	2	2	1	1	3	1	4
		1 x standard deviation from 50%ile mean	50%ile	Exceeded 50% of the time	2	2	3	2	1	3	2	4
		1 x standard deviation from 80%ile mean	80%ile	Exceeded 20% of the time	4	4	5	3	3	7	4	7
Zone of Influence	Full extent of detectable plumes (including resuspension)	Dredging-related turbidity exceeds 0.5 NTU	50%ile	Exceeded 50% of the time	0.5							
		Dredging-related turbidity exceeds 2 NTU	80%ile	Exceeded 20% of the time	2							
		Dredging-related turbidity exceeds 5 NTU	95%ile	Exceeded 5% of the time	5							
		Dredging-related turbidity exceeds 10 NTU	99%ile	Exceeded 1% of the time	10							

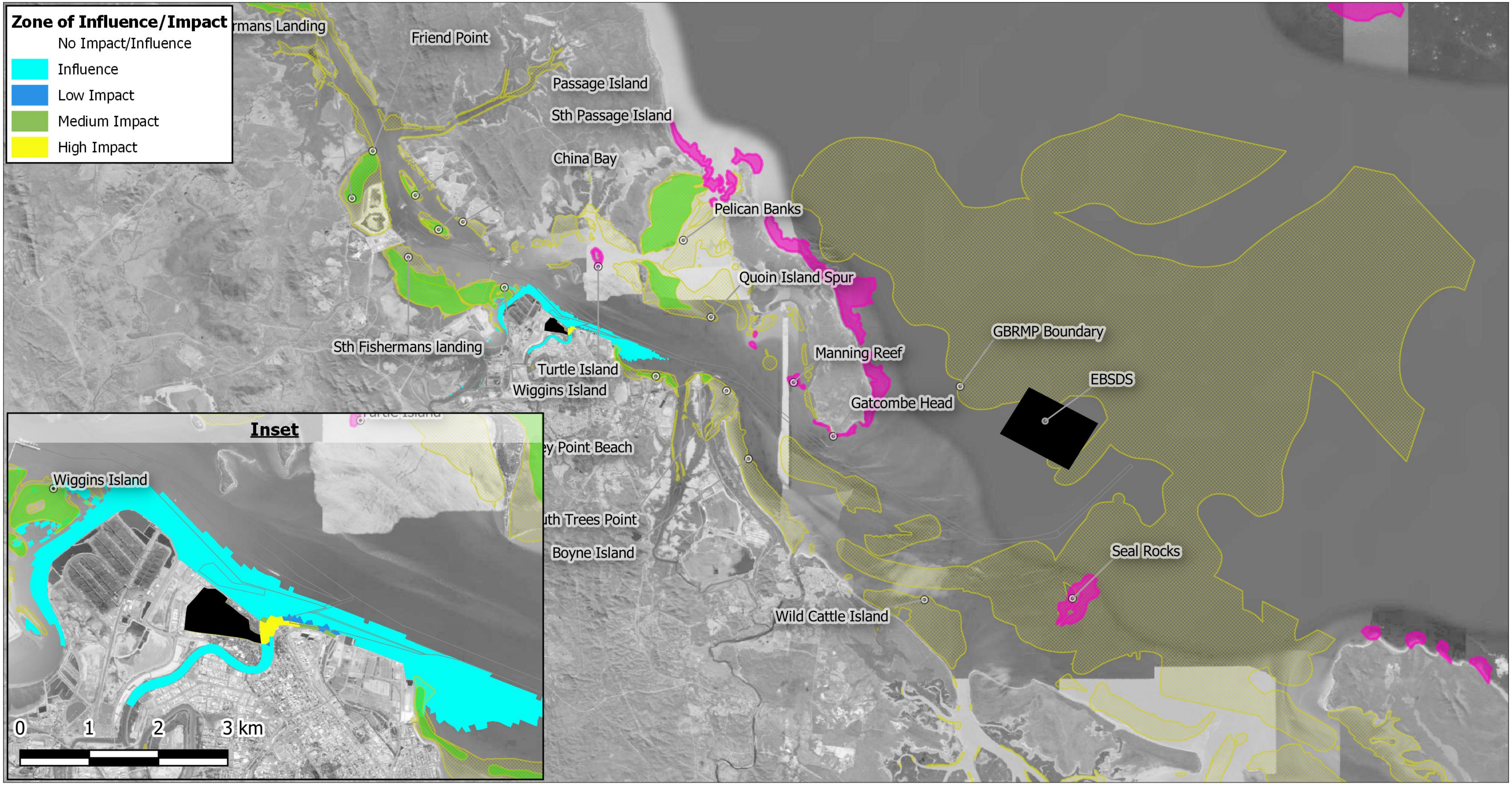
5.1.5.3 Results

The Zone of Influence and Impact for each campaign was calculated according to the methodology outlined in the previous sections.

The Zones of Impact and Zone of Influence for the 200,000 m^3 campaign with placement at the EBSDS is provided in Figure 5-9. The Zone of Influence (the area where plumes are expected to have a measurable effect on the turbidity statistics, but cause no ecological impact) extends to Wiggins Island and into the Calliope River estuary, and along the Clinton Channel to the south-east. There is a small Zone of Impact at the entrance to Auckland Inlet.

The Zone of Influence for the 40,000 m^3 campaign with in-channel placement is provided in Figure 5-10. The Zone of Influence (the area where plumes are expected to have a measurable effect on the turbidity statistics, but cause no ecological impact) extends along the Clinton Channel between the mouth of the Calliope River and South Trees. There is a very small Zone of Impact at the pipe discharge location in the Clinton Channel.

The Zone of Influence for the 150,000 m^3 campaign with in-channel placement is provided in Figure 5-11. The Zone of Influence (the area where plumes are expected to have a measurable effect on the turbidity statistics, but cause no ecological impact) extends further along the Clinton Channel, past the mouth of the Calliope River to the north-west and South Trees to the south-east. There is also a small Zone of Impact near the discharge point in the Clinton Channel, extending for a few hundred metres upstream and downstream of the discharge point.



Legend

- Time Series Output Locations
- Direct Impact
- DMPA
- Seagrass (2020)
- Coral Reefs (BMTWBM 2014)
- Seagrass Composite Distribution (2002-2020)

Title:

Zones of Impact and Zone of Influence with Mapped Sensitive Receptors - 200,000m³ Marina Campaign with Placement at the EBSDS

Figure: **5-9**

Rev: **B**

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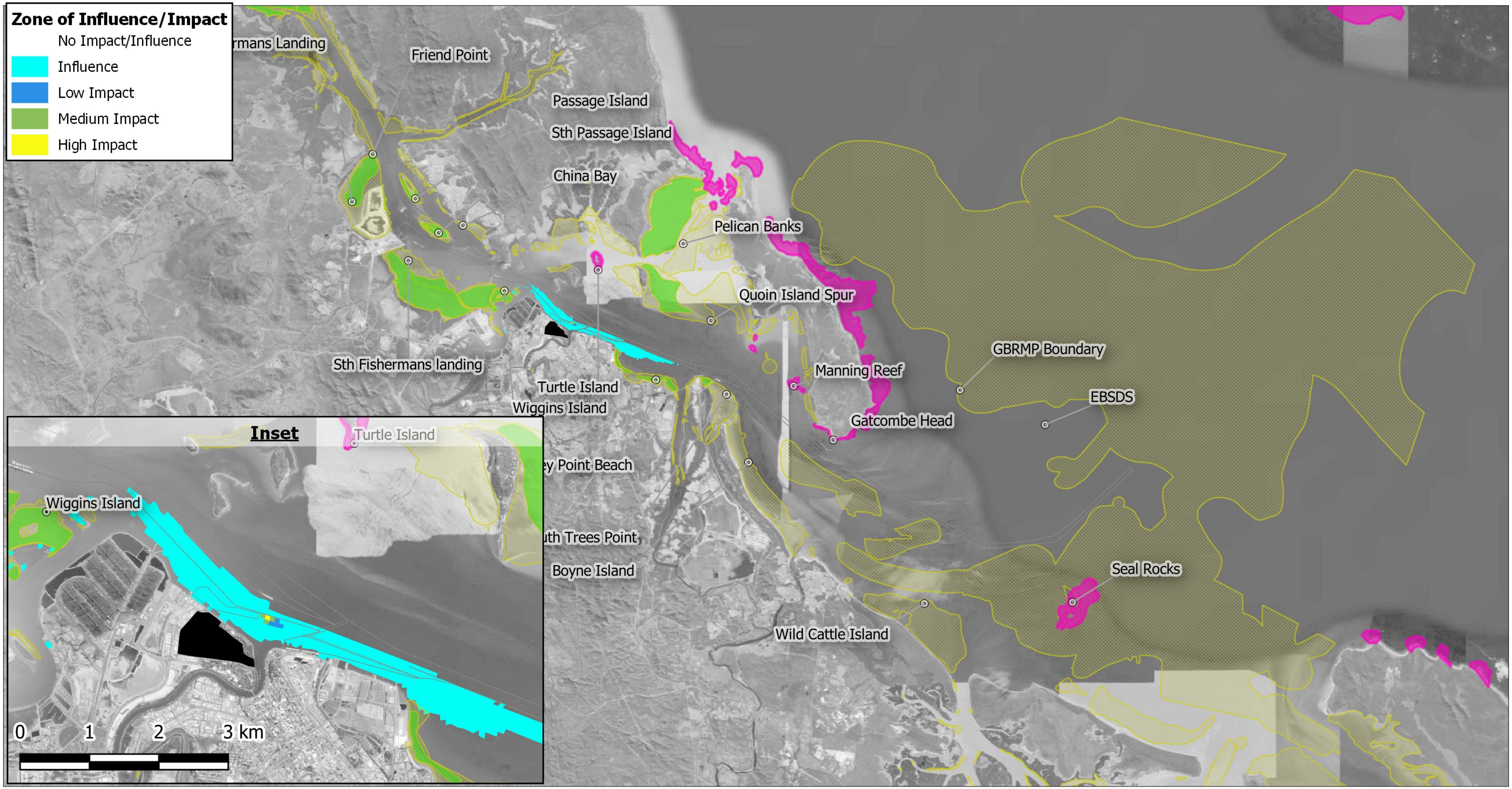

Legend

- Time Series Output Locations
- Direct Impact
- Seagrass (2020)
- Reefs (BMT 2014)
- Seagrass Composite Distribution (2002-2020)

Title:

Zones of Impact and Zone of Influence with Mapped Sensitive Receptors - 40,000m³ Marina Campaign with Placement in the Clinton Channel

Figure: **5-10**

Rev: **B**

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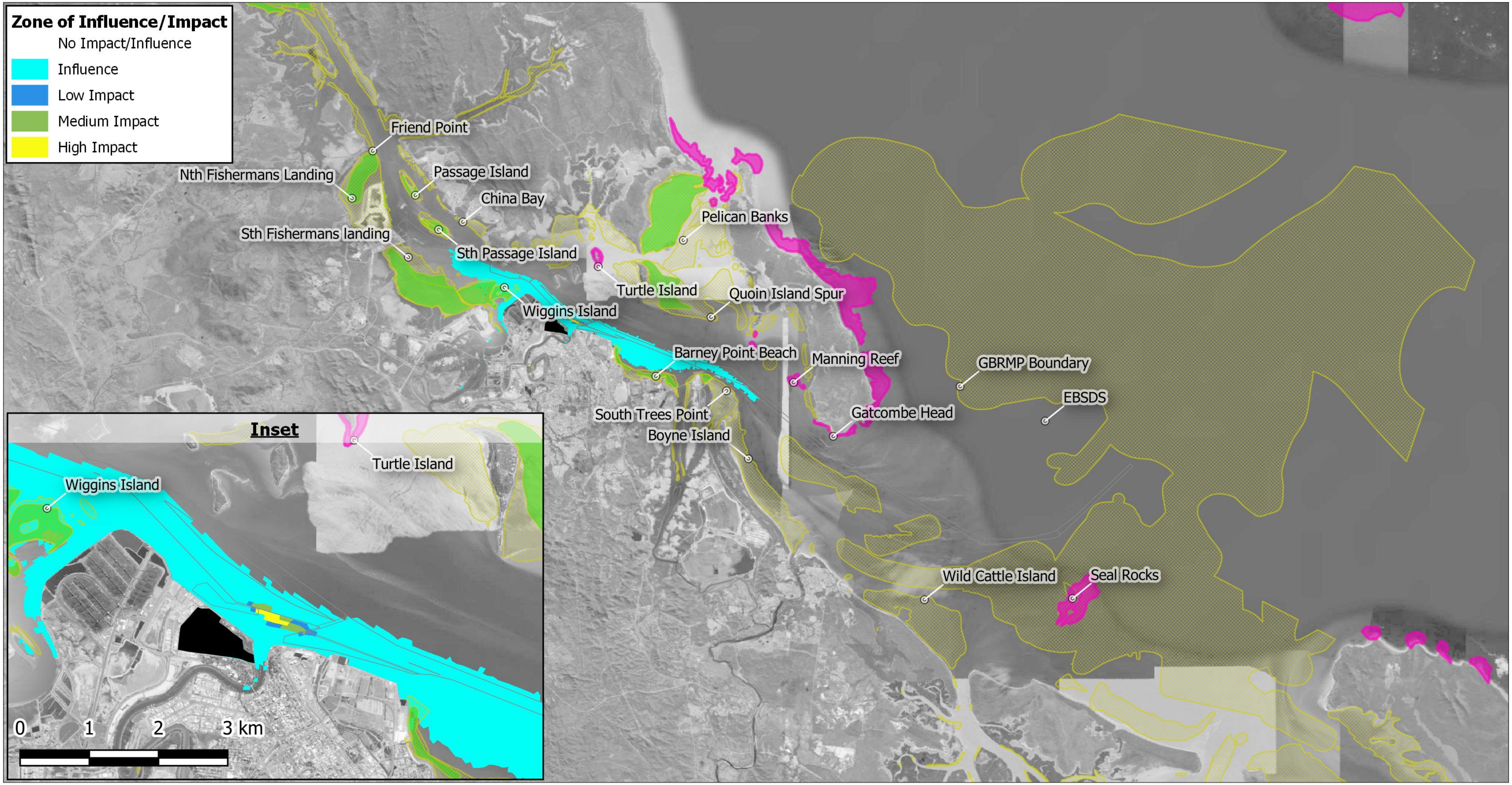

Legend

- Time Series Output Locations
- Direct Impact
- DMPA
- Seagrass (2020)
- Coral Reefs (BMTWBM 2014)
- Seagrass Composite Distribution (2002-2020)

Title:

Zones of Impact and Zone of Influence with Mapped Sensitive Receptors - 150,000m³ Marina Campaign with Placement in the Clinton Channel

Figure: **5-11**

Rev: **A**

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5.1.6 Turbidity and Deposition Rate Time Series

Time series of dredging-related changes to turbidity and deposition rate were extracted from the model at predetermined points of interest. Having simulated both dredging and ambient sediment, the time series show both these contributions to the total signal and in doing so provide important information on the relative magnitude of the dredging related signal.

Time series of depth averaged ambient and dredging-related turbidity are provided in Appendix C of this report for the output locations shown in Figure 5-11. The modelled total turbidity at each location is the sum of the dredging-related and ambient turbidity.

Time series of the deposition rate for dredged and ambient sediment at the same locations are provided in Appendix D. The dredging-related contribution to the total deposition rate is very small at all of the output locations.

5.2 Other Water Quality Parameters

The effect of maintenance dredging and disposal on other water quality parameters was considered based on a review of previous water quality monitoring programs (BMT 2017; 2021b). These results are considered representative of future campaigns given:

- sediment types in the new dredged areas (CVIP footprint) are similar to those previously assessed by BMT 2017 and 2019;
- the BMT (2021b) study examined the new dredged areas in the widened Clinton Channel;
- the increase in dredge volume due to inclusion of newly dredged areas in the widened Clinton Channel is negligible (approximately an extra 1,000 m^3 per annum); and
- the load for each dredge and disposal run is the same. Monitoring indicates that nutrient and metal/metalloid concentrations rapidly degrade in dredge and disposal plumes (measured in hours), hence there is low likelihood of cumulative impacts from multiple dredge runs.

BMT (2019a) involved monitoring at representative dredge sites throughout Port Curtis and EBSDS, and reviewed previous monitoring undertaken in 2014. BMT (2021b) monitored CVIP sites before and after dredging. These results are summarised in Table 5-3.

Most parameters had higher concentrations in 2014 than 2017 and 2019. This is consistent with PCIMP monitoring results which indicate a general improvement in water quality conditions since major flooding in 2013 (see Section 4.2.1).

Increases (above background) in nutrient species and some metals were recorded in plumes generated by dredging and disposal. Increases in nutrient and metal/metalloid concentrations in dredge plumes occur as a result of the following processes:

- Resuspension of particulate-bound nutrients and metals by the dredge head at the dredge site.
- Release of dissolved constituents contained in pore waters resulting from disturbance of the seafloor by the dredge head.
- Release of particulate-bound and dissolved constituents in dredged sediments and waters from the dredge hopper into the disposal site.

The results indicate that most nitrogen and phosphorus in dredge plumes was particulate-bound forms contained in organic matter. Particulate forms are the least bioavailable, but eventually break down over time to more readily bioavailable forms (e.g. ammonia). Organic matter degradation processes are not fundamentally altered by dredging and disposal. The degradation rates of organic matter to bioavailable nutrients in pore water depends on the form and reactivity of the organic matter. For example, phytoplankton has high reactivity and is therefore broken down at timescales less than one (1) year. Most organic matter in nearshore sediments (including dredged sediments) is terrestrial matter with low reactivity, with degradation half-life measured in years to millennia (Batley *et al.,* 2015).

In a review of monitoring studies in Queensland and worldwide, Batley *et al.* (2015) suggested that increased concentrations of soluble ammonia associated with pore water release and desorption from particles was typically of most concern, whereas release of dissolved nitrite, nitrate and phosphate were generally minor and of least concern. The results of the present study confirm that ammonia was the dominant form of bioavailable nitrogen in dredge and disposal plumes.

Ammonia (and other nutrient) concentrations exceeded the local WQO but did not approach the toxicity guideline value for ammonia. Furthermore, ammonia and other bioavailable forms are highly unlikely to result in persistent water quality impacts. While the present study represents a snap-shot and was replicated in time and space, the data shows that nutrients in plumes generated by dredging and disposal did not persist for more than one (1) hour. This is consistent with monitoring results for highly nutrient enriched dredged sediments (from Toondah Harbour) disposed at Mud Island DMPA (BMT, 2009). BMT (2009) found that ammonia concentrations in the water column were close or slightly above background concentrations within 10 minutes of dredged material placement, and had returned to background concentrations (often below laboratory detection limit of ~0.002 mg/L) within one (1) hour of disposal. These results indicate that through dilution and biological uptake of nutrients in dredged sediments in the water column, nutrient concentrations were well below levels of potential concern. Monitoring results (Table 5-3) do not suggest an increase in chlorophyll *a* concentrations in dredge plumes.

In terms of metals and metalloids, concentrations in maintenance dredge plumes at Jacobs Channel in July 2014 were below WQOs. Similarly, sampling conducted for the CVIP project (BMT 2021b)[5] found that all dissolved metals and metalloids in the dredge plumes were either below the LOR or below their respective WQOs[6]. Total concentrations of most metals/metalloids were low in the dredge plumes and within the typical range of baseline conditions. The exceptions were slightly elevated concentrations of total copper and total zinc at some sample sites, consistent with ambient monitoring by PCIMP. Total copper and zinc concentrations in dredge plumes were similar to baseline and control site measurements, indicating that a natural occurrence of these metals (see for example Angel *et al*., 2012 and Section 4.2).

[5] note that this sampling considered capital dredged material, but provides general contextual information regarding potential water quality changes in this new section of the maintenance dredge footprint
[6] note – one anomalous background sample had high dissolved copper, but was considered erroneous as it was higher than the total copper fraction

Table 5-3 Summary of dredge plume monitoring data for EBSDS and dredge sites (BMT 2014, 2019a, 2021b)

Parameter	EBSDS		Dredge Sites		
	2014	2017	2014	2017	2021 (CVIP)
Ammonia	• <0.003 mg/L (background) • 0.017-0.02 mg/L in dredge plume >WQO of 0.003 mg/L	• <0.005 to 0.018 mg/L in dredge plume • Two dredge plume samples >WQO of 0.003 mg/L • Not detected 1 hour after dredging	• Background ranged from <0.003 -0.004 mg/L • Dredge samples ranged from 0.003 - 0.062 mg/L, frequently exceeding WQO of 0.003 mg/L	• Dredge plume samples were ≤0.033 mg/L; one sample >WQO • Higher concentration in near-bed background sample indicates natural sediment nutrient flux	• Dredge plume samples <0.005 – 0.011 mg/L, with three of 39 dredge plume samples >WQO • Background samples were <0.005 mg/L
NOx	• Dredge plume and baseline samples were ≤0.003 mg/L • One plume and background sample at WQO, indicating slightly elevated background	• Not detected (<0.002 mg/L) in any samples	• Background ranged from <0.002 -0.013 mg/L • Dredge samples ranged from 0.002 - 0.038 mg/L, frequently exceeding WQO of 0.003-0.005 mg/L	• Nitrite was not detected (<0.002 mg/L) in any samples. • Nitrate was 0.003 to 0.004 mg/L in background samples, and 0.003 to 0.005 mg/L in plume samples (average = 0.003 mg/L). • Near bed concentrations were typically greater than surface in both background and plume samples, indicating some sediment nutrient flux	• Not detected (<0.002 mg/L) in any samples
Total Nitrogen	• WQO (0.1 mg/L) exceeded in background and dredge plume samples (0.1 – 0.18 mg/L)	• WQO (0.1 mg/L) met in all samples	• Background ranged from 0.013 -0.018 mg/L • Dredge samples ranged from 0.013 - 0.4 mg/L, frequently exceeding WQO of 0.13-0.17 mg/L	• WQO (0.17 mg/L) met in all samples (0.01 to 0.15 mg/L)	• WQO for TN (0.17 mg/L) was met in all but one sample (0.08 to 0.33 mg/L)
Total Phosphorus	• 0.01 – 0.015 mg/L (background) and 0.018 0.021 mg/L (dredge plumes) • WQO (0.008 mg/L) exceeded in all samples	• Concentrations <0.005 mg/L detection limit in all but one sample (surface plume = 0.006 mg/L) • WQO (0.008 mg/L) met in all samples	• Background ranged from 0.012 -0.031 mg/L • Dredge samples ranged from 0.018 - 0.140 mg/L, frequently exceeding WQO of 0.014-0.018 mg/L	• < detection limit of 0.005 mg/L in background samples • dredge plume samples ranged from <0.005 to 0.046 mg/L (average 0.018 mg/L) when overflow commenced. However, total phosphorus was below detection limits (i.e. background) in plume samples ≥1 hour after dredging. The WQO for TP (0.018 mg/L) was exceeded in three plume samples.	• Total phosphorus concentrations were <laboratory LOR and guideline value of 0.005 mg/L in all background and dredge plume samples
Filterable reactive phosphorus	• <0.002 mg/L (background) and 0.002 0.003 mg/L (dredge plumes) • WQO (0.001 mg/L) exceeded in all dredge samples	• Filterable reactive phosphorus was not detected in any samples (<0.001 mg/L), and therefore met the WQO of 0.001 mg/L.	• Background ranged from <0.002 -0.003 mg/L • Dredge samples ranged from <0.002 - 0.023 mg/L, occasionally exceeding WQO of 0.002-0.003 mg/L	• Filterable reactive phosphorus was typically either not detected (<0.001 mg/L) or 0.001 mg/L in most samples. All but one sample met the WQO of 0.003 mg/L; the near-bed plume sample at WICT during overflow (0.004 mg/L).	• Filterable reactive phosphorus concentrations were <laboratory LOR of 0.001 mg/L and guideline value (0.007 mg/L) in all background and dredge plume samples
Chlorophyll *a*	• All samples < detection limit of <1 µg/L, meeting WQO of 2 µg/L	• Not assessed	• Background ranged from <1-2 µg/L, with one sample at the WQO. Dredge sites ranged from <1-1 µg/L, which was at or below the WQO	• Not assessed	• Most samples <1 µg/L except one background sample (41 µg/L) and one dredge plume sample (41 µg/L); both samples exceeded WQO of 2 µg/L
Metals/Metalloids	• Not assessed	• Not assessed	• Metals/metalloids in the dredge plumes typically within range or slightly greater than baseline • Dissolved fractions of most parameters <laboratory LOR • Dissolved fractions < WQO, whereas total copper exceeded WQO	• Not assessed	• Metals/metalloids in the dredge plumes typically within range of baseline conditions • Most parameters <laboratory LOR and guideline values • Slight exceedances of WQO were recorded for copper, zinc and nickel in <50% of samples

Overall, these monitoring results suggest that nutrients, chlorophyll, metals/metalloids and other physio-chemical parameters (including pH, dissolved oxygen) in dredge plumes represent a low environmental risk.

5.3 Ecological Implications

Table 5-4 summarises marine communities in the dredging and disposal footprint and immediate surrounds (project area), and key impact pathways.

Table 5-4 Marine communities in the dredge and disposal footprint and immediate surrounds (project area) and potential impact pathways

Communities	Direct effects	Indirect effects
Soft-sediment benthic invertebrates	• extraction of benthos living in the channel • smothering of benthos at the disposal site	• physiological impairment by sediment • liberation of nutrients and food resources at the dredge and disposal sites
Plankton and nekton in the water column	• potential fauna injury by the dredge head • entrainment of plankton and small fish in the dredge	• physiological impairment by sediment • liberation of nutrients resulting in increased algal production
Seagrass	• not applicable (outside impact footprint)	• reduced light resulting in impaired energy production and growth
Reef communities	• not applicable (outside impact footprint)	• physiological impairment by sediment • reduced light resulting in impaired energy production and growth

5.3.1 Direct Effects

5.3.1.1 Benthic Flora and Fauna in the Dredge Footprint

The dredger will extract benthic fauna from the dredge areas, resulting in direct impacts to communities in the dredge footprint. The fate of fauna extracted by the dredger is unknown, although it is possible that some surviving fauna may colonise the EBSDS.

Benthic fauna will begin to recolonise the dredge areas shortly after dredging is completed. The dredge areas are regularly disturbed by maintenance dredging and propellor wash. Benthic communities in affected areas therefore remain in a state of flux, resulting in localised changes to community structure.

Benthos at the EBSDS could be smothered by dredged material disposal (relevant only to 200,000 m^3/EBSDS placement scenario only). Monitoring of benthic communities within and adjacent to the EBSDS by BMT (2012b) indicate benthic macroinvertebrate communities are resilient to changes associated with maintenance material placement, and the long history of dredged material placement activities has created a change in community structure within and adjacent to the EBSDS. Within the EBSDS sediments are coarser and support more attached sessile forms, while adjacent communities are dominated by deposit feeders over softer sediments.

No seagrass meadows, reef-building coral assemblages, macroalgae beds or mangroves occur in the dredge footprint.

5.3.1.2 Marine Megafauna Vessel Strike

Marine animals that swim near the water surface, such as whales, dolphins, dugongs and turtles, could interact with the dredger. A dredger is slow-moving, which would provide marine fauna time to evade the approaching vessel. Turtles are also highly mobile and will tend to avoid the dredger. When active, sea turtles must swim to the ocean surface to breathe every few minutes, however, they can remain underwater for as long as two hours without breathing when they are resting. There are recorded incidences of turtles being killed or injured by trailer suction hopper dredgers. Cutter-suction and back-hoe dredgers pose a low risk to turtles as they do not have trailing suction dragheads (Dickerson *et al*., 2004).

GHD (2005), citing personal communication from Dr Limpus, suggest that the numbers of turtles captured during dredging across all Queensland Ports is decreasing, with an average of 1.7 loggerhead turtles per year being captured across all ports. The TSHD *Brisbane* undertaking maintenance dredging in Gladstone has reported capturing five turtles in the 10 year period between 2005 and 2015 (Mocke *et al.,* 2016). Given the relatively low numbers of turtles captured by dredgers compared to other activities, and the use of effective management and operational practices to reduce the potential for turtle capture, it is not considered that the proposed dredging will have a significant impact on turtle populations in the study area. Direct effects of loading (dredger interaction) will be mitigated using existing practices aboard the *Brisbane* as a part of their environmental management plan and in accordance with GPC's permit conditions and adaptive monitoring and management framework.

5.3.1.3 Underwater Noise

Underwater noise assessments carried out in association with the Western Basin dredging suggest suggested that cetaceans and dugongs may start to show a behavioural response within two (2) km from the dredger or associated booster pumps, while turtles would be affected within 50 m (BPM, 2013). This assumes no attenuation or amplification in sound due to the physical environment. Dolphins, dugong or turtles remaining within one metre of a dredge or booster pump for more than 10 minutes would suffer immediate physical impact (BPM, 2013). However, even at relatively close distances it would take time for injuries to occur. At 100 m away, impacts would not occur for any animal until at least one (1) hour of exposure to dredge noise or three hours of exposure to booster pump noise. Given the close distances and durations required, it was considered that marine megafauna in the Gladstone region were unlikely to suffer physical impacts from dredging noise. The dredger will represent an intermittent noise source that has the potential to temporarily interfere with marine megafauna communications during the dredge campaign.

5.3.2 Indirect Effects Due to Sediments and Water Quality Changes

5.3.2.1 Nutrients and Algae

The 2017 maintenance dredging environment assessment (BMT, 2017) describes the effects of maintenance dredging and disposal on nutrient concentrations and algae biomass (chlorophyll a) in the water column. The study found that dredging resulted in short-term (less than one hour) low intensity increases in total phosphorus and filterable reactive phosphorous, and possibly nitrate. Ammonia concentrations in plume samples were less than background. Algae biomass (chlorophyll *a*) was low in both the dredge plume and background, which suggest that dredging and disposal did not result in algae blooms (see Section 5.2). The dredge and disposal scenarios considered in the present study are expected to result in similar effects.

5.3.2.2 Sediment Impacts to Soft Sediment Benthos

Soft sediment benthos occurs within the dredge/disposal areas and immediate surrounds, and may be indirectly affected by dredging as a result of:

- Increasing food resources availability in the form of suspended sediments and benthic fauna;
- Increasing sediment deposition levels, resulting in burial of sessile fauna; and
- Increasing suspended sediment concentrations causing the interference or blocking of respiratory and feeding structures.

There is a lack of information on critical levels of sedimentation or suspended sediment concentrations that would result in smothering, clogging of the filtering apparatus or other deleterious effects to benthic macroinvertebrates. The benthic macroinvertebrate communities of Port Curtis regularly experience TSS concentrations greater than 70 mg/L, and it is therefore unlikely that species that are highly sensitive to sediment loading would occur in this area.

Previous monitoring provides a basis for assessing impacts to benthic communities at the EBSDS (200,000 m^3/EBSDS scenario only). The 2011 macrobenthic monitoring campaign demonstrated that the placement of 126,000 m^3 of maintenance material had benign effects on benthic communities in and adjacent the disposal site (BMT, 2012a). Future campaigns are likely to result in similar effects on the EBSDS and surrounding soft sediment to what has been observed previously (assuming "clean" material continues to be placed, and that these effects are largely related to physical burial).

5.3.2.3 Sediment Impacts to Seagrass and Reefs

The Zones of Impact thresholds were derived in part on information on seagrass tolerances (Section 2.2.5). As discussed in Section 5.1.4, no seagrass meadows or reefs occur in the Zone of Impact. The Zone of Influence (ZOI) for two of the dredge/disposal scenarios (200,000 m^3/EBSDS and 150,000 m^3/Clinton In-Channel Placement scenarios only) extend to seagrass meadows (Figure 5-9; Figure 5-11)[7]. By definition, impacts to seagrass and other sensitive receptors are not expected to occur in the ZOI, although a visible plume may be present. While impacts to these (and other) seagrass meadows are not expected, an adaptative monitoring framework will be followed to manage unanticipated dredge plume risks.

The Zone of Impact and Zone of Influence for turbidity does not extend to fringing/coral reefs. Impacts to these communities due to dredging-related turbidity are therefore not expected.

[7] the ZOI does not extend to seagrass for the 40,000 m^3/Clinton In-Channel Placement scenario)

Analysis of the time series of deposition rate presented in Appendix D indicates that the dredging-related contribution to the total deposition rate at reef sites is very low, and therefore there are not expected to be any impacts to these communities due to dredging-related increases to sediment deposition.

5.3.2.4 Sediment Impacts to Fish and Shellfish

Fish and invertebrates that inhabit Port Curtis regularly experience periods of tidally driven turbidity. Fish have a lateral line system that it used to detect prey, which allow many fish species to feed in highly turbid waters. However, physiological effects to fish can occur at very high suspended sediment concentrations. For example, Jenkins and McKinnon (2006) suggested that TSS concentrations 4000 mg/L could block gills, eventuating in fish mortality. There are very few documented cases of fish kills resulting solely from turbid plumes, and predicted TSS levels are not predicted to approach these levels.

Prawns and portunid (mud and sand) crabs represent key species of commercial significance, and utilise both nearshore and offshore waters (including parts of the study area) as part of their life-cycle. These species primarily inhabit turbid water environments, and are tolerant of a wide range of turbidity conditions. These species are also highly mobile and actively burrow into soft sediments, and are therefore tolerant of high rates of sediment burial. Therefore, indirect impacts to prawns and crabs as a result of high suspended sediment concentrations and sedimentation from maintenance dredging are not expected.

5.3.2.5 Sediment Impacts to Marine Megafauna

The highest recorded stranding rates for turtles and dugongs were documented 2011 and 2012 across the entire Queensland coast, as a result of habitat loss (seagrass) associated with flooding, high turbidity and low visibility. These conditions make fauna more susceptible to starvation and boat strike.

Maintenance dredging plumes are not expected to significantly impact on seagrass meadows or corals (Section 5.3.2.3), nor are major changes to benthic macroinvertebrate communities expected. It is therefore highly unlikely that dredging would result in a loss of food resource availability to the extent where flow-on effects to turtles and dugong would occur.

The sediment plumes created by dredging will temporarily reduce visibility. The dolphin species found in the study area are capable of successfully foraging in turbid waters. Dolphins often stir up bed sediments when foraging for benthic prey, resulting in limited to no visibility for prey detection. It is thought that dolphins detect prey using echolocation rather than visual cues (Mustoe 2006, 2008). Dugongs have poorly developed eyesight and rely on bristles on their upper lip, rather than visual cues, to detect seagrass food resources. Therefore, high suspended solid concentrations generated by dredging and dredged material placement are not expected to adversely affect foraging success for cetaceans or dugongs. Sea turtles generally have good eyesight and rely on visual and olfactory cues to detect prey and other food resources (e.g. Swimmer *et al*., 2005). Flatback turtles are known to feed in turbid shallow waters (Robins, 1995) and may not be directly affected by turbid plumes generated by dredging. Other species such as green turtle (which is common in Port Curtis) and hawksbill turtle (which is occasionally found in the port), which feed on seagrass and/or in reef environments, may avoid areas affected by turbid plumes. It is noted however that the key feeding areas for these species are not predicted to be exposed to highly turbid dredge plumes.

5.3.3 Introduced Marine Pests

5.3.3.1 Existing Status

More than 250 non-indigenous marine species have been recorded in Australian waters to date (NIMPCG, 2013). There are several potential vectors by which non-indigenous species may enter domestic waters; however, it is thought that most species are unintentionally introduced through shipping and vessel movements, either in ballast waters or from biofouling on the hull of vessels (Hewitt and Campbell, 2010). Other vectors include intentional transfer of aquaculture and mariculture organisms, transfer of food products for the aquarium trade and use of biological material for packing (Hewitt and Campbell, 2010). Asian green mussels (*Perna viridis*), considered to be a potential threat in tropical waters, were found on a vessel's hull in Cairns harbour 2001 and Caribbean tubeworm (*Hydroides sanctaecrucis*) has also been introduced there (Souter, 2009).

A baseline marine pest survey was carried in Port Curtis in 2000 (Lewis *et al.,* 2001). This aim of this baseline survey was to describe existing non-indigenous species, including target pest species listed by the Australian Ballast Water Management Committee, Hewitt and Martin (1996) and Furlani (1996). Although no pest species were detected, 10 introduced species were found, including the ascidians *Styela plicata* and *Botrylloides leachi*; the bryozoans, *Amathia distans*, *Bugula neritina*, *Cryptosula pallasiana*, *Watersipora subtorquata*, and *Zoobotryon verticillatum*; the hydrozoan *Obelia dichotoma*; the isopod, *Paracerceis sculpta*, and the dinoflagellate *Alexandrium sp*. Each of these species are found in ports across Australia and internationally, and were not thought to represent a threat to native species in Port Curtis, apart from some spatial competition from some of the bryozoans species (Lewis *et al.,* 2001).

Vision Environment (2015) undertook a marine pest survey in Port Curtis in 2015. The survey discovered four species registered on National Introduced Marine Pest Information System (NIMPIS), including the Caribbean tubeworm (*Hydroides sanctaecrucis*), sea lettuce (*Ulva fasciata*), sponge isopod (*Paracerceis sculpta*), and the encrusting bryozoan (*Cryptosula pallasiana*) (Vision Environment, 2015). These species appear to be relatively widespread throughout the port and are not considered high-risk species, although the Caribbean tubeworm is considered medium impact pest by CSIRO. Based on their ubiquity in other Australian ports, throughout Port Curtis, and their present pest status, their presence did not warrant a pest emergency response (Vision Environment, 2015).

DAF (2021) undertook as pilot marine pest survey at Port Curtis using e-DNA methodology. No invasive marine pests were detected. The methodology successfully resolved the detection of taxa from marine pest 'families', but in most cases invasive marine pest targets were ruled out. The exception was the detection of *Sargassum* seaweed, however the analysis could not resolve whether this was detection was the invasive *Sargassum muticum*. The introduced feather-duster worm *Branchiomma bairdi* was also detected. This worm is not a declared invasive marine pest in Australia, however DAF (2021) recommended that future surveillance could target this species.

It should be noted that field studies of introduced marine species should not be considered exhaustive, given the difficulties associated with surveying large ports and the fundamental lack of taxonomic information for many marine species (Sliwa *et al.* 2009). Given that many marine taxa are difficult to identify to species, these could represent native species or non-native introductions. Lewis *et al.* (2001) specifically targeted known or potential pest species so it is likely that marine pest prevalence estimates are more reliable than those of total introduced species estimates.

5.3.3.2 Potential Impacts

There are two (2) key vectors for introduced marine pests entering a port: biofouling of the vessel hull, or the release of pests into the marine environment via ballast waters (Hewitt and Campbell, 2010). Vessels (including dredgers, cargo vessels, high speed craft etc.) can subsequently translocate pests within and outside the port area. In areas containing marine pests, there is a risk that pests could be transferred by the dredger from the dredge site to the EBSDS. As discussed above, despite the presence of introduced species in Port Curtis, none of these are considered marine pest species. Based on this, it is considered that the risk of translocating pest species within the port (i.e. from the loading site to the EBSDS) is considered to be low.

Any dredger contracted to undertake dredging works will be required to comply with best practices, including AQIS and Biosecurity Queensland requirements in relation to ballast water and marine pest management, including the National System for the Prevention and Management of Marine Pest Incursions, in particular the National Biofouling Management Guidance for Non-Trading Vessels.

The TSHD *Brisbane* represents a low risk of species translocation because it works primarily within Queensland ports and the Port of Melbourne.

5.4 Impacts on Other Users

Maintenance dredging operations and associated plumes and sedimentation have the potential to impact other users of the area, including commercial and recreational fishers, recreational boating enthusiasts, and vessel traffic to the LNG projects on Curtis Island.

Potential impacting processes include:

- interference with other vessels. Maintenance dredging operations are unlikely to significantly interfere with small craft movements. Dredger movements comprise a small proportion of total ship movements in the port. MSQ also advises small craft to keep clear of ship navigation areas, including shipping channels, berths, swing basins etc. subject to maintenance dredging. Dredging operations are co-ordinated around the movements and berthing schedules of larger ships.
- direct effects to fishing operations. Commercial fishing activities in Port Curtis includes setting of crab pots, nets and trawling. Netting and trawling are not permitted in navigational areas subject to maintenance dredging, therefore direct effects to commercial fishing operators are not expected.
- indirect effects due to dredge plume. Modelling predicts that sediment plumes and sedimentation rates created by dredging will be within the range of natural tidally generated turbidity during spring tides. As described in Section 5.1.4, plumes are not expected to significantly impact on

high value fisheries habitats such as seagrass, high-density epibenthos or mangroves, and on this basis significant impacts to fisheries resource values are not expected.

5.5 Impact Significance to MNES

The impact of dredging and disposal plumes to MNES was assessed using criteria set out in the Matters of National Environmental Significance Significant impact guidelines 1.1 (Commonwealth of Australia, 2013). The vulnerability of MNES to water quality changes resulting from dredge plumes was considered in the assessment of the impact significance criteria. Vulnerability is a product of three factors (De Lange *et al.,* 2010; Figure 5-12):

- Exposure – the intensity, duration of dredge plumes at the receptor site, as determined from dredge modelling results
- Sensitivity – the sensitivity of the receptor to water quality changes, including direct sensitivity (e.g. interference to feeding or physiological impact) or indirect sensitivity (sensitivity of food and habitat resources, and the capacity of species to switch to other resources
- Adaptative capacity – the capacity of receptor to adapt or recover from stress.

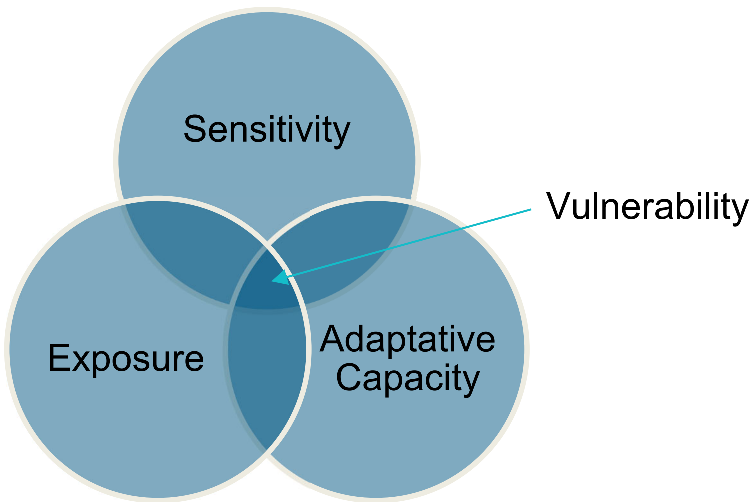

Figure 5-12 Elements defining vulnerability

The impact significance assessment for each MNES is structured around these three elements of vulnerability, as described below.

5.5.1 Threatened Ecological Communities

No TECs occur in marine waters of the study area (i.e. no exposure). No impacts to these communities will occur as a result of the project.

5.5.2 Critically Endangered and Endangered Species

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population

- reduce the area of occupancy of the species
- fragment an existing population into two (2) or more populations
- adversely affect habitat critical to the survival of a species
- disrupt the breeding cycle of a population
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
- introduce disease that may cause the species to decline
- interfere with the recovery of the species.

Critically Endangered or Endangered Species that are likely to occur in the study area, and the potential impact of the project on this species is provided in Table 5-5. Based on the above criteria, no significant impacts are expected to occur to these species or their habitat.

Table 5-5 Potential Impacts to Critically Endangered or Endangered Species known to, or likely to occur, within the study area

Species	Exposure (Likelihood of occurrence in project area)	Sensitivity and Adaptive Capacity	Assessment
White's Seahorse *Hippocampus whitei*	Very low – potential habitat present, but not known from central Qld	Direct – would require resilience to periodic high turbidity given background conditions. Indirect – uses food resources with varying sensitivity to turbidity (mostly micro-crustaceans). Uses biogenic and abiogenic habitat – the most sensitive being macroalgae (as occurs around shallow reefs)	No significant impact – current species distribution does not overlap with disturbed areas, unlikely to be highly sensitive to the predicted short-term water quality changes
Blue Whale *Balaenoptera musculus*	Very low – Possible (but highly unlikely) transient visitor to Port Curtis during summer, highly unlikely to regularly use dredge/disposal sites	If present, would require resilience to periodic high turbidity given background conditions	No significant impact – preferred habitat does not overlap with disturbed areas, and unlikely to be highly sensitive to short-term water quality changes
Loggerhead Turtle *Caretta caretta*	High - Known to use channels in Port Curtis. Remote from nesting habitat (sandy beaches) and designated critical habitat (nesting) and BIA (inter-nesting habitat outside Port Curtis)	Direct – resilient to periodic high turbidity given background conditions Indirect – Flexible diet, uses food resources with varying sensitivity to turbidity.	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Leatherback Turtle	Low – Possible transient visitor to Port Curtis, highly unlikely to regularly use dredge/disposal	Direct – resilient to periodic high turbidity	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project

Species	Exposure (Likelihood of occurrence in project area)	Sensitivity and Adaptive Capacity	Assessment
Dermochelys coriacea	sites. Remote from nesting habitat and designated BIA (inter-nesting habitat outside Port Curtis)	given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity.	area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Olive Ridley Turtle *Lepidochelys olivacea*	Low – Possible transient visitor to Port Curtis, highly unlikely to regularly use dredge/disposal sites. Remote from nesting habitat	Direct – if present, would require resilience to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity.	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources

5.5.3 Vulnerable Species

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of an important population of a species
- reduce the area of occupancy of an important population
- fragment an existing important population into two (2) or more populations
- adversely affect habitat critical to the survival of a species
- disrupt the breeding cycle of an important population
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
- introduce disease that may cause the species to decline, or
- interfere substantially with the recovery of the species.

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

Vulnerable species that are likely to occur in the study area, and the potential impact of the project on this species is provided in Table 5-6. In the context of important populations, Port Curtis provides:

- All Queensland coastal waters represent a BIA for Humpback Whale. Port Curtis and dredge/disposal sites are not known to be regularly frequented by this species, and it is unlikely to be directly or indirectly affected by transient, localized dredge plumes.
- Critical Habitat (nesting) and BIA (inter-nesting) occur at and adjacent to sandy beaches of Port Curtis for loggerhead turtle and flatback turtle. These areas are remote from dredge plumes. Port Curtis and dredge/disposal sites may be frequented by both species, but they are unlikely to be directly or indirectly affected by transient, localized dredge plumes.

Based on the criteria, no significant impacts are expected to occur to Vulnerable species or their habitat.

Table 5-6 Potential Impacts to Vulnerable species known to, or likely to occur, within the study area

Species	Exposure (Likelihood of occurrence in project area)	Sensitivity and Adaptive Capacity	Assessment
Humpback Whale *Megaptera novaeangliae*	Low – Possible transient visitor to Port Curtis during winter, highly unlikely to regularly use dredge/disposal sites BIA present (all Qld coastal waters)	Direct – would require resilience to periodic high turbidity given background conditions. Indirect – does not feed in tropical waters and uses pelagic habitat.	No significant impact – preferred habitat does not overlap with disturbed areas, not sensitive to be short-term water quality changes
Green Turtle *Chelonia mydas*	High - Known to occur around channels in Port Curtis, but more abundant around seagrass feeding habitat. Remote from nesting habitat	Direct – resilient to periodic high turbidity given background conditions Indirect – Seagrass specialist, and therefore potentially sensitive to indirect turbidity impacts	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Hawksbill Turtle *Eretmochelys imbricata*	Moderate – While not a core habitat, there are multiple records of this species in Port Curtis. Remote from nesting habitat	Direct – resilient to periodic high turbidity given background conditions Indirect – Flexible diet - uses food resources with varying sensitivity to turbidity	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Flatback Turtle *Natator depressus*	High – Potential foraging habitat (especially reefs) occur near channels. Remote from nesting habitat and designated Critical Habitat (nesting and inter-nesting buffer)	Direct – resilient to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Great White Shark *Carcharodon carcharias*	Low – Possible transient visitor to Port Curtis (year-round), highly unlikely to regularly use dredge/disposal sites	Direct – if present, would require some tolerance to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity (fish, marine mammals)	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Green Sawfish *Pristis zijsron*	Very low – potential habitat present, but not known from central Qld	Direct – highly tolerant of high turbidity. Indirect – uses food resources with varying sensitivity to turbidity (shellfish, fish).	No significant impact – current species distribution does not overlap with disturbed areas, unlikely to be highly sensitive to the predicted short-term water quality changes
Whale Shark *Rhincodon typus*	Very low – Possible (but highly unlikely) transient visitor to Port Curtis (year-round), highly	Direct – if present, would require some tolerance to periodic	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project area. Short-term water quality

Species	Exposure (Likelihood of occurrence in project area)	Sensitivity and Adaptive Capacity	Assessment
	unlikely to regularly use dredge/disposal sites	high turbidity given background conditions Indirect - Uses food resources with varying sensitivity to turbidity (zooplankton, small fish)	changes are not expected to have direct effects or lead to significant impacts to habitats or food resources

5.5.4 Listed Migratory Species

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

An area of 'important habitat' for a migratory species is:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- habitat that is of critical importance to the species at particular life-cycle stages, and/or
- habitat utilised by a migratory species which is at the limit of the species range, and/or
- habitat within an area where the species is declining.

