Gladstone Ports Corporation
Growth, prosperity, community.

Port of Gladstone Maintenance Dredging Environmental Monitoring Procedure

Brief description

This document describes environmental sensitive receptors, monitoring and related adaptive management framework specifically designed for the Port of Gladstone maintenance dredging. The appropriate monitoring and management of this activity is in fact essential to ensure that the potential environmental impacts of this activity are identified, avoided or minimised. The program, the result of government guidelines, best practise, years of monitoring and research, is robust, science-based and fit for purpose.

Document information	
Current version	#1013458v25a
First released	06/01/2013
Last updated	24/11/2023
Review frequency	Every year or as required
Review before	05/05/2024 or as required
Audience	Specialist Harbours and Channels, Environment Team, Contractors, GPC qualified auditors, external auditors, Administering Authorities

Document accountability	
Role	**Position**
Owner	Executive General Manager – Marine Operations
Custodian	Environment Superintendent

Endorsed by	GPC on 30/11/2023 DCCEEW on 21/12/2023 DES on 07/11/2018

If you require any further information, please contact the Custodian.

Contents

1 Terms and definitions 4

2 Introduction 5

2.1 Purpose 5

2.2 Scope 5

2.3 Objectives 5

3 Procedure 6

3.1 Roles and Responsibilities 6

3.2 Environmental Monitoring Framework 6

3.3 Activity Based WQ Monitoring 7

3.3.1 Water Quality Monitoring 9

3.3.2 Turbidity and management trigger values 10

3.3.3 Turbidity Adaptive Management 13

3.3.4 BPAR Monitoring 15

3.3.5 Seagrass Monitoring Background 15

3.3.6 BPAR Monitoring Site 16

3.3.7 BPAR Adaptive Management 16

3.4 Dredge Data 17

3.5 Reporting 18

3.6 Long Term Monitoring Programs 18

3.6.1 Sediment Analysis Plan 18

3.6.2 Specialised Equipment 19

3.6.3 Bioavailability Studies 19

3.6.4 Water Quality (Plume Validation) 20

3.6.5 Reefs Survey 20

3.6.6 MRA Benthic Habitats 20

3.6.7 Hydrographic Survey 21

3.6.8 Marine Pests 21

3.6.9 PCIMP 21

3.6.10 GHHP 22

3.6.11 Seagrass Surveys 22

3.7 Data Management 23

3.7.1 Data Validation 23

3.7.2 Access to Reports and Data 23

4 MP Review 24

5 References 24

6 Related Documents 25

7 Revision History 25

Figures

Figure 1: PoG MD footprint (zone of impact) and zone of influence (delimited by red line) (BMT WBM, 2017).

Figure 2: PoG MD water quality monitoring stations.

Figure 3: PoG MD turbidity (EWMA) adaptive management flowchart for the dry and wet season.

Tables

Table 1: Maintenance dredging telemetered WQ monitoring sites.

Table 2: WQ grabs sampling sites coordinates.

Table 3: WQ grabs analyses.

Table 4: Turbidity triggers summary at WQ monitoring stations.

Table 5: PoG MD BPAR monitoring sites.

Table 6: Adaptive management for BPAR to be implemented during PoG MD operations.

1 Terms and definitions

"ANZECC" means Australian and New Zealand Environment and Conservation Council.

"ARMCANZ" means Agriculture and Resource Management Council of Australia and New Zealand.

"AWAC" means Acoustic Wave and Current profiler.

"BPAR" means Benthic Photosynthetically Active Radiation.

"DAF" means Department of Agriculture and Fisheries.

"DCCEEW" means Department of Climate Change, Energy, the Environment and Water (Commonwealth)

"DES" means Department of Environment and Science.

"DO" means dissolved oxygen.

"EA" means Environmental Authority.

"EBSDS" means East Banks Sea Disposal Site, also known as 'Dredged Material Placement Area

"EC" means electrical conductivity.

"EIS" means Environmental Impact Statement.

"EM" means environmental monitoring.

"EMP" means Environmental Management Plan.

"EMS" means Environmental Management System.

"EWMA" means Exponentially Weighted Moving Average.

"GGCDP" means Gatcombe Golding Channel Duplication Project.

"GHHP" means Gladstone Healthy Harbour Partnership.