Table 5-7 lists migratory species that occur, or are likely to occur, in the study area. Note that this list excludes critically endangered, endangered or threatened species already considered in previous sections.

In the context of important populations, Port Curtis provides:

- All Queensland coastal waters represent a BIA for Humpback Whale. Port Curtis and dredge/disposal sites are not known to be regularly frequented by this species, and it is unlikely to be directly or indirectly affected by transient, localized dredge plumes.
- Critical Habitat (nesting) and BIA (inter-nesting) occur at and adjacent to sandy beaches of Port Curtis for loggerhead turtle and flatback turtle. These areas are remote from dredge plumes. Port Curtis and dredge/disposal sites may be frequented by both species, but they are unlikely to be directly or indirectly affected by transient, localized dredge plumes.
- Coastal waters south of Shoalwater Bay to Rodds Bay (particularly Port Alma and the PoG), within the 20m depth contour represent a BIA for Australian Humpback Dolphin. Port Curtis and dredge/disposal sites are regularly frequented by this species. This species can feed in highly turbid waters, and because it has a relatively broad diet, it is able to switch to alternate pretty.

The transient, localized dredge plumes are unlikely to lead to significant direct and indirect impacts to this species or its habitats.

Based on the impact significance criteria, no significant impacts are expected to occur to listed migratory species or their habitat.

Table 5-7 Potential Impacts to migratory species known to, or likely to occur, within the study area (excluding threatened migratory species described elsewhere)

Species	Exposure (Likelihood of occurrence in project area)	Sensitivity and Adaptive Capacity	Assessment
Australian Snubfin Dolphin *Orcaella heinsohni*	High – Feeding and breeding in Port Curtis year-round, highly likely to occur at dredge/disposal sites	Direct – resilient to periodic high turbidity given background conditions Indirect – Flexible diet, uses food resources with varying sensitivity to turbidity (multiple shellfish and fish species)	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Australian Humpback Dolphin *Sousa sahulensis (=chinensis)*	High – Feeding and breeding in Port Curtis year-round, highly likely to occur at dredge/disposal sites BIA (calving, feeding) present for the species geographic range (inc. Port Curtis)	Direct – resilient to periodic high turbidity given background conditions Indirect – Flexible diet, uses food resources with varying sensitivity to turbidity (multiple shellfish and fish species)	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Dugong *Dugong dugon*	High - Known to traverse throughout Port Curtis, but more abundant around seagrass feeding habitat	Direct – resilient to periodic high turbidity given background conditions Indirect – Seagrass specialist, and therefore potentially sensitive to indirect turbidity impacts	No significant impact – occurs in project area, but the short-term water quality changes are not expected to have direct effects or lead to significant impacts to seagrass habitats or food resources
Bryde's Whale *Balaenoptera edeni*	Very low – Mostly oceanic but possible transient visitor to Port Curtis (year-round), highly unlikely to regularly use dredge/disposal sites	Direct – if present, would require some tolerance to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity (plankton, small fish)	No significant impact – preferred habitat does not overlap with project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Killer Whale *Orcinus orca*	Very low – Mostly oceanic but possible transient visitor to Port Curtis (year-round), highly unlikely to regularly use dredge/disposal sites	Direct – if present, would require some tolerance to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources	No significant impact – preferred habitat does not overlap with project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources

Species	Exposure (Likelihood of occurrence in project area)	Sensitivity and Adaptive Capacity	Assessment
		with varying sensitivity to turbidity (fish, marine mammals)	
Salt-water Crocodile *Crocodylus porosus*	Moderate – potential habitat present, but not known from central Qld	Direct – highly tolerant of high turbidity. Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity (mostly fish and some shellfish, birds, terrestrial animals)	No significant impact – current species distribution does not overlap with disturbed areas, unlikely to be highly sensitive to the predicted short-term water quality changes
Oceanic Whitetip Shark *Carcharhinus longimanus*	Very low – Mostly oceanic but possible transient visitor to Port Curtis (year-round), highly unlikely to regularly use dredge/disposal sites	Direct – if present, would require some tolerance to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity (mostly fish and some shellfish, birds)	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Porbeagle Shark *Lamna nasus*	Very low – Mostly oceanic but possible transient visitor to Port Curtis (year-round), highly unlikely to regularly use dredge/disposal sites	Direct – if present, would require some tolerance to periodic high turbidity given background conditions Indirect - Flexible diet, uses food resources with varying sensitivity to turbidity (mostly fish and some shellfish)	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources
Reef Manta Ray *Mobula alfredi* Giant Manta Ray *Mobula birostris*	Very low – Mostly oceanic but possible transient visitor to Port Curtis (year-round), highly unlikely to regularly use dredge/disposal sites	Direct – if present, would require some tolerance to periodic high turbidity given background conditions Indirect - Uses food resources with varying sensitivity to turbidity (zooplankton, small fish)	No significant impact – preferred habitat does not overlap with disturbed areas occurs in project area. Short-term water quality changes are not expected to have direct effects or lead to significant impacts to habitats or food resources

5.5.5 Commonwealth Marine Area

Commonwealth Marine Area occurs >5 km east of Facing Island, remote from the influence of dredge and disposal plumes (i.e. no exposure). No impacts to Commonwealth Marine Area will therefore occur as a result of the project.

5.5.6 Great Barrier Reef World Heritage Area and Natural Heritage Place

An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:

- one or more of the World Heritage values to be lost
- one or more of the World Heritage values to be degraded or damaged, or
- one or more of the World Heritage values to be notably altered, modified, obscured or diminished.

Examples of significant impact thresholds in the impact significance guidelines that are relevant to the project are as follows.

Geological

(1) damage, modify, alter or obscure important geological formations in a World Heritage property

(2) damage, modify, alter or obscure landforms or landscape features, for example, by excavation or infilling of the land surface in a World Heritage property

(3) modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes, in a World Heritage property

(4) substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a World Heritage property.

Dredging and disposal will not result in significant impacts to geological formations or geological processes (criteria 1-3 above). Dredge and disposal plumes will result in increased pollutant concentrations (criteria 4). However the increased pollutant concentrations are not considered 'substantial' given plumes will be highly localised, short-term (measured at timescales of 10s of minutes to hours), not cumulative, and levels are within the upper range of natural variability (e.g. during storms).

Biological

(5) reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property

(6) fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property

(7) cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property, and

(8) fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.

Dredging activities will be carried out in the GBRWHA, which will result in temporary impacts to water quality near the dredge loading site during dredging, and effects to benthic communities within the dredge loading site (which based on Section 5.1, suggest impacts are of a temporary nature). Significant impacts to biodiversity values are not expected as:

- Dredging will be carried out within existing channels, which represents a previously disturbed environment rather than a green-field site.

- Dredging areas are not known or likely to support habitats of critical importance to threatened or otherwise conservation dependent species or communities.
- Habitat within the disturbance footprint is not known or likely to provide unique or critical functions to the maintenance of aquatic ecosystems within Port Curtis.
- Indirect impacts to habitats and communities of high biodiversity value (seagrass, and surrounding reefs) are not expected.
- Direct or flow-on impacts to threatened or migratory species are not expected.

On the basis of the above, in the context of EPBC Act Significant Impact Guidelines 1.1 (DEWHA, 2013; see Table 5-8), it is expected that the proposed dredging will:

- Not result in loss of one or more World Heritage values;
- Not result in one or more World Heritage values to be degraded or damaged; and
- Not result in one or more World Heritage values to be notably altered, modified, obscured or diminished.

Table 5-8 Criteria listed by the EPBC Act 1999 for a 'significant impact' and the 'likelihood' of impact to World Heritage Values, Commonwealth Marine Waters or Great Barrier Reef

Significance criteria	Assessment
Reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property.	Maintenance dredging will lead to short-term modifications to benthic fauna assemblage structure as a result of dredging in the channel and disposal at the EBSDS. These impacts are expected to be highly localised (i.e. within the lawful dredging and disposal footprint), and are not expected to result in broader scale impacts to the biodiversity values of Port Curtis.
Fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property.	Maintenance dredging will remove sediments from less than one square kilometre of existing channel extent. Such habitats are well represented elsewhere within other parts of the non-dredged channel. None of the area to be disturbed is habitat that is known to be unique to Port Curtis. Maintenance dredging will not isolate marine habitats. Maintenance dredging and disposal at the EBSDS will not form a barrier to fauna movements within, or in and out of, Port Curtis.
Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property. Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in the World Heritage property.	In the absence of mitigation, modelling suggests that maintenance dredging could lead to short-term water quality impacts at some meadows at Passage Islands. Any detectable secondary effects to seagrass meadows are expected to be minor in magnitude (possible stress but unlikely to cause major loss of biomass), highly localised and of a temporary nature. Long term declines in the population status of any species are not expected to occur as a result of maintenance dredging. Endemic coral species are known from northern Port Curtis, but these are thought to be remote from the potential impacts of dredging.

5.5.6.1 Impacts to OUV

The outstanding universal value (OUV) of the Great Barrier Reef is composed of cultural and natural heritage elements. The four natural heritage criteria that the GBRWHA satisfy are its geological phenomena, ecological and biological processes, its aesthetics and natural beauty, and its biological diversity including the threatened species it supports. The integrity of the GBRWHA and the value of these attributes are supported by the sheer size of the property and its potential for effective conservation management.

As described above, proposed maintenance dredging is not expected to impact flora, fauna, or have flow-on effects to threatened species (Section 5.5.2 - 5.5.4). The proposed dredging is also not expected to affect the property's geological phenomena, or significantly impact the ecological or biological processes. The dredging works will not permanently alter the natural beauty of the property beyond the dredge campaign; they will not result in greater vessel occupancy or additional permanent infrastructure. Therefore, impacts to the OUV are not expected from the maintenance dredging activity.

5.6 Matters of State Environmental Significance

Section 4.5 provides an overview on MSES relevant to the proposed maintenance dredging, and potential impacts were considered based on the study findings in Section 5.

5.6.1 Wetlands and Watercourses

Dredging activities will be carried out with the potential for turbid plume impacts to result in temporary reductions in water quality affecting seagrass meadows near the dredge loading site. Seagrass meadows are listed as wetlands of high ecological significance and offsets may be required if dredging is deemed to have significant residual impact. Significant residual impacts to seagrass meadows are not expected because:

- Major direct or indirect impacts to seagrass meadows are not expected.
- Seagrass meadows with potential to be affected by dredge plumes could be protected by mitigation measures that may include the relocation of the dredger or the establishment of an adaptive monitoring program.
- The potential for dredging to introduce invasive species into the wetland (seagrass meadows) is very low considering:
  - There are no high-risk marine pests in Port Curtis.
  - Current pest species are largely found on pylons.

5.6.2 Protected Wildlife Habitat

Section 5.5.2, 5.5.3 and 5.5.4 considers potential impacts to marine fauna. The proposed dredging activities are not expected to lead to significant direct or indirect effects to protected wildlife. In accordance with the significant residual impact criteria, the proposed dredging is predicted:

- Not to lead to a long-term decrease in the size of a local population.

- Not to reduce the extent of occurrence of the species or fragment and existing population.
- Not to result in genetically distinct populations resulting from habitat isolation.
- Not to result in invasive species establishing that are detrimental to endangered or vulnerable species.
- Not to introduce diseases that may cause the population to decline.
- Not to interfere with the recovery of a species.
- Not to disrupt ecologically significant locations used for breeding, feeding, nesting, migration or resting.

5.6.3 Fish Habitat Areas and Highly Protected Zone of State Marine Parks

The dredging activities will take place adjacent to the Great Barrier Reef Coastal Marine Park which covers similar areas to the GBR marine park. Based on significant residual impact criteria for protected areas, the proposed dredging will **not:**

- Result in exclusion or reduction in the public use or enjoyment of the part or all of the nearby protected areas.
- Reduce the natural or cultural values of all or part of the Coastal Marine Park.

State significant residual impact criteria for highly protected zones of State Marine Parks refer specifically to works to be conducted within these zones. As the proposed dredging falls outside of these area boundaries, these criteria are not relevant.

5.7 Assessment of Performance Outcomes - State Code 8 Coastal Development and Tidal Works

Categories known or potentially relevant to dredging and disposal are set out in Table 5-9. Compliance with these performance outcomes ensures coastal processes, resources, protection and management is maintained. For dredging and disposal operations key performance outcomes include maintaining water quality of the dredged area and receiving environment of placement activities, ensuring coastal processes such as the natural sediment balance are adequately maintained, ensuring dredged material is not harmful upon disturbance and handling and ensuring impacts to Matters of State Environmental Significance (MSES) are assessed via the avoid, minimise, mitigate and offset hierarchy.

Table 5-9 State Code 8 Coastal Development and Tidal Works Performance Outcomes Relevant to the Project

Category	Performance outcome	Response	Notes
Water Quality	PO11 Development: 1. maintains or enhances environmental values of receiving waters 2. achieves the water quality objectives of Queensland waters 3. avoids the release of prescribed water contaminants to tidal waters.	As per 5.2, assessment of the effect of maintenance dredging and disposal on water quality parameters indicates that there are minor exceedances of nutrients during dredging which typically persist over short time frames (less than one hour). The assessment also indicted that metals and metalloids in the dredge plumes are either below the LOR or below their respective WQOs. Overall, monitoring results suggest that nutrients, chlorophyll, metals/metalloids and other water quality parameters in dredge plumes represent a low environmental risk. See Section 5.2 for further detail. Dredging and disposal will also be supported by a Dredge Management Plan (to be supplied by GPC).	See Environmental Protection (Water and Wetland Biodiversity) Policy 2019 for the relevant water quality objectives.
Matters of state environmental significance	PO16 Development: 1. avoids impacts on matters of state environmental significance; or 2. minimises and mitigates impacts on matters of state environmental significance after demonstrating avoidance is not reasonably possible; and 3. provides an offset if, after demonstrating all reasonable avoidance, minimisation and mitigation measures are undertaken, the development results in an acceptable significant residual impact on a matter of state environmental significance.	No significant residual impact assessment for MSES. Refer to Section 5.6 for further detail.	Statutory note: (3) only applies to development on Brisbane core port land within the area identified as E1 Conservation/Buffer, E2 Open Space or Buffer/Investigation in the Brisbane Port LUP precinct plan. Note: Guidance for determining if the development will have a significant residual impact on the matter of state environmental significance is provided in the Significant Residual Impact Guideline, Department of State Development, Infrastructure and Planning, 2014. Where the significant residual impact is considered an acceptable impact on the matter of state environmental significance and an offset is considered appropriate,

Category	Performance outcome	Response	Notes
			the offset should be delivered in accordance with the Environmental Offsets Act 2004.
Disposal of dredged material other than from artificial waterways	PO19 Dredged material is returned to tidal water where this is needed to maintain coastal processes and sediment volume.	Placement of dredged material at the EBSDS ensures that the sediment is retained in the dynamic nearshore sedimentary system and helps to maintain natural coastal processes.	None
	PO20 Where it is not needed to maintain coastal processes and sediment volume, the quantity of dredged material disposed to tidal water is minimised through beneficial reuse or disposal on land.	Alternative placement locations that are still within the coastal sedimentary system but that also involve some beneficial reuse (e.g. beach nourishment) are being actively investigated as part of GPC's Sustainable Sediment Management project (see https://www.gpcl.com.au/ssm-project)	None
All dredging and any disposal of dredged material in tidal water	PO21 All dredging and any disposal of dredged material in tidal water is: 1. demonstrated to be safe with regard to protection of the marine environment and by meeting the National Assessment Guidelines for Dredging (NAGD) 2009, Department of Environment and Energy, 2009, or later version; and 2. supported by a monitoring and management plan that protects the marine environment and that complies with the National Assessment Guidelines for Dredging 2009, Department of Environment and Energy, 2009, or later version.	Contaminant concentrations in dredged material are typically below screening level or background concentrations. In accordance with NAGD, only material that is deemed clean will be disposed in marine waters. Refer to Section 4.2.2 for further detail. Dredging and disposal will also be supported by a Dredge Management Plan (to be supplied by GPC).	None

6 Conclusion

The potential environmental impacts associated with three (3) alternative maintenance dredging campaigns at the Gladstone Marina using different dredging methodologies were assessed. The three (3) scenarios are assessed were:

- 200,000 m^3 dredged from the Marina by a small Trailing Suction Hopper Dredger (TSHD) with placement at the EBSDS DMPA;
- 40,000 m^3 dredged from the Marina by CSD and pumped to the Clinton Channel Placement Area; and
- 150,000 m^3 dredged from the Marina by CSD and pumped to the Clinton Channel Placement Area.

The potential effects of dredging were assessed using a numerical model to estimate increases in turbidity and deposition rate above natural or ambient levels, consistent with the methodology used for the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS (BMT, 2019b). Both ambient and dredge related signals were resolved in the numerical model, which allows for an understanding of how significant the dredge contribution is in relation to ambient conditions.

The study found:

- Consistent with previous dredge plume monitoring studies, modelling predicts that turbid plumes will be short-term features (measured in tens to hundreds of minutes duration) of limited spatial extent (largely within and directly adjacent to dredged areas)
- Seagrass and reef habitats occur within five (5) kilometres of the dredged area. Turbid plumes from maintenance dredging are expected to cause measurable increases in turbidity in some seagrass areas, but not at reef areas.
- Modelling indicates that turbid plumes at seagrass sites will mostly be short-lived features and result in small increases in turbidity above the natural background levels.
- The Zone of Influence (the area where plumes are expected to have a measurable effect on the turbidity statistics, but cause no ecological impact) is largest in extent for the 150,000m^3 dredging scenario with in-channel placement. There is also a small Zone of Impact associated with this scenario. In the other two (2) scenarios there is no Zone of Impact and the Zone of Influence is much smaller (slightly larger in extent in the 200,000 m^3 scenario than in the 40,000 m^3 scenario).
- Seagrass and reef habitats are considered unlikely to be impacted given the predicted low intensity and short duration of dredge plumes at these sites. Validation monitoring is recommended.
- Soft sediment benthic communities within the dredging footprint and the two DMPAs will be adversely affected by dredging and disposal in the short-term, but are expected to rapidly recover (measured in months to tens of months).
- Significant impacts to threatened species, migratory species, and properties/ features listed as MNES or MSES are not expected.

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Appendix A PMST Report

Australian Government

Department of Agriculture, Water and the Environment

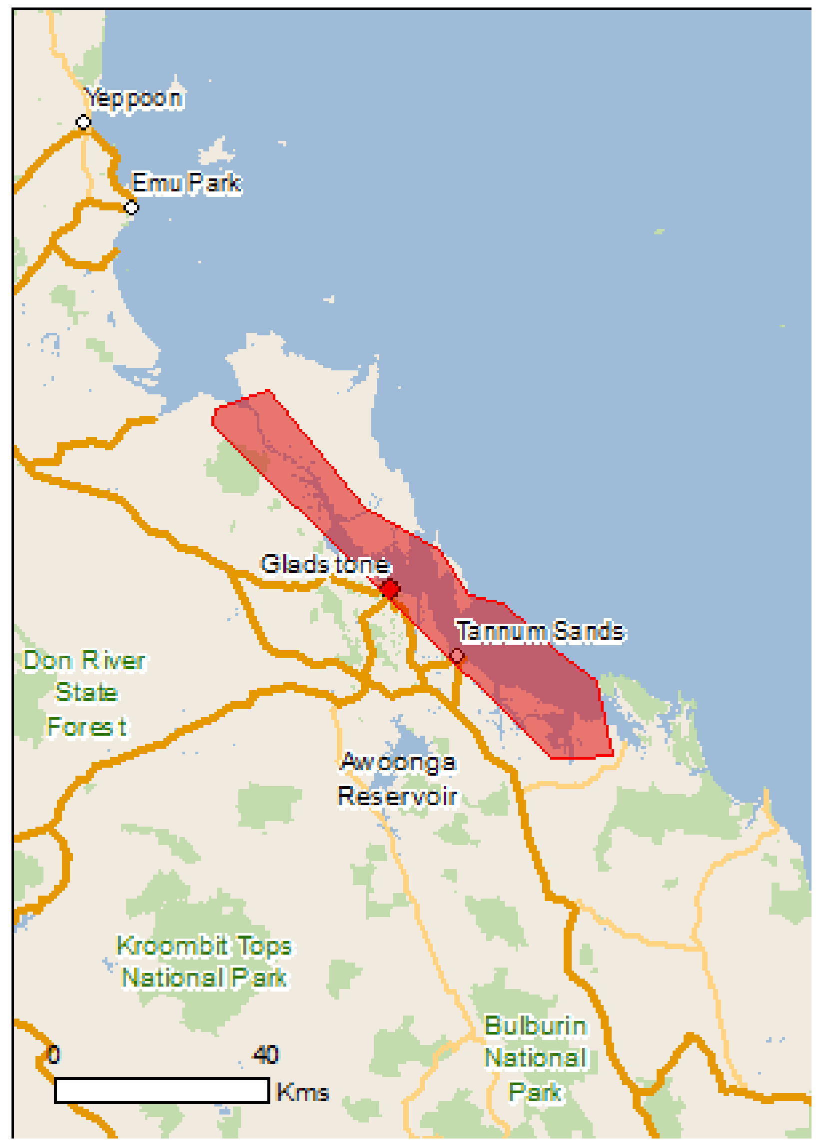
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

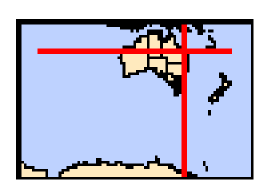
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 15/03/21 11:30:00



Coordinates

Buffer: 0.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	5
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	7
Listed Threatened Species:	67
Listed Migratory Species:	68

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	111
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	43
Nationally Important Wetlands:	5
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Great Barrier Reef	QLD	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Great Barrier Reef	QLD	Listed place

Great Barrier Reef Marine Park [Resource Information]

Type	Zone	IUCN
Conservation Park	CP-23-4110	IV
General Use	GU-21-6016	VI
Habitat Protection	HP-23-5369	VI
Habitat Protection	HP-23-5370	VI
Habitat Protection	HP-23-5374	VI

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community may occur within area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community likely to occur within area
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area

Name	Status	Type of Presence
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Cyclopsitta diophthalma coxeni Coxen's Fig-Parrot [59714]	Endangered	Species or species habitat may occur within area
Epthianura crocea macgregori Capricorn Yellow Chat, Yellow Chat (Dawson) [67090]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species

Name	Status	Type of Presence
		habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat known to occur within area
Fish		
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat known to occur within area
Plants		
Bosistoa transversa Three-leaved Bosistoa, Yellow Satinheart [16091]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Bulbophyllum globuliforme Miniature Moss-orchid, Hoop Pine Orchid [6649]	Vulnerable	Species or species habitat may occur within area
Cossinia australiana Cossinia [3066]	Endangered	Species or species habitat may occur within area
Cupaniopsis shirleyana Wedge-leaf Tuckeroo [3205]	Vulnerable	Species or species habitat known to occur within area
Cycas megacarpa [55794]	Endangered	Species or species habitat may occur within area
Cycas ophiolitica [55797]	Endangered	Species or species habitat may occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Fontainea venosa [24040]	Vulnerable	Species or species habitat may occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat likely to occur within area
Marsdenia brevifolia [64585]	Vulnerable	Species or species habitat may occur within area
Parsonsia larcomensis Mt Larcom Silk Pod [64587]	Vulnerable	Species or species habitat may occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat likely to occur within area
Samadera bidwillii Quassia [29708]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat may occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat likely to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Defence - GLADSTONE ARES DEPOT

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat likely to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area

Name	Threatened	Type of Presence
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur

Name	Threatened	Type of Presence within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Corythoichthys paxtoni Paxton's Pipefish [66204]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus bargibanti Pygmy Seahorse [66721]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]	Endangered	Species or species habitat may occur within area
Hippocampus zebra Zebra Seahorse [66241]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Nannocampus pictus Painted Pipefish, Reef Pipefish [66263]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Laticauda colubrina a sea krait [1092]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Curtis Island	QLD
Curtis Island	QLD
Eurimbula	QLD
Garden Island	QLD
Wild Cattle Island	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus africanus Climbing Asparagus, Climbing Asparagus Fern [66907]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red		Species or species habitat likely to occur

Name	Status	Type of Presence
Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus		
Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp.		
Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Vachellia nilotica		
Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Ramphotyphlops braminus		
Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat may occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Colosseum Inlet - Rodds Bay	QLD
Fitzroy River Delta	QLD
Great Barrier Reef Marine Park	QLD
Port Curtis	QLD
The Narrows	QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.566442 150.960017,-23.537488 151.047908,-23.719921 151.21133,-23.786539 151.336299,-23.85438 151.385738,-23.866939 151.444789,-23.938503 151.531306,-23.984936 151.602717,-24.099064 151.627437,-24.105332 151.52444,-23.590357 150.955897,-23.566442 150.960017

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

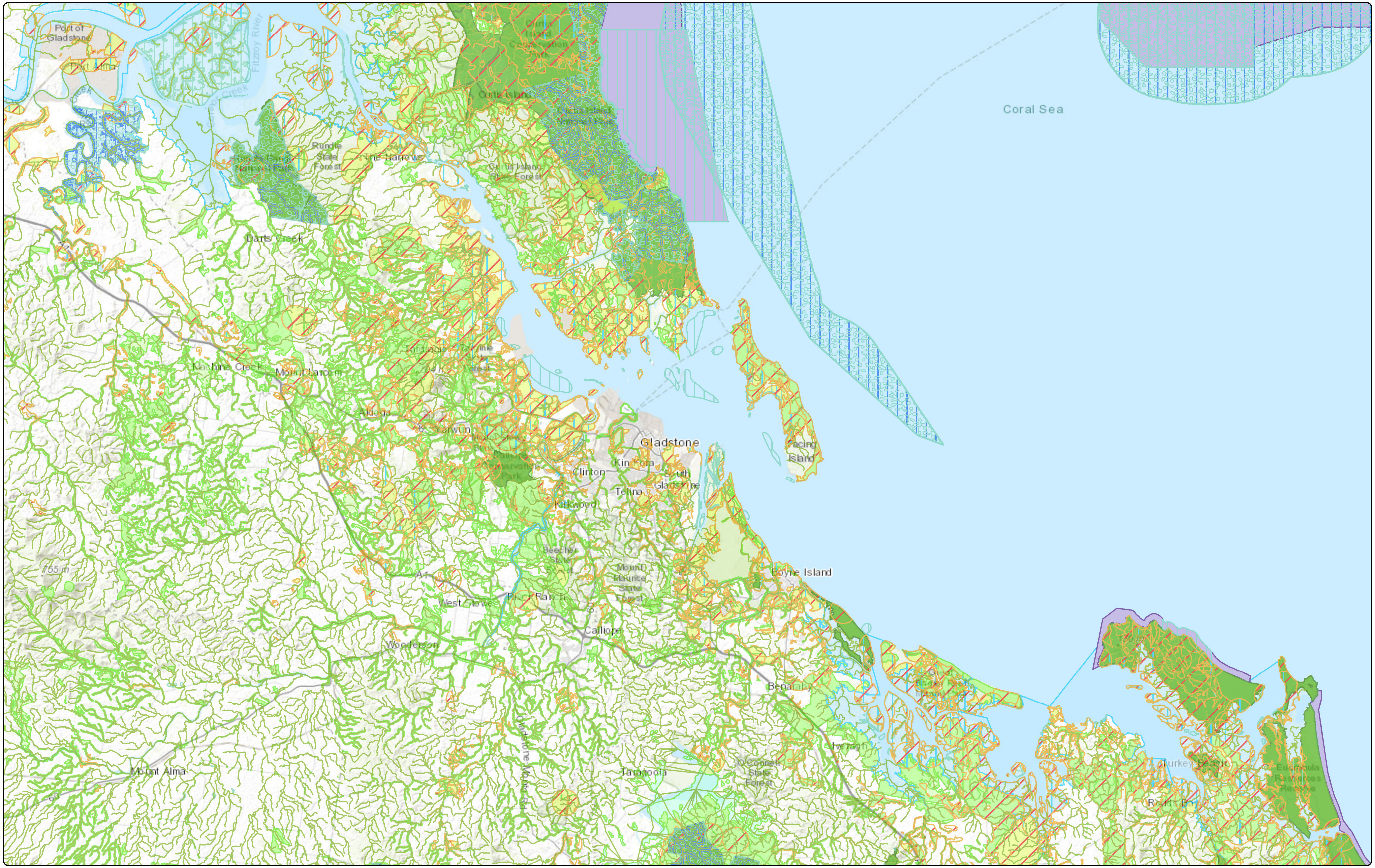
- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of Agriculture Water and the Environment
GPO Box 858
Canberra City ACT 2601 Australia
+61 2 6274 1111

Appendix B SPP Mapping Tool Results



Queensland Government

Queensland Government

N

State Planning Policy

Making or amending a local planning instrument and designating land for community infrastructure

0 4,750 9,500 14,250 19,000

Metres

Date: 29/03/2021

Legend

MSES - Regulated vegetation (intersecting a watercourse)

MSES - Regulated vegetation (intersecting a watercourse)

MSES - High ecological value waters (watercourse)

MSES - High ecological value waters (watercourse)

High ecological value water areas

High ecological value water areas

Water resource catchments

Water resource catchments

MSES - Wildlife habitat (endangered or vulnerable)

MSES - Wildlife habitat (endangered or vulnerable)

MSES - Wildlife habitat (special least concern animal)

MSES - Wildlife habitat (special least concern animal)

MSES - Wildlife habitat (koala habitat areas - core)

MSES - Wildlife habitat (koala habitat areas - core)

MSES - Wildlife habitat (koala habitat areas - locally refined)

MSES - Wildlife habitat (koala habitat areas - locally refined)

MSES - Strategic environmental areas (designated precinct)

MSES - Strategic environmental areas (designated precinct)

MSES - High ecological significance wetlands

MSES - High ecological significance wetlands

MSES - High ecological value waters (wetland)

MSES - High ecological value waters (wetland)

MSES - Legally secured offset area (offset register)

MSES - Legally secured offset area (offset register)

MSES - Legally secured offset area (regulated vegetation offsets)

MSES - Legally secured offset area (regulated vegetation offsets)

MSES - Protected areas (estate)

MSES - Protected areas (estate)

MSES - Protected areas (special wildlife reserve)

MSES - Protected areas (special wildlife reserve)

MSES - Protected areas (nature refuge)

MSES - Protected areas (nature refuge)

MSES - Marine park (highly protected areas)

MSES - Marine park (highly protected areas)

MSES - Declared fish habitat area

MSES - Declared fish habitat area

MSES - Regulated vegetation (category B)

MSES - Regulated vegetation (category B)

MSES - Regulated vegetation (category C)

MSES - Regulated vegetation (category C)

MSES - Regulated vegetation (category R)

MSES - Regulated vegetation (category R)

MSES - Regulated vegetation (essential habitat)

MSES - Regulated vegetation (essential habitat)

MSES - Regulated vegetation (wetland)

MSES - Regulated vegetation (wetland)

Water supply buffer area

Water supply buffer area

Queensland Government

Queensland Government

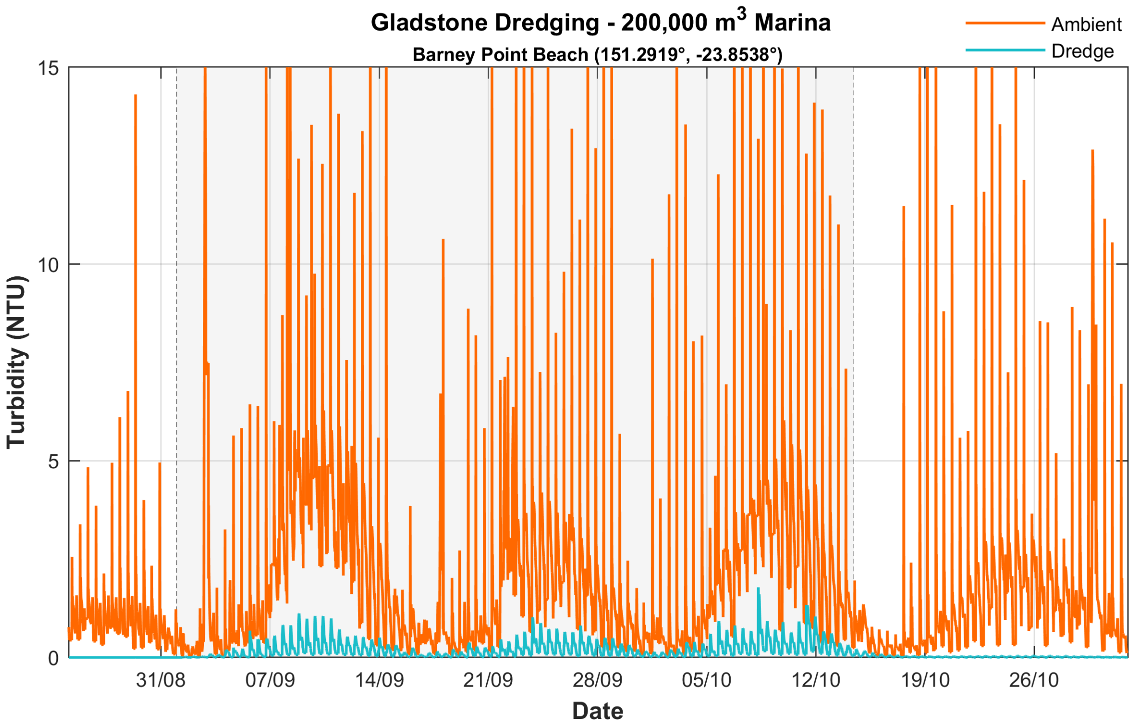
State Planning Policy

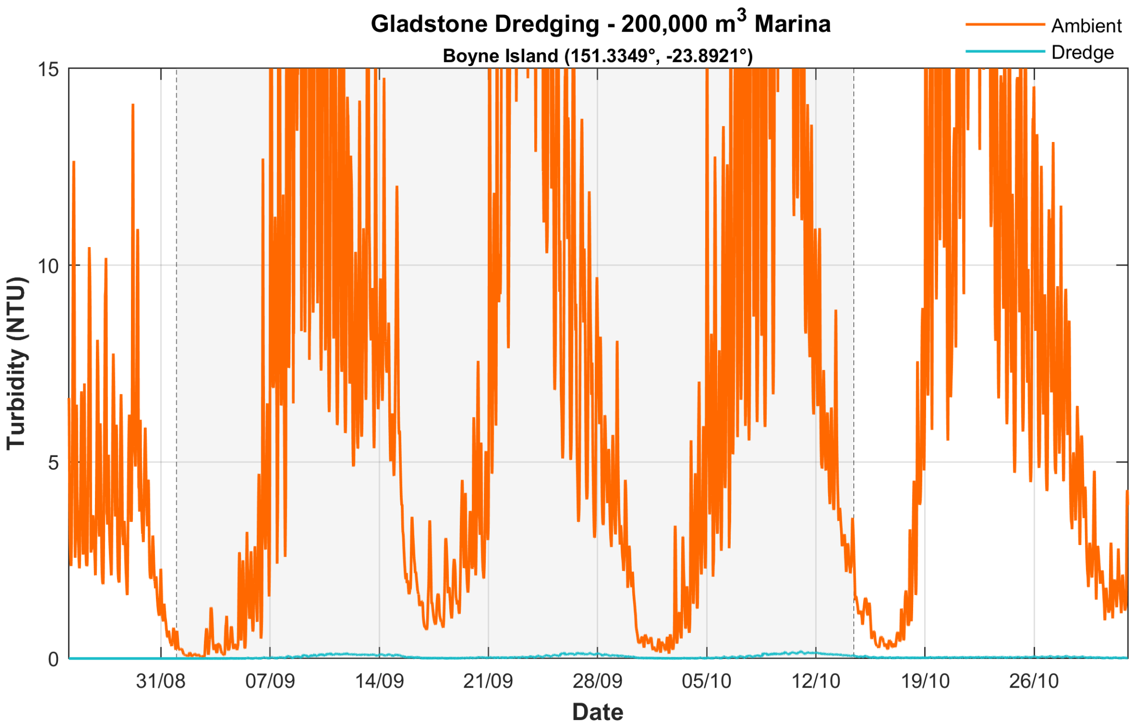
Making or amending a local planning instrument and designating land for community infrastructure

Date: 29/03/2021

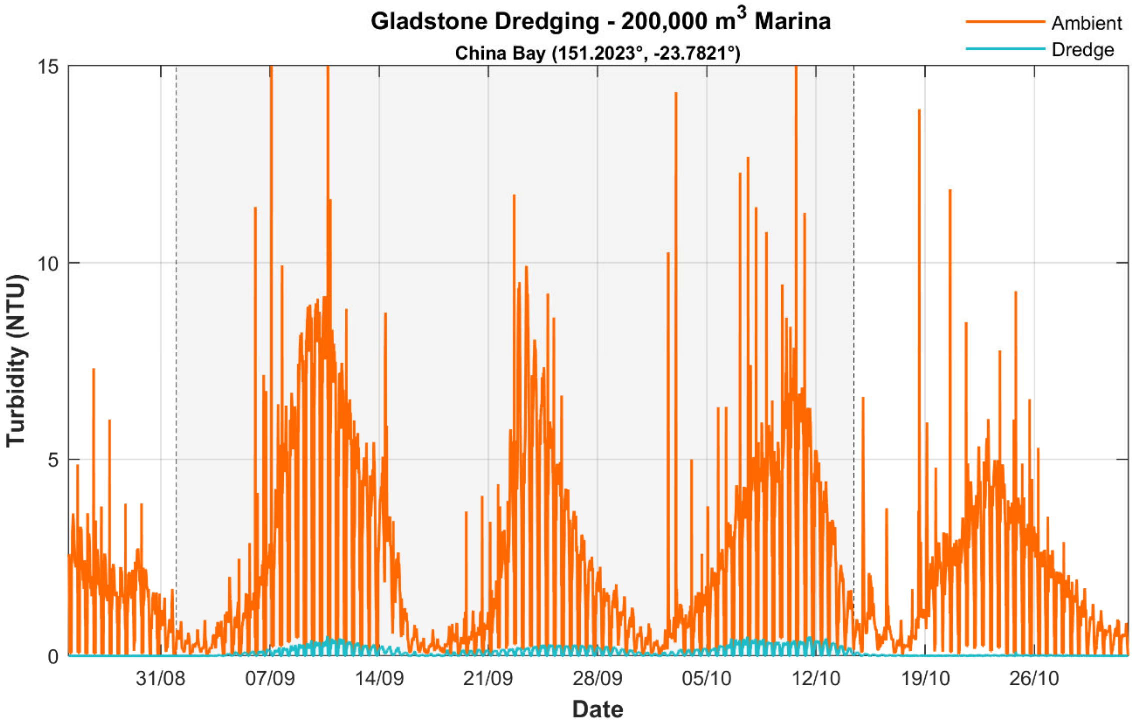
Appendix C Time Series of Modelled Turbidity

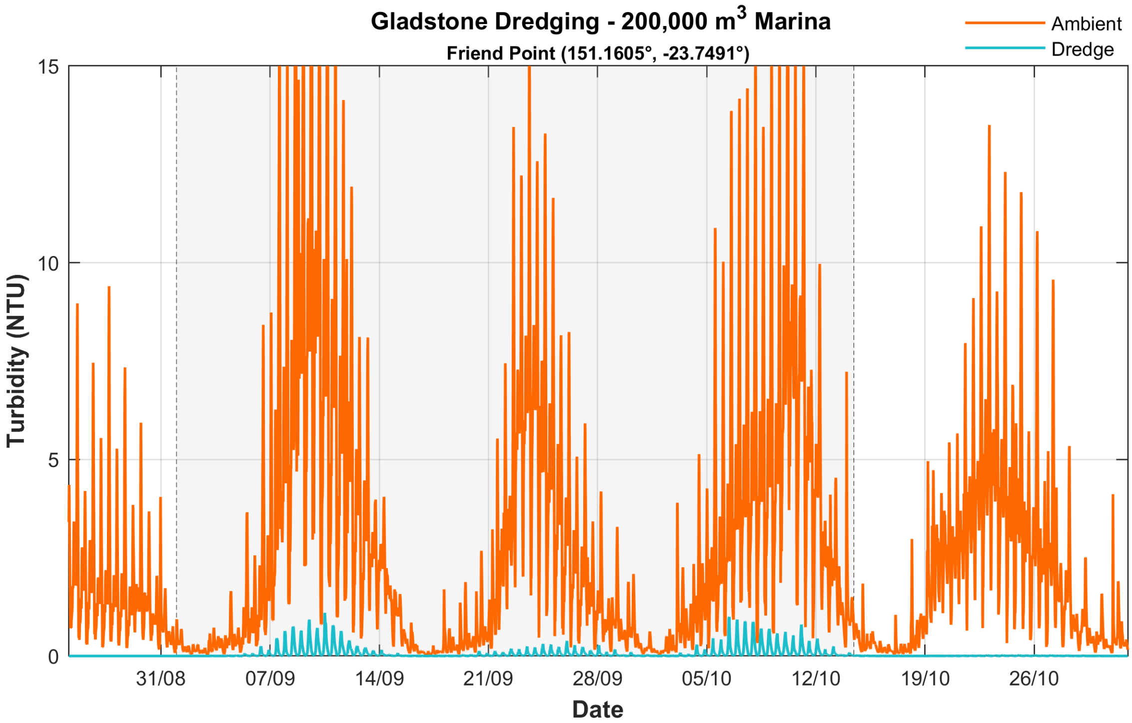
C.1 200,000m³ TSHD Campaign with Placement at EBSDS Results



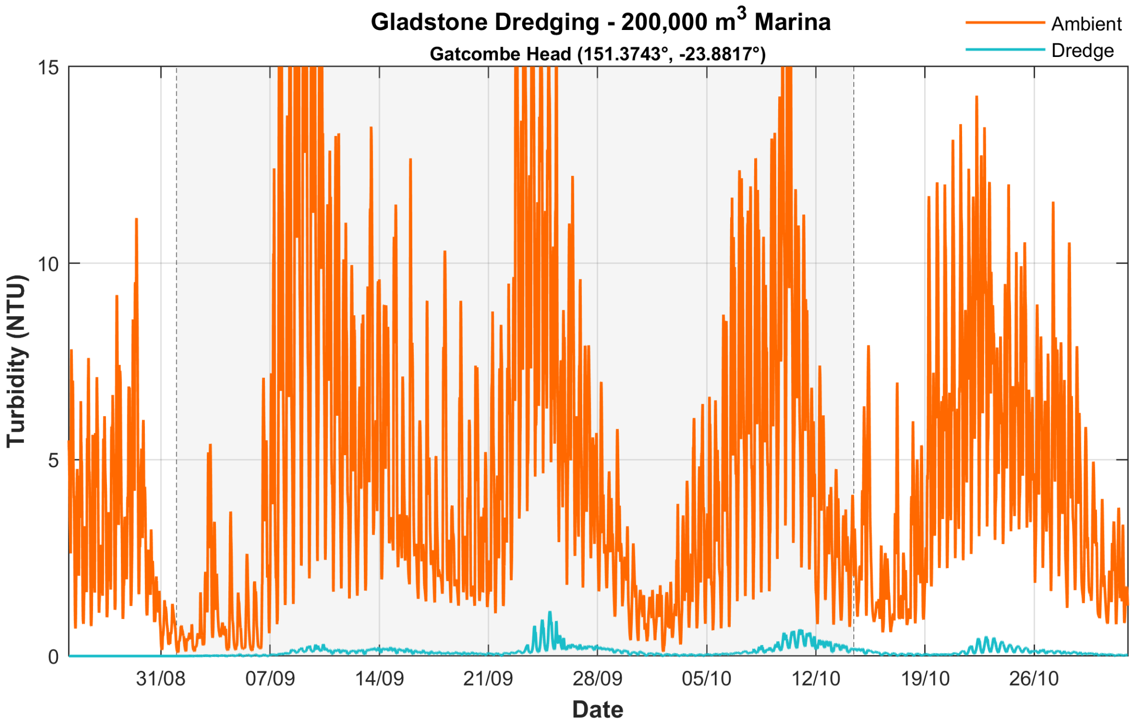


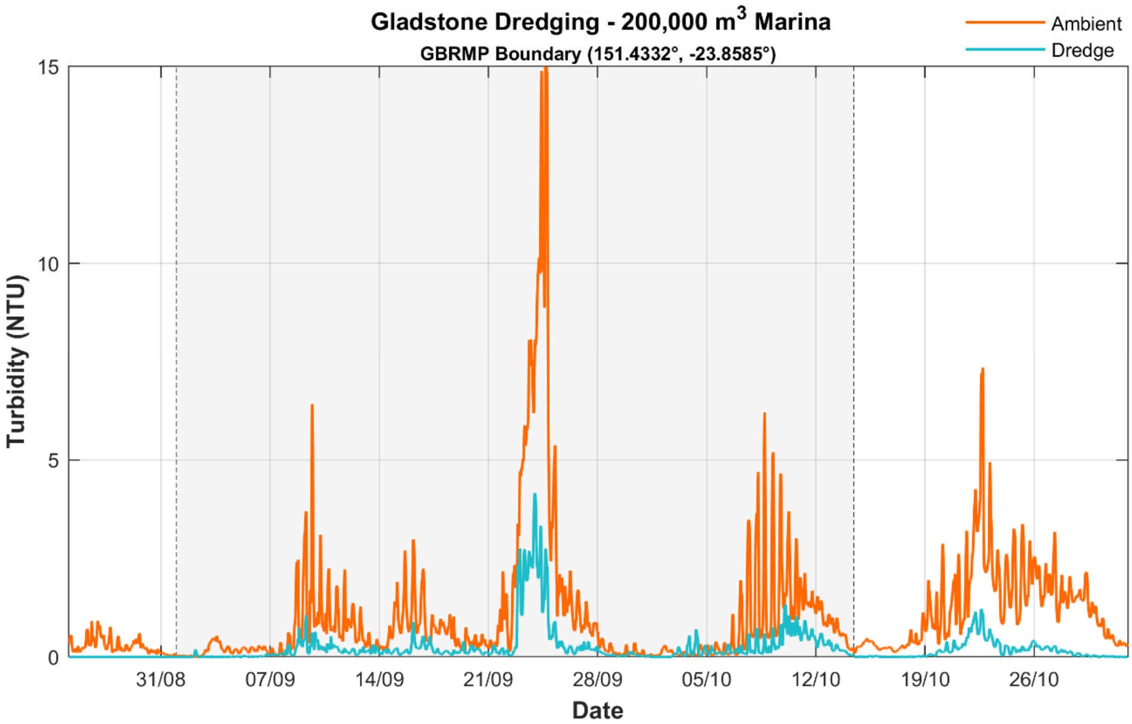
Time Series of Modelled Turbidity

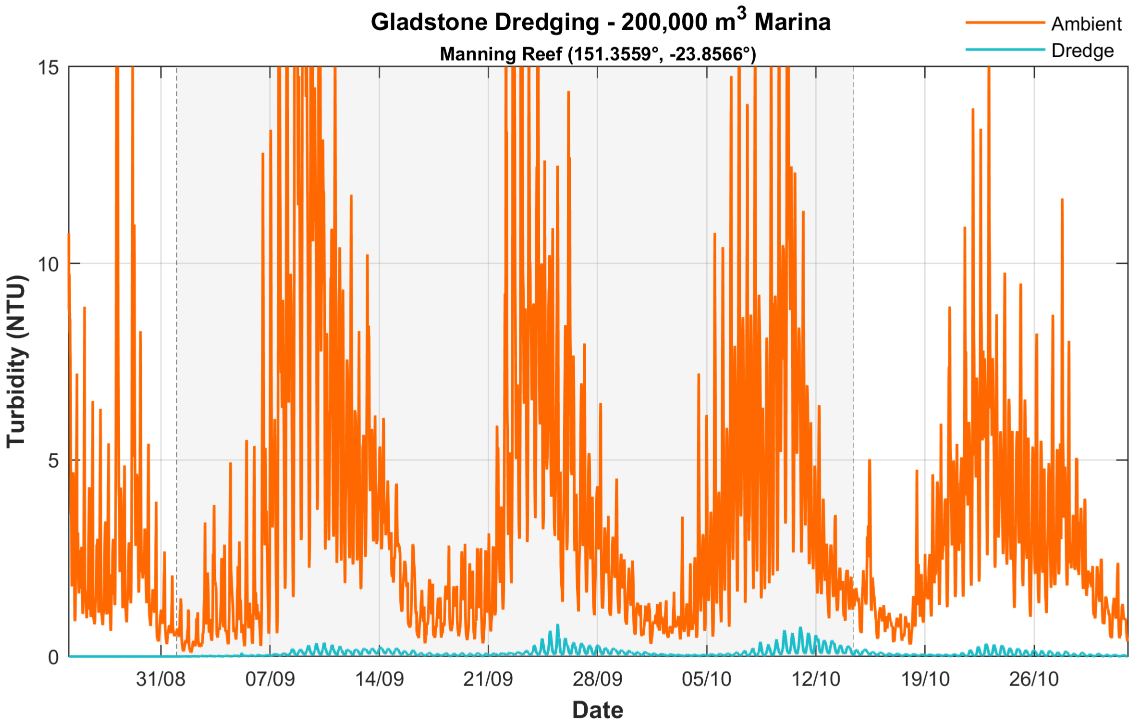


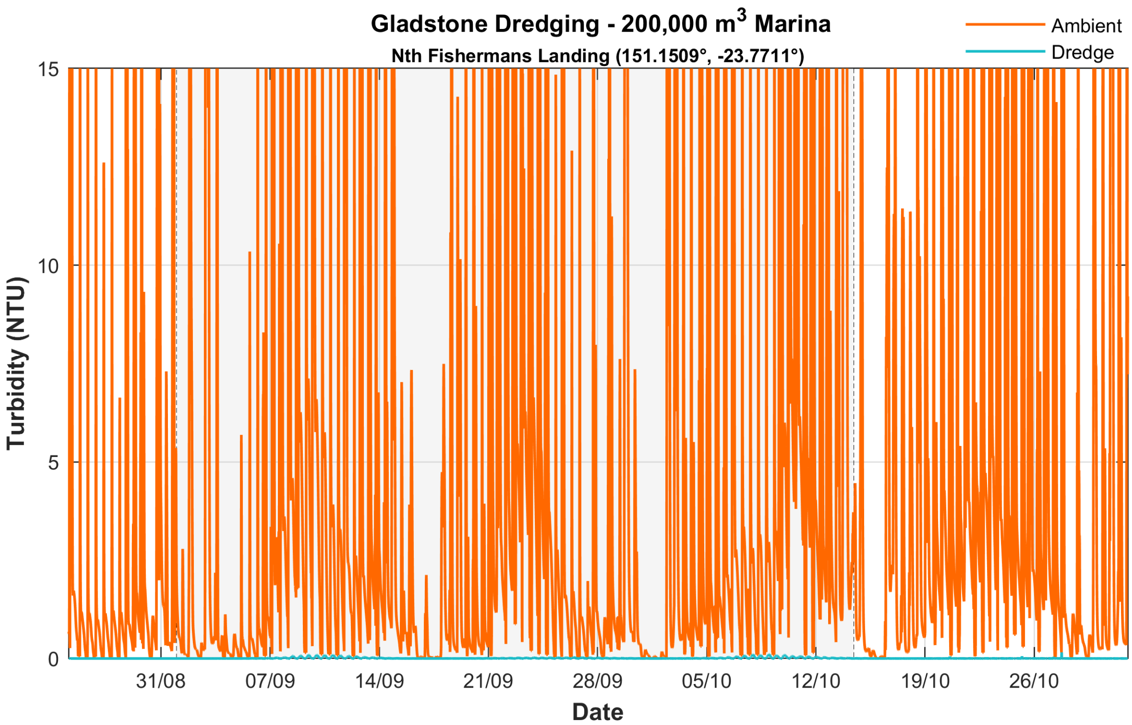


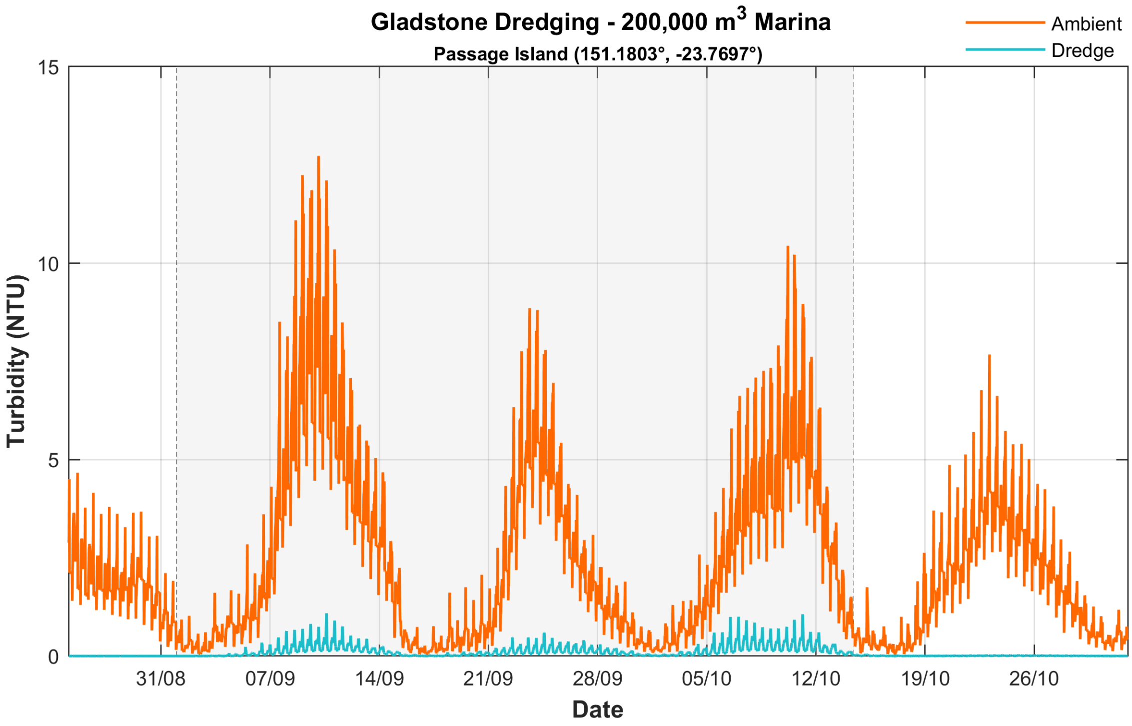
Time Series of Modelled Turbidity

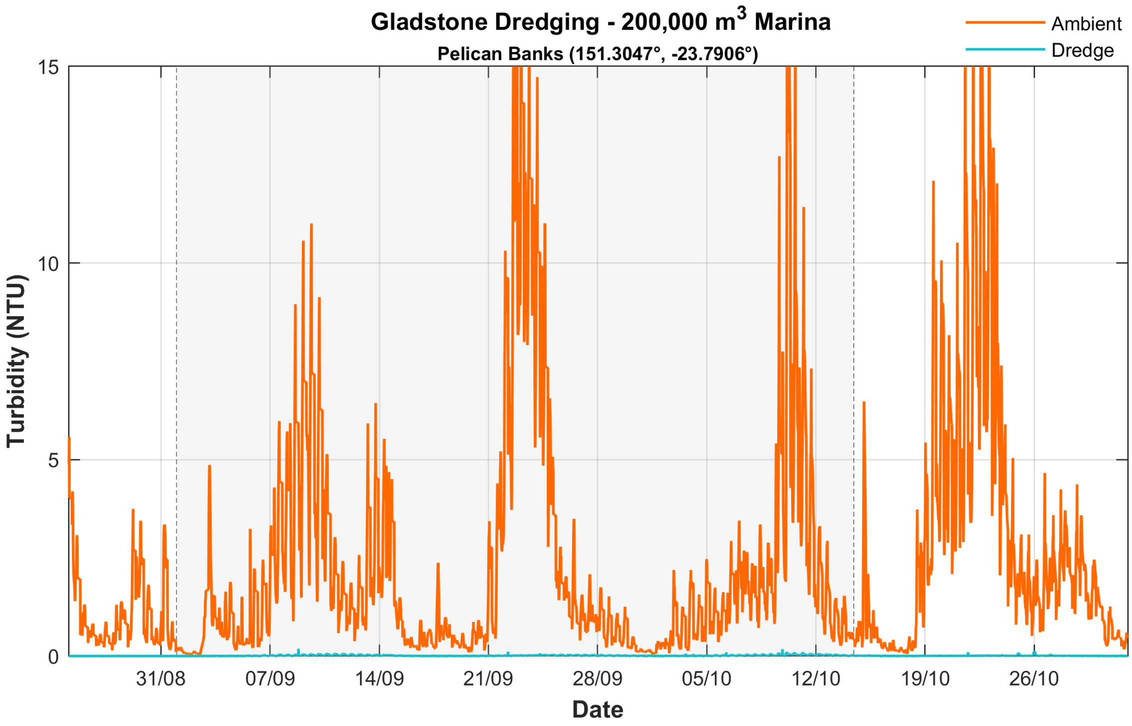


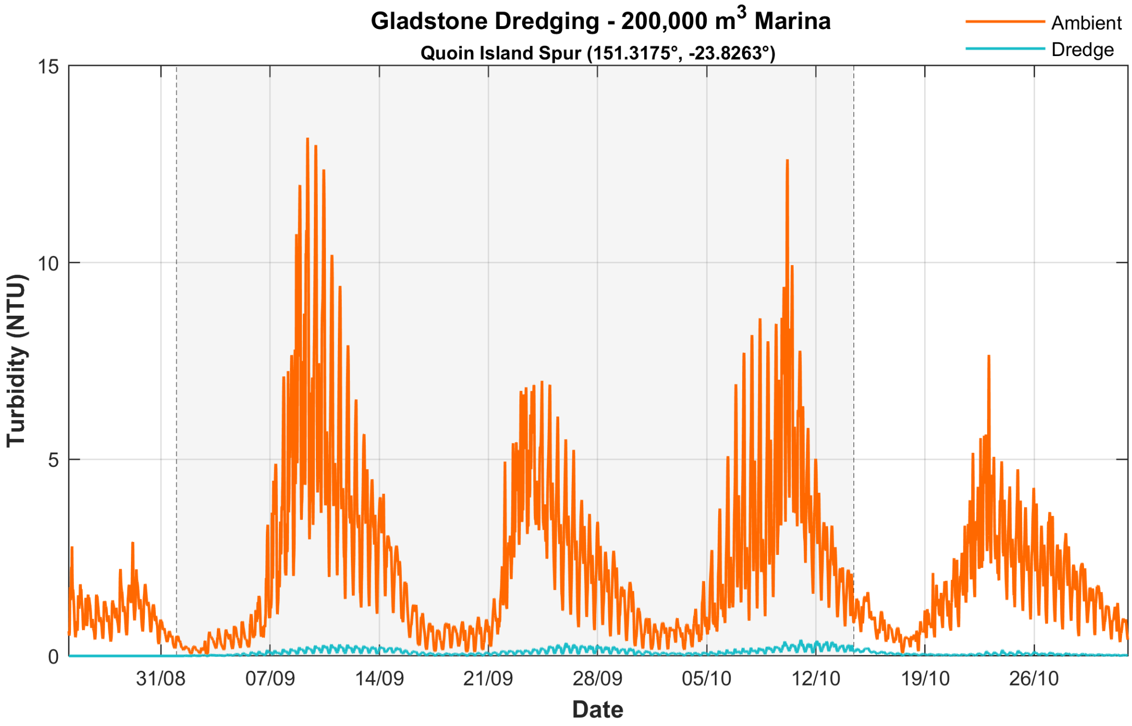



Gladstone Dredging - 200,000 m3 Marina
Manning Reef (151.3559°, -23.8566°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 200,000 m3 Marina
Nth Fishermans Landing (151.1509°, -23.7711°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 200,000 m3 Marina
Passage Island (151.1803°, -23.7697°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 200,000 m3 Marina
Pelican Banks (151.3047°, -23.7906°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 200,000 m3 Marina
Quoin Island Spur (151.3175°, -23.8263°)
Ambient
Dredge
Turbidity (NTU)
15
10
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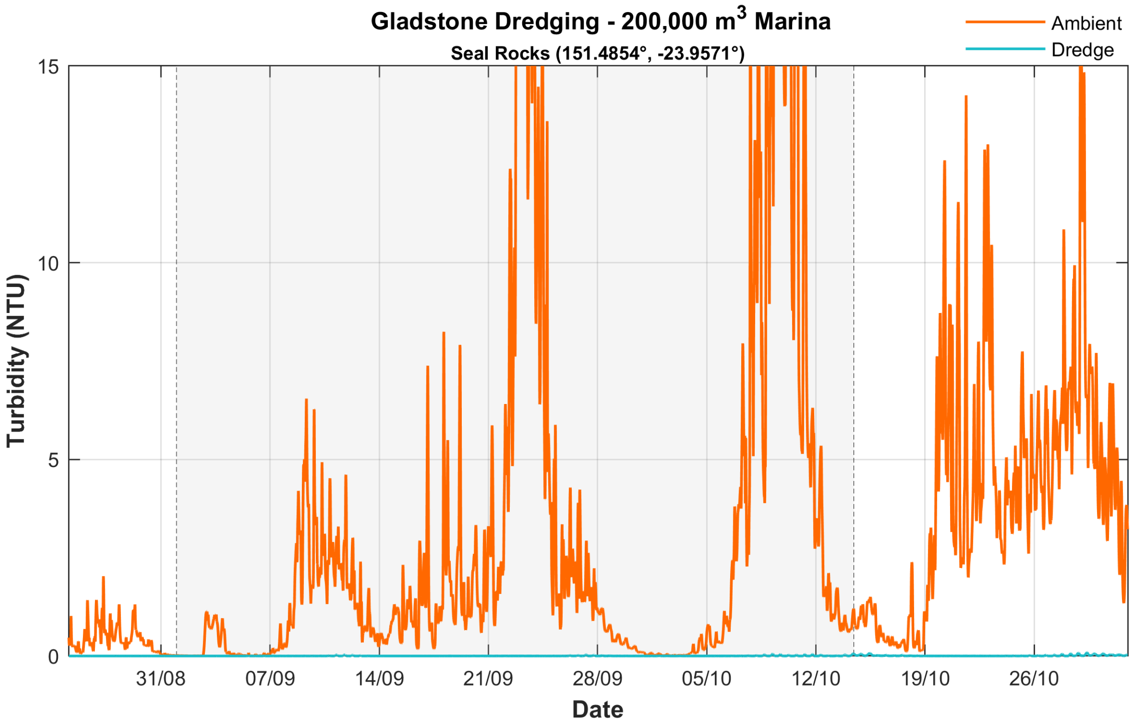
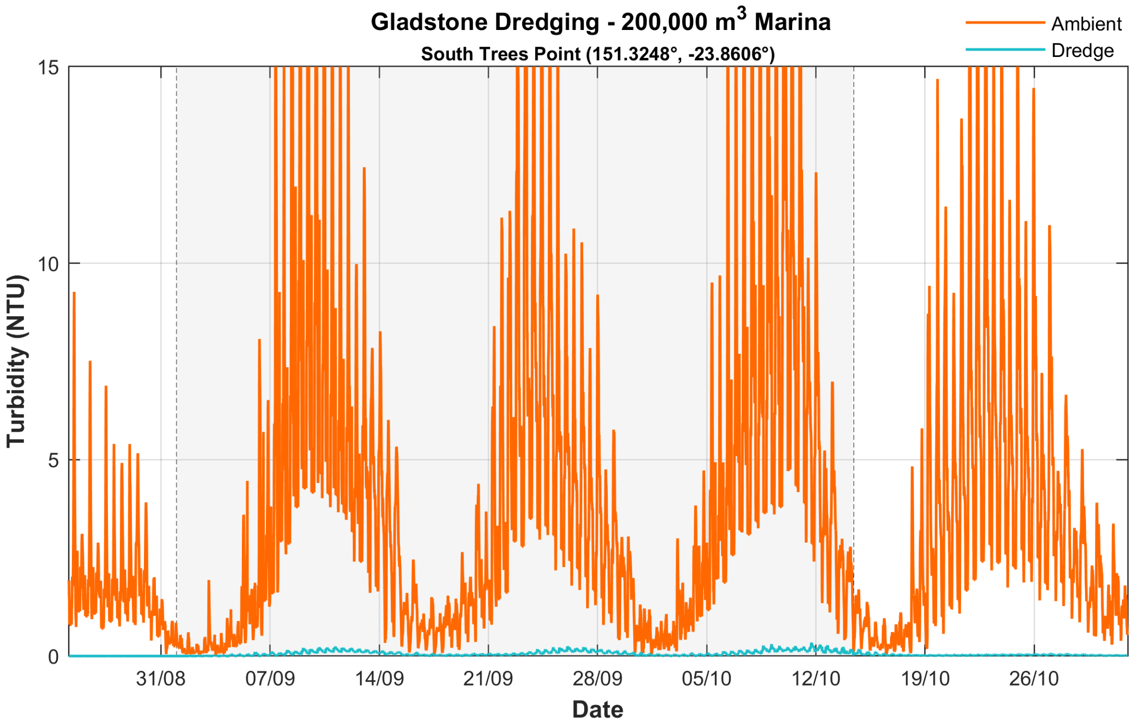
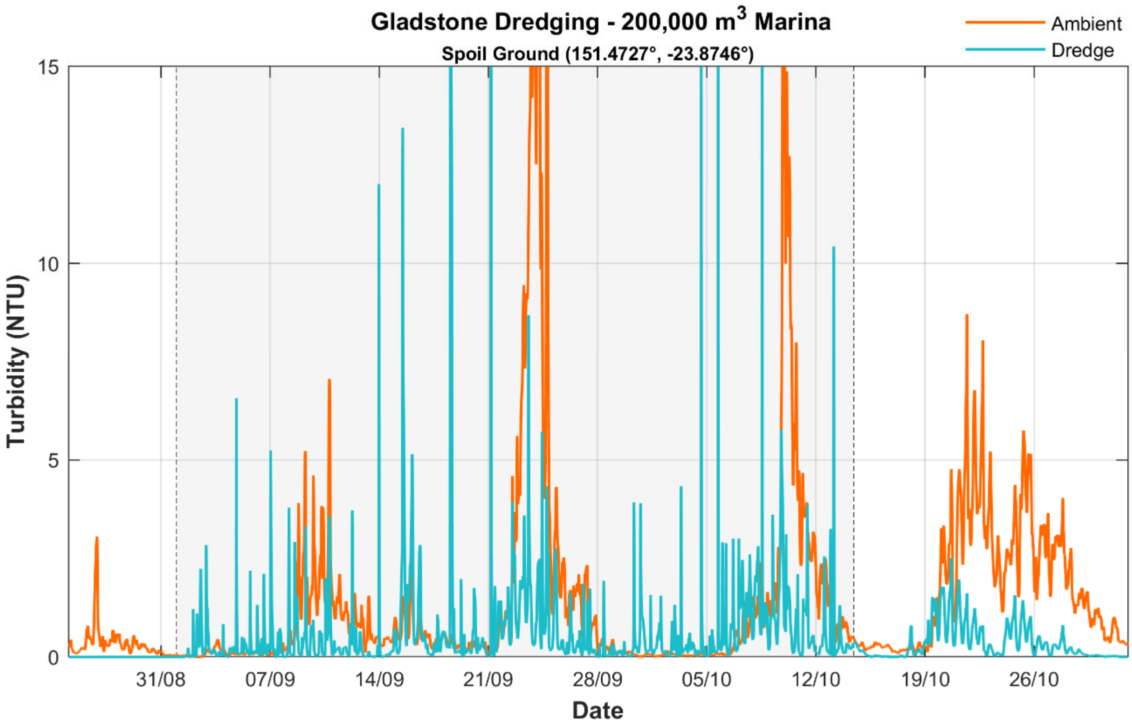
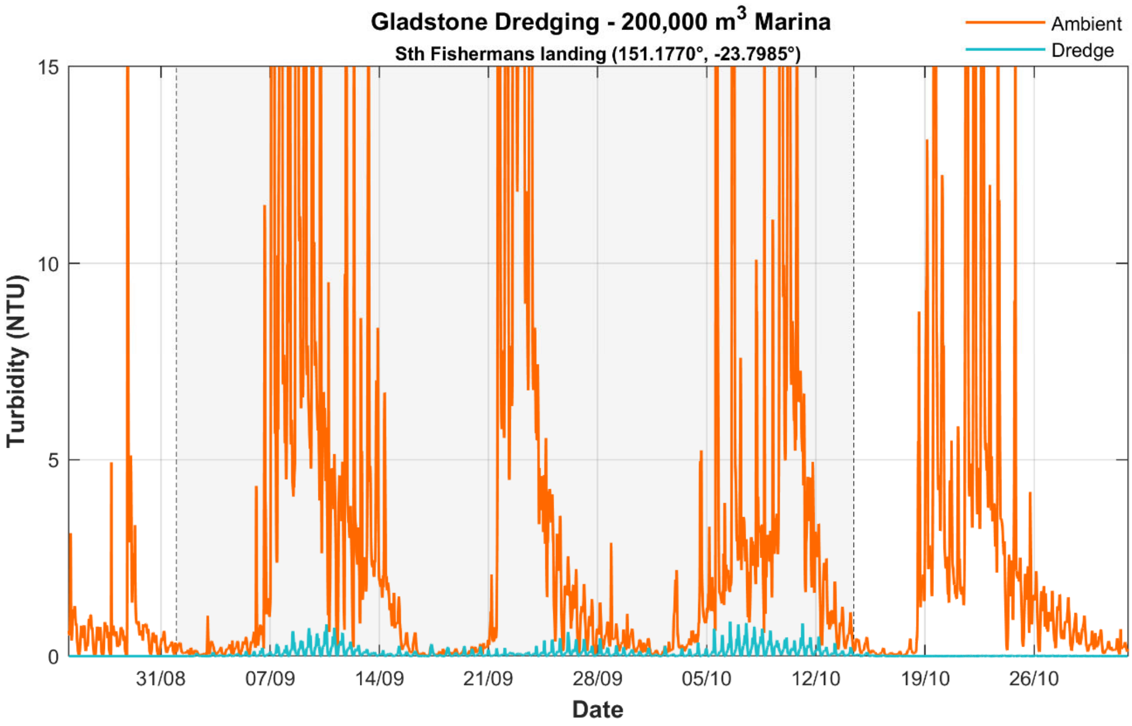
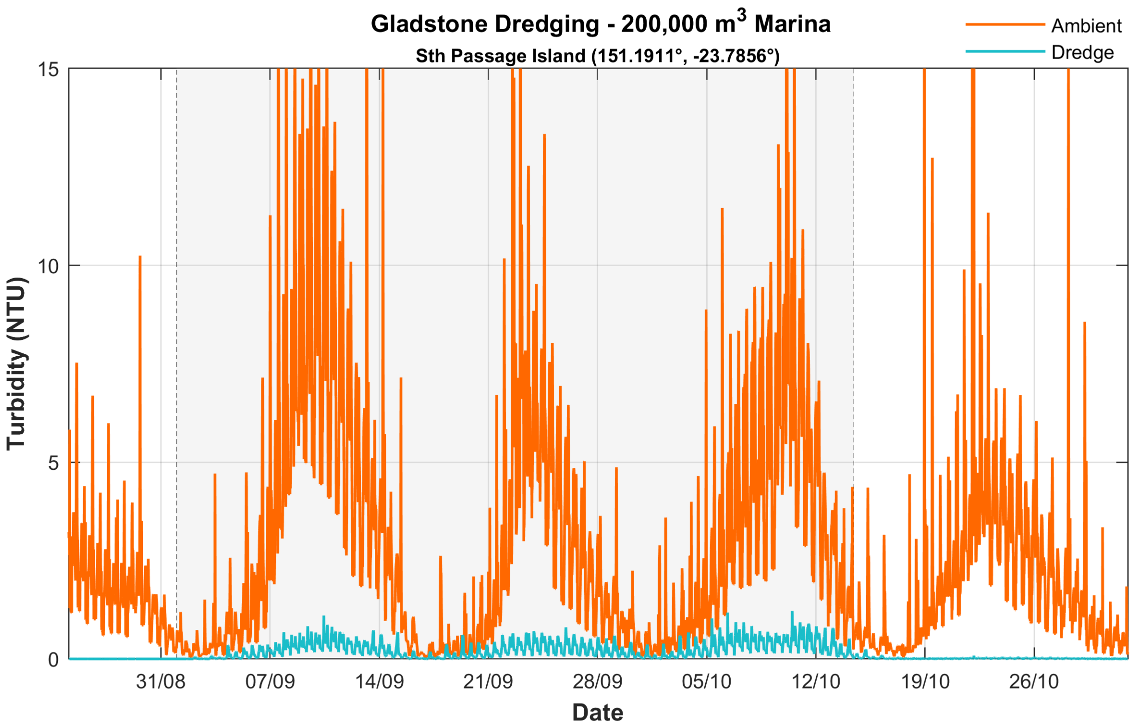
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

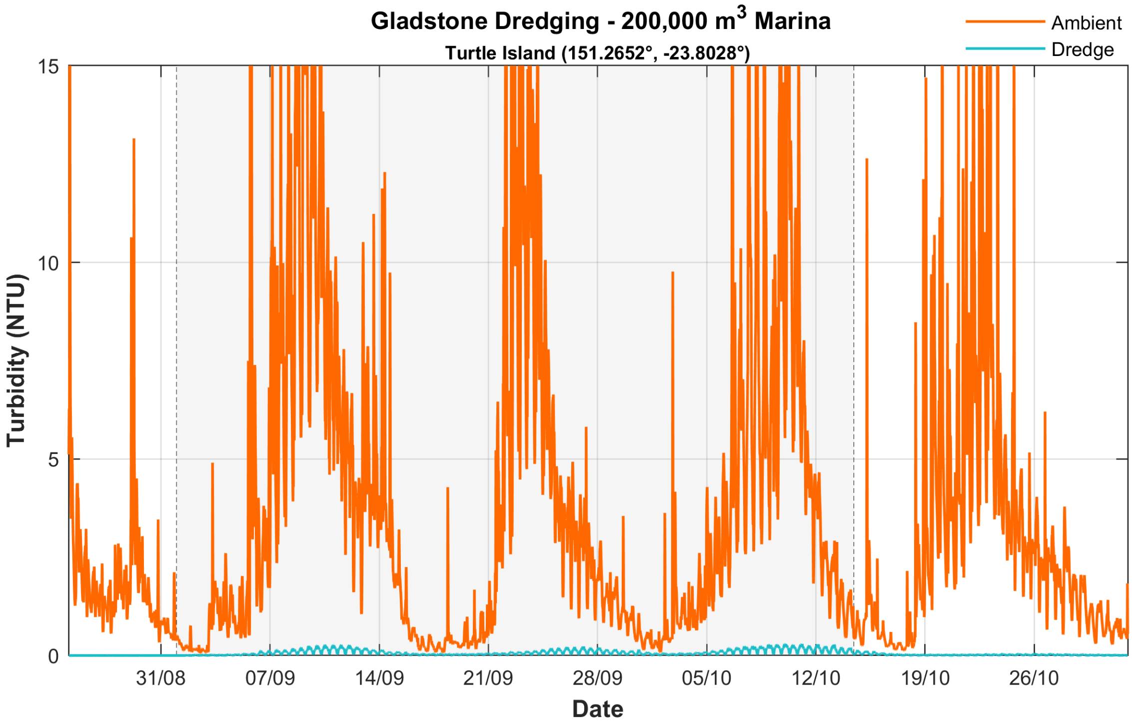

Gladstone Dredging - 200,000 m3 Marina
Seal Rocks (151.4854°, -23.9571°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

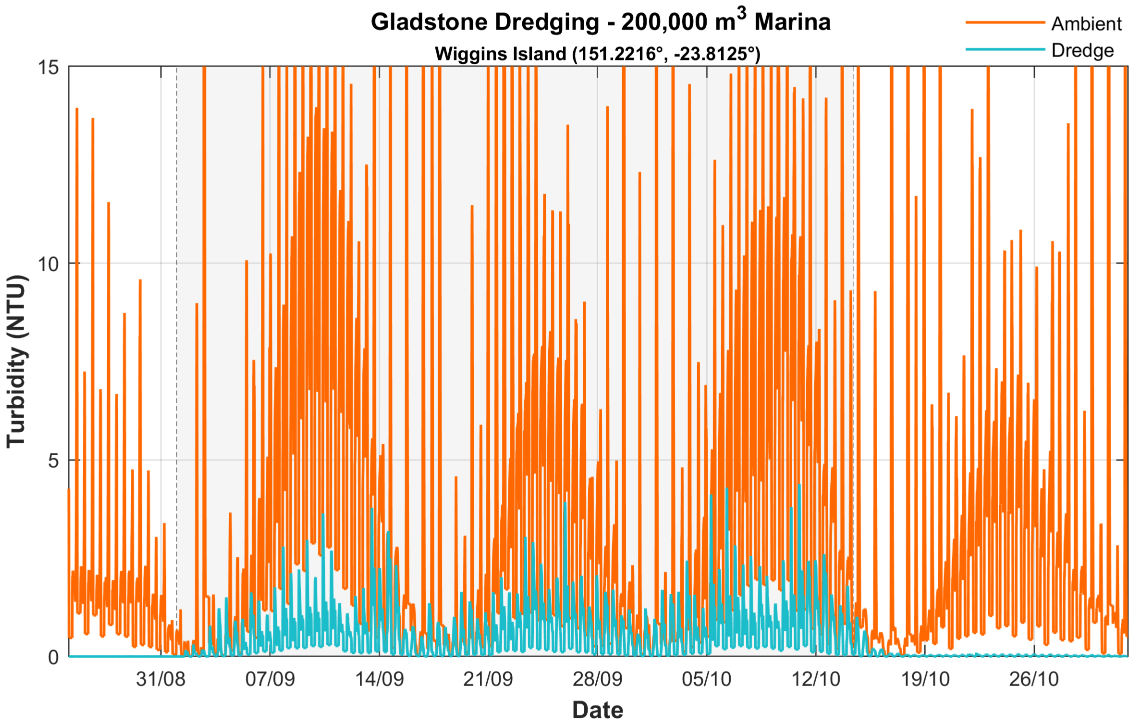

Gladstone Dredging - 200,000 m3 Marina
South Trees Point (151.3248°, -23.8606°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

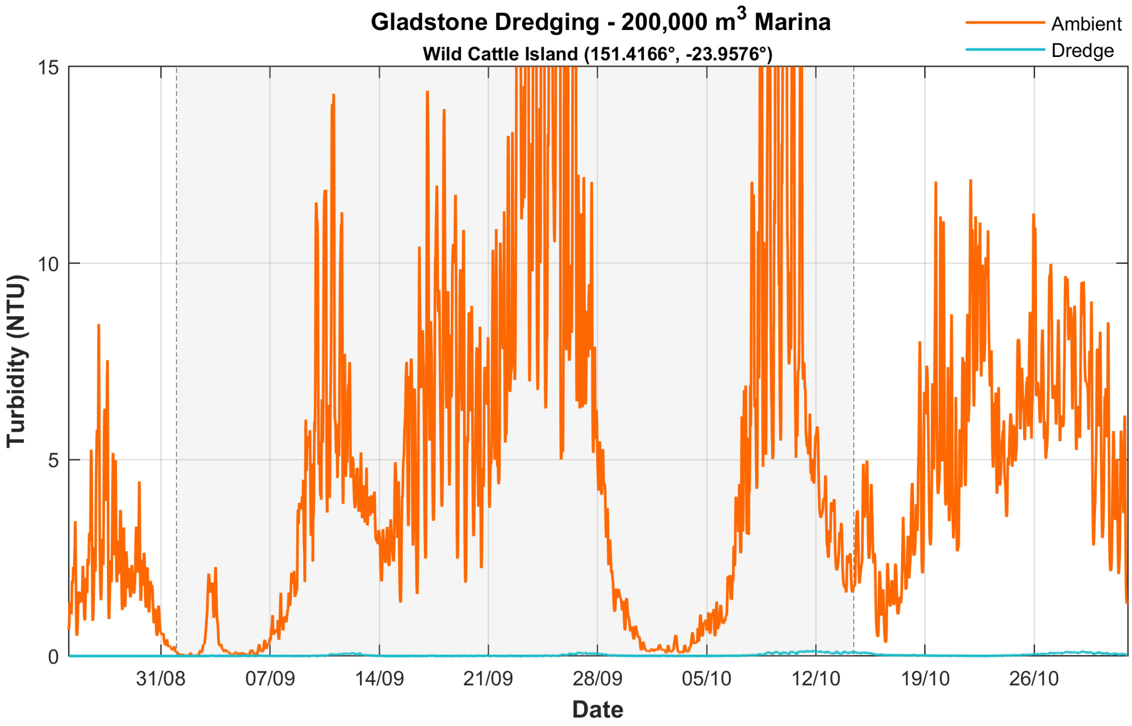

Gladstone Dredging - 200,000 m3 Marina
Spoil Ground (151.4727°, -23.8746°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 200,000 m3 Marina
Sth Fishermans landing (151.1770°, -23.7985°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

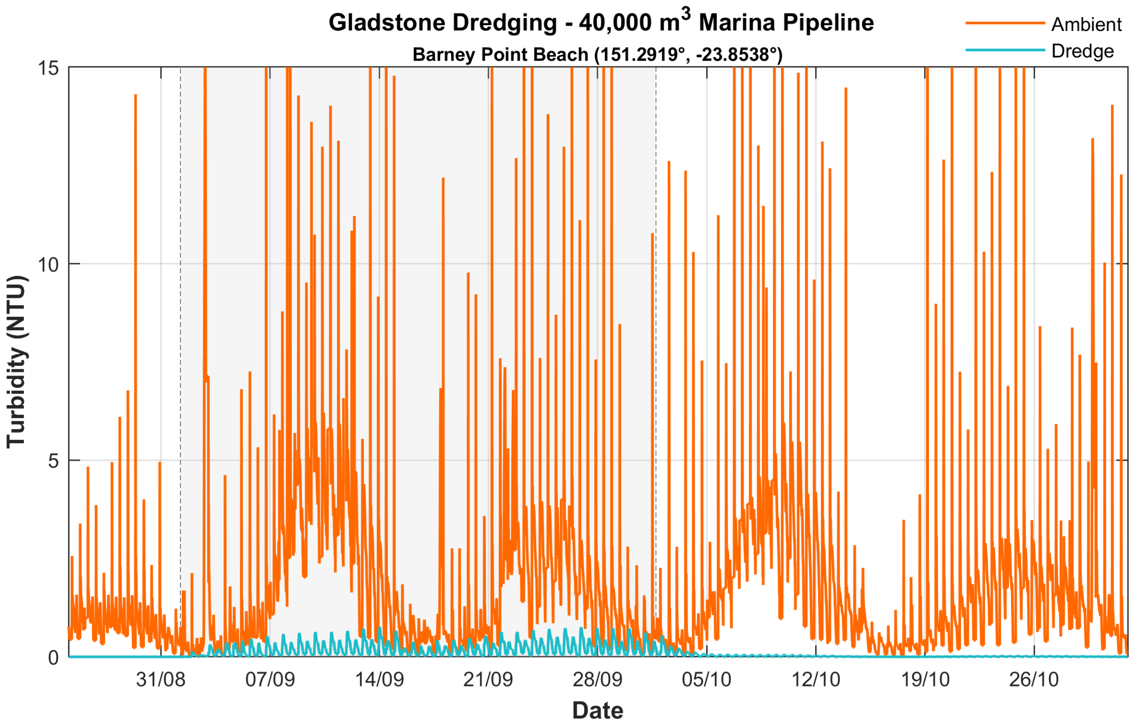

Gladstone Dredging - 200,000 m3 Marina
Sth Passage Island (151.1911°, -23.7856°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

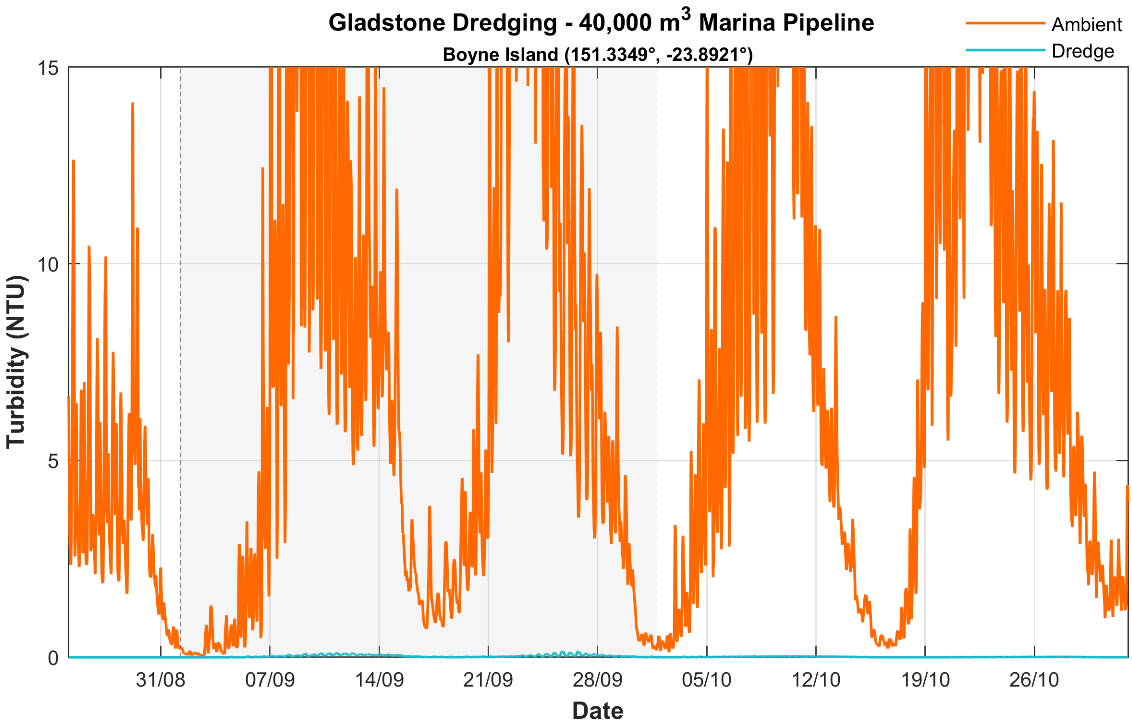

Gladstone Dredging - 200,000 m3 Marina
Turtle Island (151.2652°, -23.8028°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

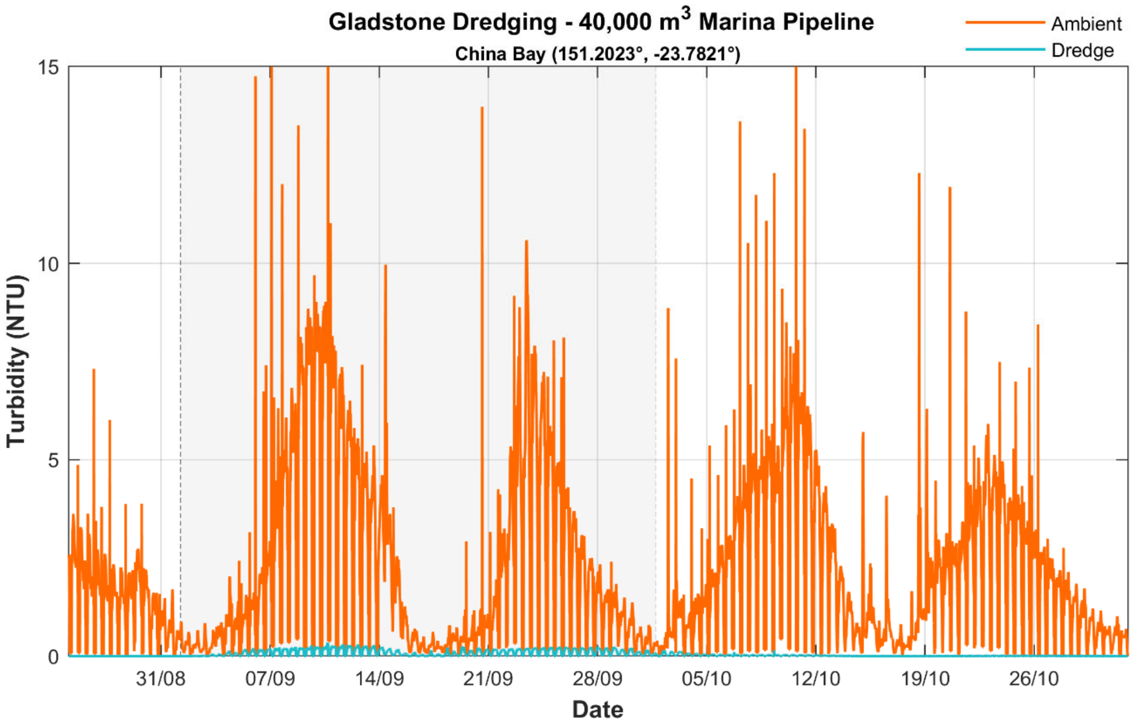

Gladstone Dredging - 200,000 m3 Marina
Wiggins Island (151.2216°, -23.8125°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

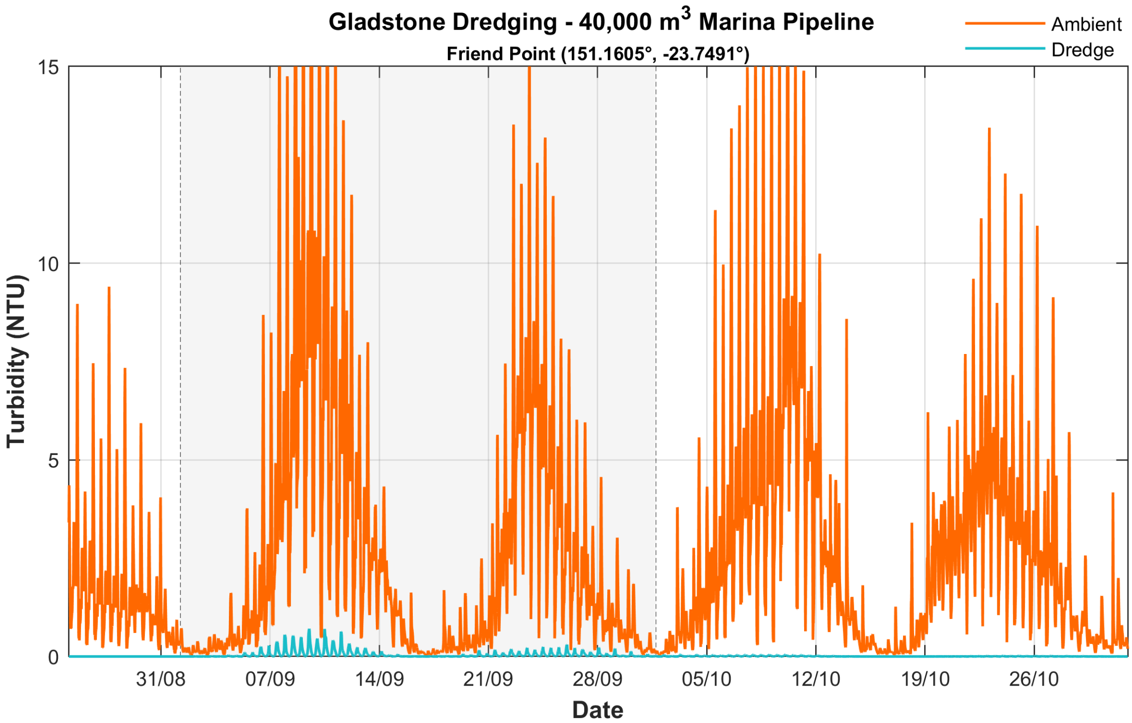

Gladstone Dredging - 200,000 m³ Marina
Wild Cattle Island (151.4166°, -23.9576°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

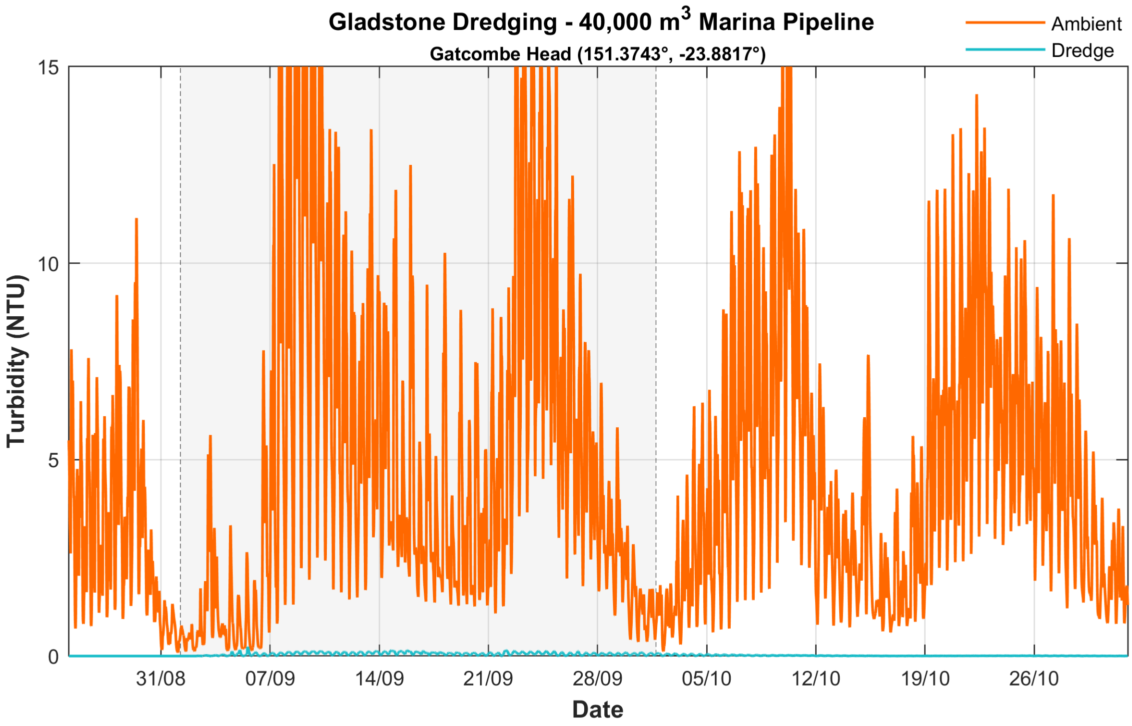
C.2 40,000m³ CSD Campaign with In-Channel Placement Results