"GPC" means Gladstone Ports Corporation Limited.

"IMO" means International Maritime Organisation.

"LMDMP" means Long Term Maintenance Dredging Management Plan.

''MD'' means maintenance dredging.

''MNES'' means Matters of State and National Environmental Significance.

"MP" means Monitoring Procedure.

"MRA" means Off-shore Material Relocation Area, also known as East Banks Sea Disposal Site

"NADG" means National Assessment Guidelines for Dredging.

"NTU" means Nephelometric Turbidity Units.

"PCIMP" means Port Curtis Integrated Monitoring Program.

"PoG" means Port of Gladstone.

''RA'' means rolling average.

"SAP" means sediment analysis plan.

''TACC'' means Technical Advisory and Consultative Committee.

"TDP" means Total Daily Par.

"TBT" means Tributyltin.

"WBDDP" means Western Basin Dredging and Disposal Project.

"WQ" means water quality.

"WQOs" means Water Quality Objectives.

2 Introduction

2.1 Purpose

This Monitoring Procedure (**"MP"**) has been developed to:

- Describe the GPC systems to monitor, assess, prevent or minimise potential environmental risks and impacts associated with maintenance dredging (**''MD''**) activities in the Port of Gladstone (**"PoG"**);
- Describe the monitoring program design, monitoring locations, water quality (**''WQ''**) indicators, methods and adaptive management framework to be implemented during MD; and
- Address compliance requirements and commitments;

2.2 Scope

The present MP covers all aspects of the environmental monitoring (**"EM"**) undertaken around the PoG annual MD campaigns. The latter, herein referred to as Activity Based EM, will be conducted starting four (4) weeks prior MD operations commencement, it will continue throughout dredging operations and it will conclude two (2) weeks post operations completion.

The present MP implements, supports and should be read in conjunction with:

- The Port of Gladstone Maintenance Dredging Environmental Management Plan (EMP) (#879363); and
- The Port of Gladstone Long Term Maintenance Dredging Management Plan (LMDMP) (#1385321).

This MP also introduces and describes aspects of the LMDMP and associated Long Term Monitoring Schedule. Whilst part of the same framework, the yearly Activity Based EM conducted around MD is undertaken and assessed for compliance purposes to prevent, minimise and manage any potential environmental harm. Monitoring elements part of the Long Term Monitoring Schedule are instead commitments in place to help to determine and assess potential long terms impacts of MD on the receiving environment and sensitive receptors.

2.3 Objectives

This MP aims to maintain compliance with the relevant permits and approvals detailed in the EMP by implementing the required and appropriate EM program. Adaptive management actions based on monitoring results are in place to ensure any potential environmental harm from MD related plumes on sensitive receptors are identified, assessed, prevented or minimised.

This procedure addresses:

- Environmental values and risks;

- Risk based approach and framework as well as related monitoring programs;
- Environmental monitoring of MD activities and related adaptive management framework. This can be subdivided into three (3) aspects:
  - Ambient monitoring;
  - Impact detection; and
  - Adaptive management.
- Implementation of the Long Term Monitoring Schedule.

The performance of this MP will be measured through a post dredging audit as well as risk reviews, inspections, incident and complaint investigations and reporting (EMP Section 5.18).

3 Procedure

3.1 Roles and Responsibilities

GPC Employees and Contractors are responsible for the environmental performance of their activities and for complying with the general environmental duty as set out in Section 319 (1) of the *Environmental Protection Act 1994* (Qld) which states:

'A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to minimise the harm'.

Roles and responsibilities in relation to this MP are detailed in Section 5.7 of the EMP.

3.2 Environmental Monitoring Framework

GPC's Risk Management Framework provides the processes to ensure the Environmental Management System (**"EMS"**) suitably manages all aspects under the control or influence of GPC. The PoG MD risk assessment is maintained in GPC's Risk system. Monitoring based risk controls and actions are documented and detailed in this MP and are derived from the LMDMP which set the long term monitoring programs for MD activities.

As mentioned in Section 2.2, as well as the Activity Based EM undertaken yearly before, during and after MD campaigns this MP details also the Long Term Monitoring Schedule which includes a range of monitoring programmes (LMDMP Table 15). These incorporate plume monitoring, seagrass, reef and benthic monitoring as well as hydrographic surveys; most of these programmes are undertaken five (5) yearly, whilst others are yearly or ad-hoc (Section 3.6).