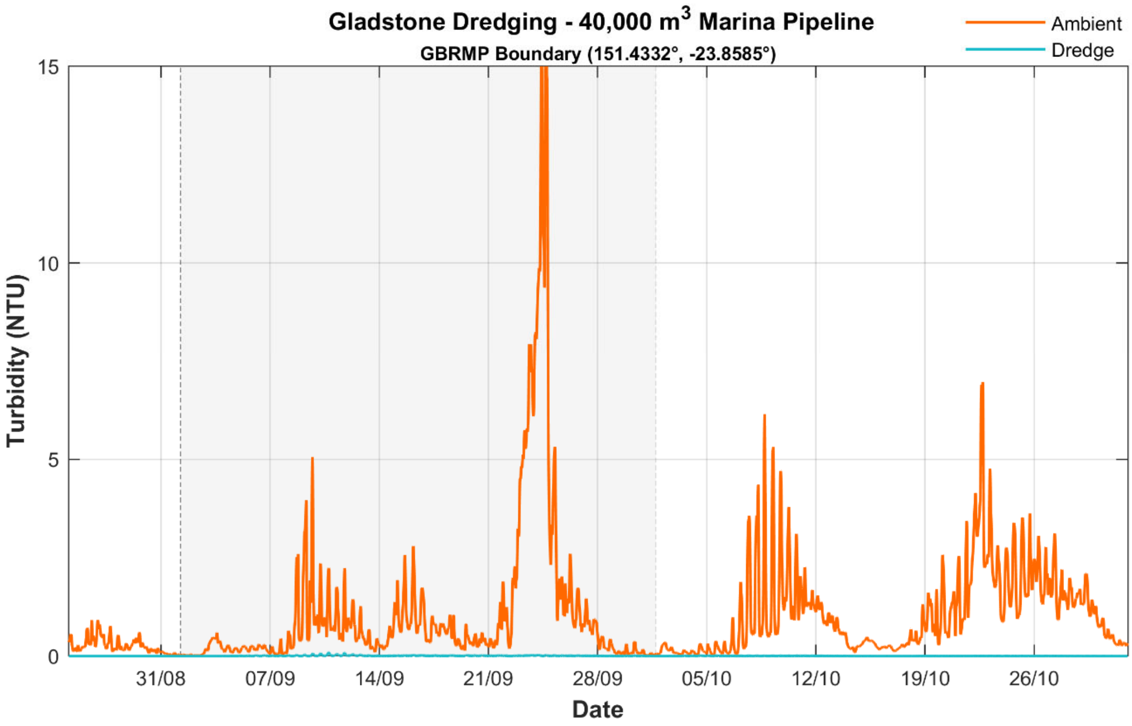


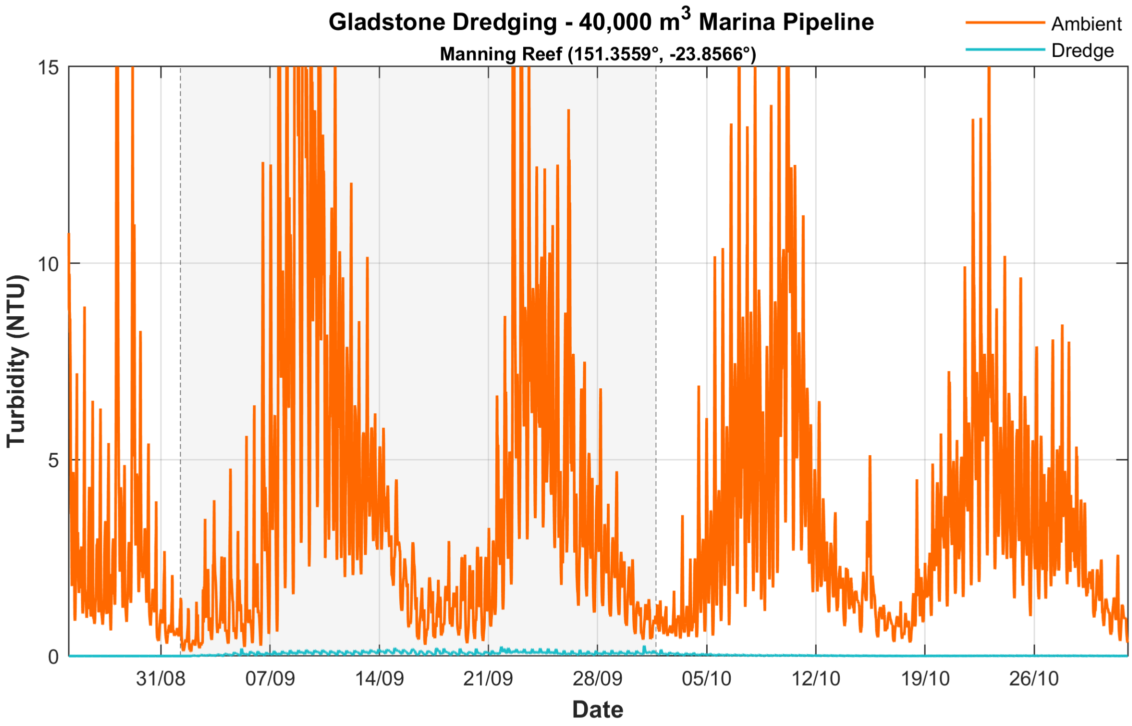


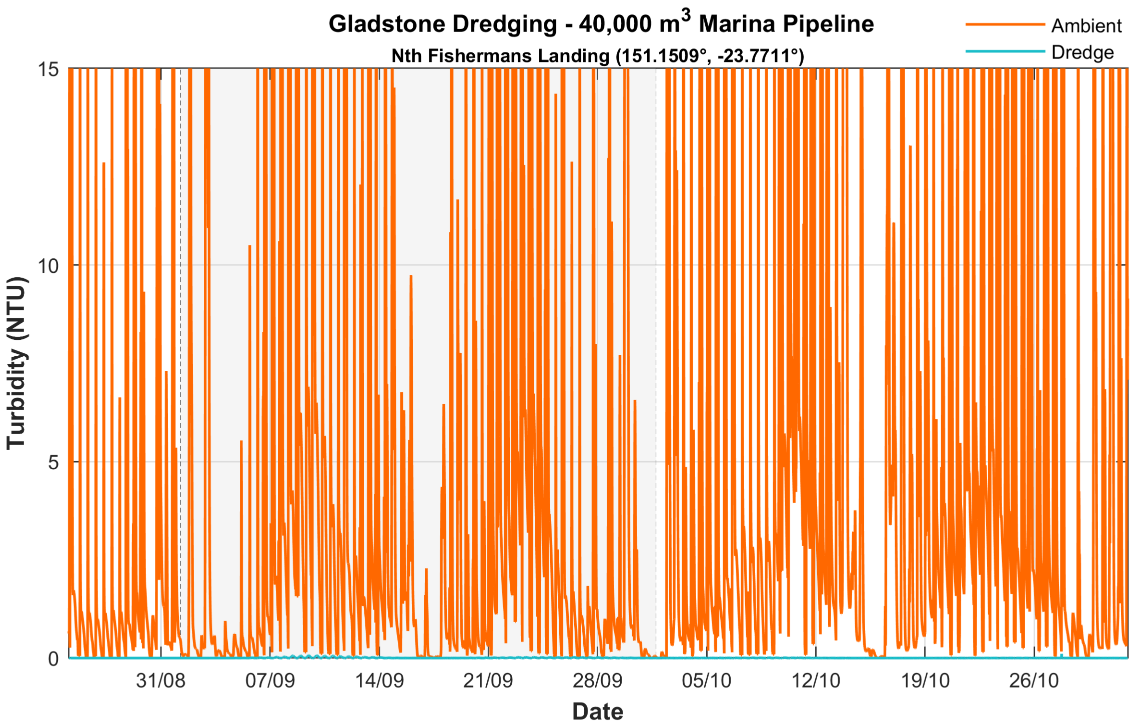

Gladstone Dredging - 40,000 m3 Marina Pipeline
China Bay (151.2023°, -23.7821°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 40,000 m3 Marina Pipeline
Friend Point (151.1605°, -23.7491°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 40,000 m3 Marina Pipeline
Gatcombe Head (151.3743°, -23.8817°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 40,000 m3 Marina Pipeline
GBRMP Boundary (151.4332°, -23.8585°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 40,000 m3 Marina Pipeline
Manning Reef (151.3559°, -23.8566°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 40,000 m3 Marina Pipeline
Nth Fishermans Landing (151.1509°, -23.7711°)
Ambient
Dredge
Turbidity (NTU)
0
5
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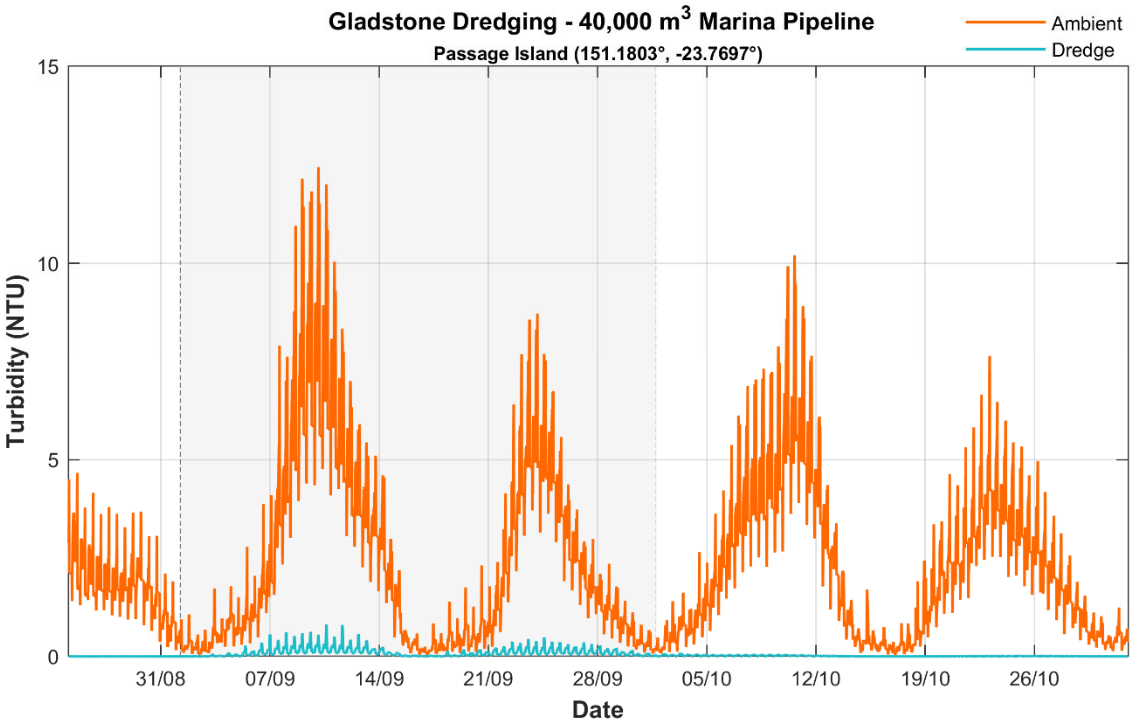
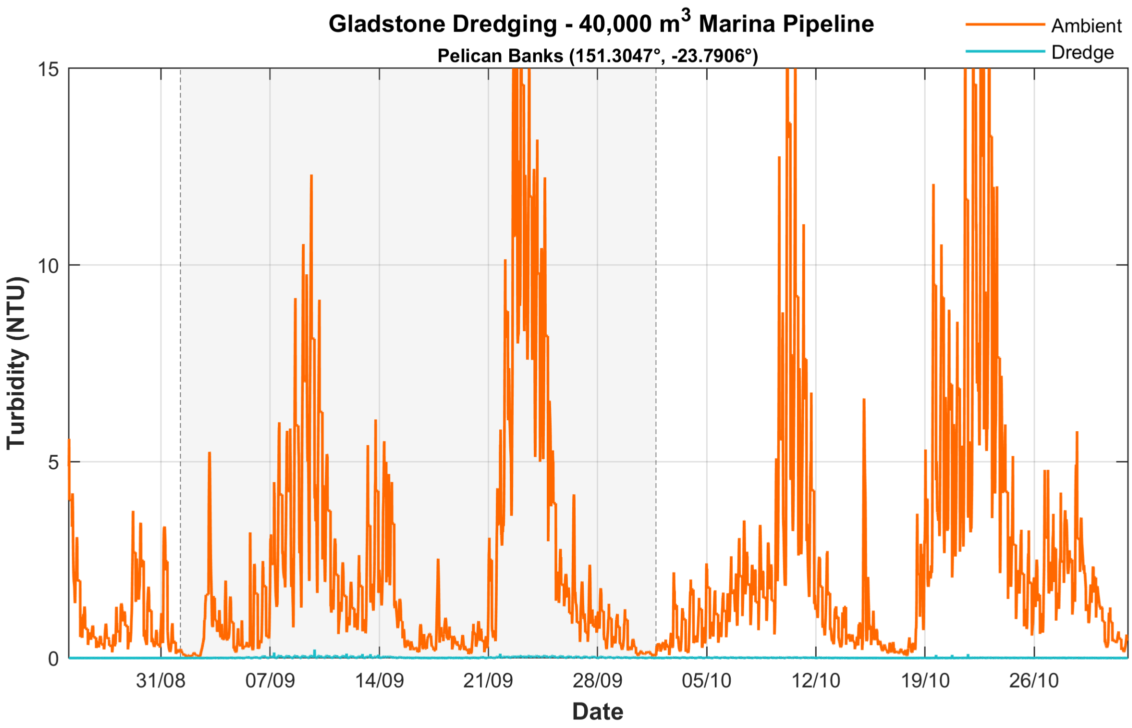
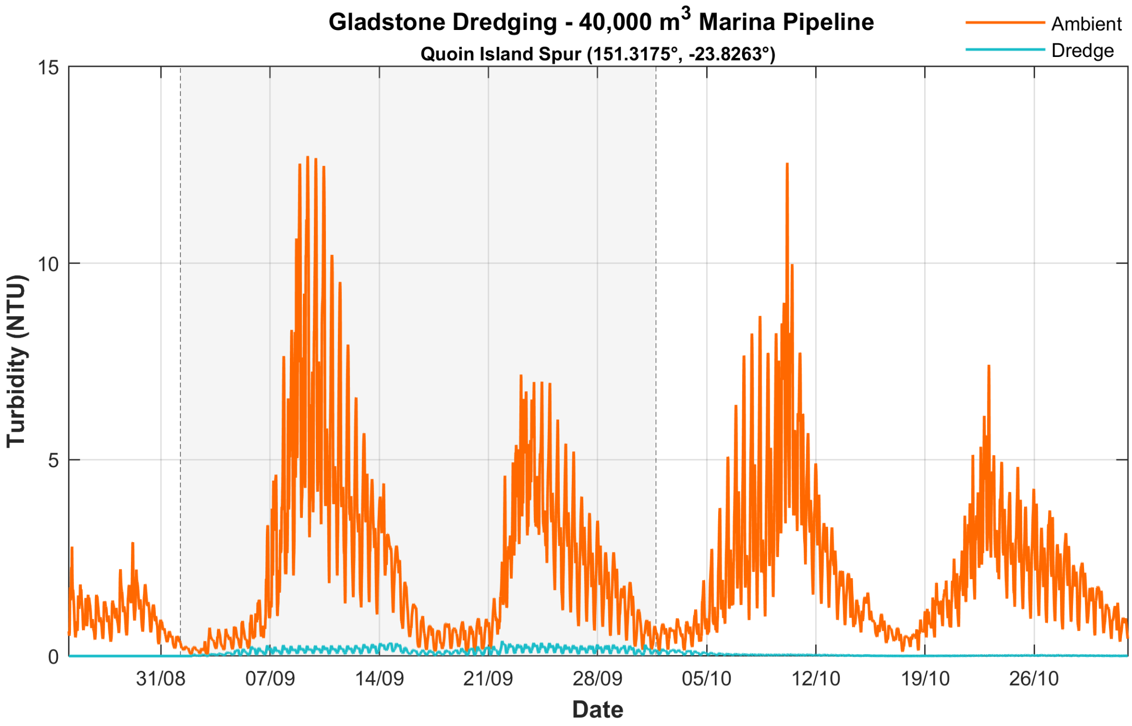
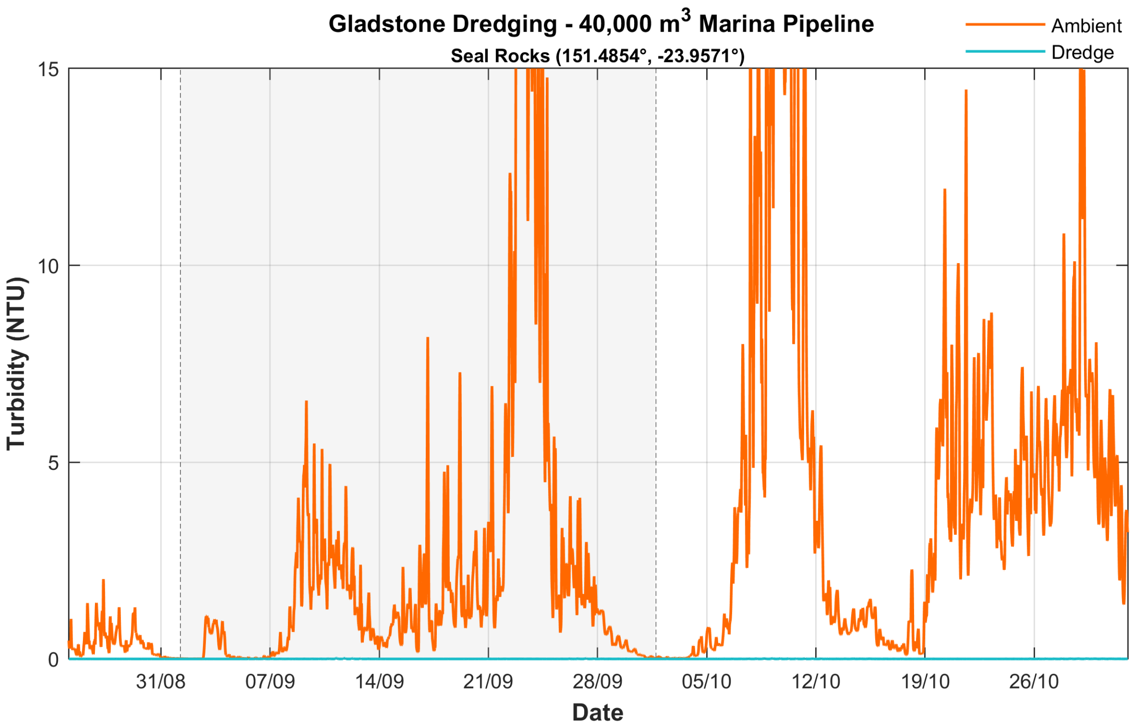
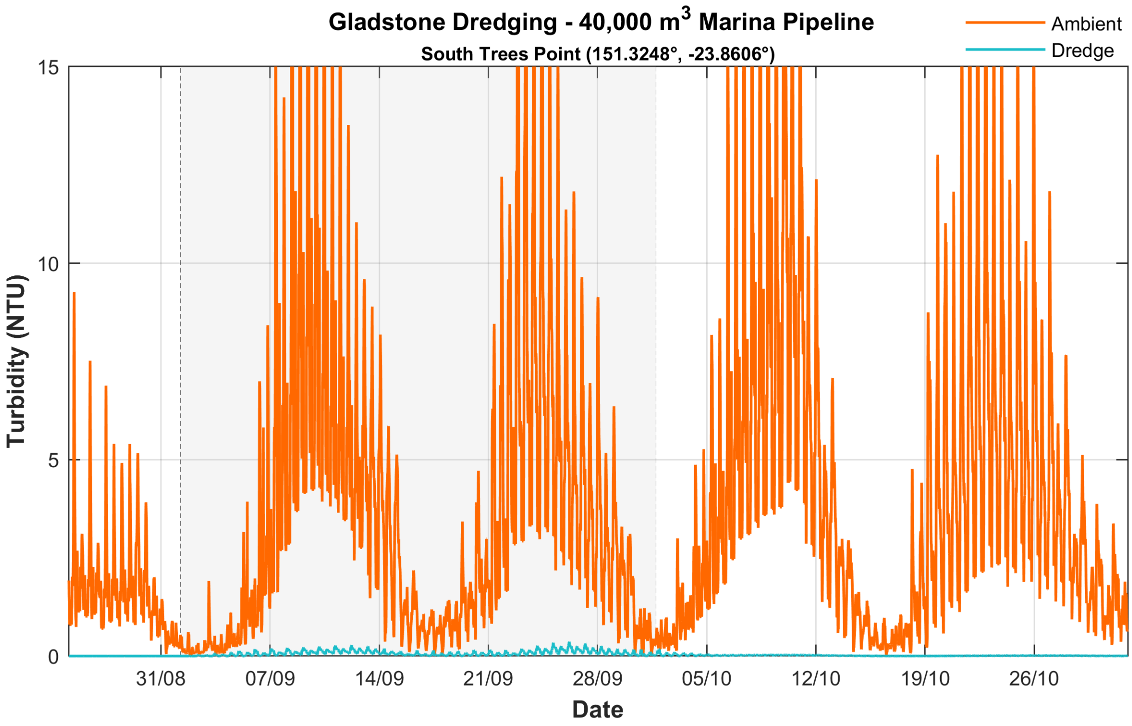
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

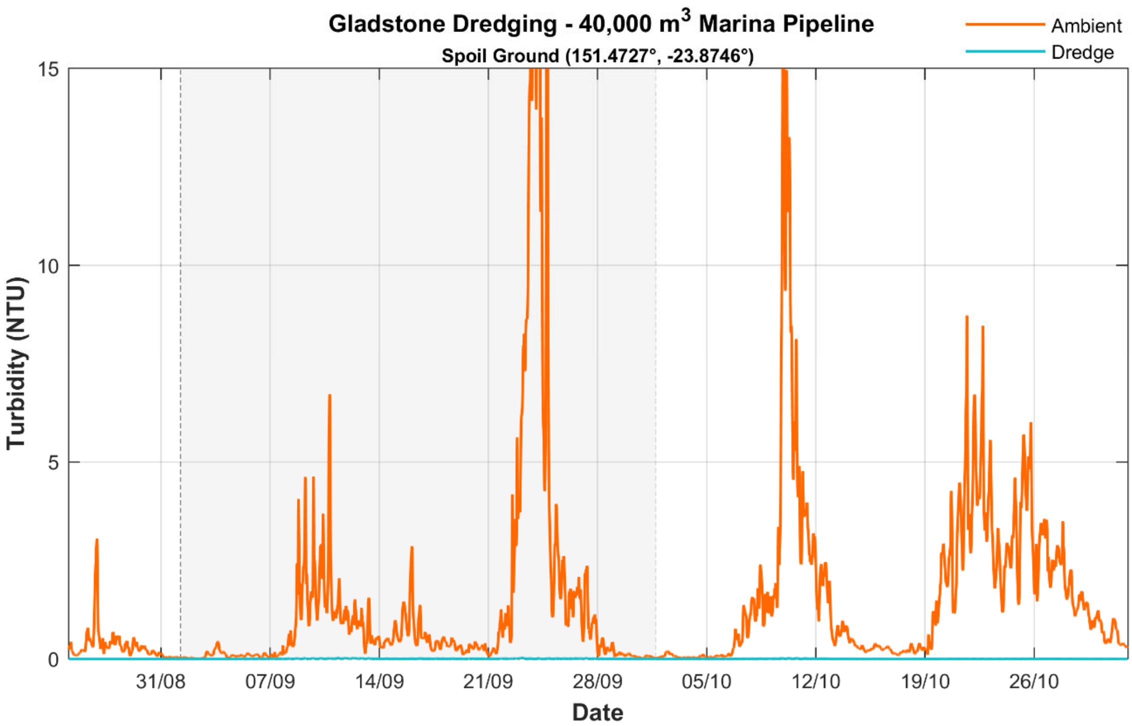

Gladstone Dredging - 40,000 m3 Marina Pipeline
Passage Island (151.1803°, -23.7697°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone Dredging - 40,000 m3 Marina Pipeline
Pelican Banks (151.3047°, -23.7906°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

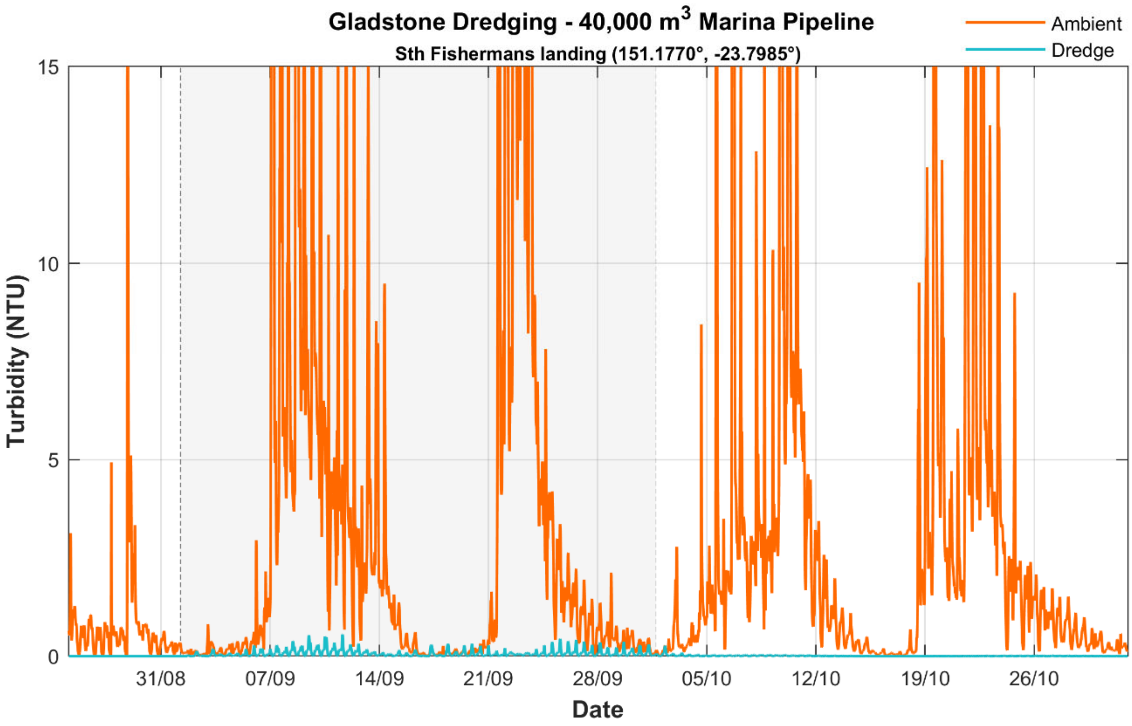

Gladstone Dredging - 40,000 m3 Marina Pipeline
Quoin Island Spur (151.3175°, -23.8263°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

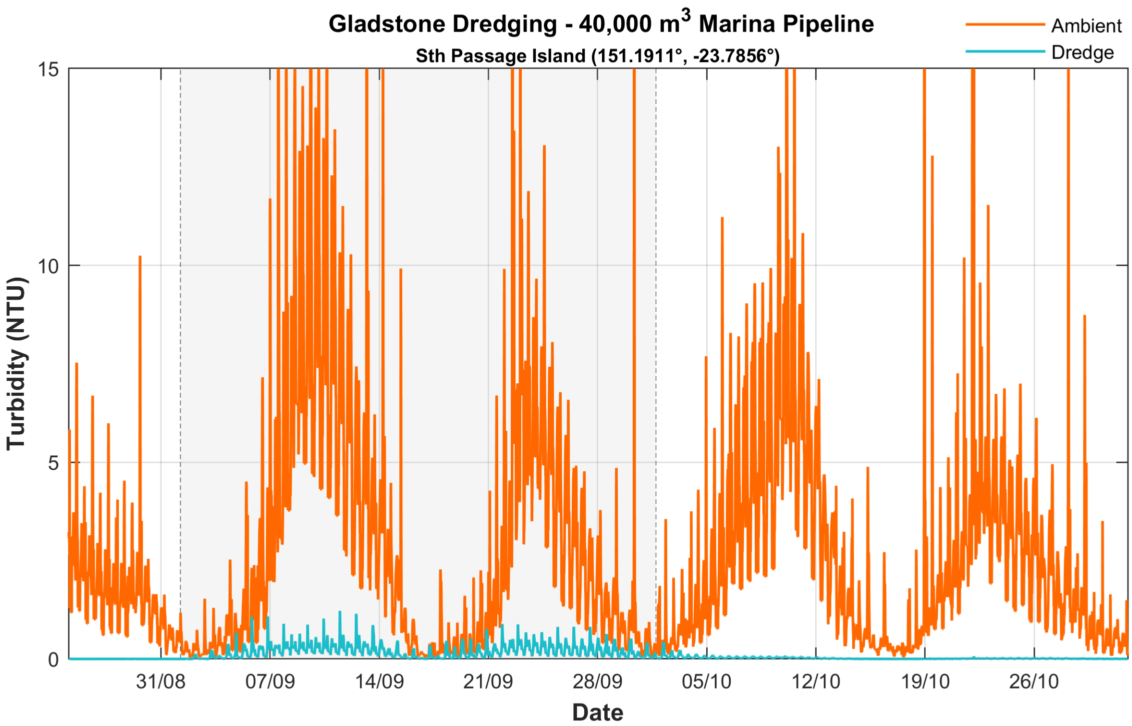

Gladstone Dredging - 40,000 m3 Marina Pipeline
Seal Rocks (151.4854°, -23.9571°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

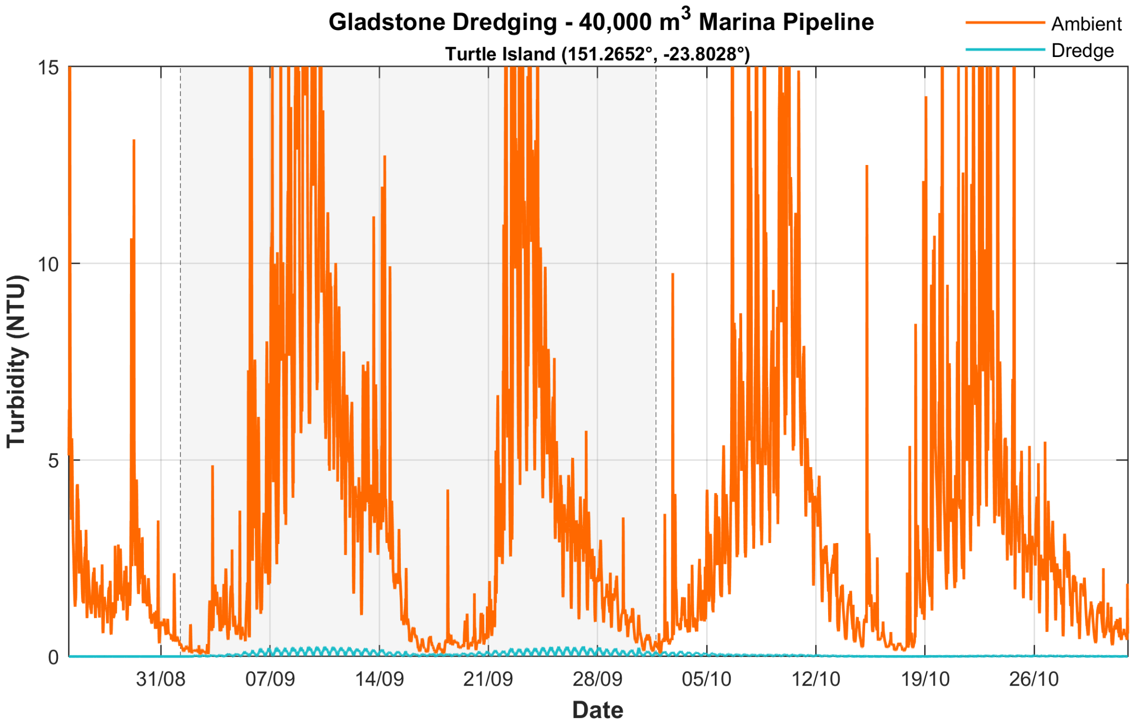

Gladstone Dredging - 40,000 m3 Marina Pipeline
South Trees Point (151.3248°, -23.8606°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

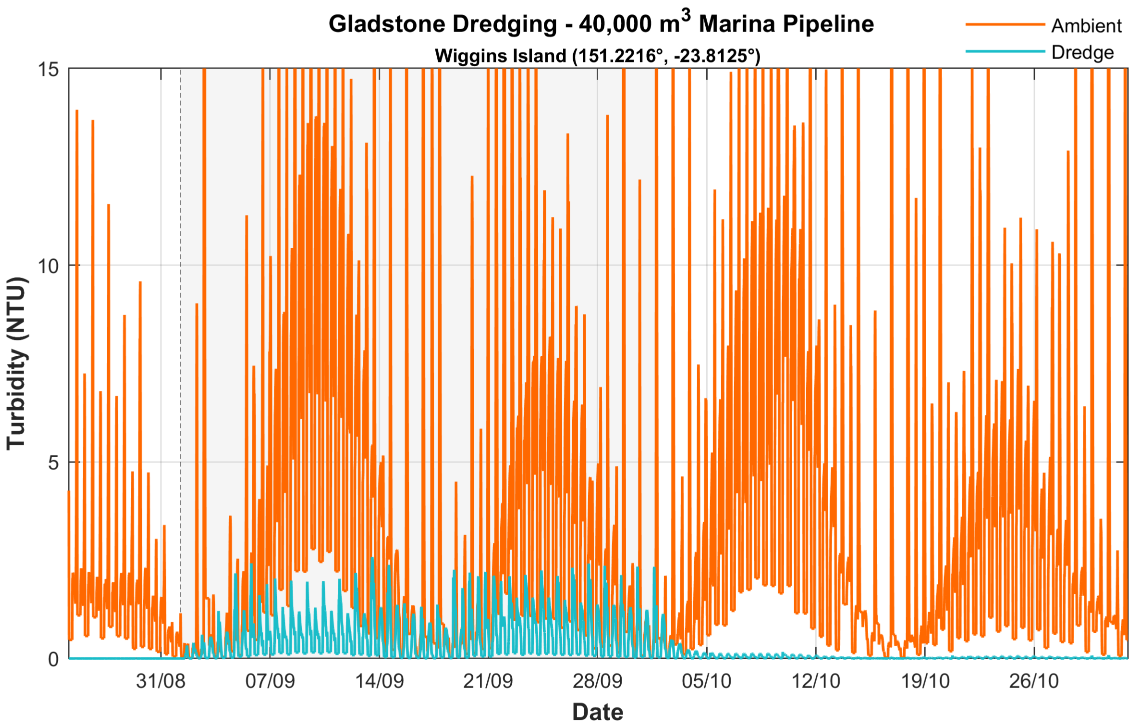

Gladstone Dredging - 40,000 m3 Marina Pipeline
Spoil Ground (151.4727°, -23.8746°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

Time Series of Modelled Turbidity

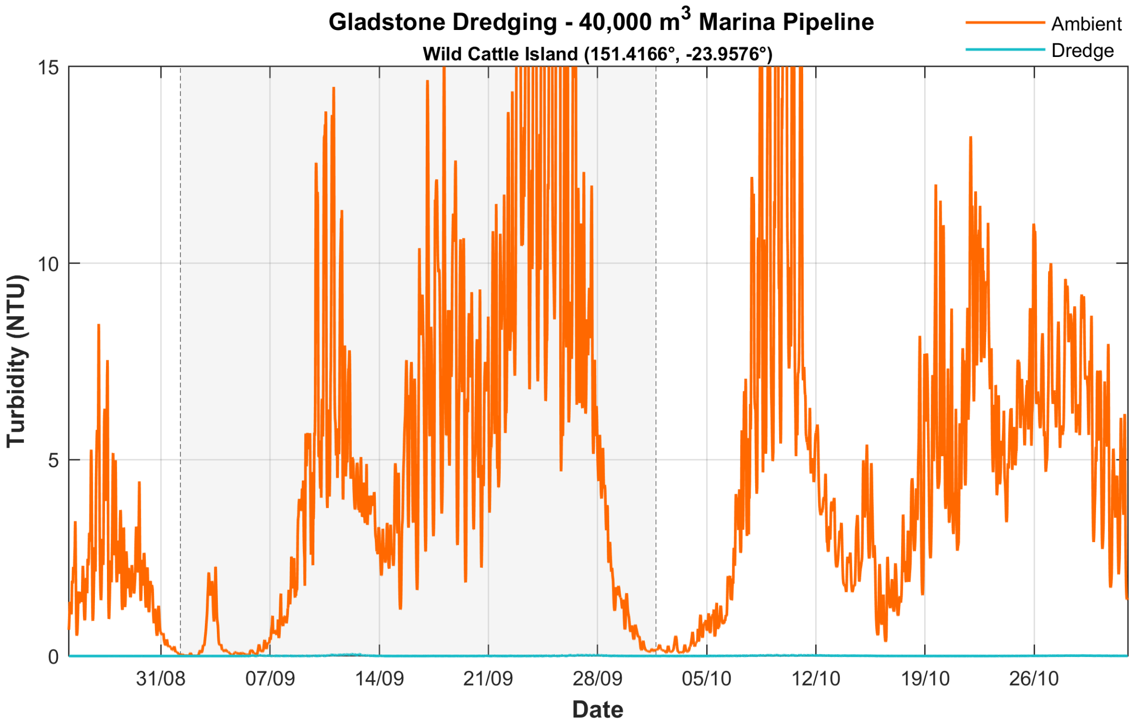




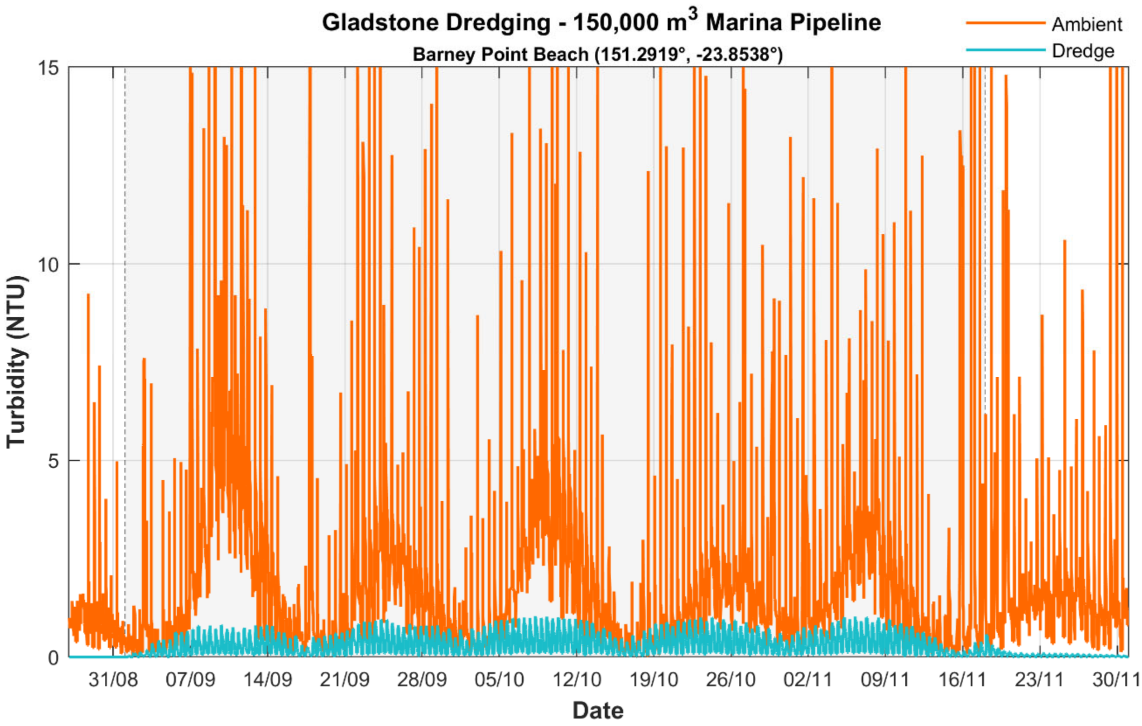

Gladstone Dredging - 40,000 m3 Marina Pipeline
Turtle Island (151.2652°, -23.8028°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

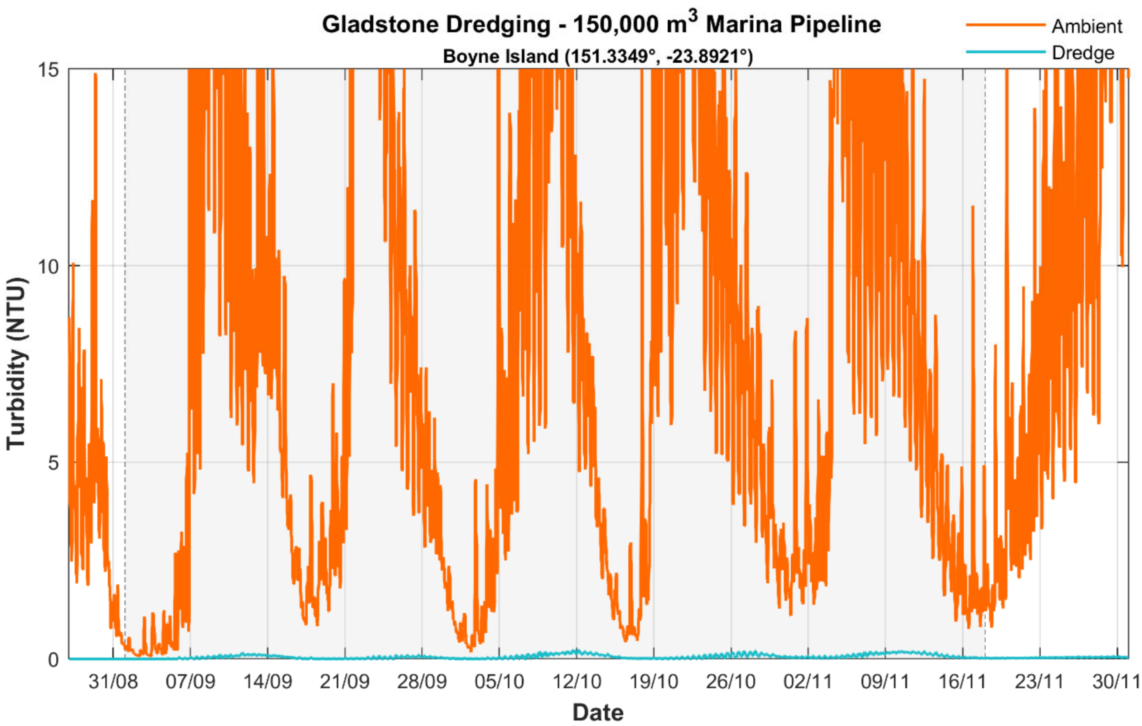

Gladstone Dredging - 40,000 m3 Marina Pipeline
Wiggins Island (151.2216°, -23.8125°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

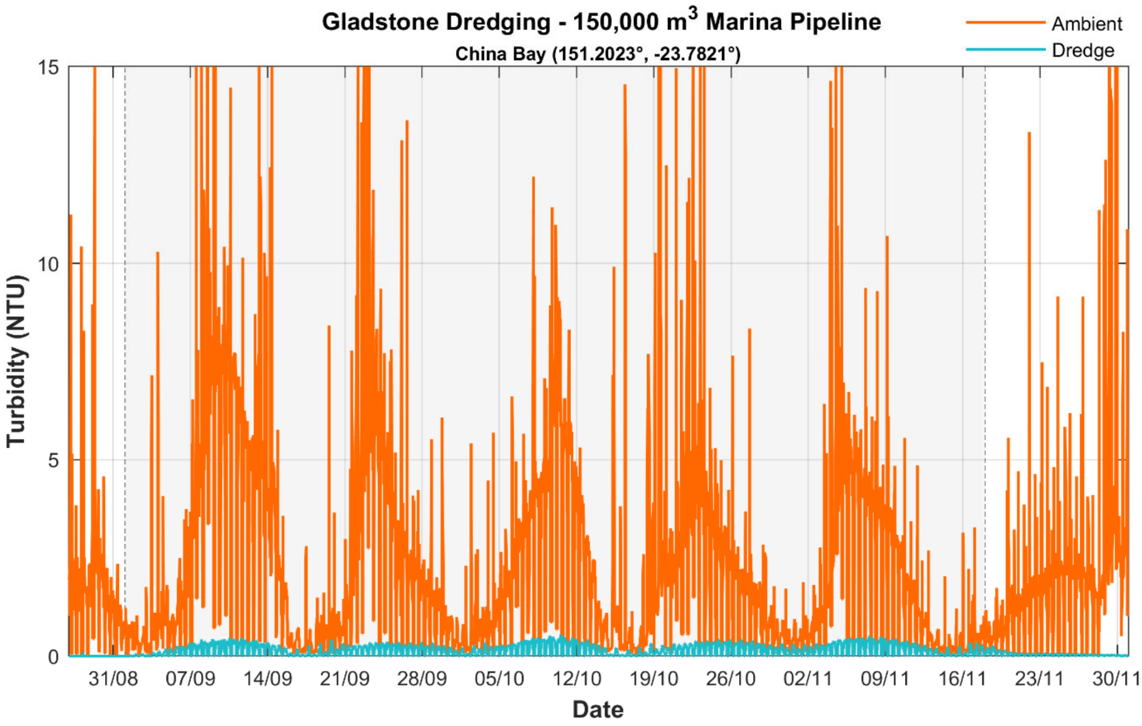
Time Series of Modelled Turbidity

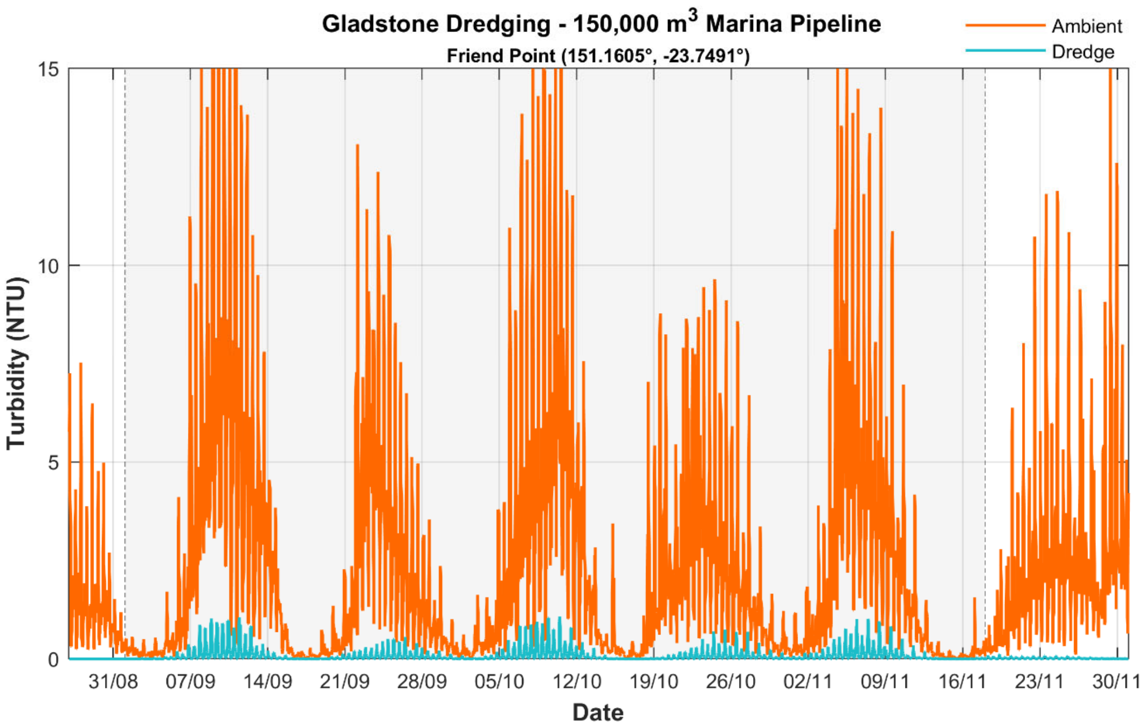


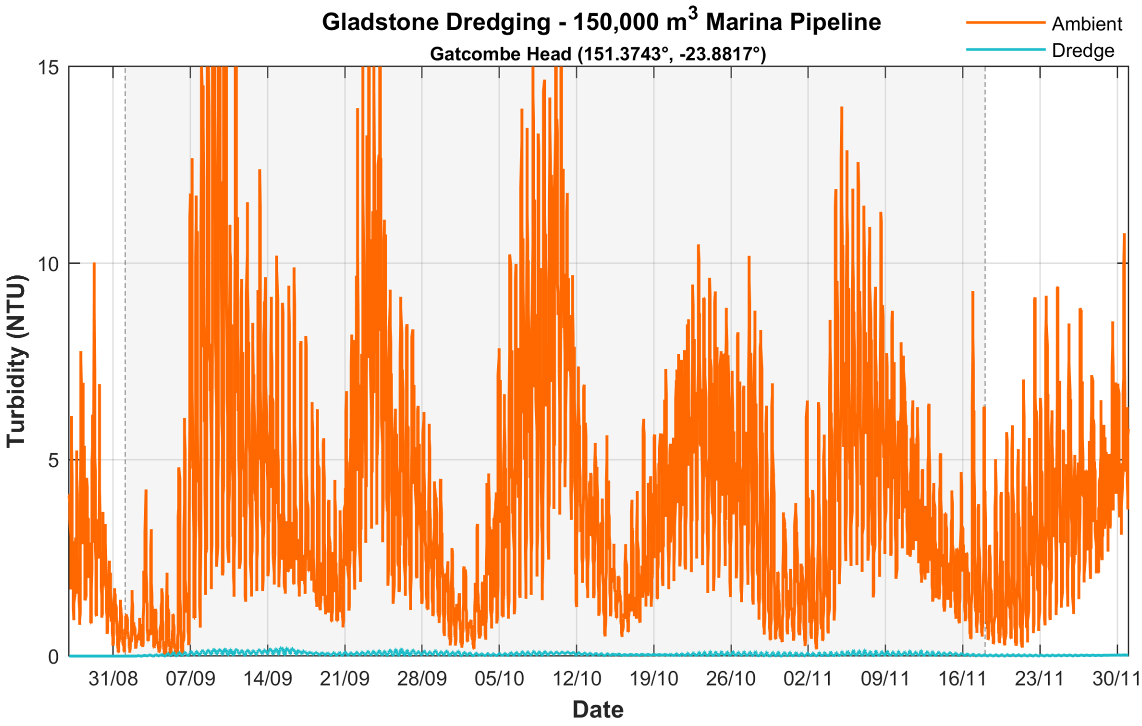
C.3 150,000m³ CSD Campaign with In-Channel Placement Results

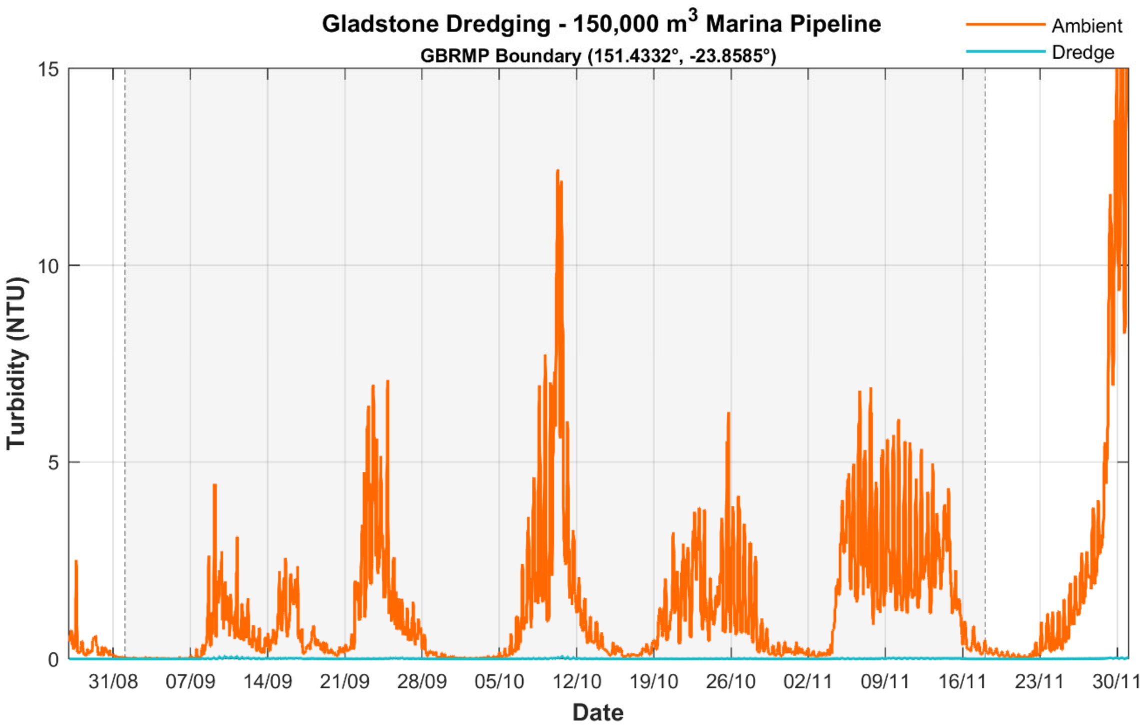




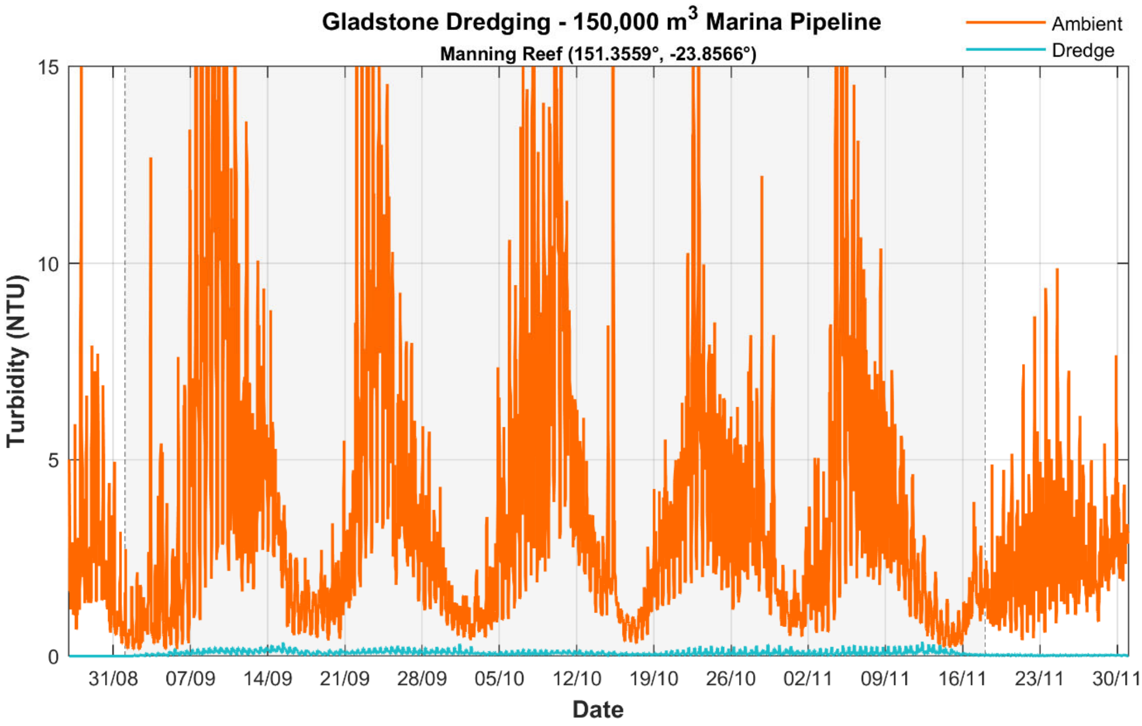

Gladstone Dredging - 150,000 m3 Marina Pipeline
China Bay (151.2023°, -23.7821°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

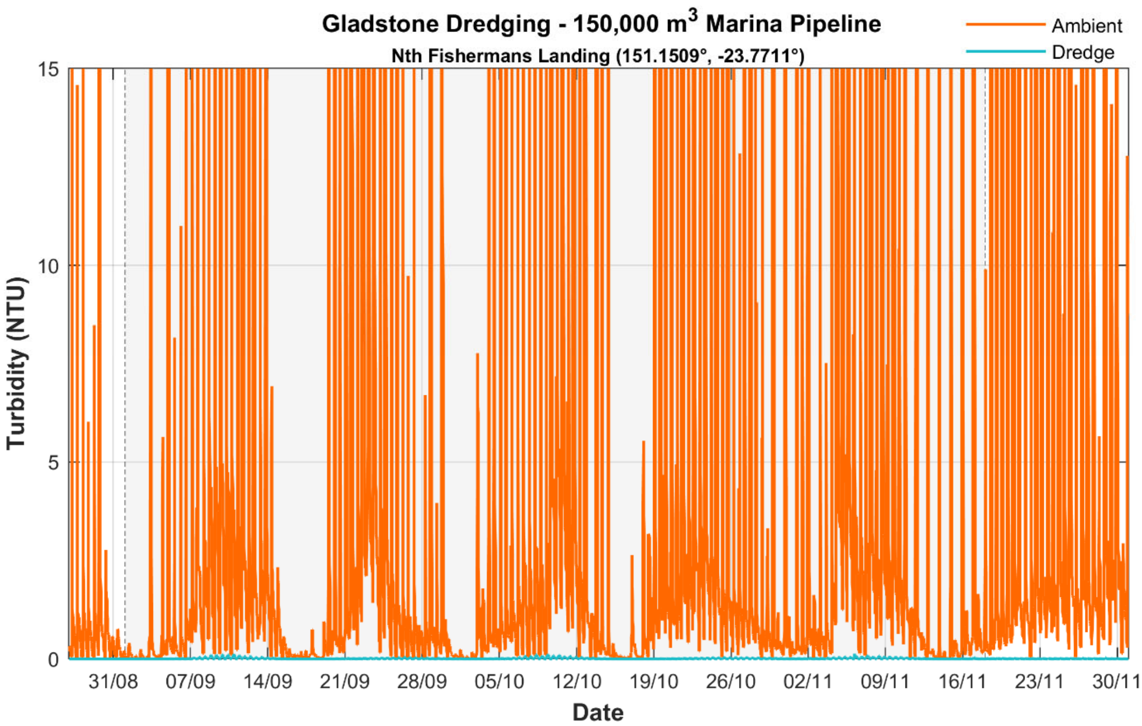

Gladstone Dredging - 150,000 m3 Marina Pipeline
Friend Point (151.1605°, -23.7491°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

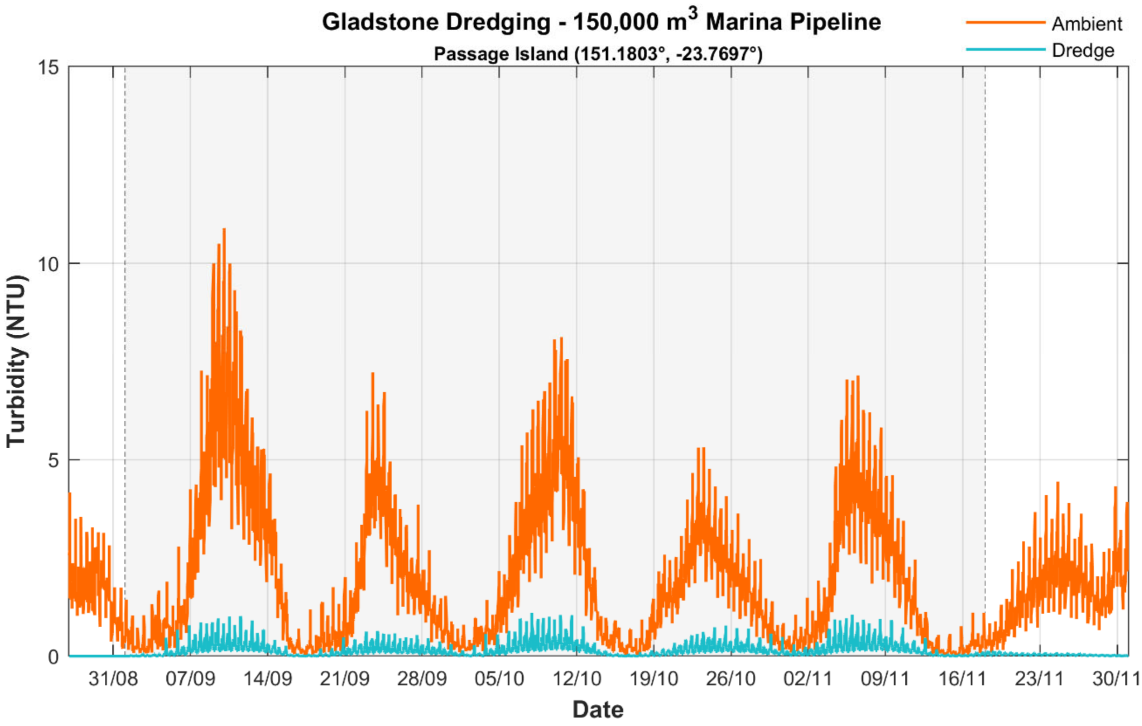

Gladstone Dredging - 150,000 m3 Marina Pipeline
Gatcombe Head (151.3743°, -23.8817°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

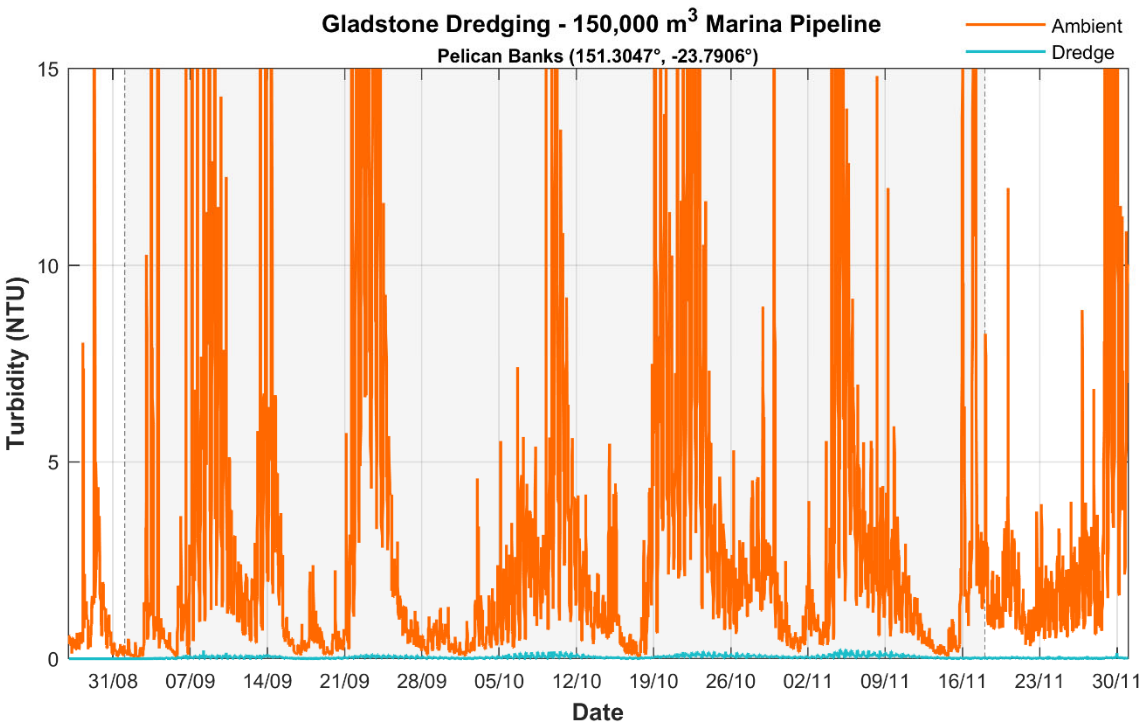

Gladstone Dredging - 150,000 m3 Marina Pipeline
GBRMP Boundary (151.4332°, -23.8585°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

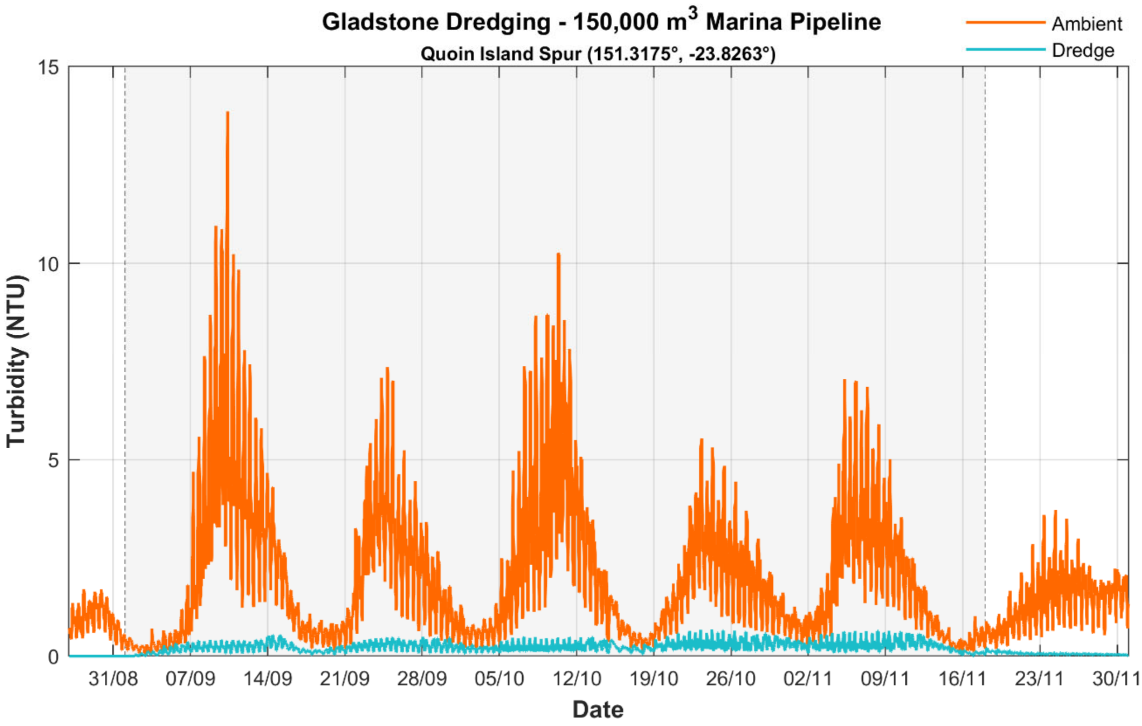
Time Series of Modelled Turbidity

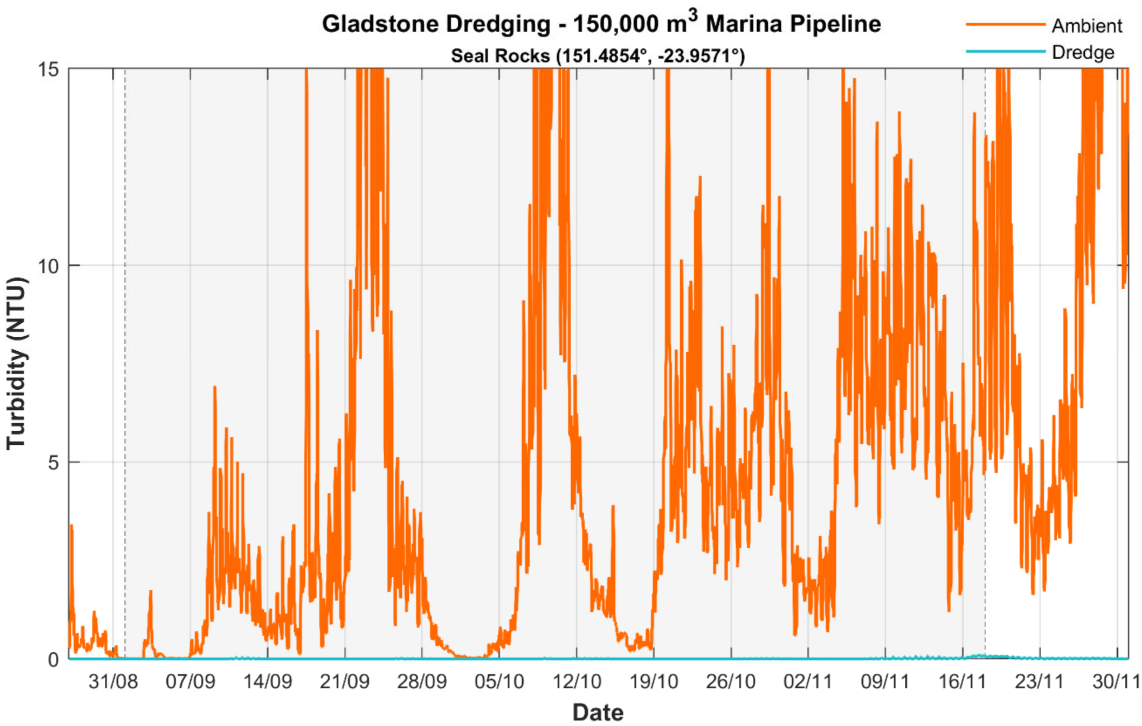


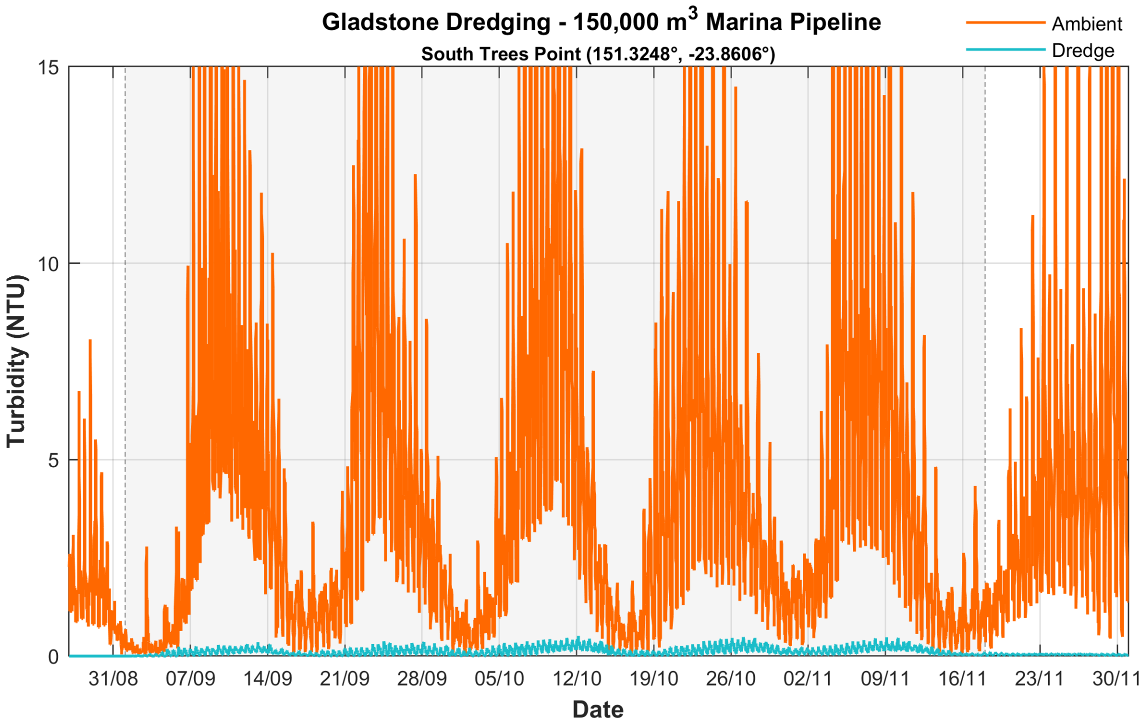


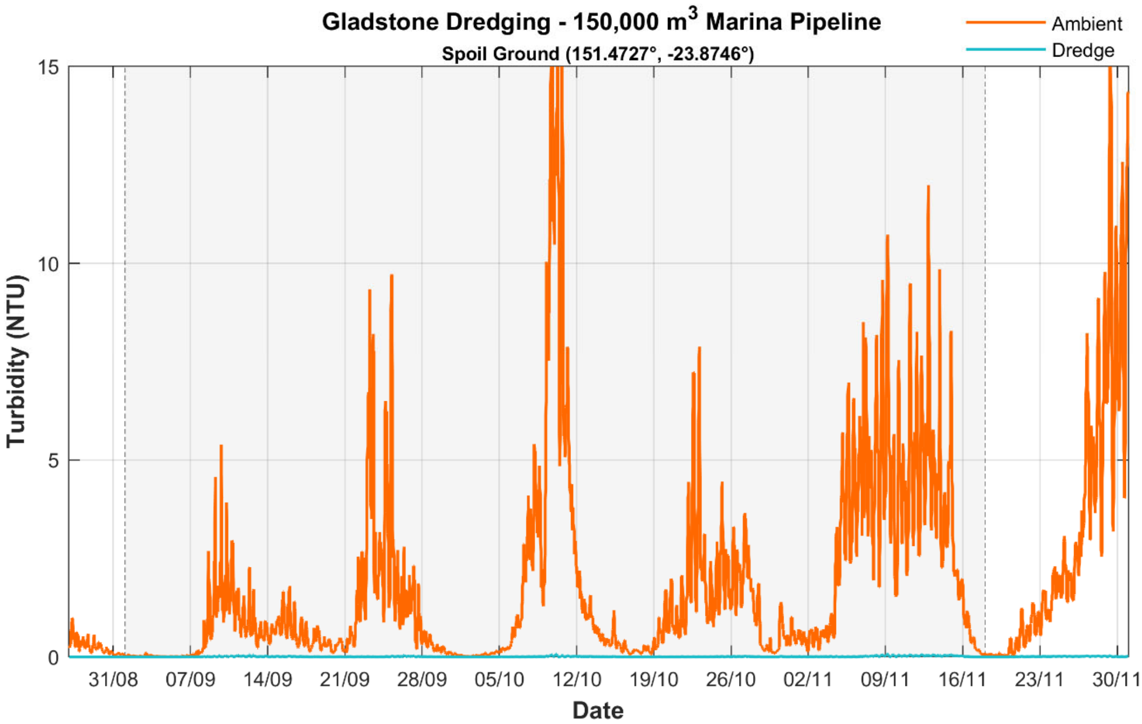

Gladstone Dredging - 150,000 m3 Marina Pipeline
Passage Island (151.1803°, -23.7697°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

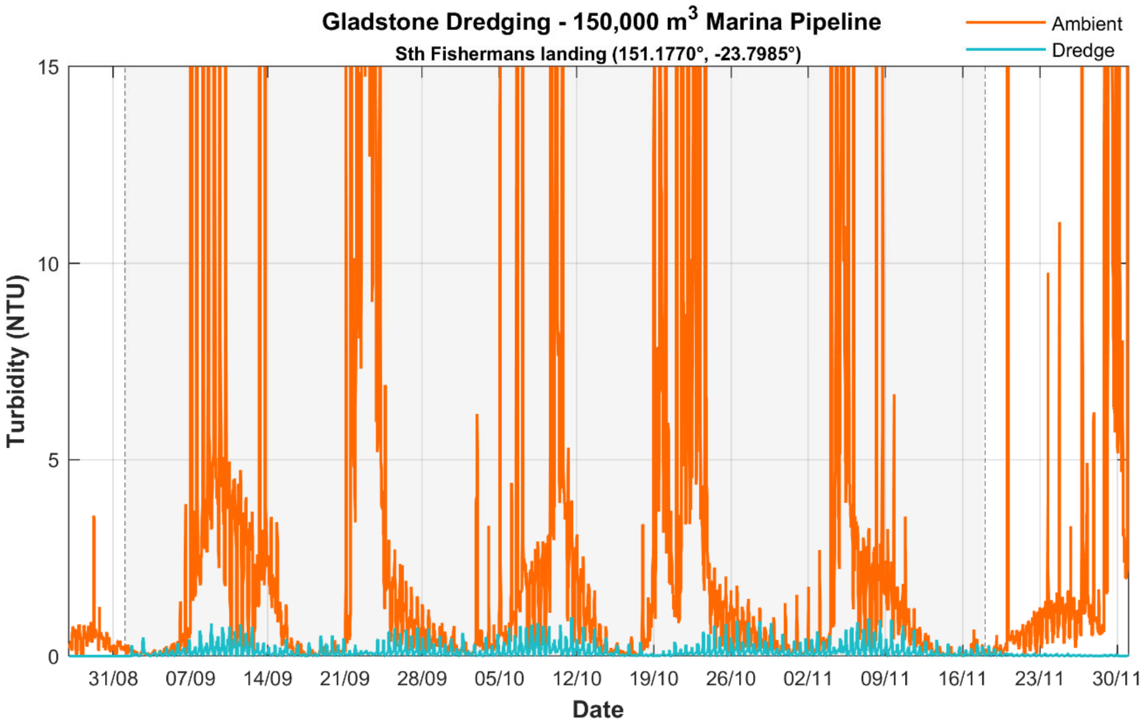

Gladstone Dredging - 150,000 m3 Marina Pipeline
Pelican Banks (151.3047°, -23.7906°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

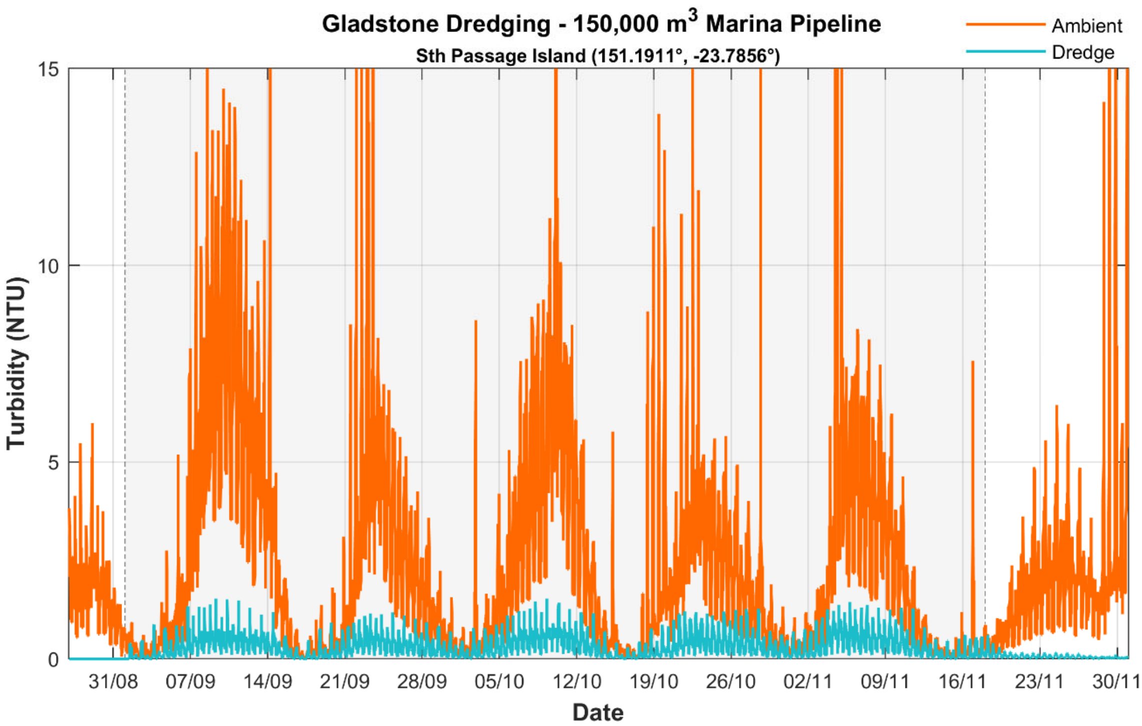

Gladstone Dredging - 150,000 m3 Marina Pipeline
Quoin Island Spur (151.3175°, -23.8263°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

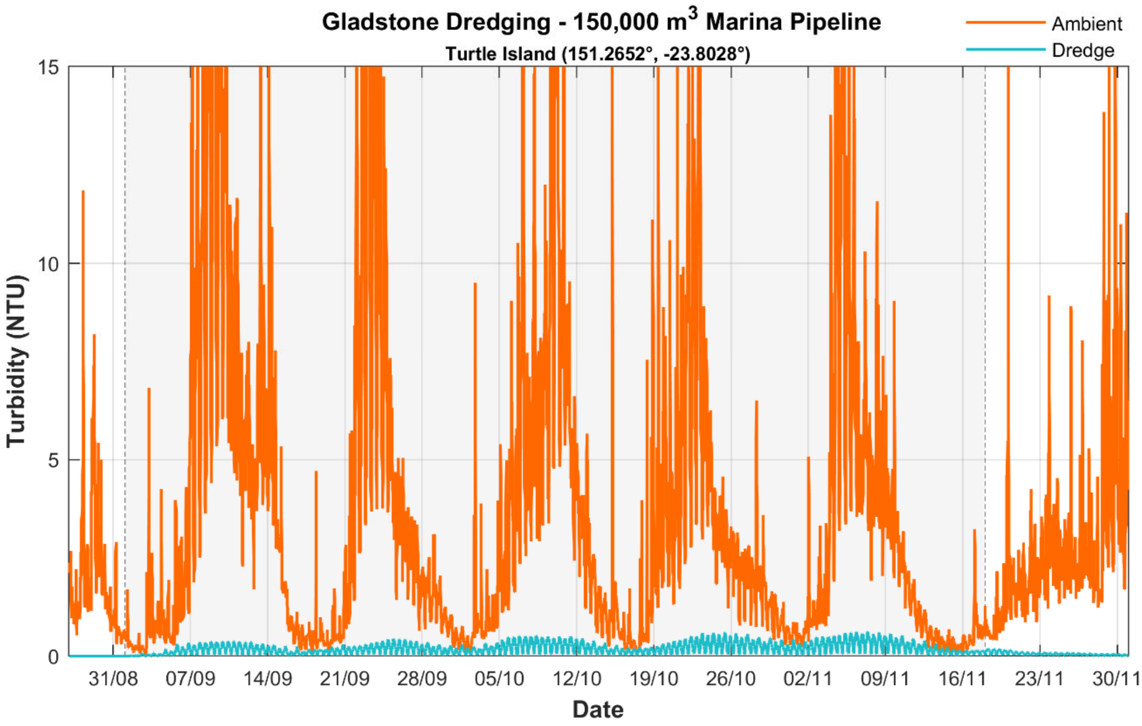

Gladstone Dredging - 150,000 m3 Marina Pipeline
Seal Rocks (151.4854°, -23.9571°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

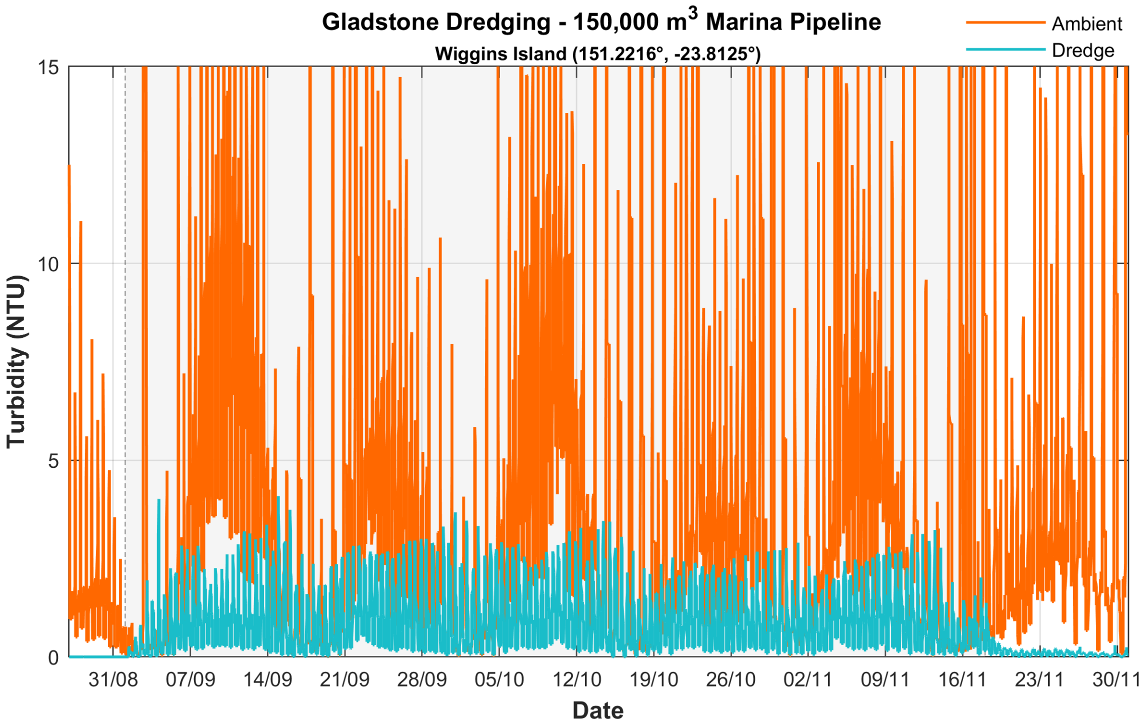

Gladstone Dredging - 150,000 m3 Marina Pipeline
South Trees Point (151.3248°, -23.8606°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date


Gladstone Dredging - 150,000 m3 Marina Pipeline
Spoil Ground (151.4727°, -23.8746°)
Ambient
Dredge
Turbidity (NTU)
0
5
10
15
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

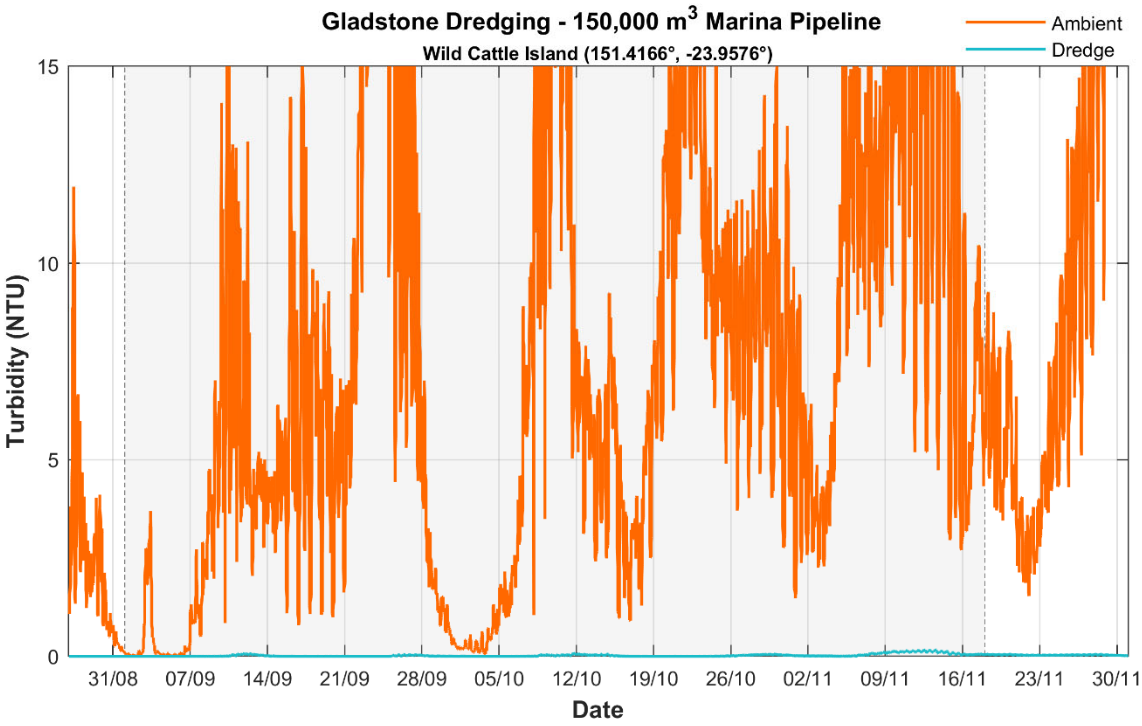

Gladstone Dredging - 150,000 m3 Marina Pipeline
Sth Fishermans landing (151.1770°, -23.7985°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date


Gladstone Dredging - 150,000 m3 Marina Pipeline
Sth Passage Island (151.1911°, -23.7856°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date


Gladstone Dredging - 150,000 m3 Marina Pipeline
Turtle Island (151.2652°, -23.8028°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

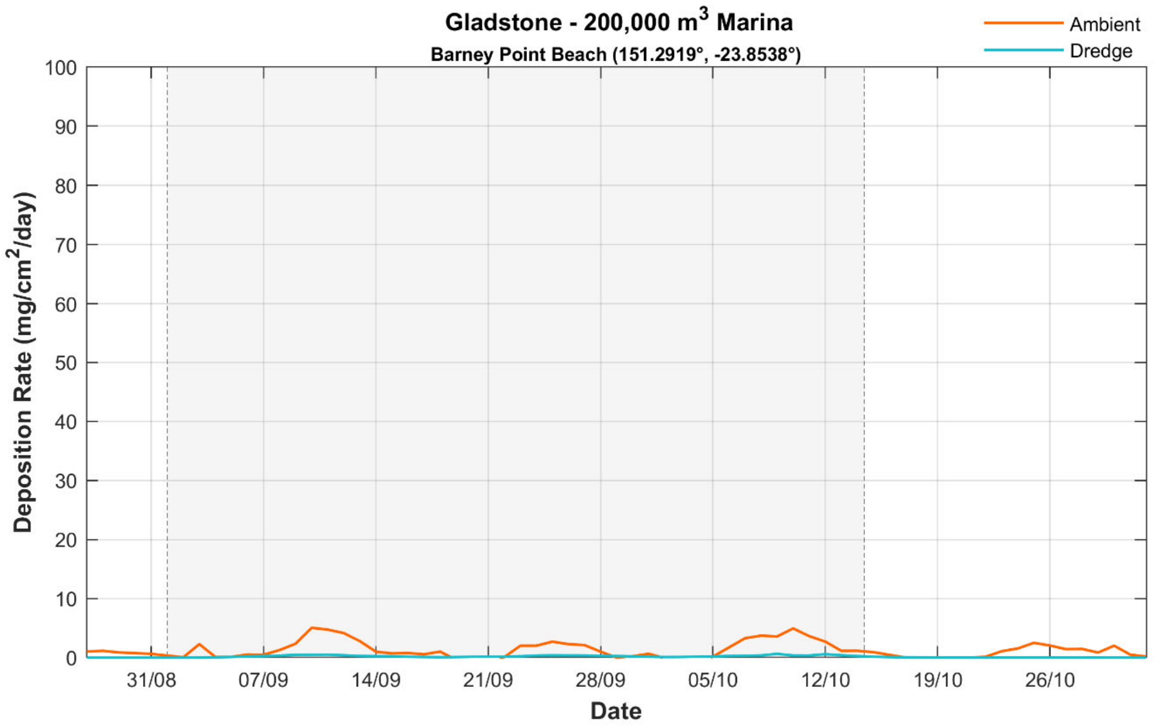

Gladstone Dredging - 150,000 m3 Marina Pipeline
Wiggins Island (151.2216°, -23.8125°)
Ambient
Dredge
Turbidity (NTU)
15
10
5
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

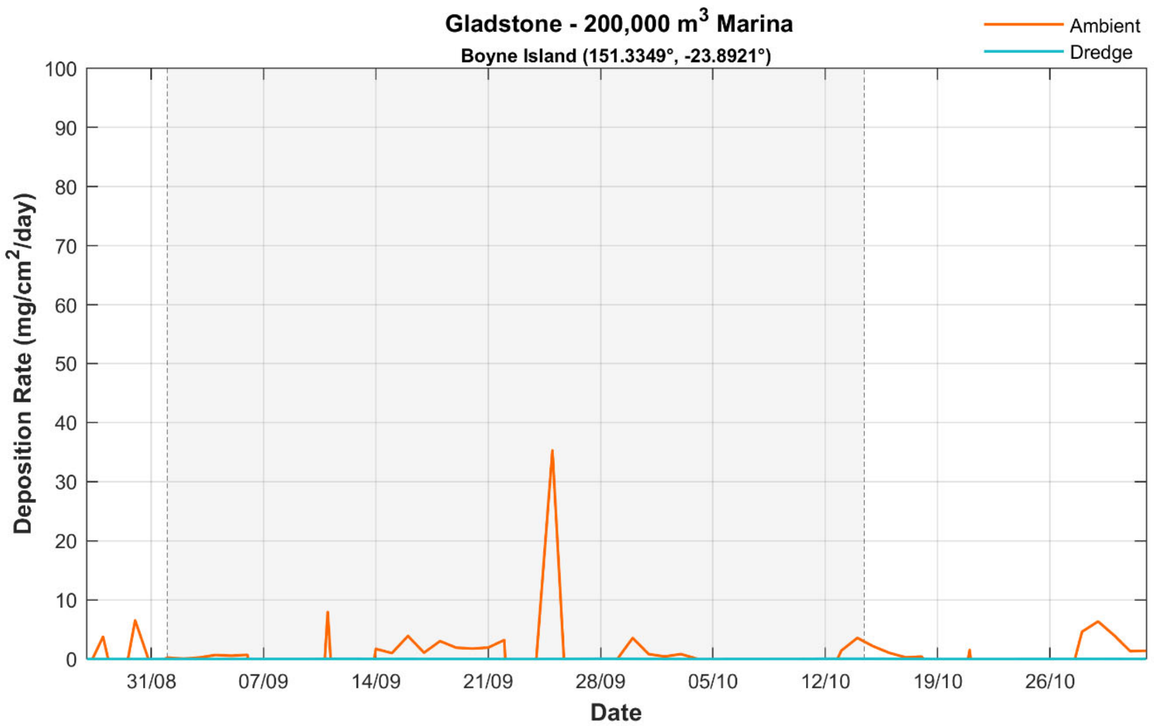
Time Series of Modelled Turbidity



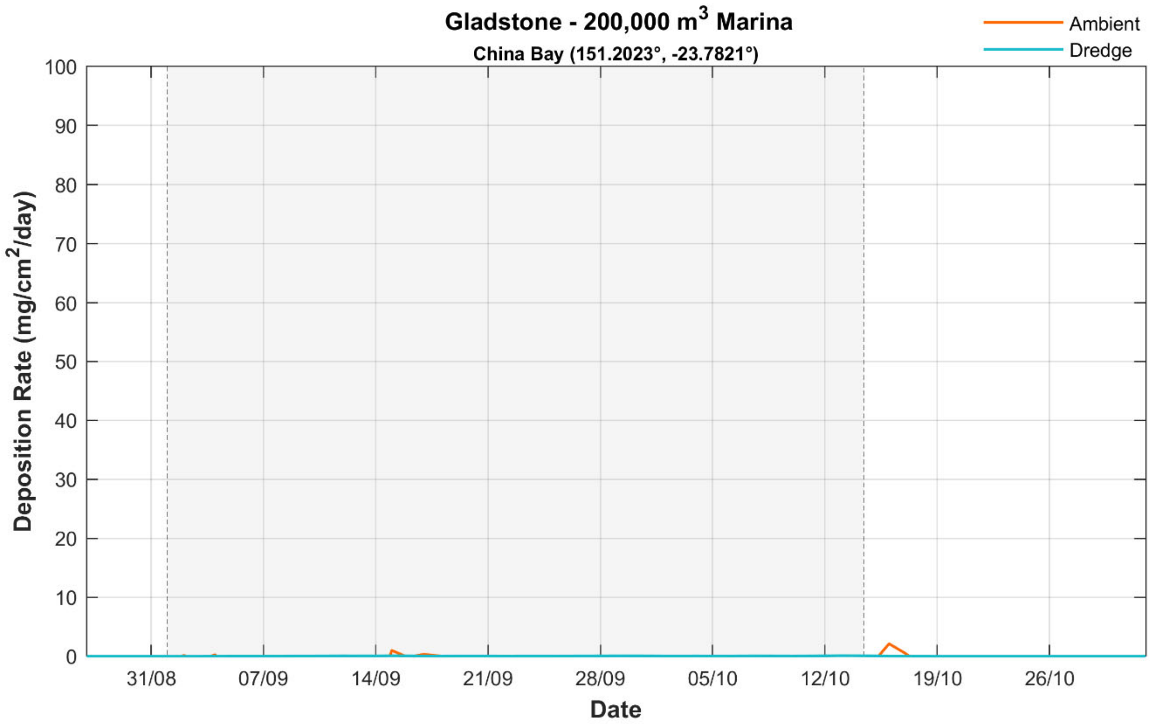
Appendix D Time Series of Modelled Deposition Rate

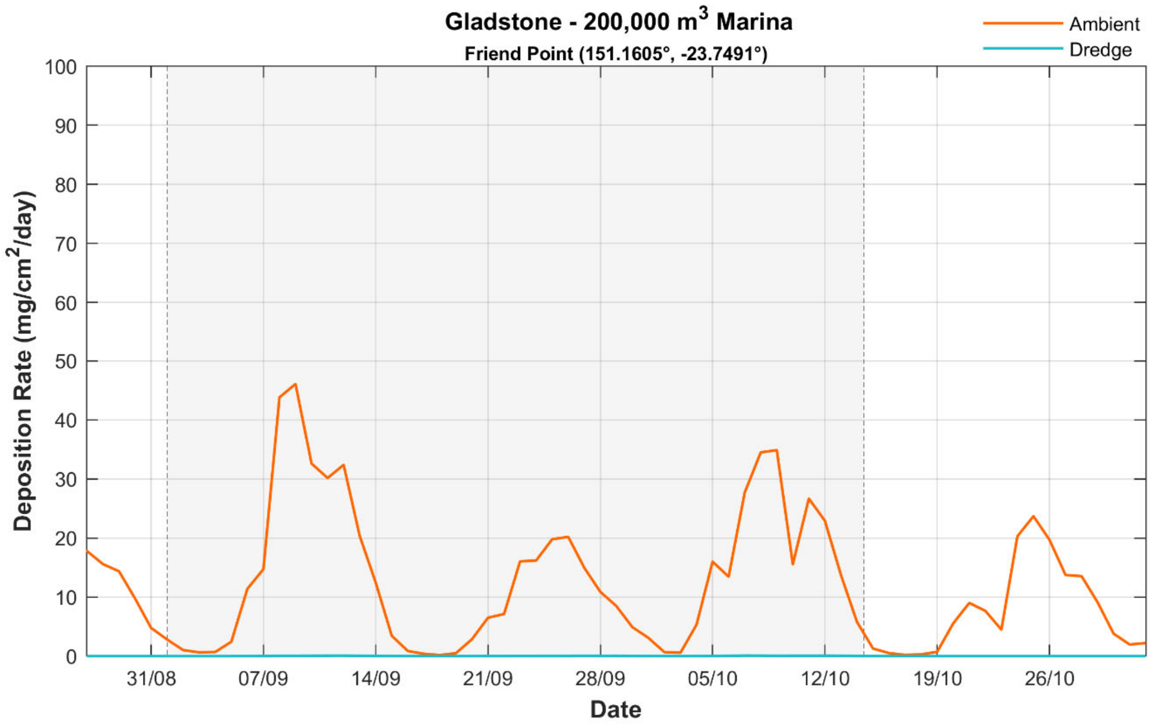
D.1 200,000m³ TSHD Campaign with Placement at EBSDS Results