Monitoring outputs inform GPC's adaptive management of MD and the continual improvement processes described in the LMDMP. To establish the Activity Based and some of the components of the Long Term Monitoring Schedule, GPC applies a risk assessment framework and considers the following aspects and impacts:

- Identification of environmental values and sensitive receptors through impact assessment (LMDMP Section 3). These include WQ, flora and fauna, and Matters of State and National Environmental Significance (**''MNES''**);

- Modelled and forecasted impacts of MD on identified environmental values and sensitive receptors through hydrodynamic and plume modelling as well as abovementioned impact assessment (LMDMP Section 3);

- State-wide MD considerations to optimise operational efficiency and minimise potential environmental impacts; and

- Environmental information and observations for evaluation purposes.

3.3 Activity Based WQ Monitoring

As mentioned in the previous section, the Activity Based EM was devised upon hydrodynamic and plume modelling as well as impact assessment and long term data sets (BMT WBM, 2017). Modelling outputs were used to determine possible zones of impact and influence associated with MD activities (Figure 1).

It is important to notice that the current Activity Based monitoring detailed in this MP is geared towards modelling outputs of a maximum 340,000 m^3 MD campaign in the PoG main channels with spoil placement at the off-shore Material Relocation Area (MRA) also known as the East Banks Sea Disposal Site (**"EBSDS"**). Therefore the MP is adequate for smaller campaigns as showed by the different modelling outputs which were also validated through a range of field studies as well as with data collected during Activity Based monitoring. Detailed information on MD impact assessment, modelling and zones of impact can be found on GPC website (Maintenance Dredging Gladstone - Gladstone Ports Corporation (gpcl.com.au).

Using the abovementioned modelling outputs, areas that can be influenced by dredging operations were highlighted and thus used to identify appropriate monitoring locations. The latter will therefore be appropriate and used to protect the receiving environment and sensitive receptors through monitoring and adaptive management (Section 3.3).

Monitoring will comprise of real-time WQ and light (Benthic Photosynthetically Active Radiation (**"BPAR"**)) and will be undertaken to:

- Measure WQ, specifically turbidity, and BPAR levels adjacent and at sensitive receptors sites within the PoG (Figure 1). The data and observations collected will inform adaptive management; and

- Implement adaptive management and mitigation measures to prevent or minimise any potential impact of MD activities on sensitive receptors within the PoG.

Additional to real-time WQ and light, monitoring aspects such due diligence in situ WQ grabs form part of the overall Activity Based EM detailed in this MP as well as monitoring components of the Long Term Monitoring Schedule and thus LMDMP which are implemented as per approved timelines detailed in Table 15 of the LMDMP. As mentioned in Section 2.2, the Activity Based monitoring will be conducted prior to MD commencement to gain baseline data (two weeks for WQ and 4 weeks for BPAR), it will continue throughout dredging operations concluding two (2) weeks post operations completion. All monitoring will be undertaken by suitably qualified personnel and following relevant and appropriate guidelines.

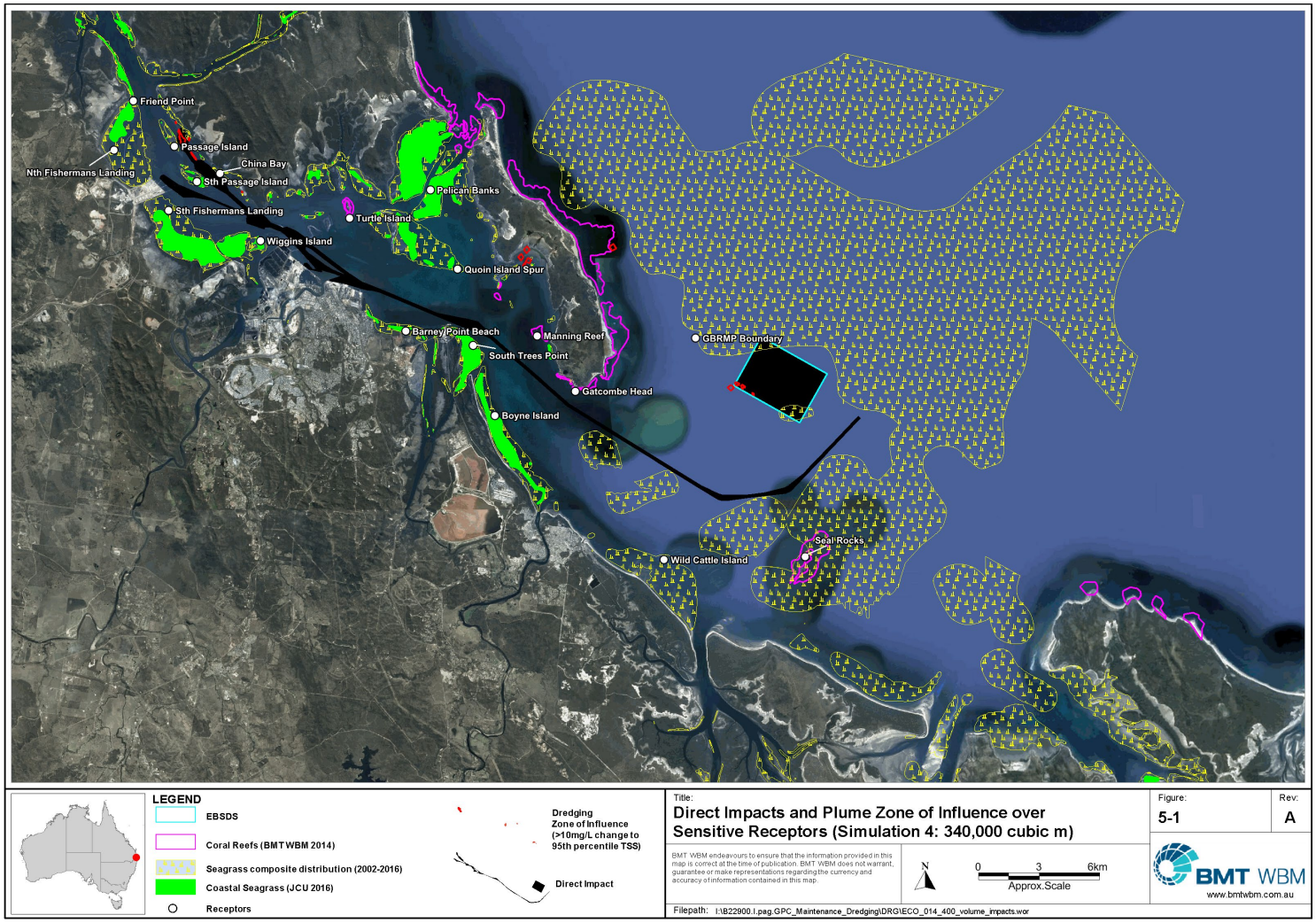

Figure 1: *PoG MD footprint (zone of impact) and zone of influence (delimited by red line) (BMT WBM, 2017).*

3.3.1 Water Quality Monitoring

Two (2) WQ sites, one (1) compliance and one (1) support, were selected as per methods mentioned in Section 3.2 and 3.3 (Table 1 and Figure 2). Both sites were also utilised during the Western Basin Dredging and Disposal Project (**"WBDDP"**) therefore information and long term data sets from which turbidity triggers have been derived are available (Section 3.3.2). At these WQ monitoring sites, modified buoys equipped with dual multiparameter sondes and telemetry system will be installed, commissioned and maintained. These will log readings every fifteen (15) minutes which will be transmitted in near real time by the telemetry system. All equipment will be appropriately serviced and maintained.

At the compliance site turbidity levels (as an Exponentially Weighted Moving Average (**''EWMA''**)) (Section 3.3.2) will be screened against triggers for compliance purposes. Turbidity is in fact the key parameter and the only one that can be directly influenced by MD operations. The same will occur at the support site and thus well away from the modelled zone of influence, however here turbidity levels as EWMA will be monitored for due diligence and comparative purposes in order to confirm and highlight patterns and dynamics and thus isolate potential MD impacts. As well as turbidity, at the compliance and support monitoring location, the whole remaining suite of standard physical-chemical parameters (temperature, electrical conductivity (''**EC''**), pH and dissolved oxygen ''**DO**'') will be recorded as due diligence and utilised in data analysis and trending.

The WQ monitoring site locations and naming is consistent with the Port Curtis Integrated Monitoring Program (**"PCIMP"**) which is a long term, far field ambient WQ program.