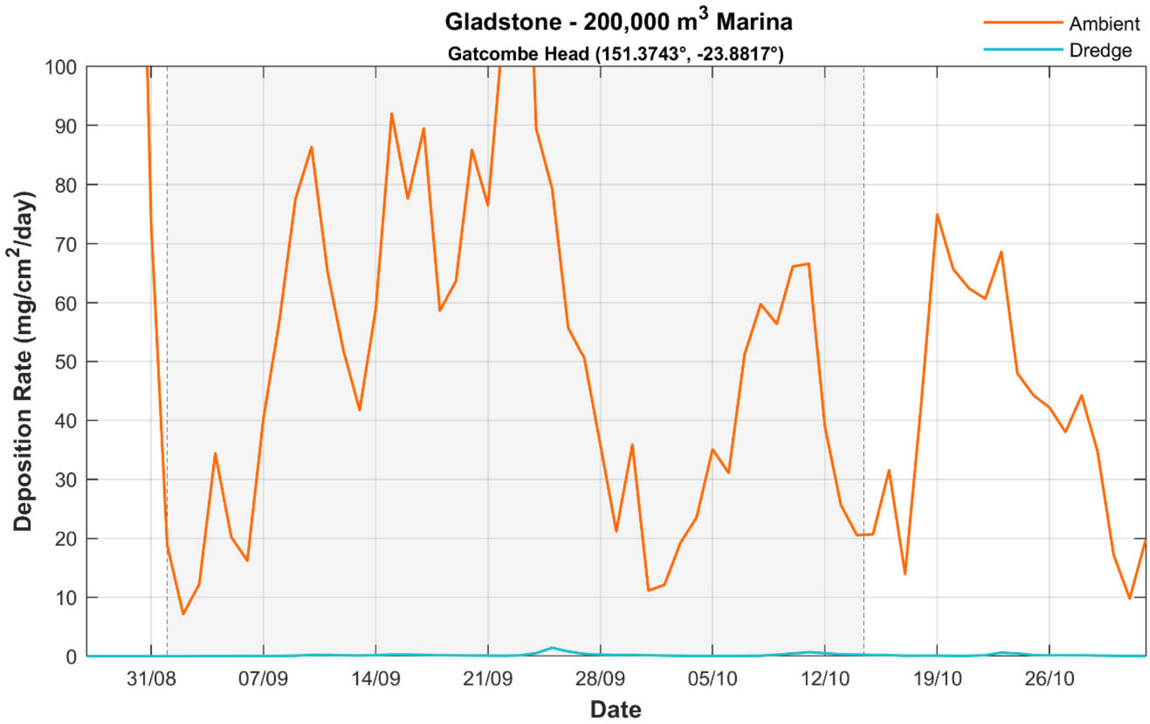


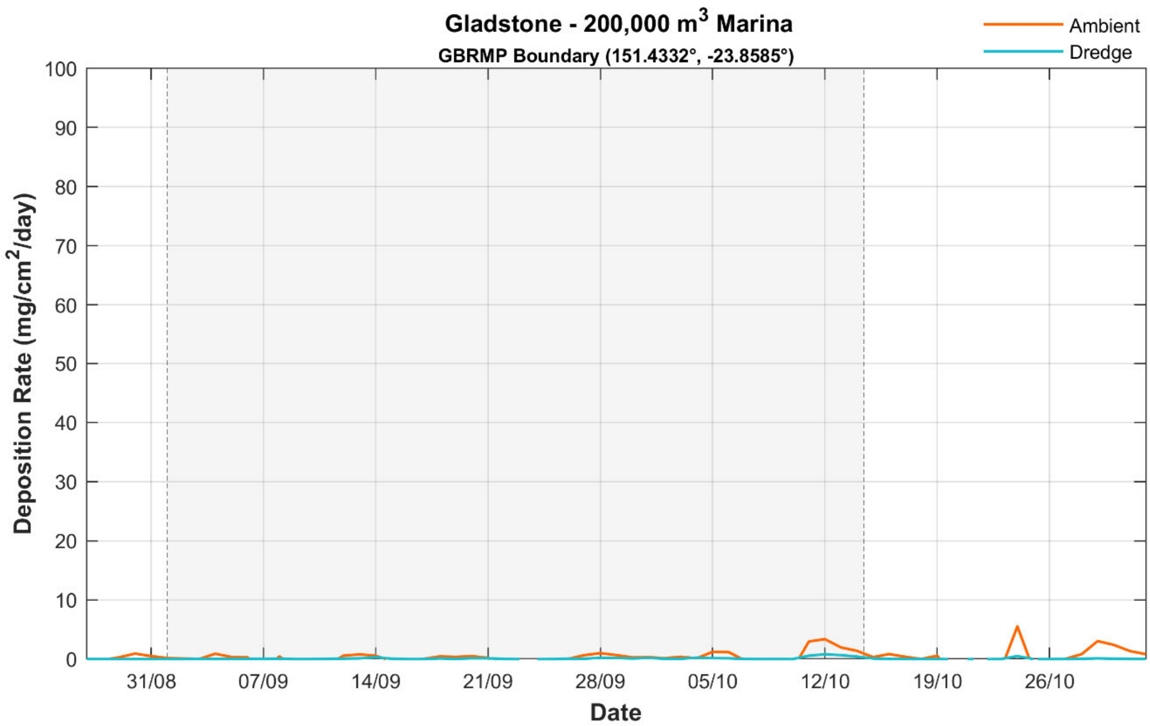
Time Series of Modelled Deposition Rate

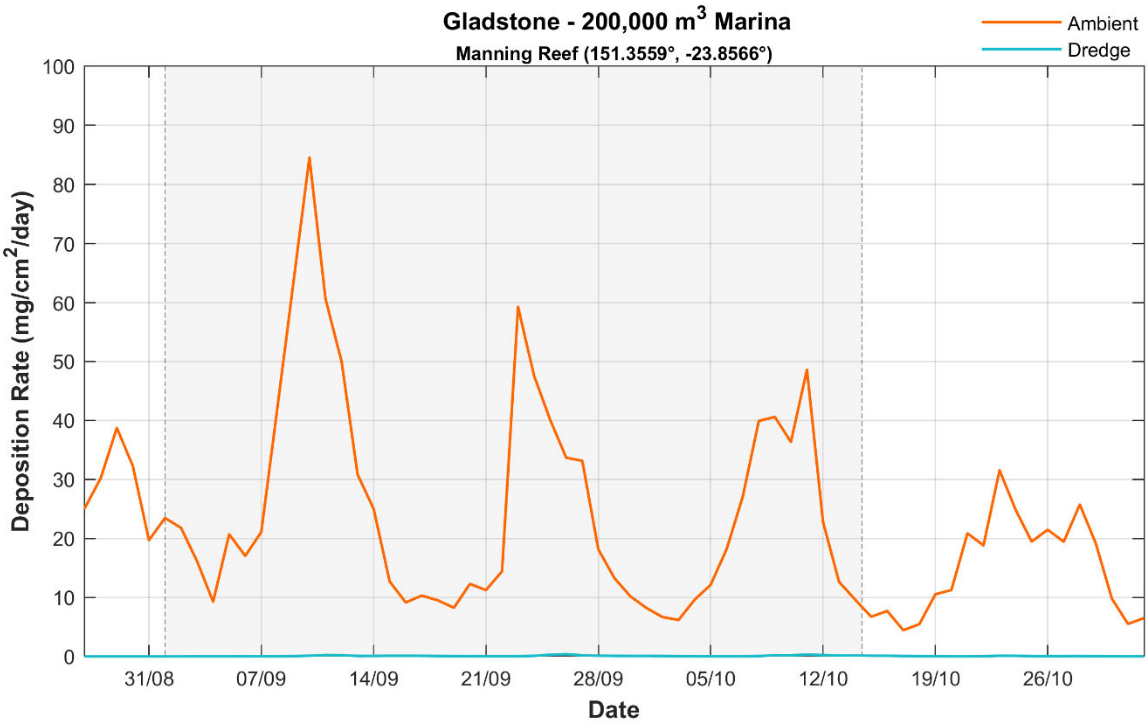


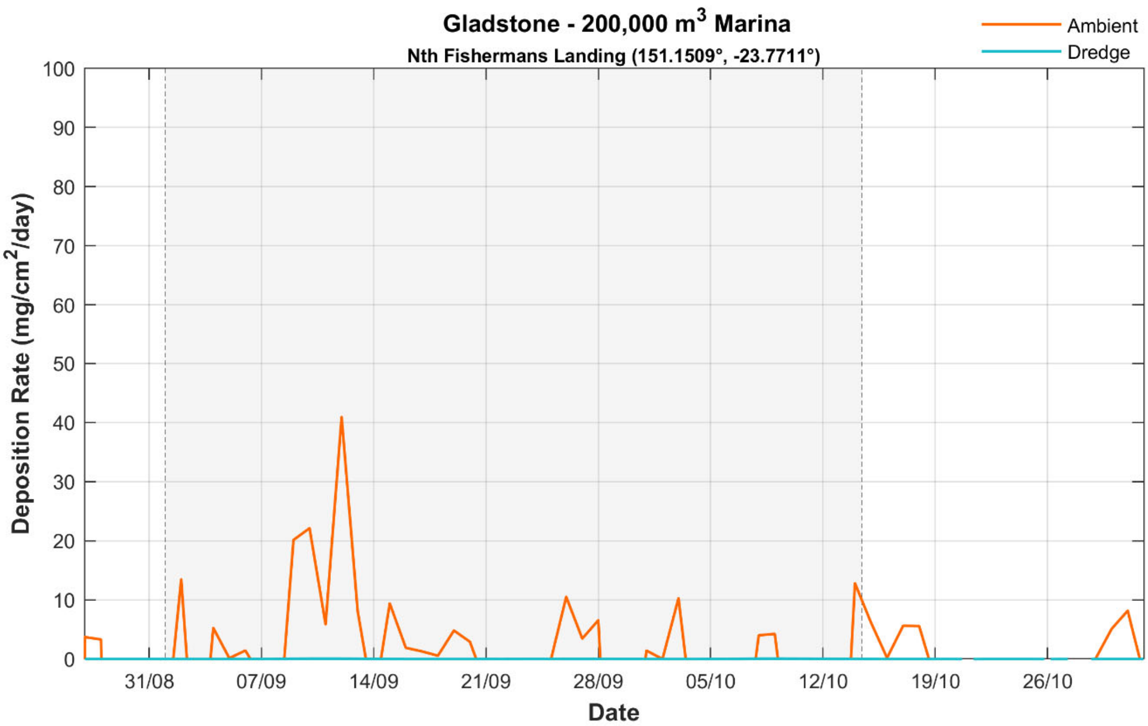


Time Series of Modelled Deposition Rate

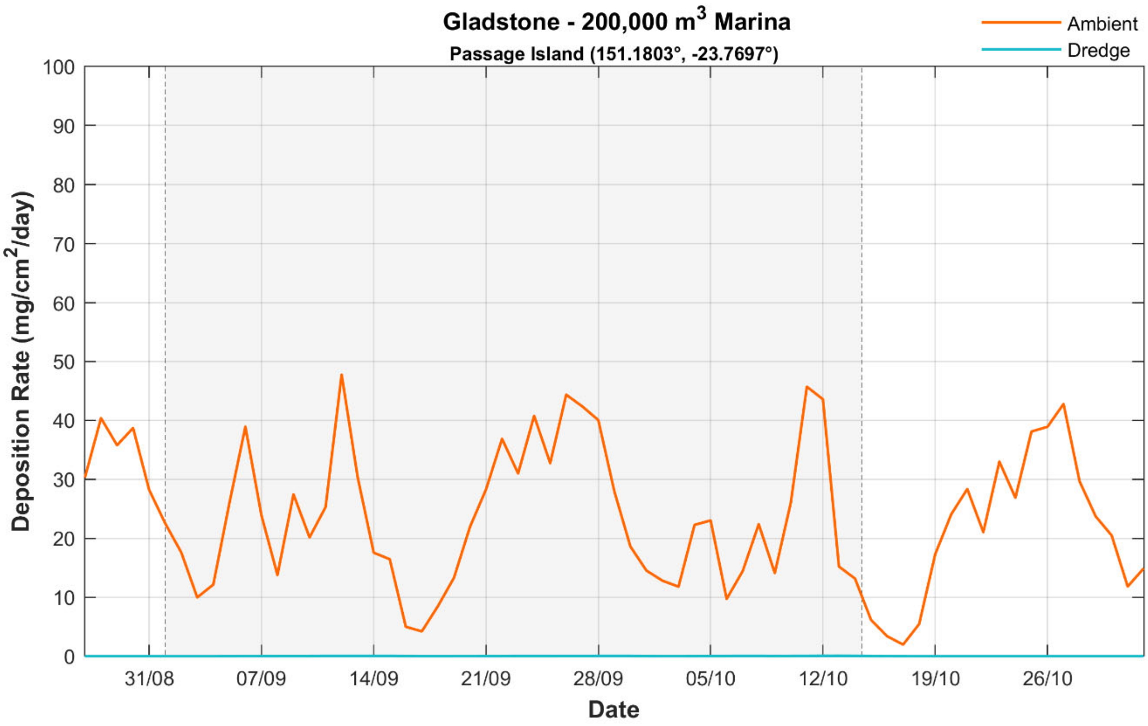


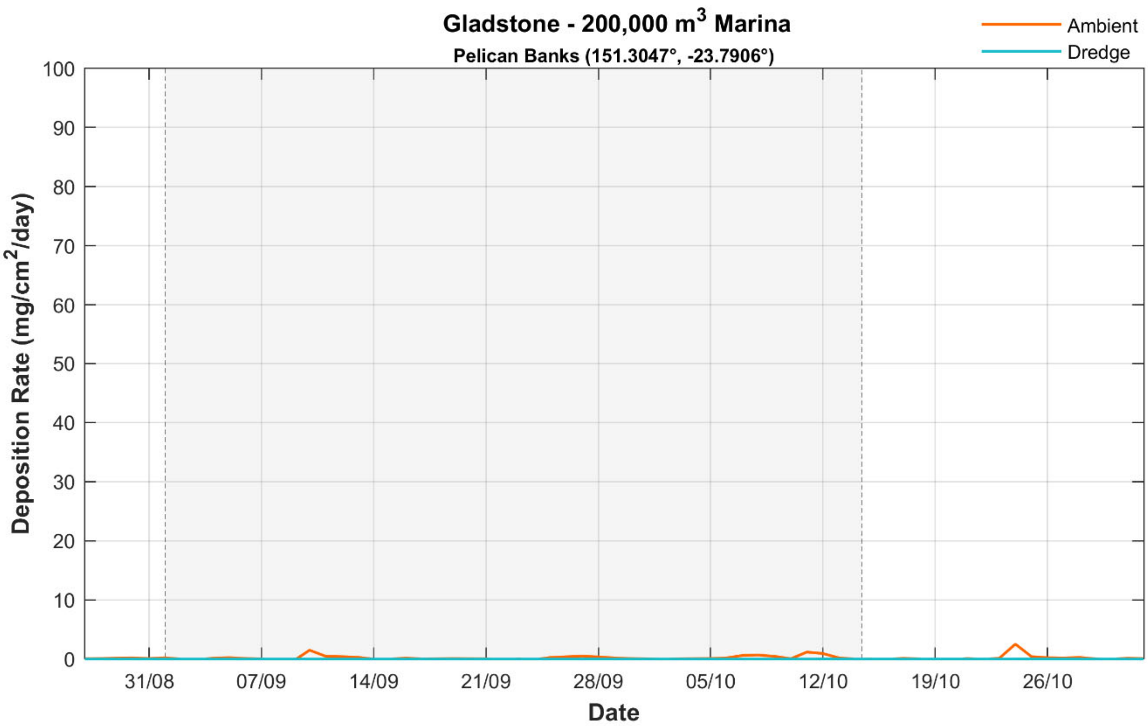


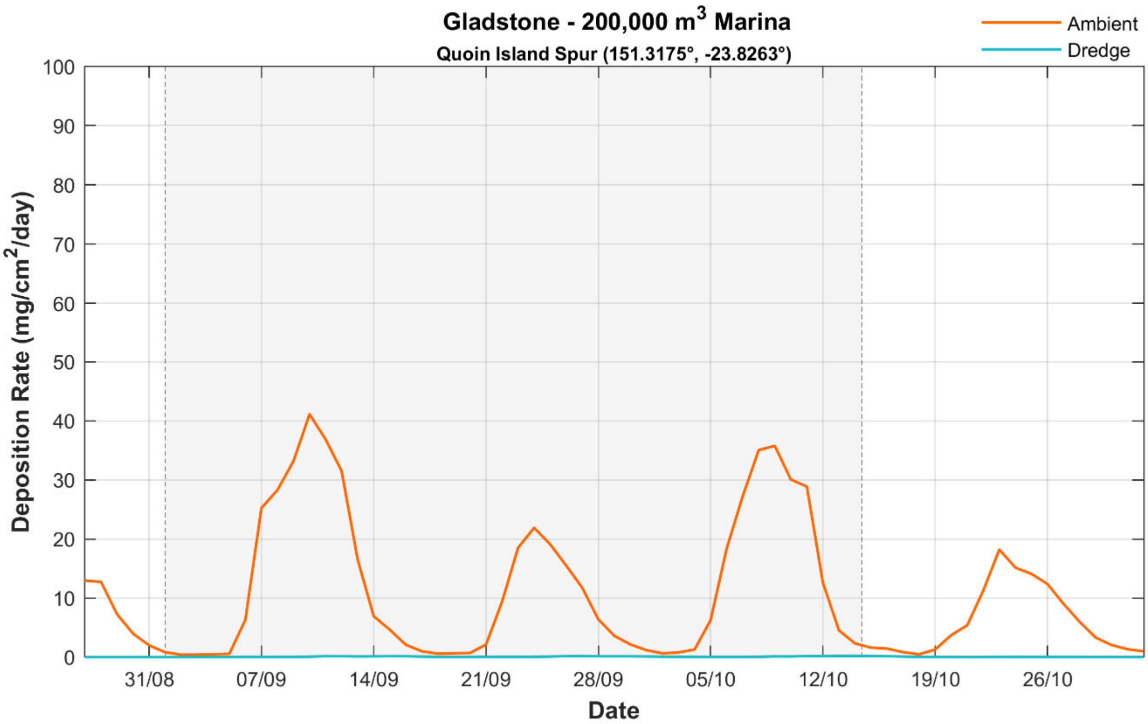

Gladstone - 200,000 m3 Marina
Manning Reef (151.3559°, -23.8566°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

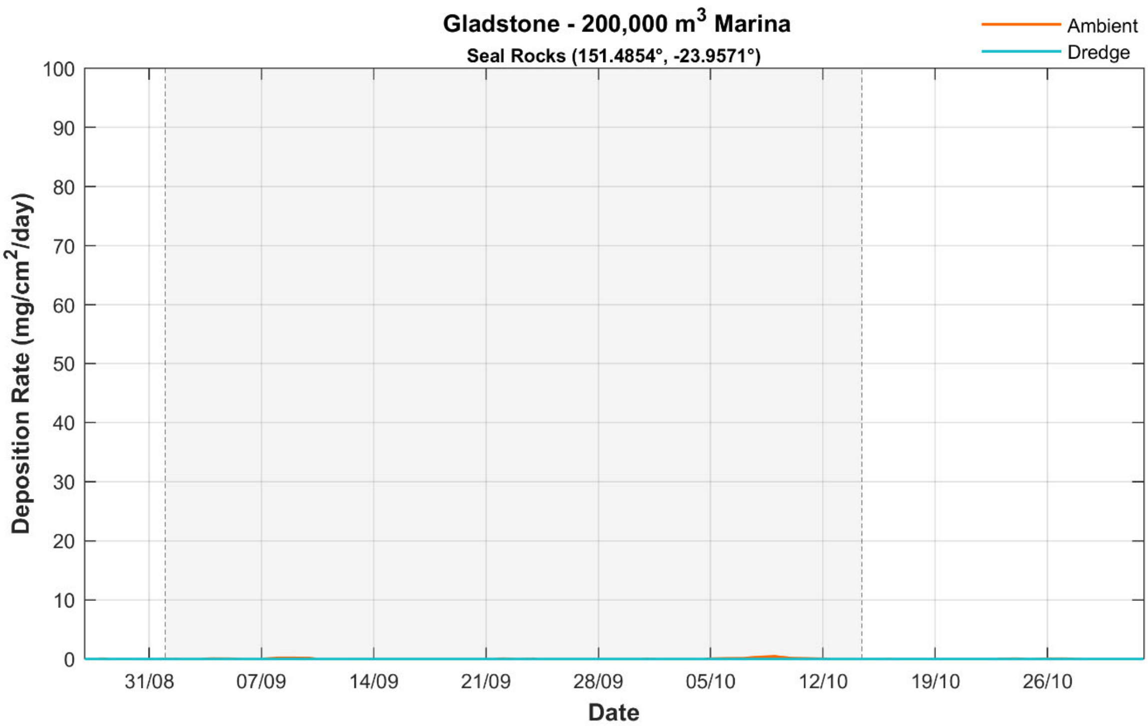

Gladstone - 200,000 m3 Marina
Nth Fishermans Landing (151.1509°, -23.7711°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

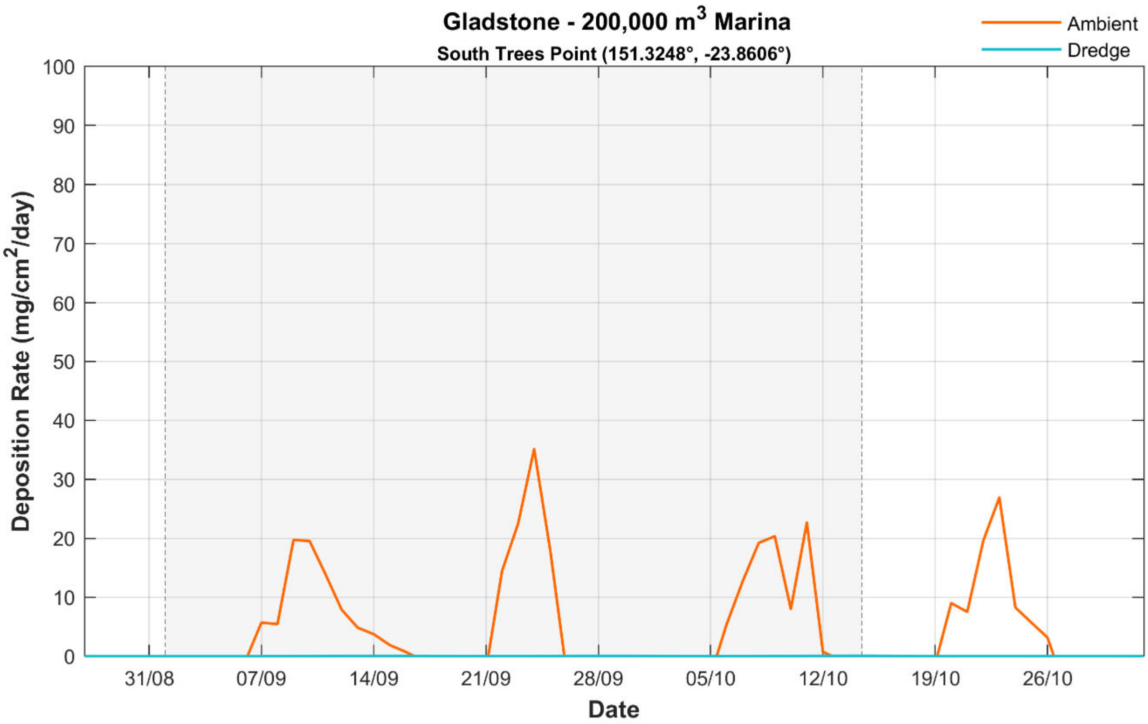
Time Series of Modelled Deposition Rate

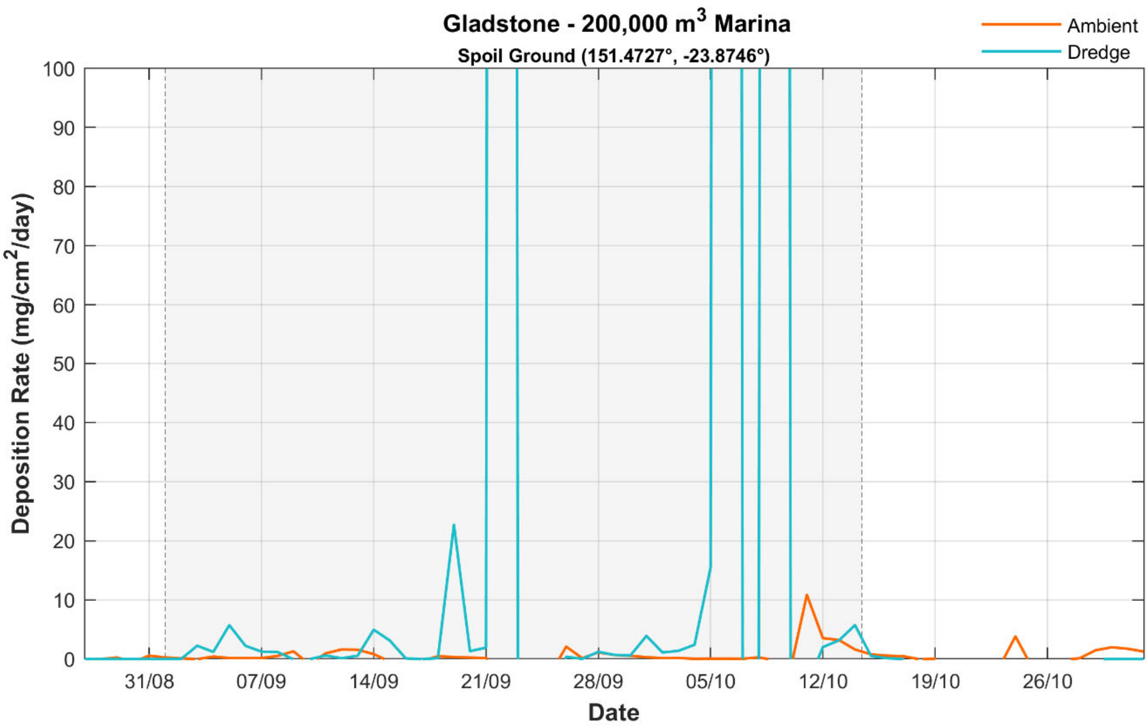




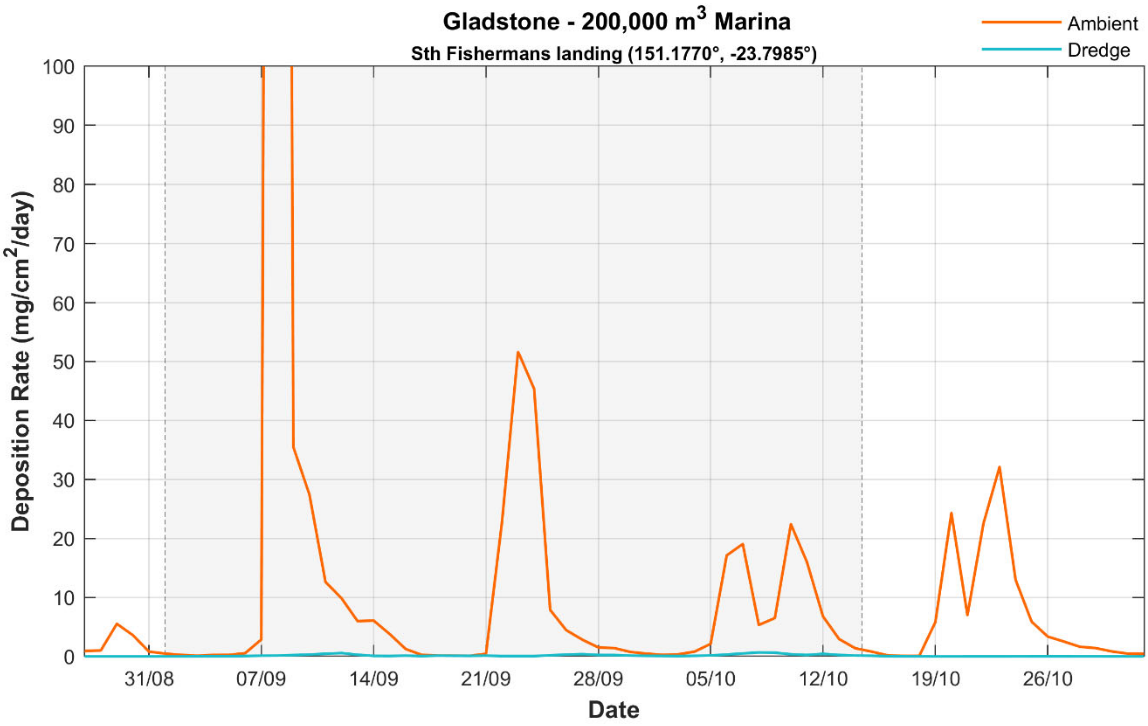

Gladstone - 200,000 m3 Marina
Quoin Island Spur (151.3175°, -23.8263°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

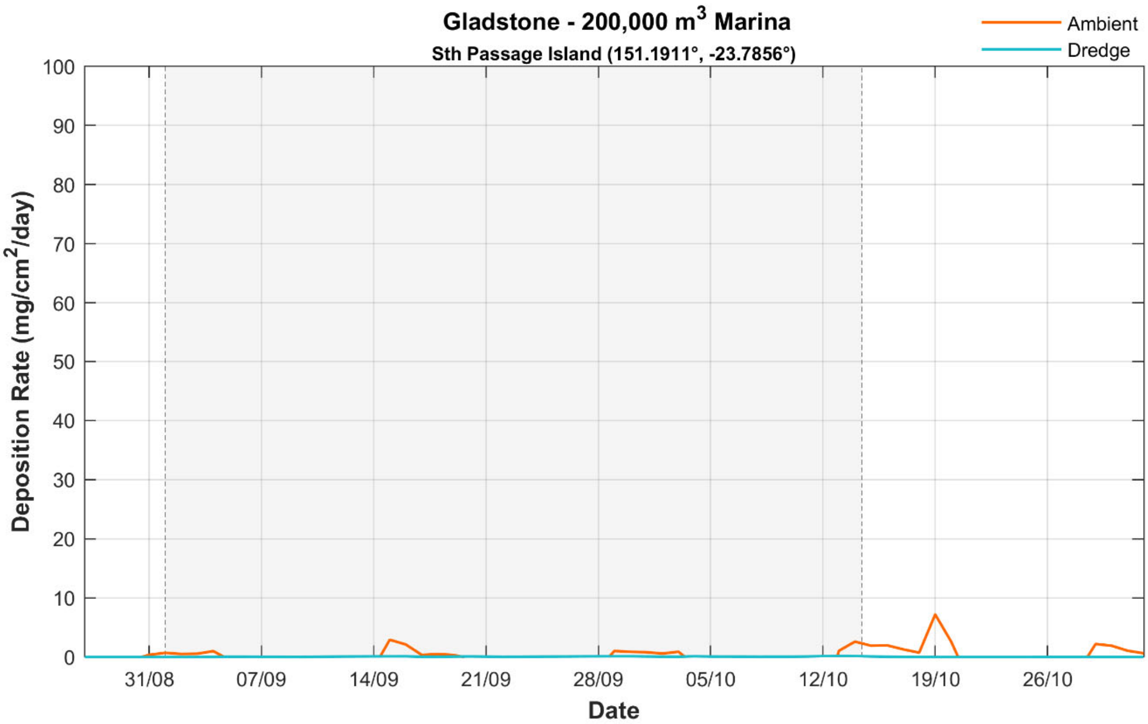

Gladstone - 200,000 m3 Marina
Seal Rocks (151.4854°, -23.9571°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone - 200,000 m3 Marina
South Trees Point (151.3248°, -23.8606°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

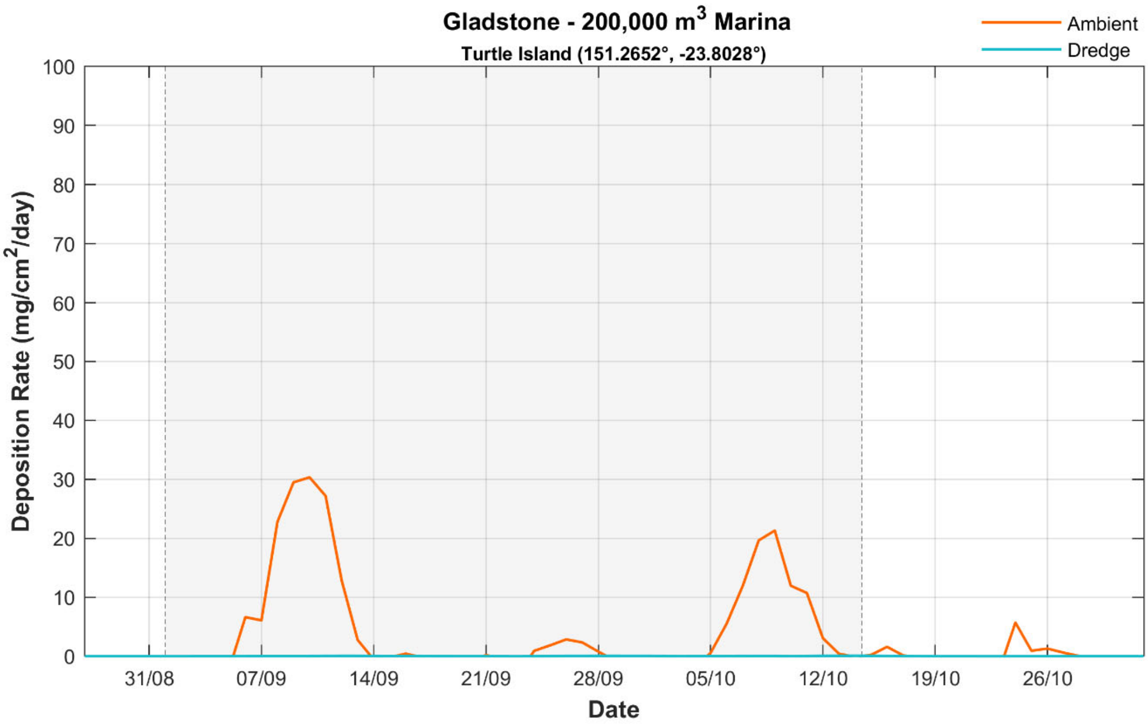

Gladstone - 200,000 m3 Marina
Spoil Ground (151.4727°, -23.8746°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

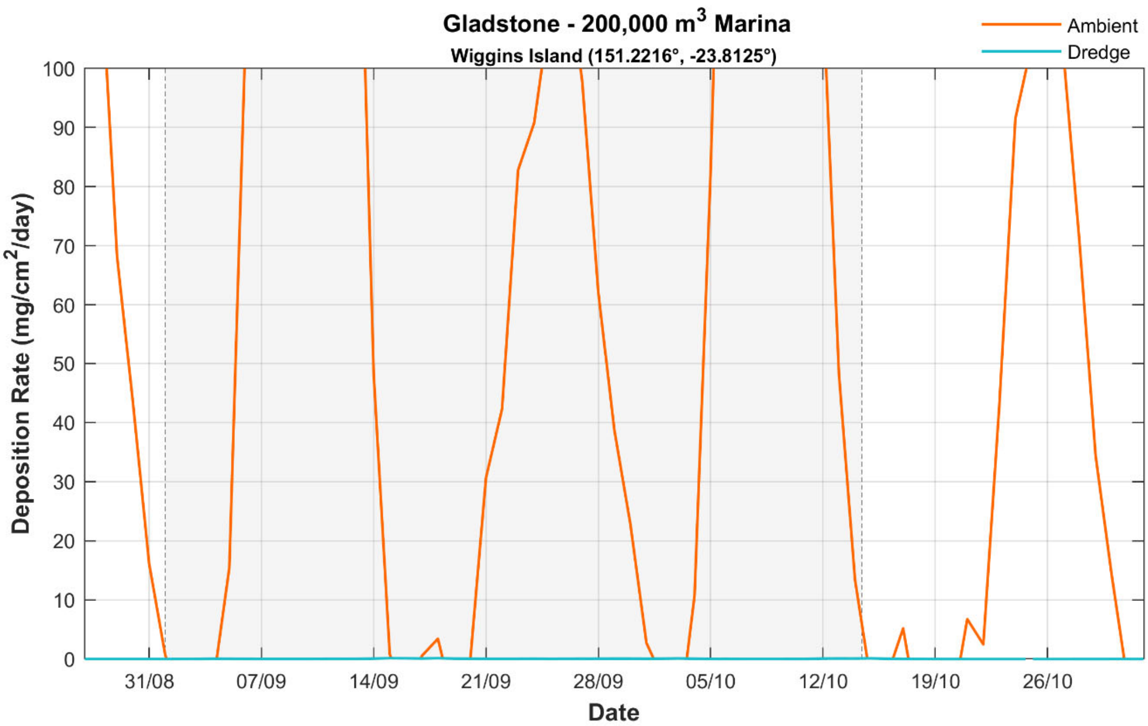
Time Series of Modelled Deposition Rate

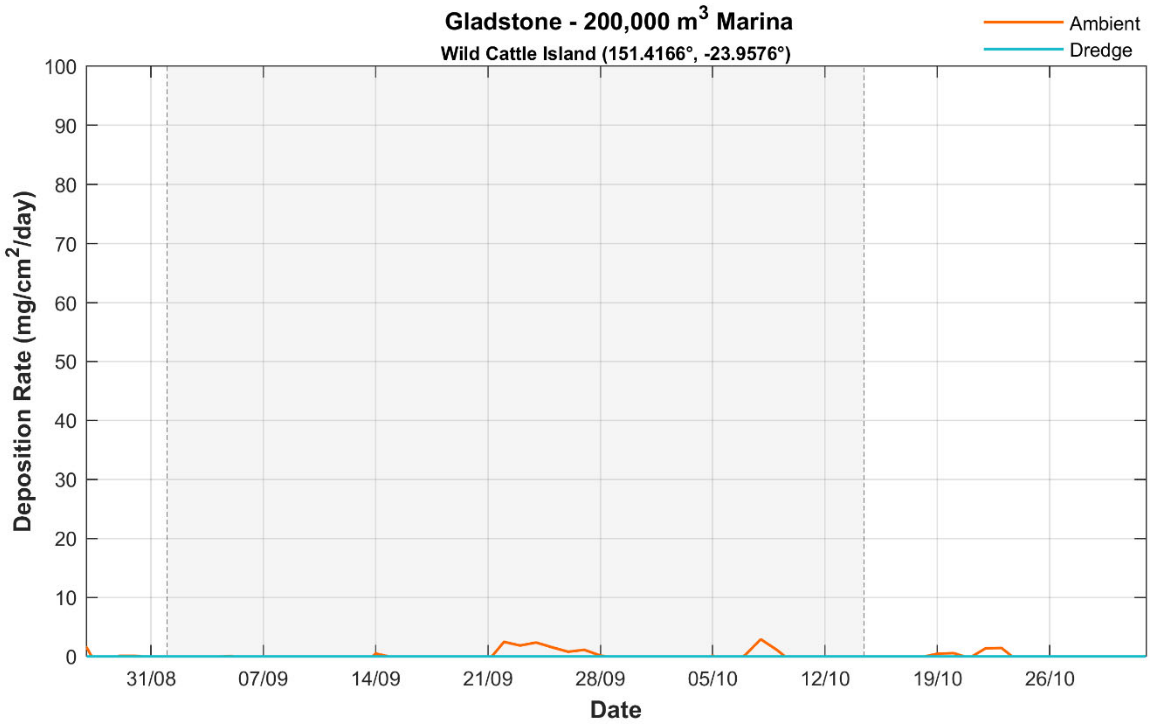




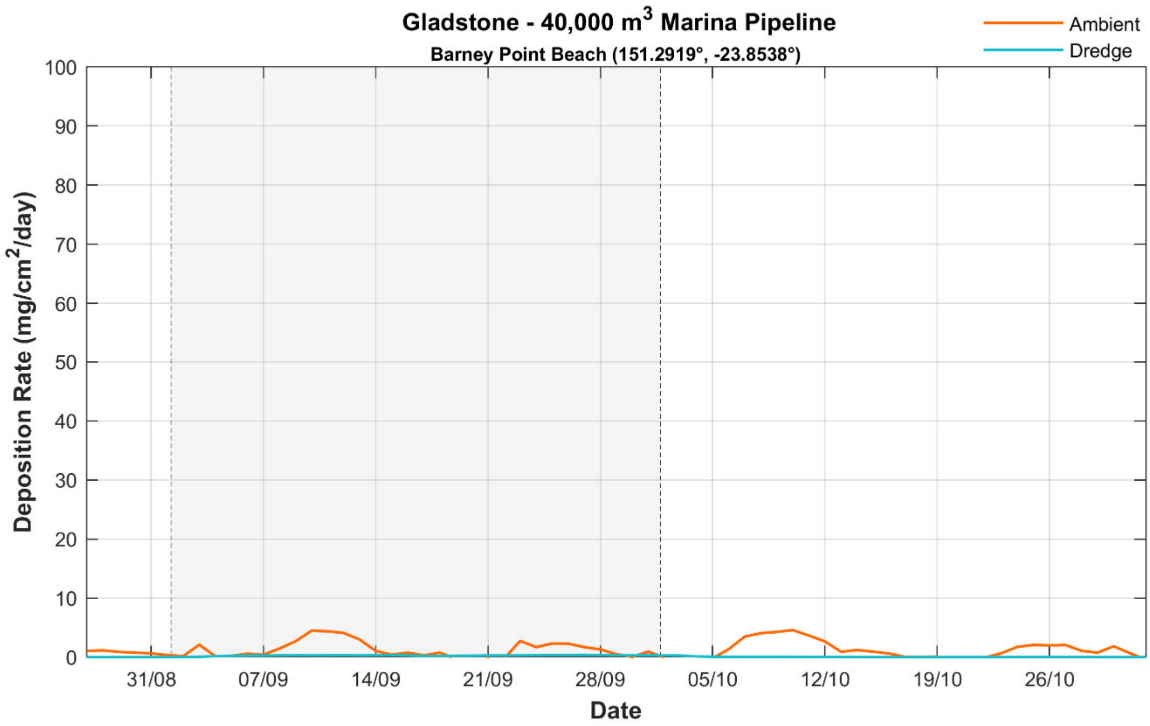
Time Series of Modelled Deposition Rate

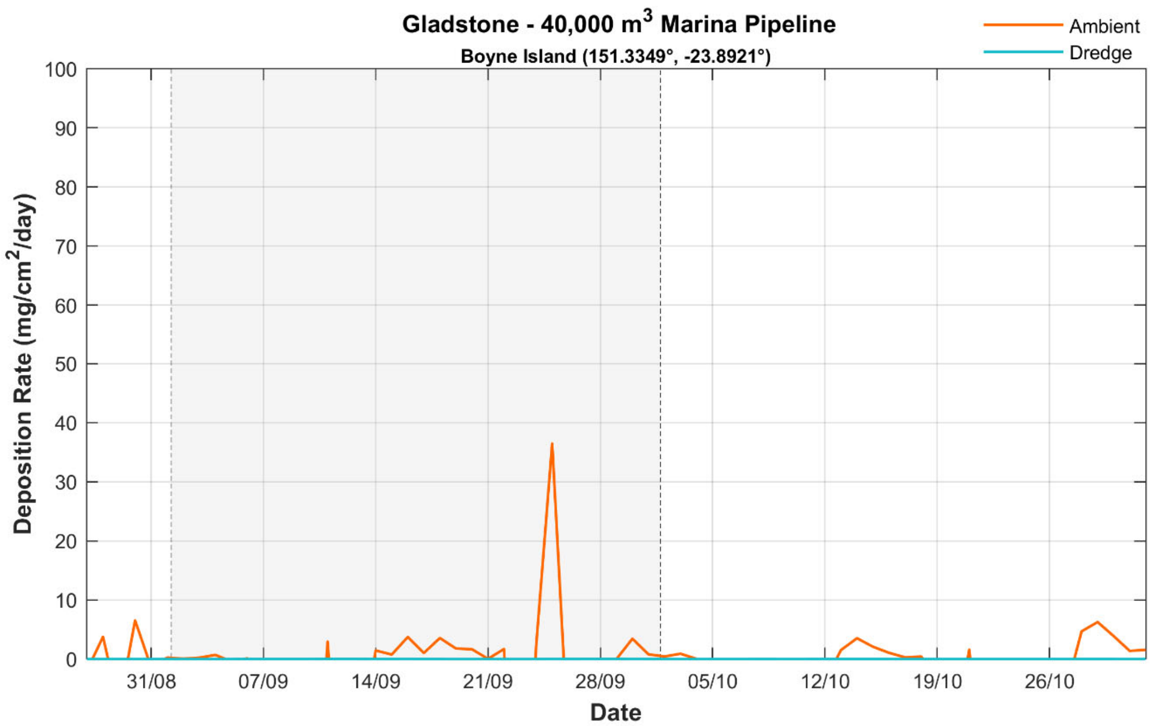


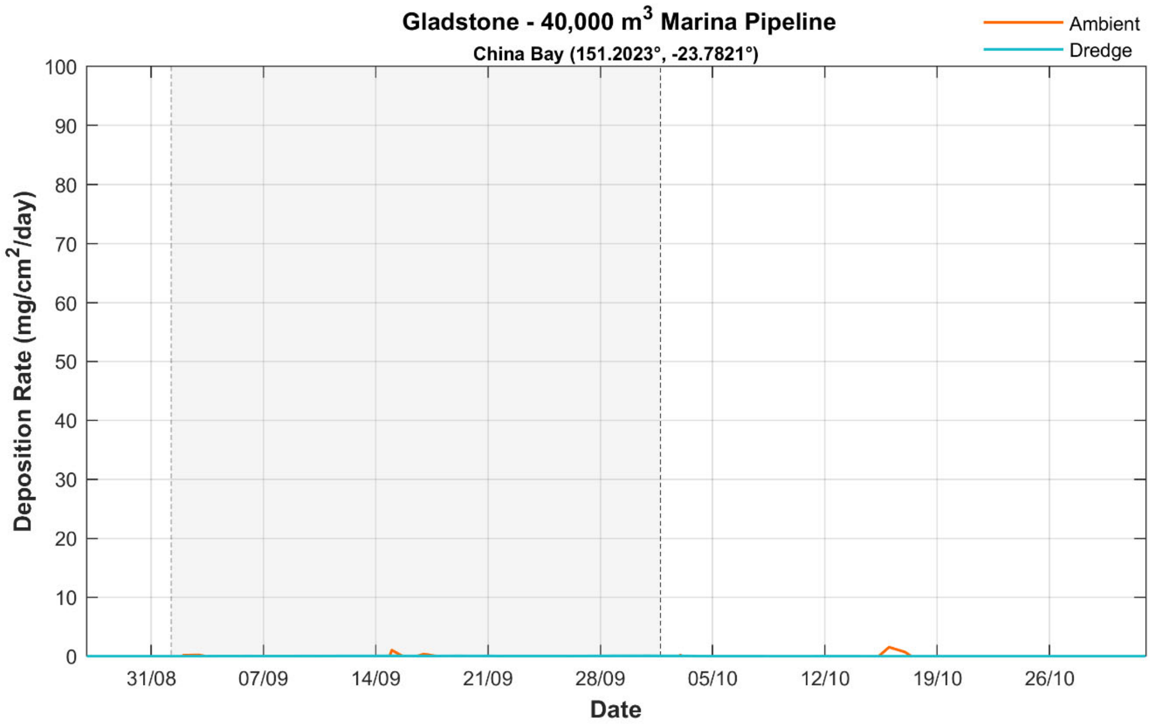


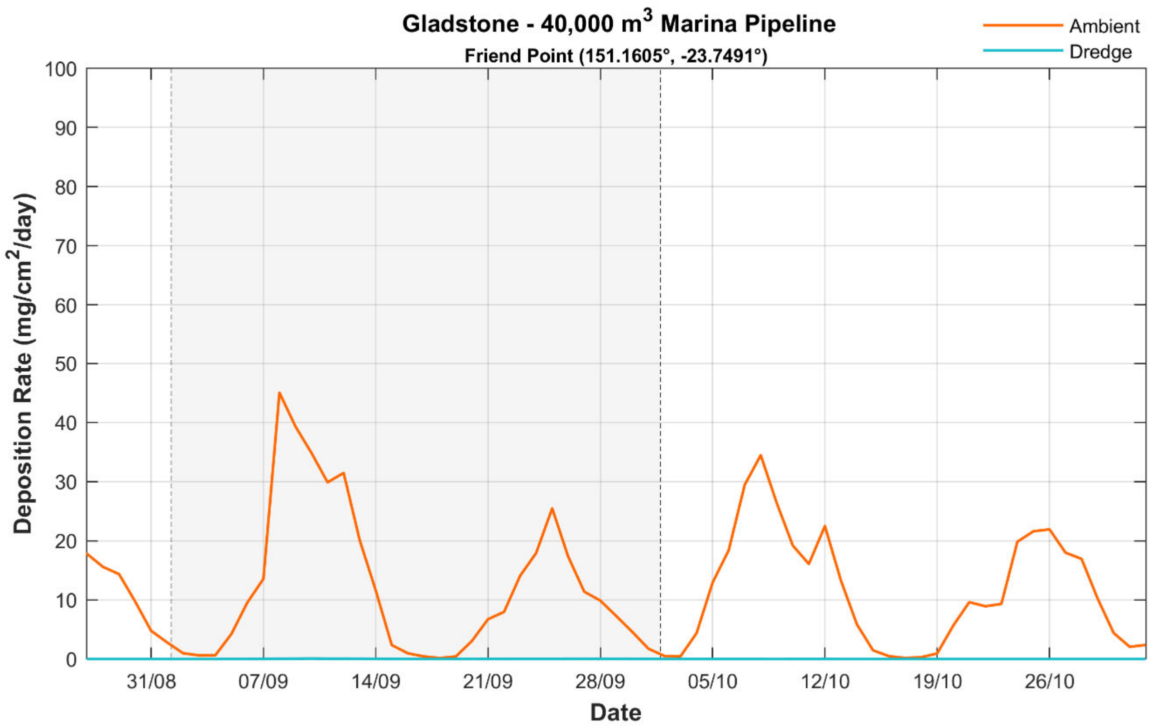

Gladstone - 200,000 m3 Marina
Wild Cattle Island (151.4166°, -23.9576°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

D.2 40,000m³ CSD Campaign with In-Channel Placement Results

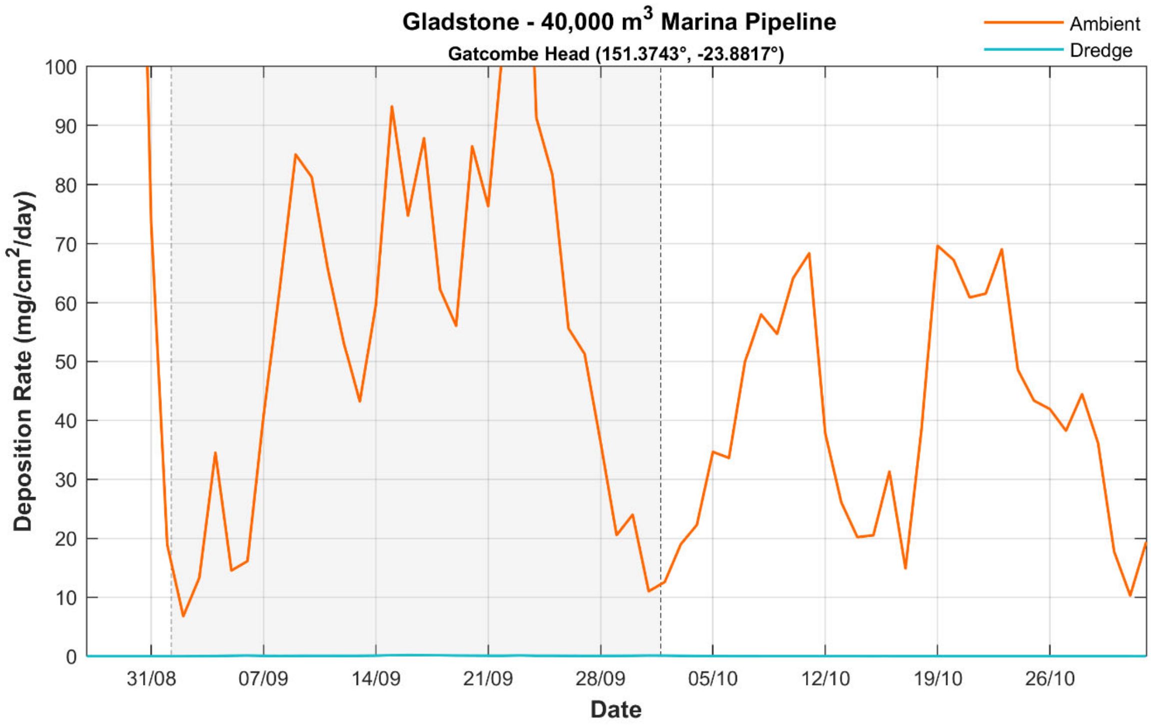


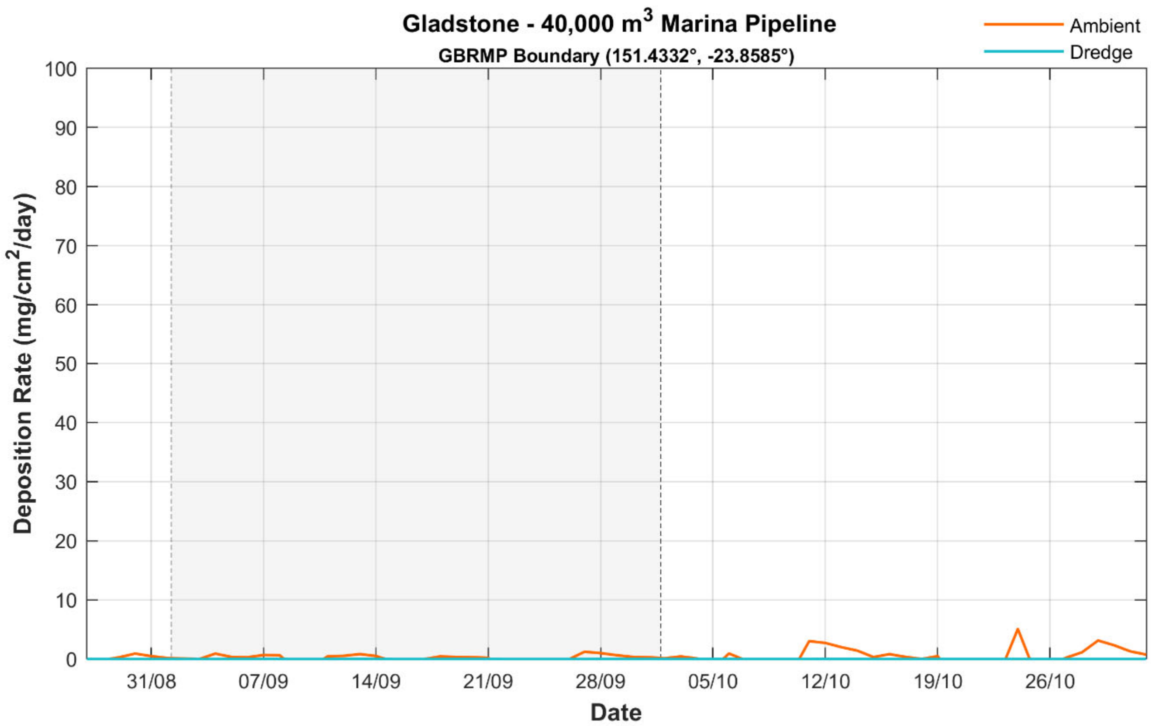


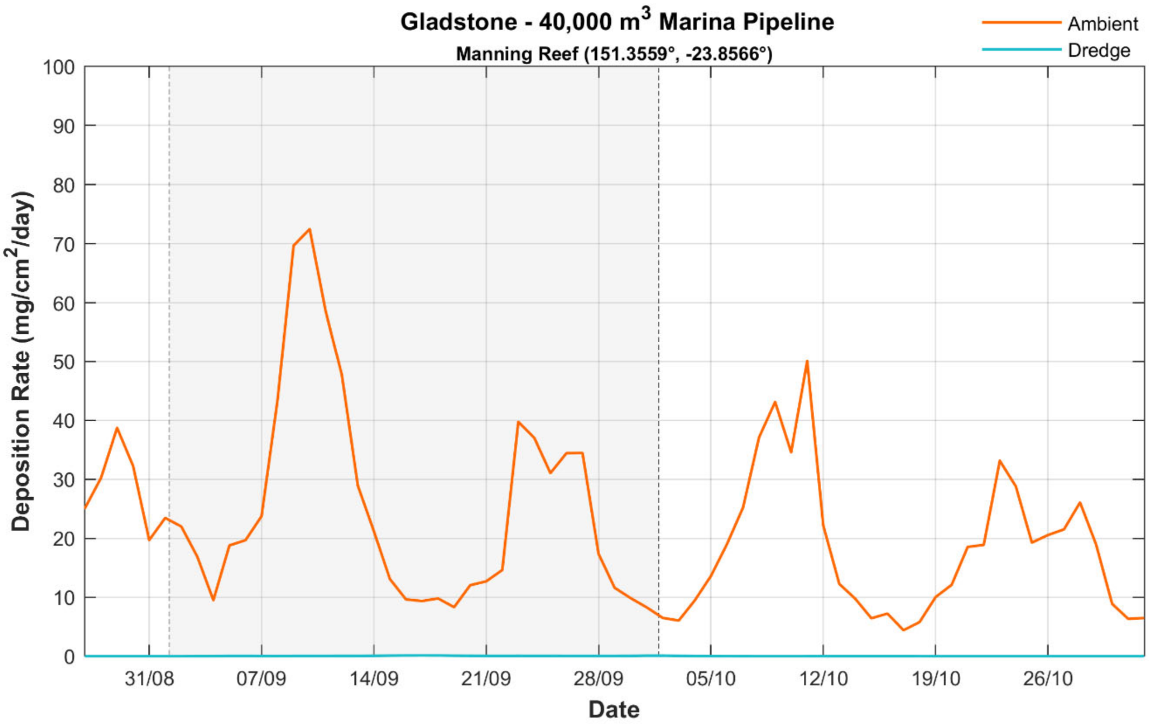

Gladstone - 40,000 m3 Marina Pipeline
China Bay (151.2023°, -23.7821°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

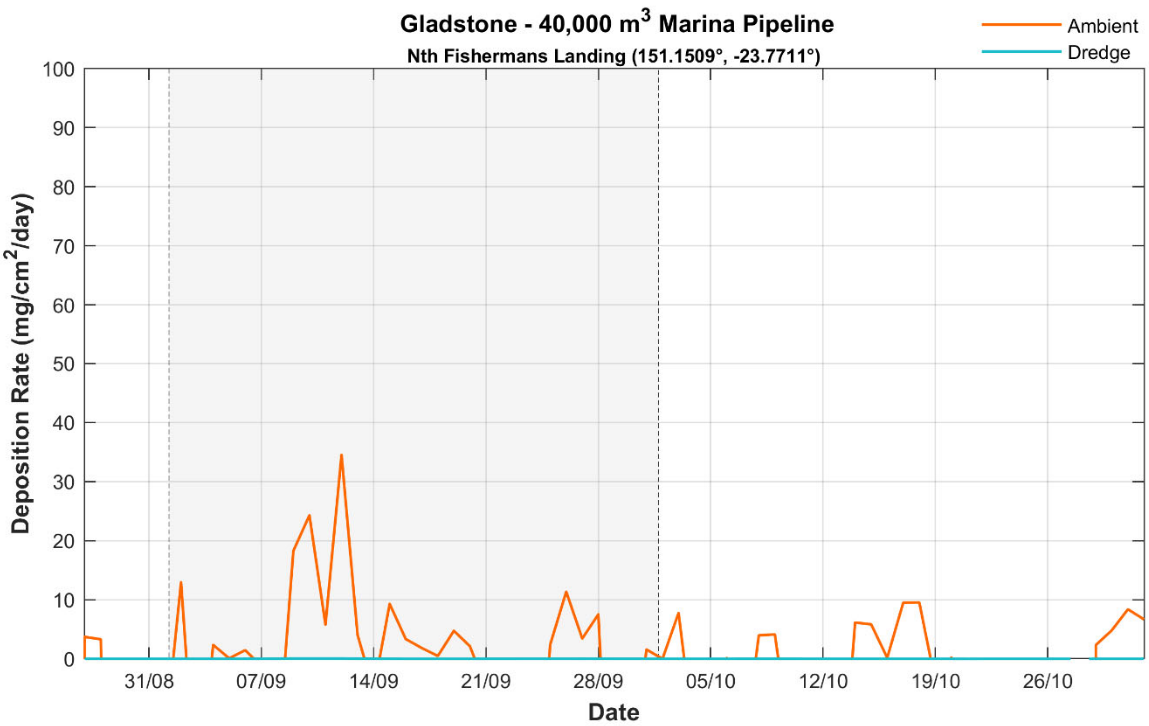

Gladstone - 40,000 m3 Marina Pipeline
Friend Point (151.1605°, -23.7491°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

Time Series of Modelled Deposition Rate

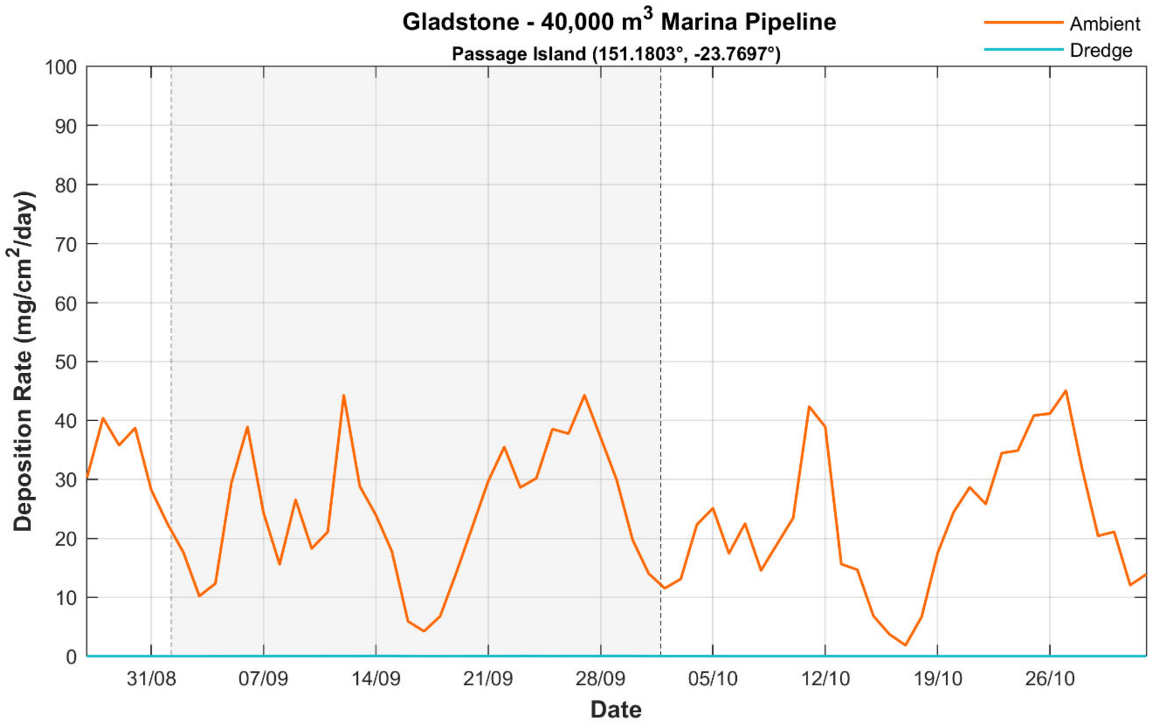


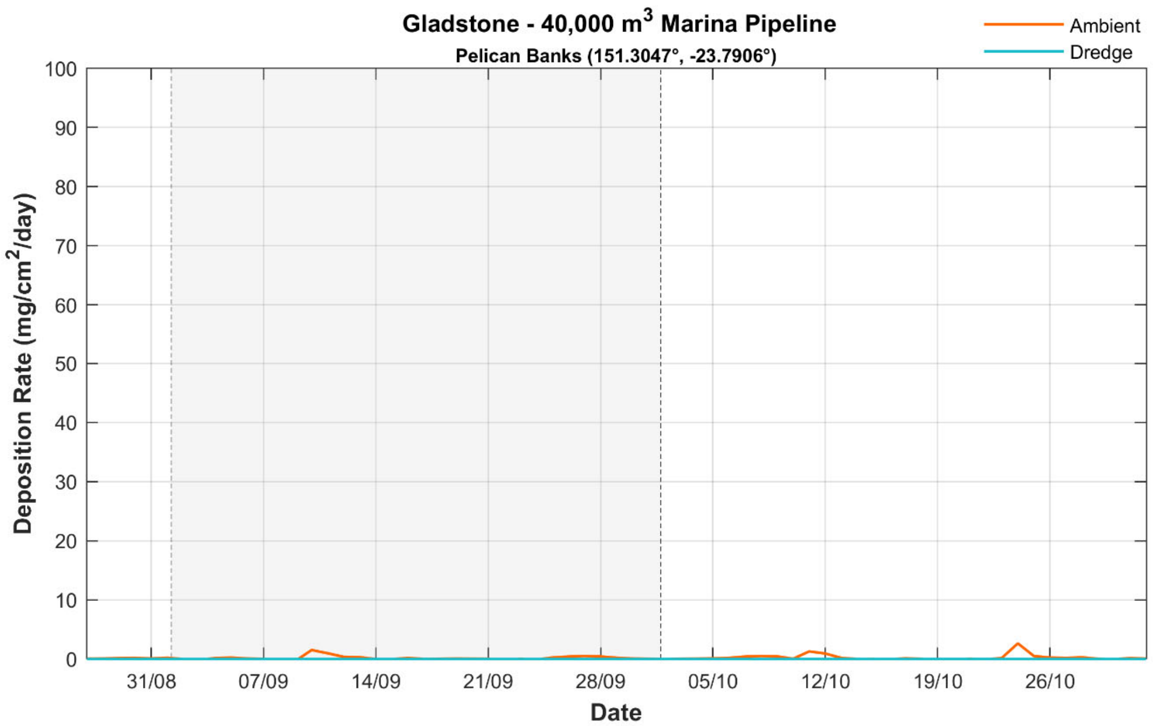



Gladstone - 40,000 m3 Marina Pipeline
Manning Reef (151.3559°, -23.8566°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
Date
0
10
20
30
40
50
60
70
80
90
100
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10

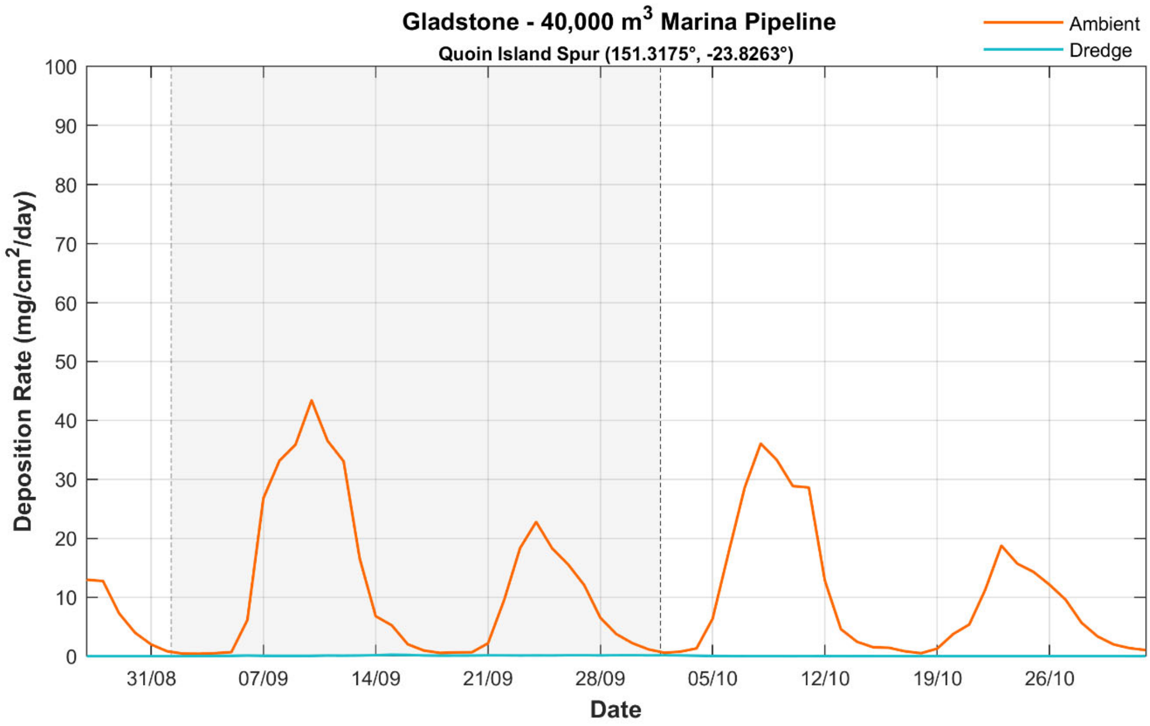

Gladstone - 40,000 m3 Marina Pipeline
Nth Fishermans Landing (151.1509°, -23.7711°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
Date
0
10
20
30
40
50
60
70
80
90
100
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10

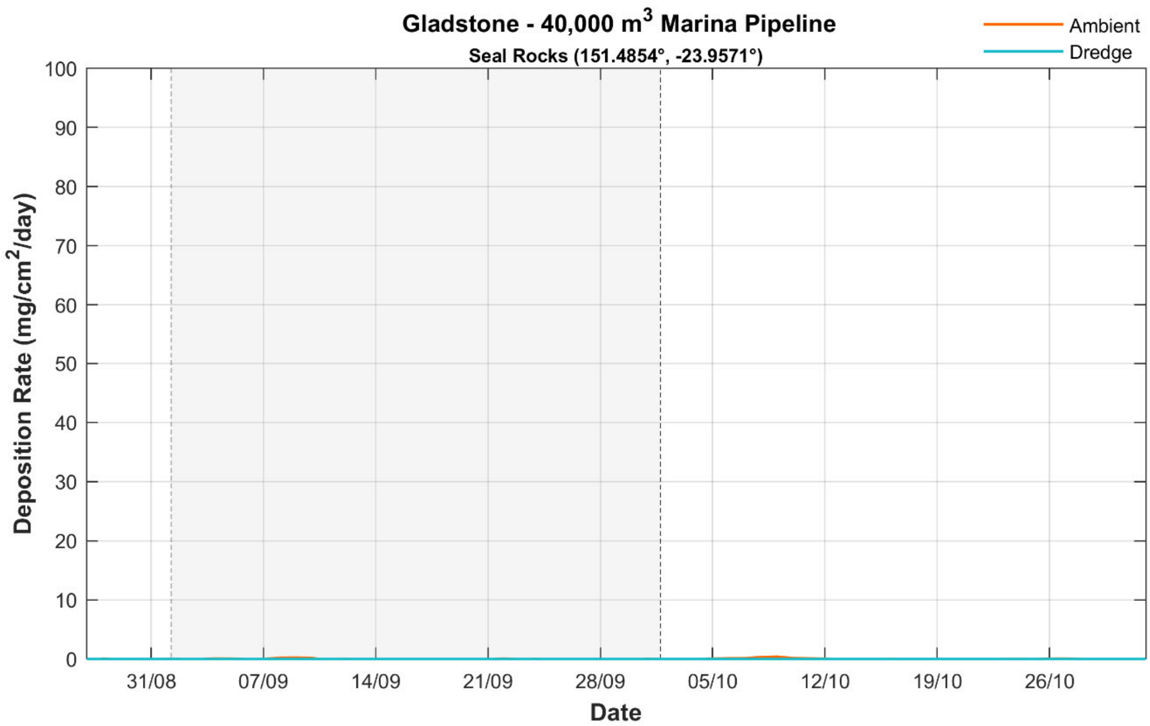
Time Series of Modelled Deposition Rate

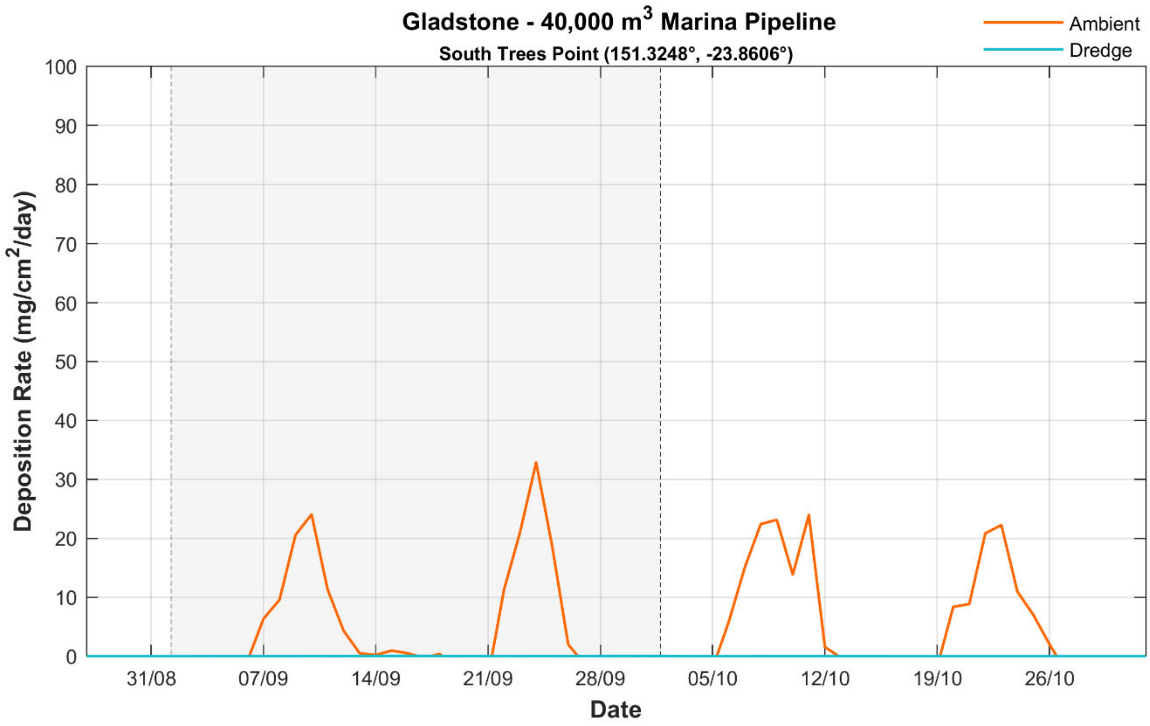


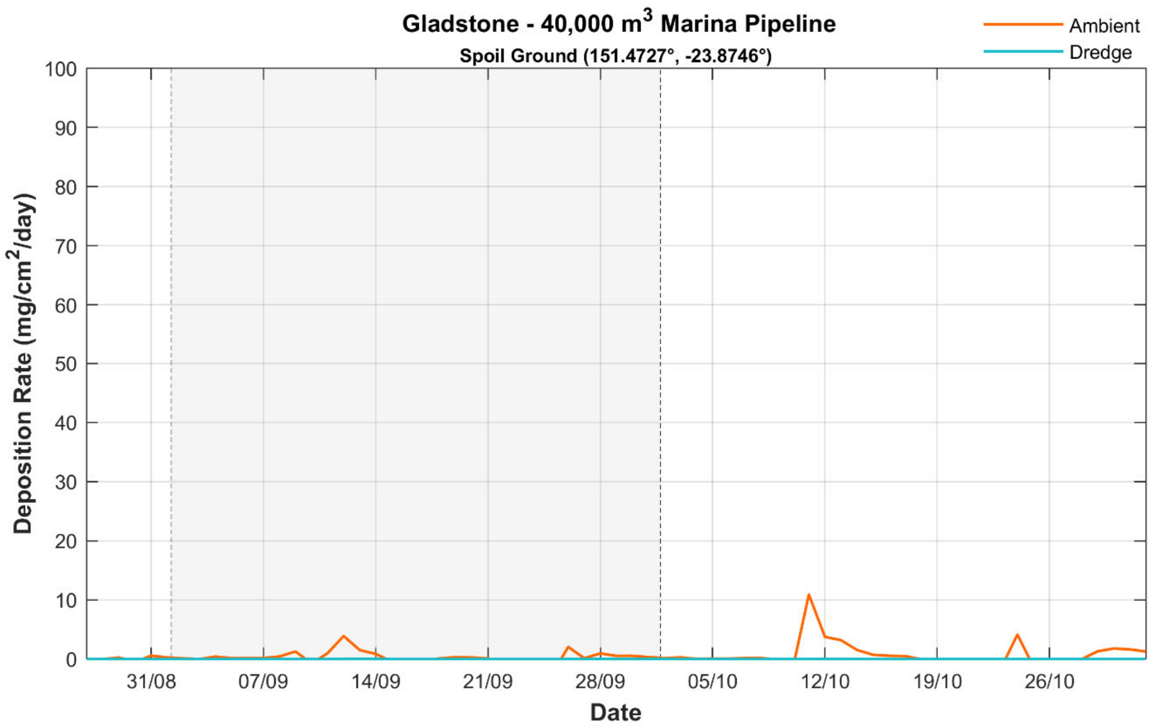


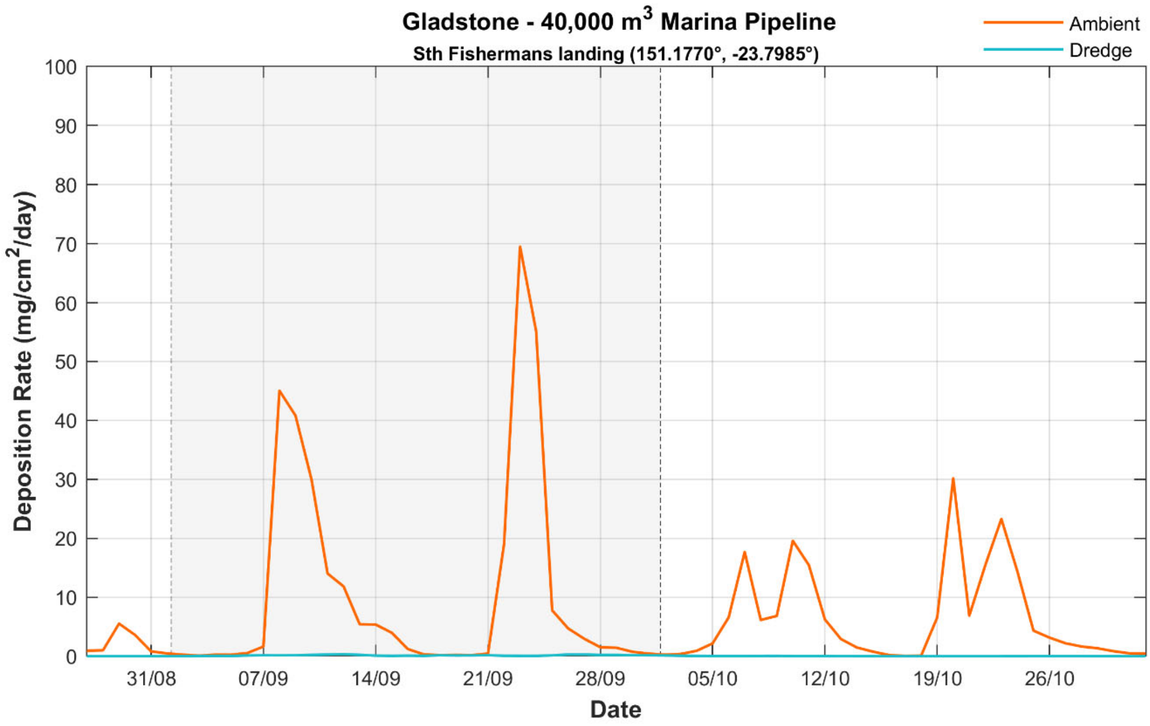
Time Series of Modelled Deposition Rate

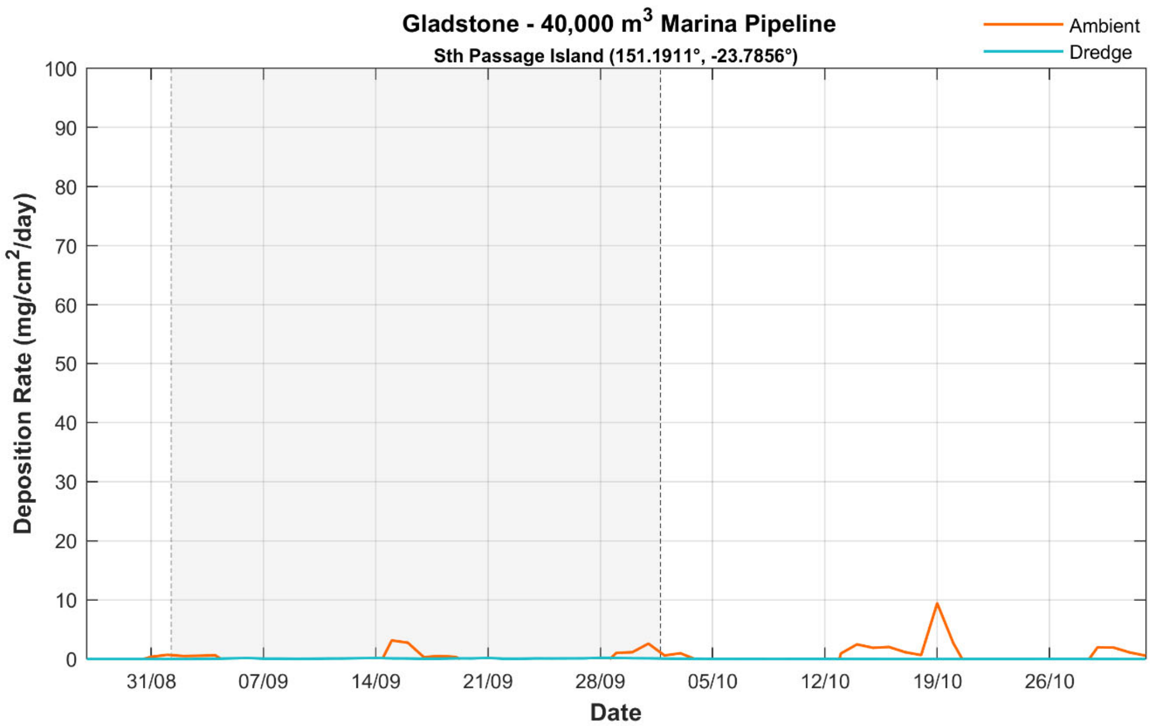




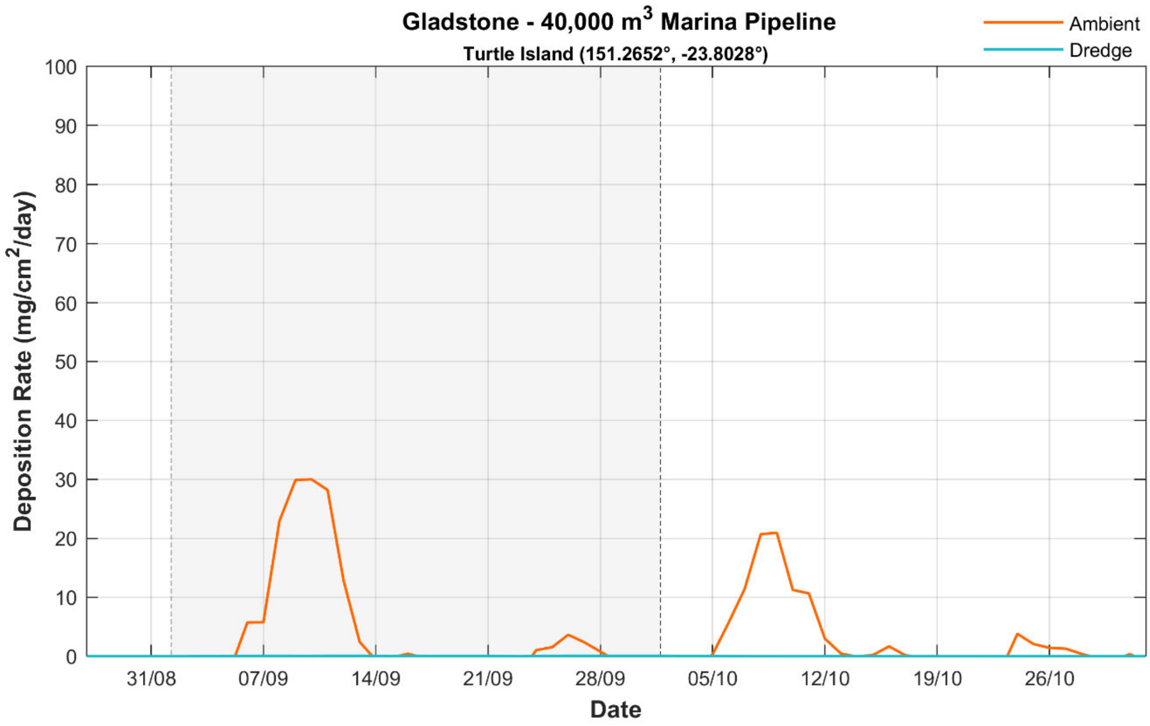

Gladstone - 40,000 m3 Marina Pipeline
South Trees Point (151.3248°, -23.8606°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
0
10
20
30
40
50
60
70
80
90
100
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

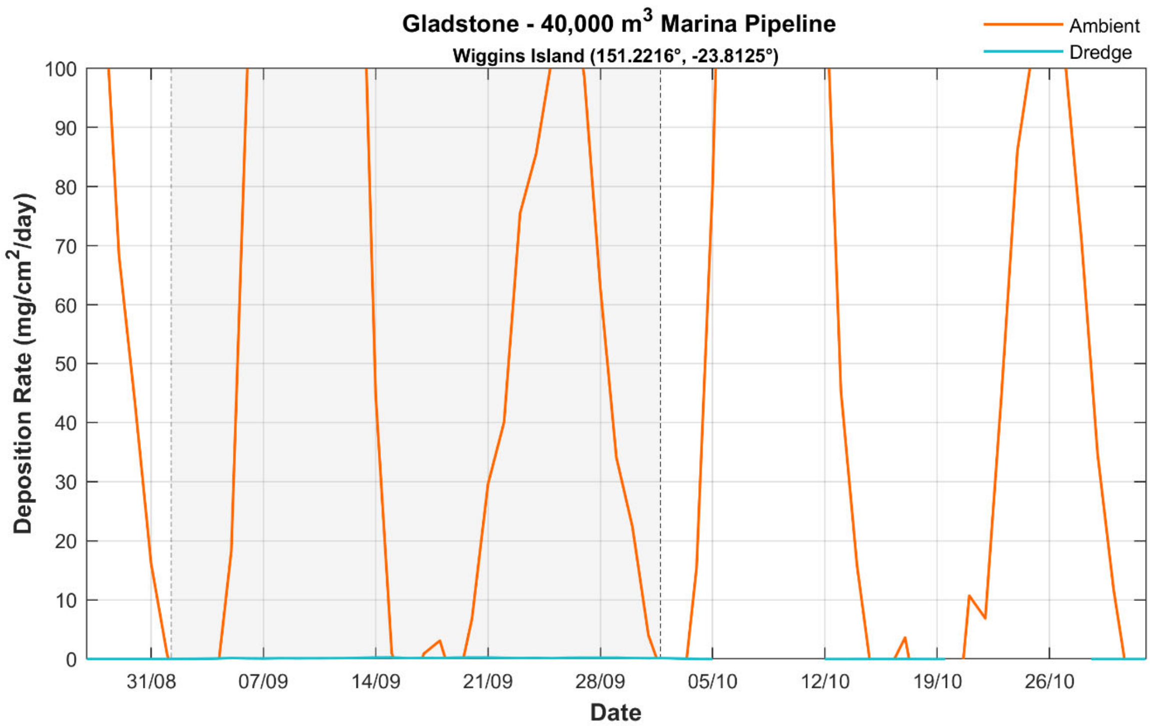

Gladstone - 40,000 m3 Marina Pipeline
Spoil Ground (151.4727°, -23.8746°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
0
10
20
30
40
50
60
70
80
90
100
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date


Gladstone - 40,000 m3 Marina Pipeline
Sth Fishermans landing (151.1770°, -23.7985°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

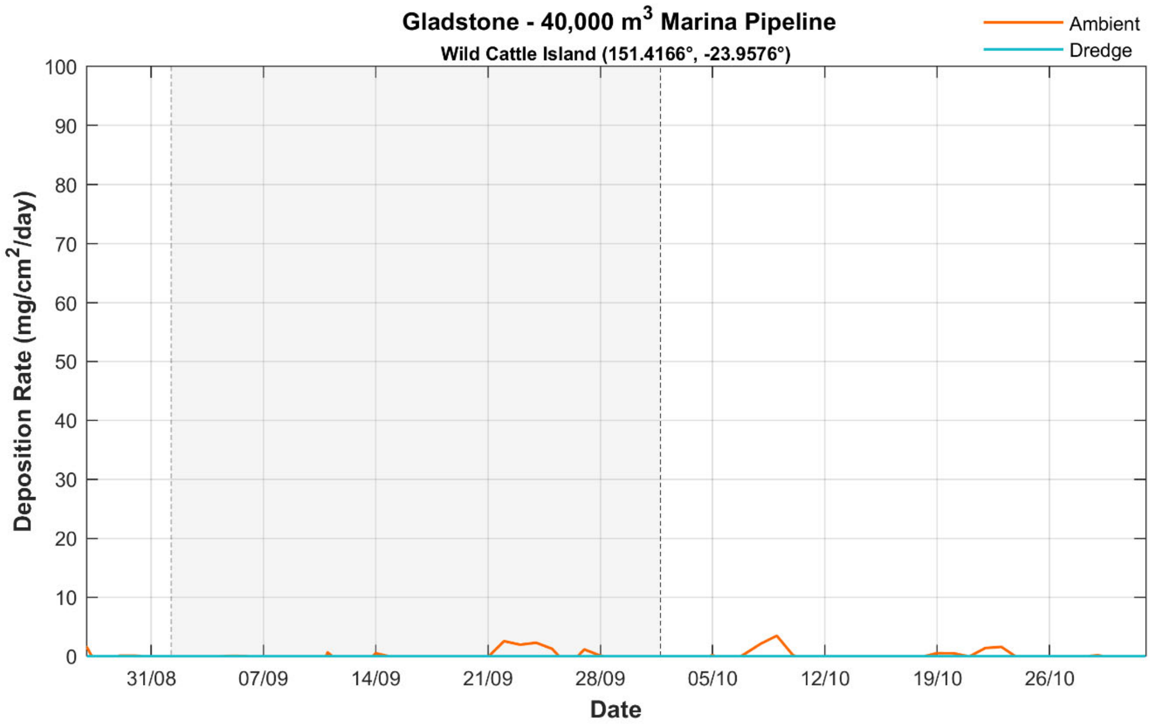

Gladstone - 40,000 m3 Marina Pipeline
Sth Passage Island (151.1911°, -23.7856°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
Date

Time Series of Modelled Deposition Rate

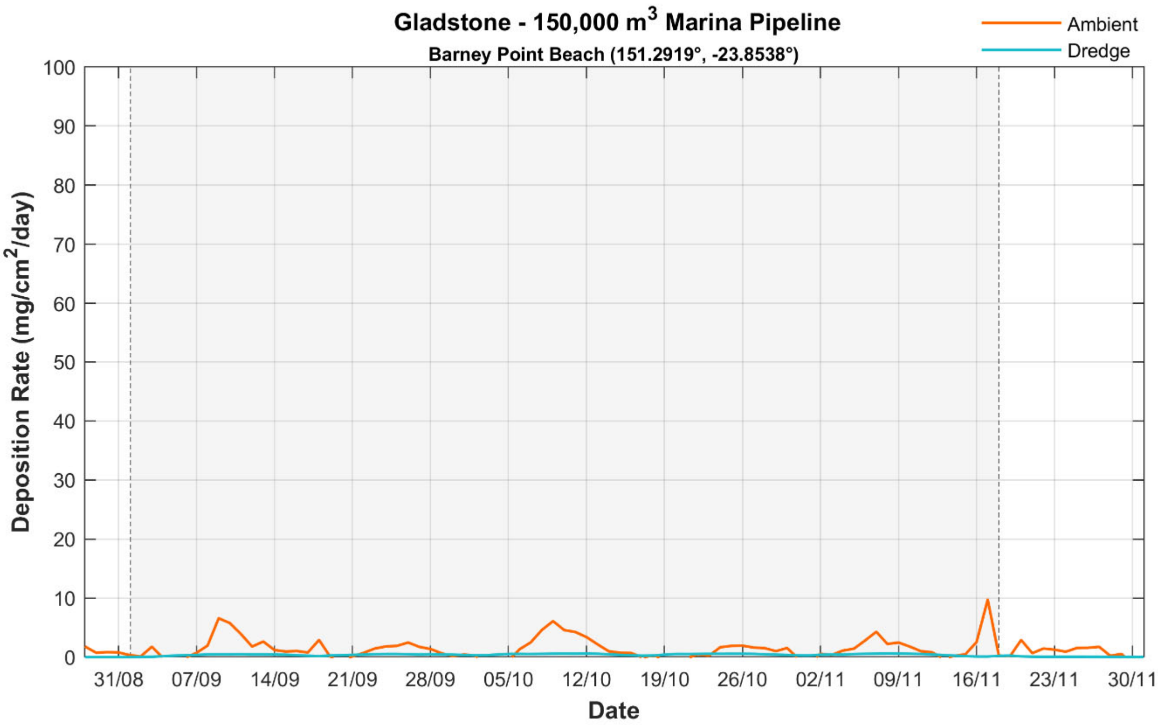


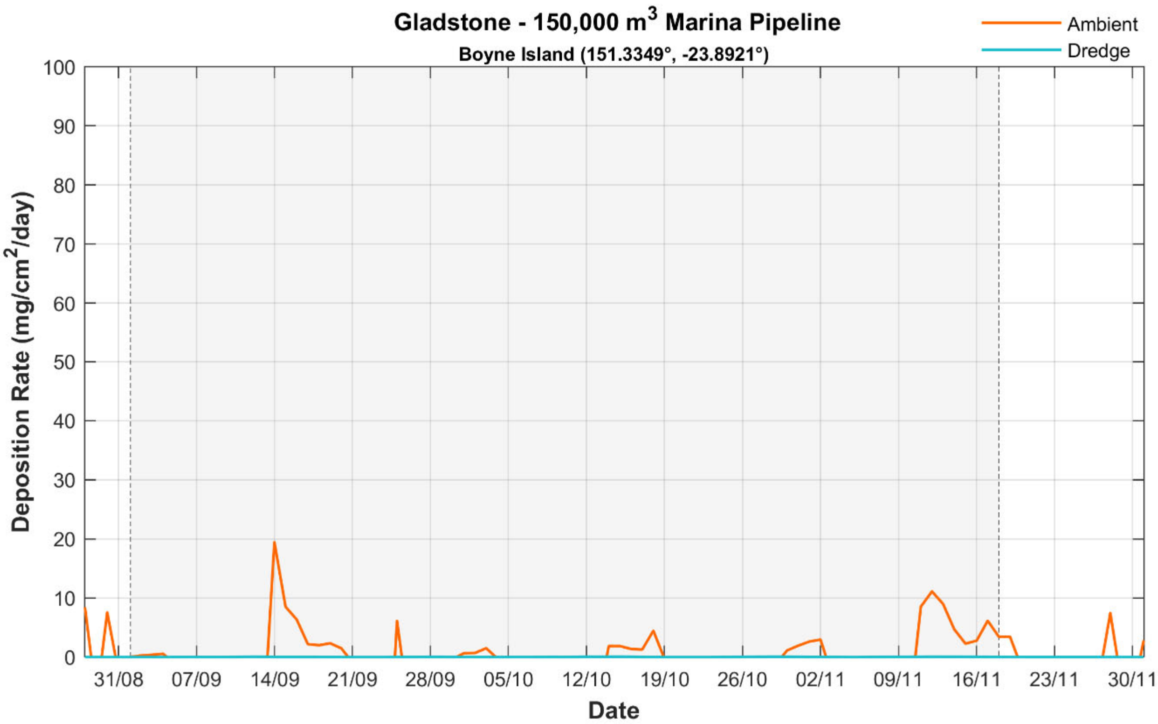


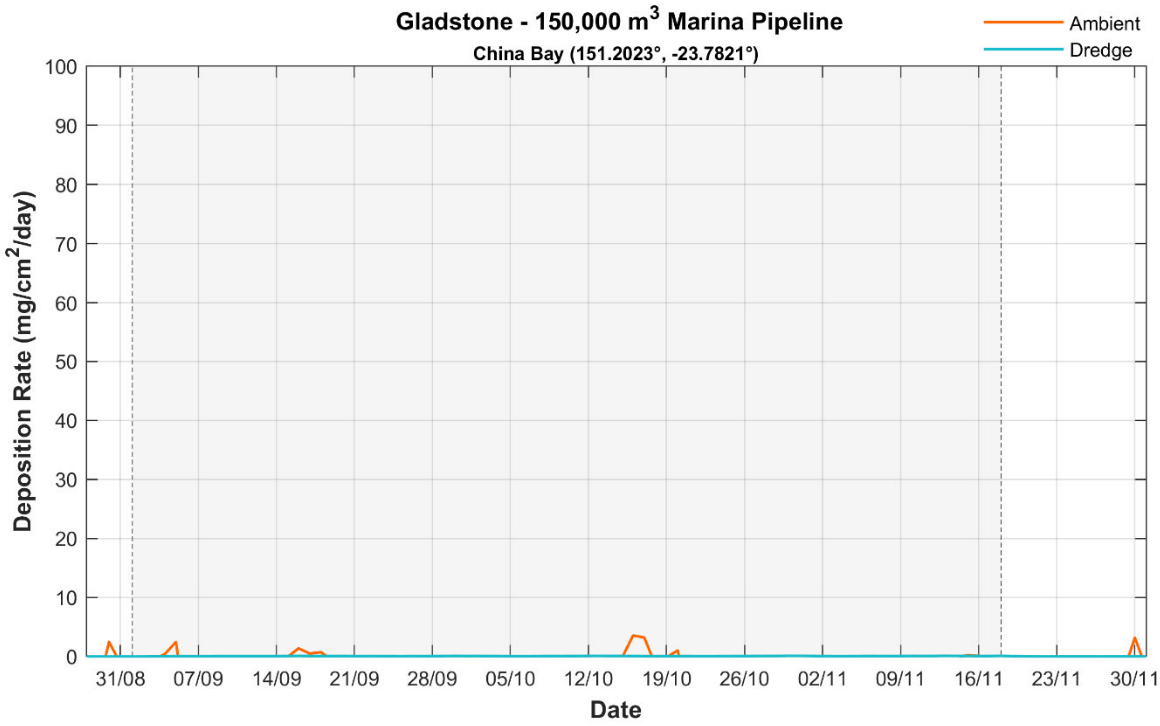
Time Series of Modelled Deposition Rate

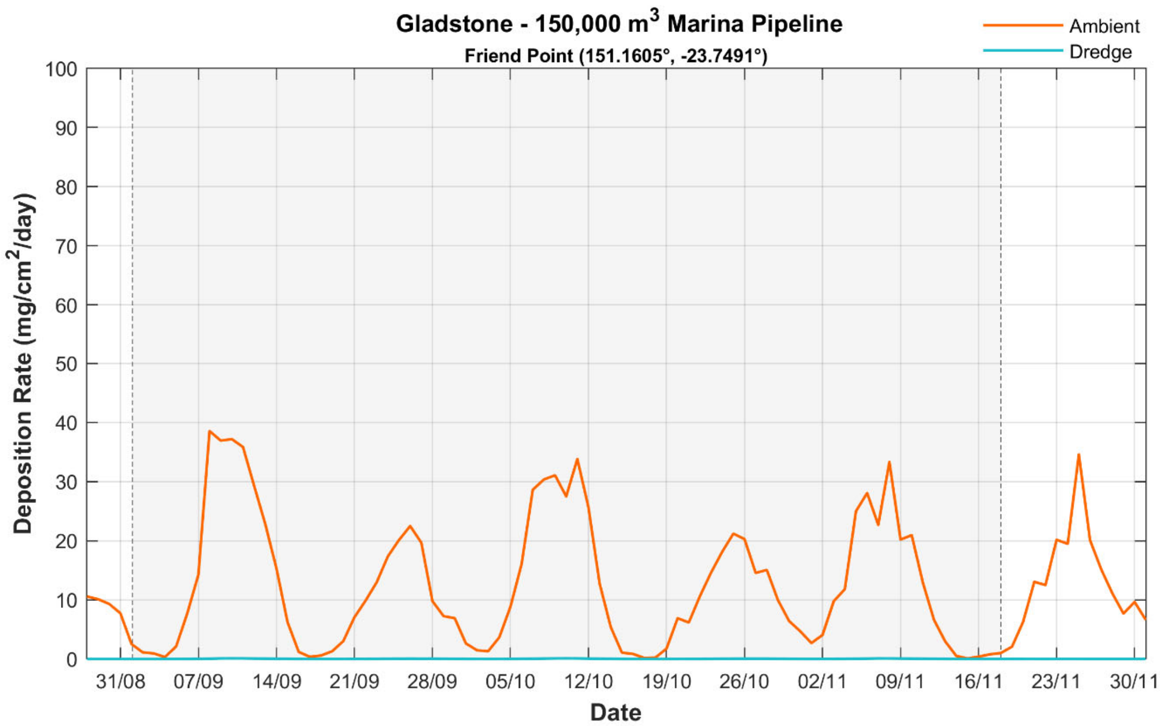


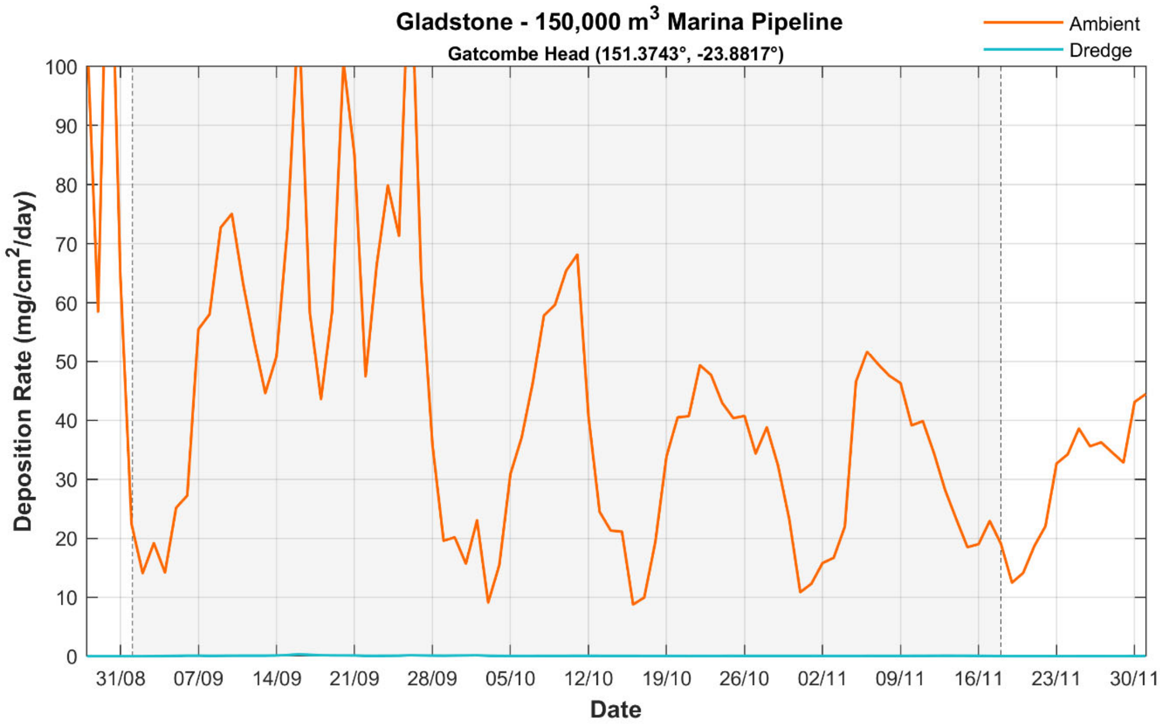
D.3 150,000m³ CSD Campaign with In-Channel Placement Results

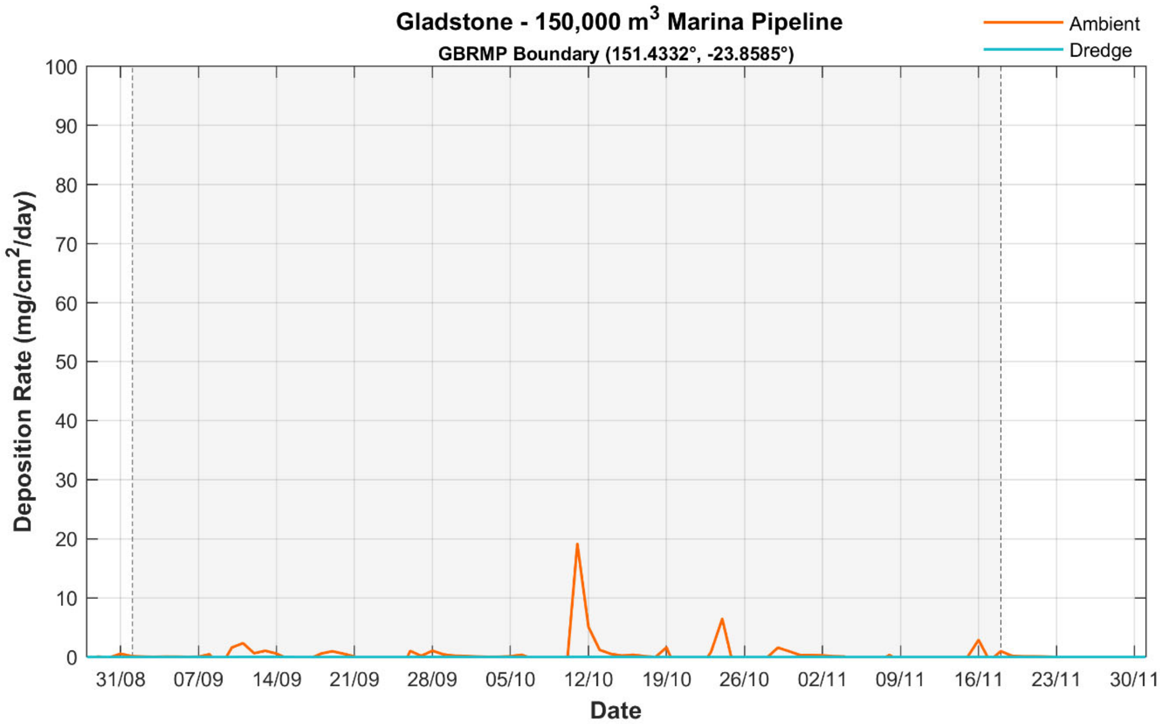




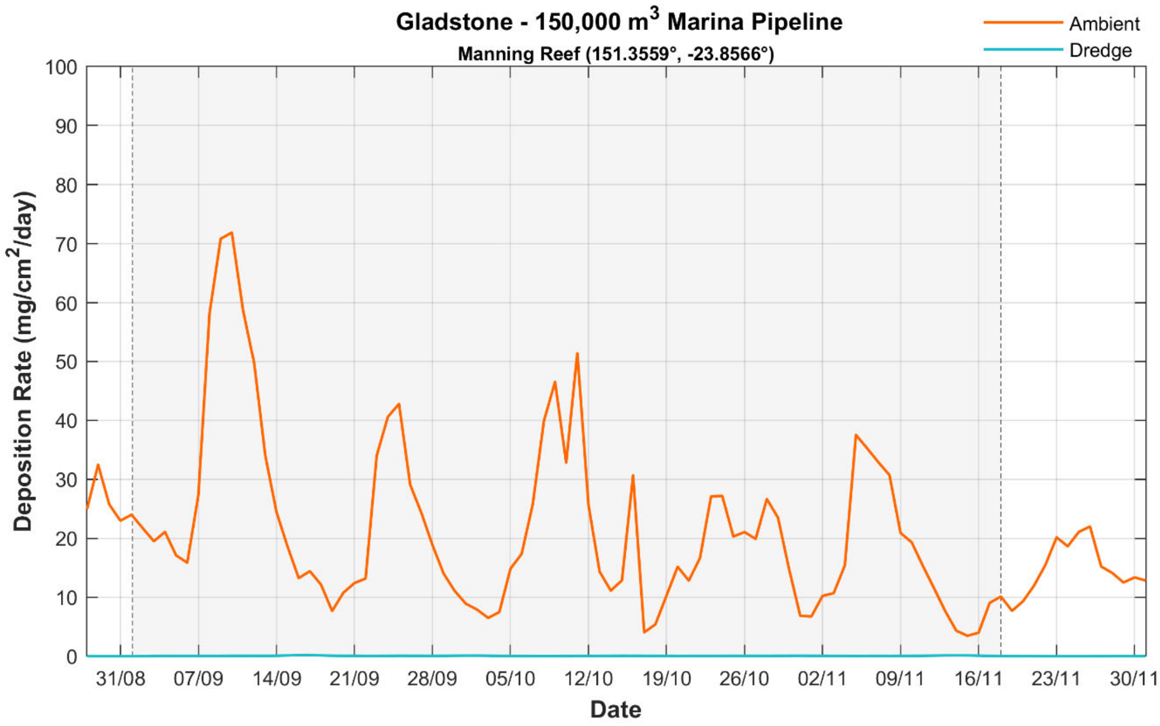

Gladstone - 150,000 m3 Marina Pipeline
China Bay (151.2023°, -23.7821°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

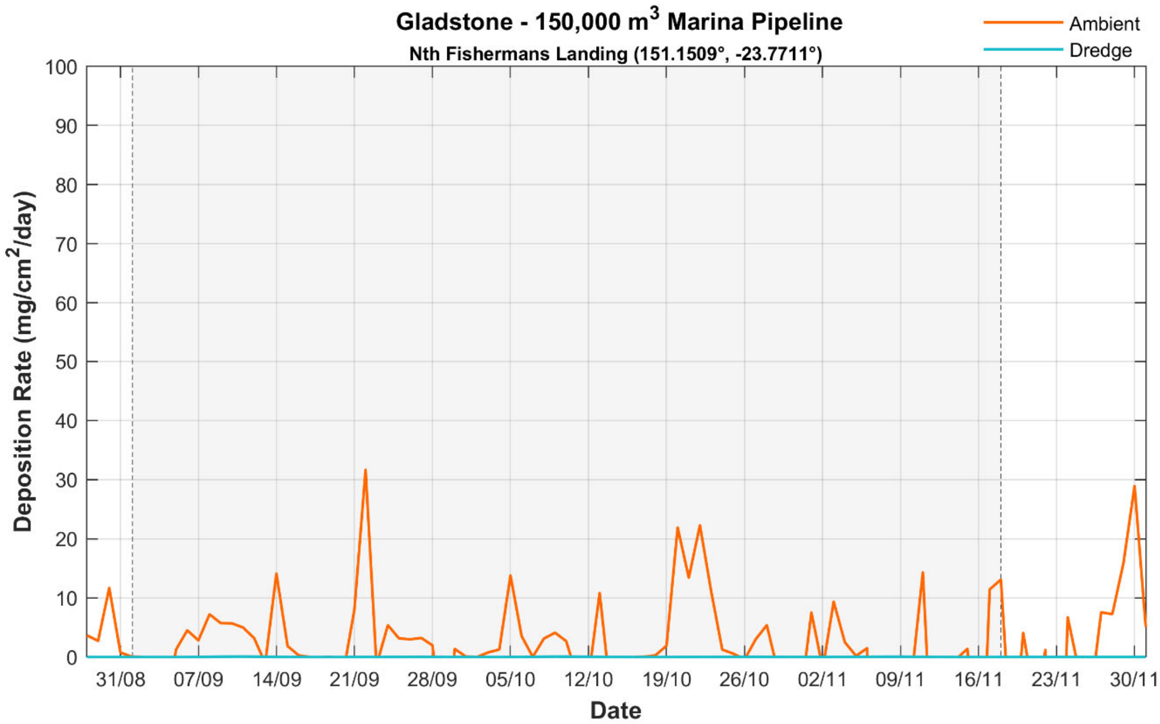

Gladstone - 150,000 m3 Marina Pipeline
Friend Point (151.1605°, -23.7491°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

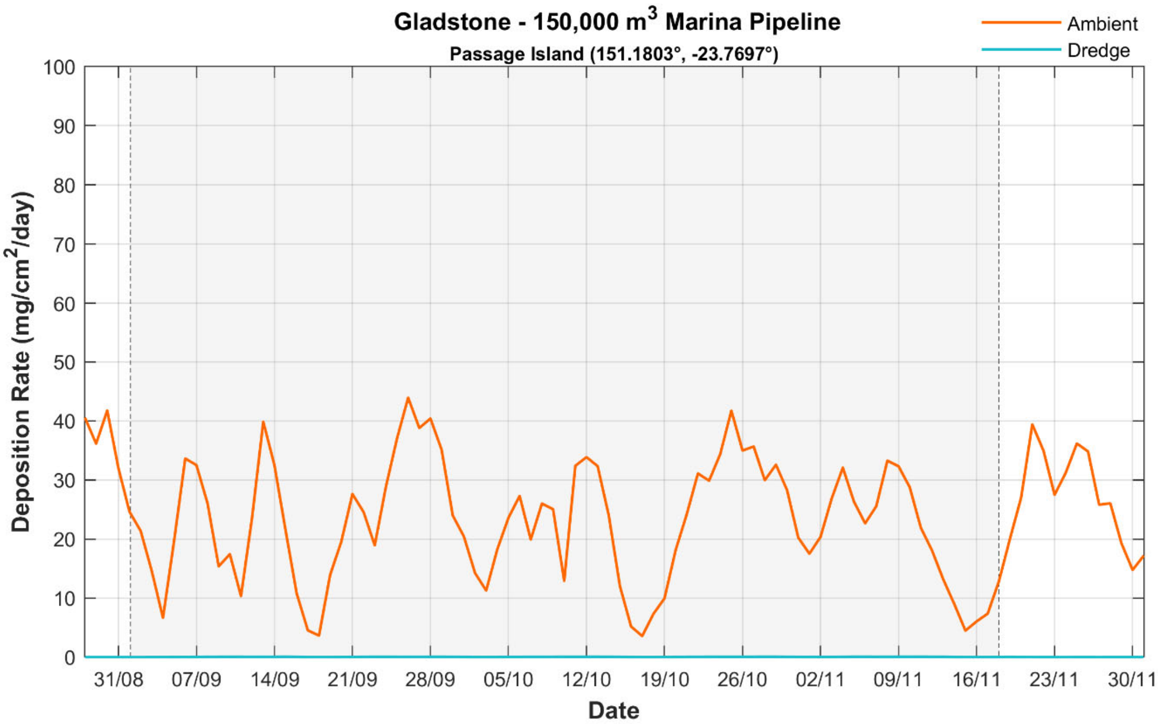

Gladstone - 150,000 m3 Marina Pipeline
Gatcombe Head (151.3743°, -23.8817°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

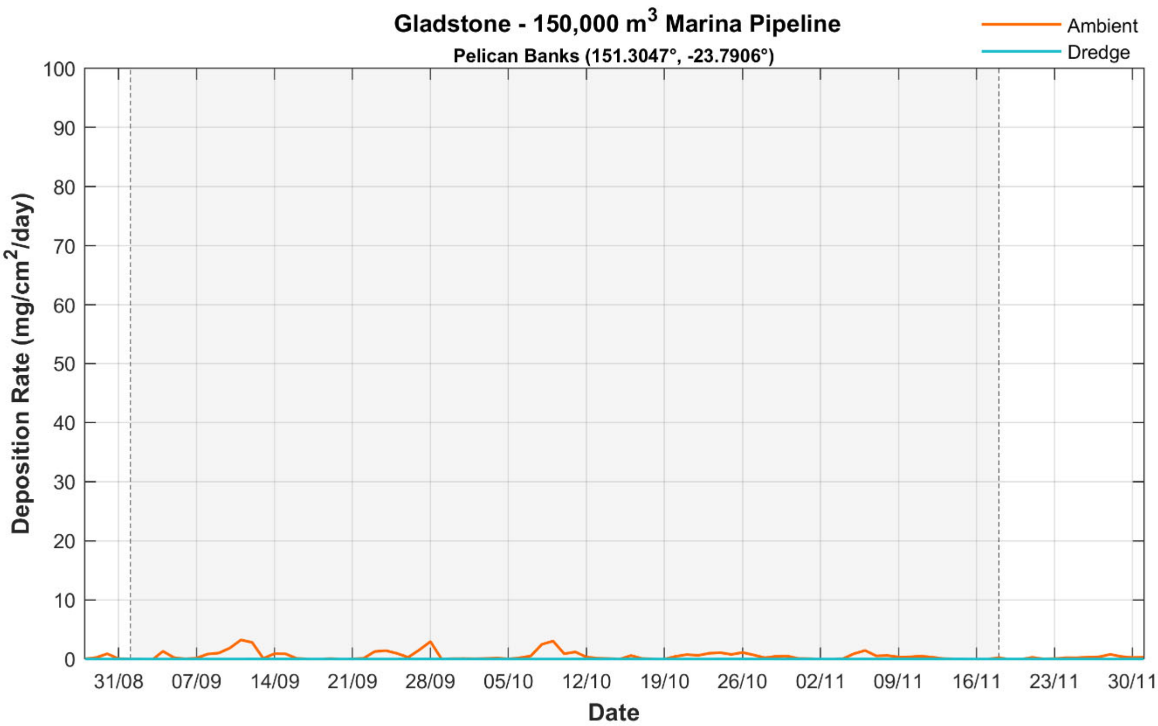

Gladstone - 150,000 m3 Marina Pipeline
GBRMP Boundary (151.4332°, -23.8585°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

Time Series of Modelled Deposition Rate

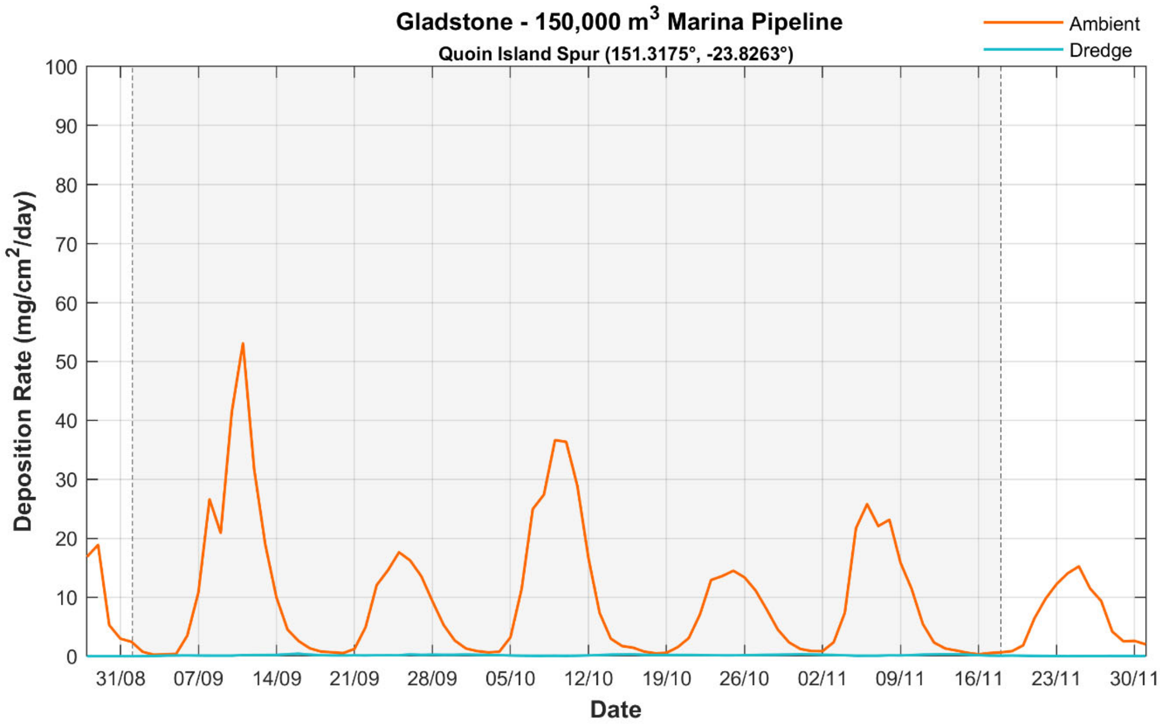


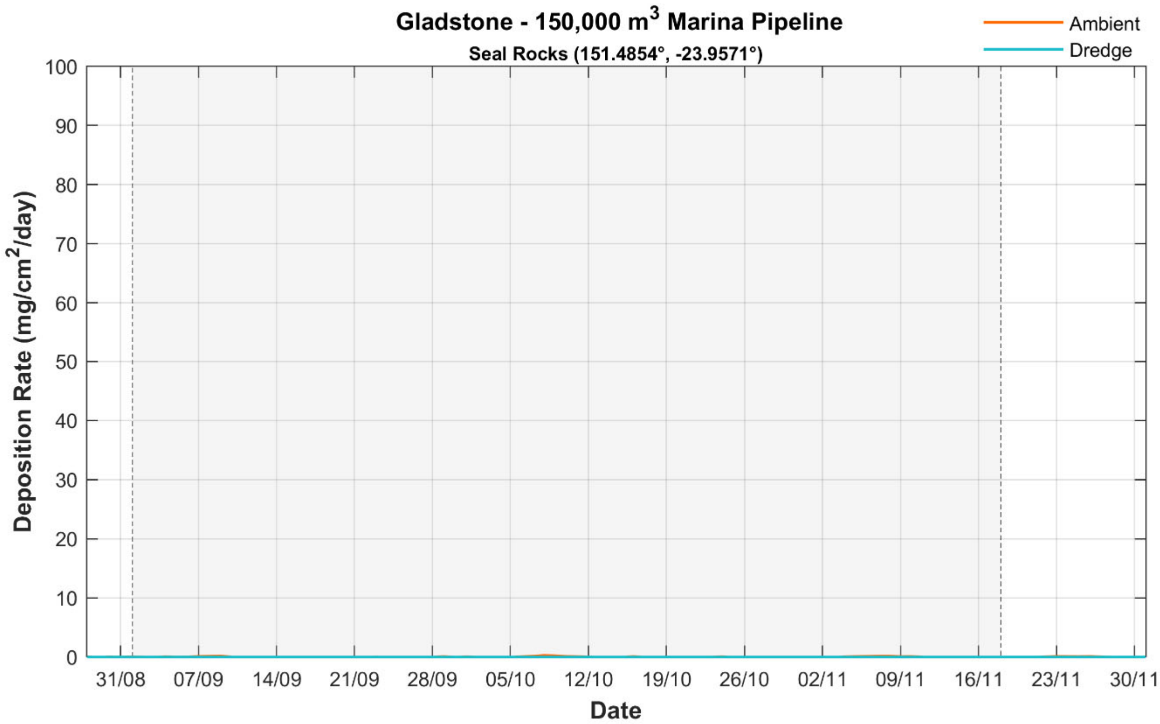



Gladstone - 150,000 m3 Marina Pipeline
Passage Island (151.1803°, -23.7697°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

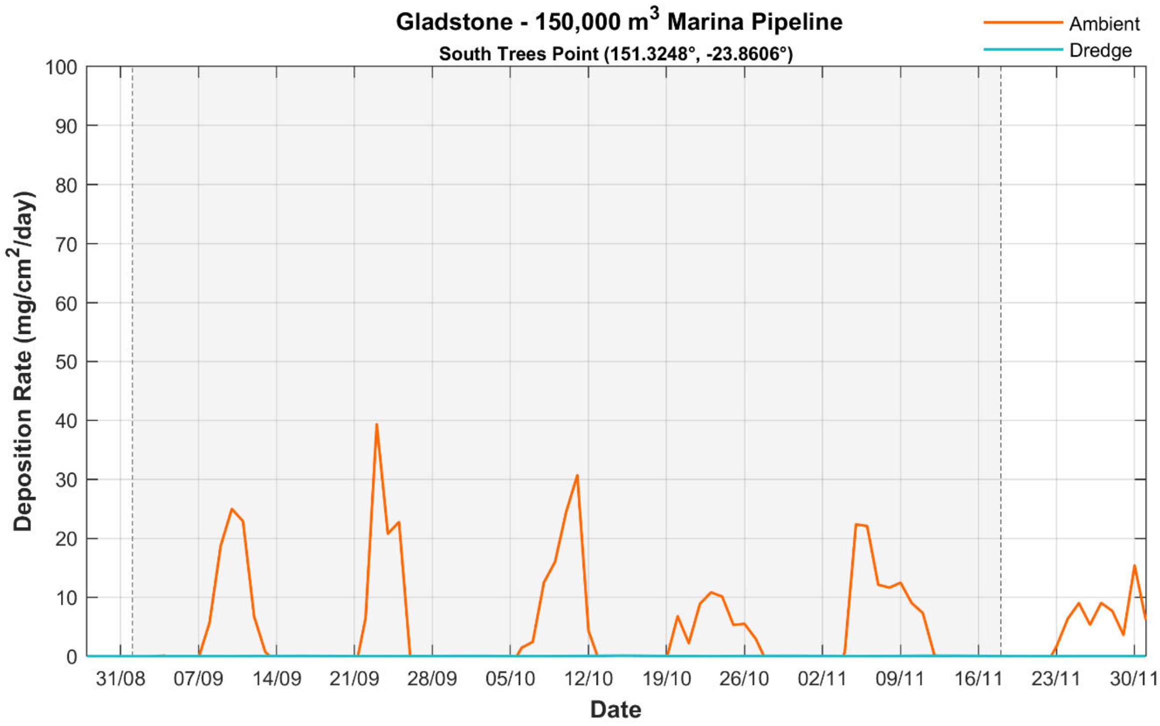

Gladstone - 150,000 m3 Marina Pipeline
Pelican Banks (151.3047°, -23.7906°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

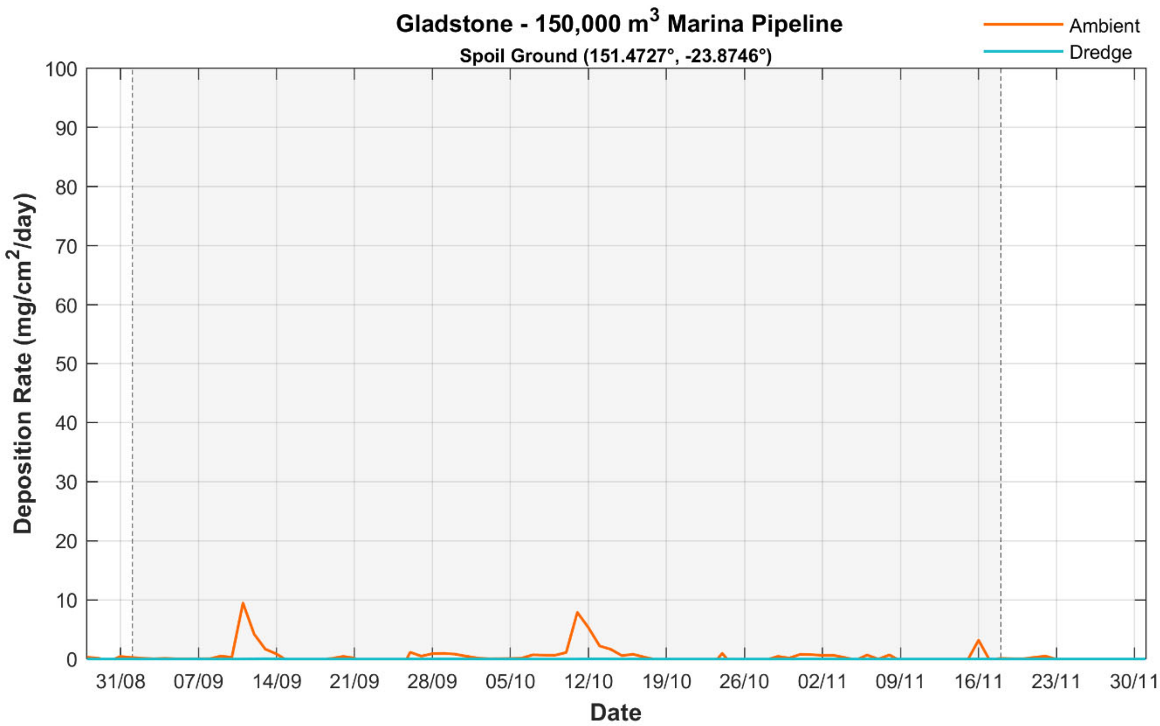
Time Series of Modelled Deposition Rate



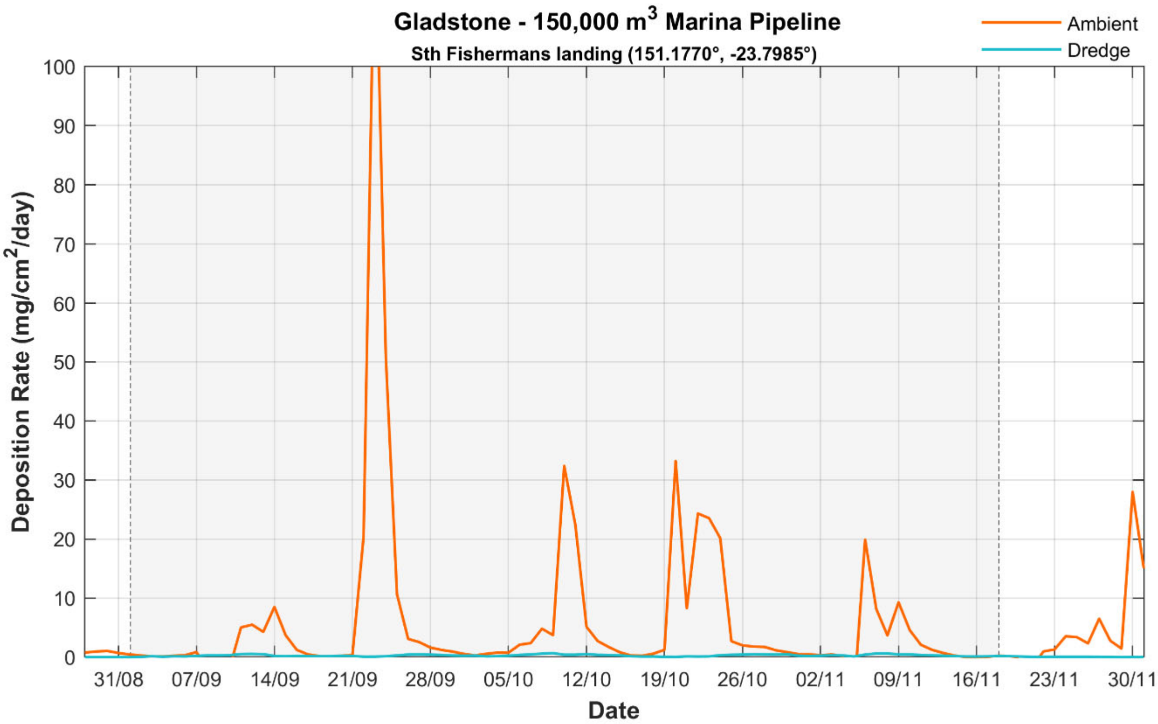


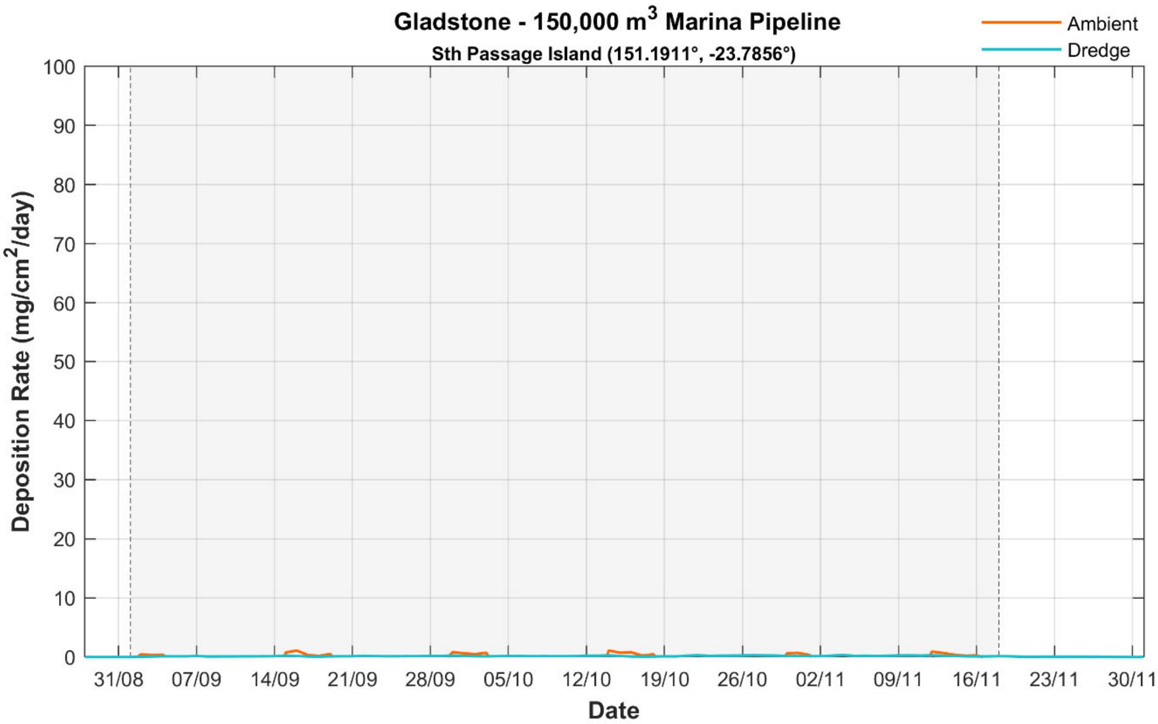
Time Series of Modelled Deposition Rate

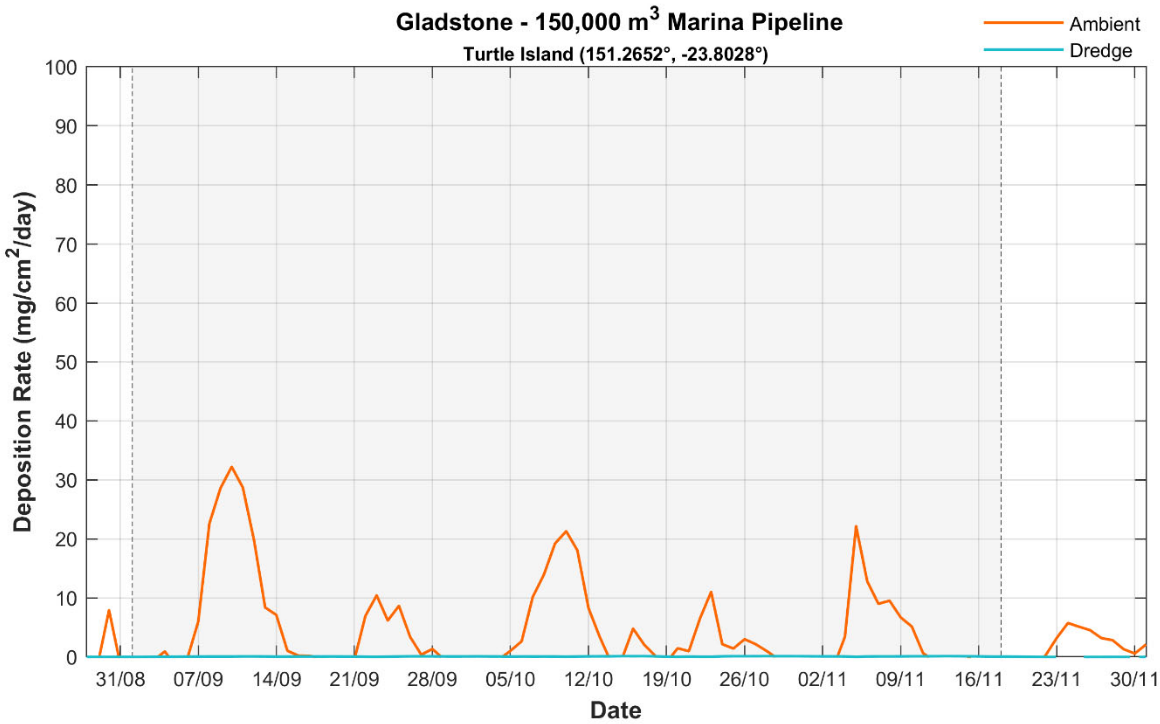


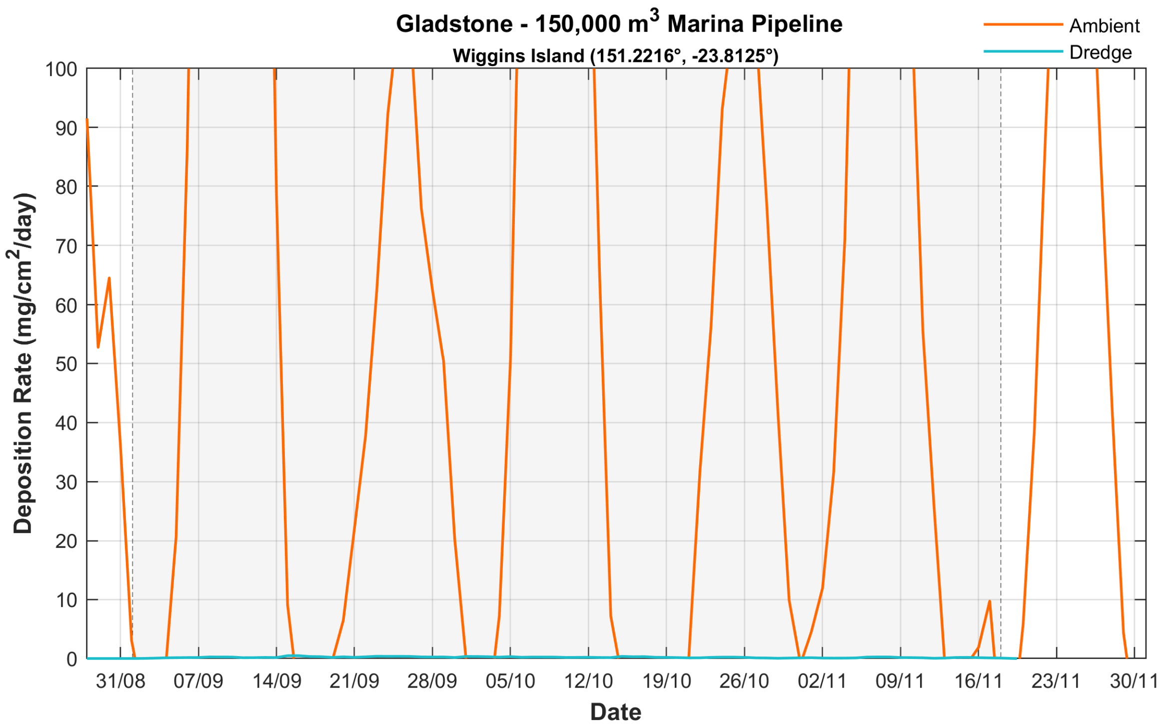


Time Series of Modelled Deposition Rate

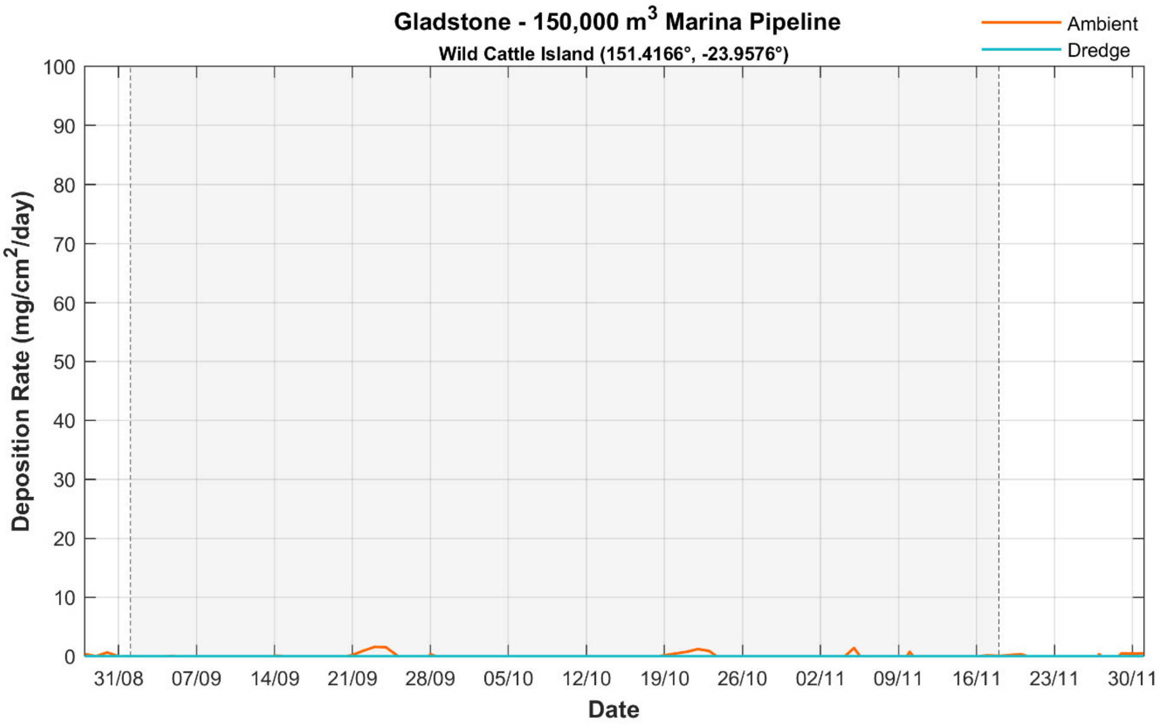





Gladstone - 150,000 m3 Marina Pipeline
Turtle Island (151.2652°, -23.8028°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date


Gladstone - 150,000 m3 Marina Pipeline
Wiggins Island (151.2216°, -23.8125°)
Ambient
Dredge
Deposition Rate (mg/cm2/day)
100
90
80
70
60
50
40
30
20
10
0
31/08
07/09
14/09
21/09
28/09
05/10
12/10
19/10
26/10
02/11
09/11
16/11
23/11
30/11
Date

Time Series of Modelled Deposition Rate



BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.

Brisbane
Level 5, 348 Edward Street
Brisbane Queensland 4000
PO Box 203 Spring Hill Queensland 4004
Australia
Tel +61 7 3831 6744
Fax +61 7 3832 3627
Email environment@bmtglobal.com

Melbourne
Level 5, 99 King Street
Melbourne Victoria 3000
Australia
Tel +61 3 8620 6100
Fax +61 3 8620 6105
Email environment@bmtglobal.com

Newcastle
Level 1, 161 King Street
Newcastle New South Wales 2300
Tel +61 2 4940 8882
Fax +61 2 4940 8887
Email environment@bmtglobal.com

Adelaide
5 Hackney Road
Hackney Adelaide South Australia 5069
Australia
Tel +61 8 8614 3400
Email info@bmtdt.com.au

Northern Rivers
Suite 5
20 Byron Street
Bangalow New South Wales 2479
Australia
Tel +61 2 6687 0466
Fax +61 2 6687 0422
Email environment@bmtglobal.com

Sydney
Suite G2, 13-15 Smail Street
Ultimo Sydney New South Wales 2007
Australia
Tel +61 2 8960 7755
Fax +61 2 8960 7745
Email environment@bmtglobal.com

Perth
Level 4
20 Parkland Road
Osborne Park Western Australia 6017
PO Box 2305 Churchlands Western Australia 6018
Australia
Tel +61 8 6163 4900
Email environment@bmtglobal.com

London
Zig Zag Building, 70 Victoria Street
Westminster
London, SW1E 6SQ
UK
Tel +44 (0) 20 8090 1566
Email environment.uk@bmtglobal.com

Leeds
Platform
New Station Street
Leeds, LS1 4JB
UK
Tel: +44 (0) 113 328 2366
Email environment.uk@bmtglobal.com

Aberdeen
11 Bon Accord Crescent
Aberdeen, AB11 6DE
UK
Tel: +44 (0) 1224 414 200
Email environment.uk@bmtglobal.com

Asia Pacific
Indonesia Office
Perkantoran Hijau Arkadia
Tower C, P Floor
Jl: T.B. Simatupang Kav.88
Jakarta, 12520
Indonesia
Tel: +62 21 782 7639
Email asiapacific@bmtglobal.com

Arlington
2900 South Quincy Street, Suite 210
Arlington, VA 22206
United States
Tel: +1 703 920 7070
Email inquiries@dandp.com