Table 1: *Maintenance dredging telemetered WQ monitoring sites.*

Site	Status	Site description and water area	WQ zone of impact
WB50	Compliance	Outside the mouth of the Calliope River and adjacent to the Wiggins Island Coal Terminal and Wiggins Island seagrass meadows. Western Basin (MD2421).	Zone of influence
MH10	Support	Adjacent to Pelican banks seagrass meadows. Mid Harbour (MD2423).	Outside of zone of influence

Due diligence grab samples at five (5) locations will also be undertaken once per each monitoring phase and thus before, during and after MD (Table 2 and Figure 2). Samples will be analysed for a range of metals, Tributyltin (''**TBT''**) and Chlorophyll *a* by a National Association of Testing Authorities (**"NATA"**) accredited laboratory holding the accreditation for the analyses required (Table 3).

Table 2: *WQ grabs sampling sites coordinates.*

Site	GPS coordinates
NW70	S23°44.351' E151°10.703'
WB50	S23°48.304' E151°12.555’
IH15	S23°47.733’ E151°14.307’
MH40	S23°50.779' E151°20.481’
MH50	S23°52.887’ E151°22.648’

WQ telemetry and grab samples for metals, TBT and Chlorophyll *a* will test the following impact hypothesis:

Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.

Results will be used to examine if any changes are observed during the monitoring program and will aid in the long term management of PoG MD activities. Despite this monitoring component being due diligence, GPC will screen the results against Water Quality Objectives (**“WQOs”**) for Gladstone Harbour Zones. Note that for metals the WQOs for Gladstone Harbour Zones adopt the Australian and New Zealand Environment and Conservation Council (**“ANZECC”**) and Agriculture and Resource Management Council of Australia and New Zealand (**“ARMCANZ”**) guidelines. Thus results will be screened against ANZECC/ARMCANZ thresholds for 95% marine species protection. In the case of elevation GPC will investigate and determine the reason of such elevations. If these are deemed to be caused by MD activities appropriate corrective actions will be implemented to prevent any potential harm to the environment; for more information refer to Section 5.14 of the EMP.

Table 3: WQ grabs analyses.

Analyte	Unit
Aluminium (filtered)	µg/L
Cadmium (filtered)	µg/L
Chromium (filtered)	µg/L
Copper (filtered)	µg/L
Lead (filtered)	µg/L
Mercury (filtered)	µg/L
Nickel (filtered)	µg/L
Silver (filtered)	µg/L
Zinc (filtered)	µg/L
Tributyltin (TBT)	ngSn/L
Chlorophyll *a*	µg/L

3.3.2 Turbidity and management trigger values

Turbidity monitoring during the PoG MD will test the following impact hypothesis:

Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.

Turbidity is a measurement of water clarity and is influenced by suspended matter (organic and inorganic) as well as dissolved matter. Turbidity is an expression of the optical property of light to be scattered and absorbed with a greater amount of matter within the water column leading to a higher amount of light scattering and thus higher turbidity. Dredging activities have the capacity to increase background turbidity levels potentially resulting in environmental harm. Therefore turbidity is an important parameter to measure during dredge operations.

During maintenance dredging operations, turbidity as EWMA will be screened against turbidity triggers developed for the WQ compliance site WB50 as per methods mentioned in Section 3.2 and 3.3 (Table 4). Both percentiles and turbidity triggers were initially developed and employed for the WBDDP, these are:

- 80th percentile: internal alert when turbidity values as EWMA exceed trigger > 36 consecutive hrs; and
- 95th percentile: external notification when turbidity values as EWMA exceed trigger > 24 consecutive hrs.

Table 4: *Turbidity triggers summary at WQ monitoring stations.*

Site name	Status	Zone	Compliance parameter	Wet season triggers (01 Oct – 31 Mar)	Dry season triggers (01 Apr – 31 Sep)	Data requirements
WB50	Compliance	Western Basin	Turbidity (NTU) as EWMA	30 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	17 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Data logged every 15 minutes. Near real time (telemetry) feed. Automatically de-confounded WQ data + 6 hourly EWMA computation for turbidity
				48 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	27 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
MH10	Support	Mid-harbour	N/A	N/A	N/A	
				N/A	N/A	

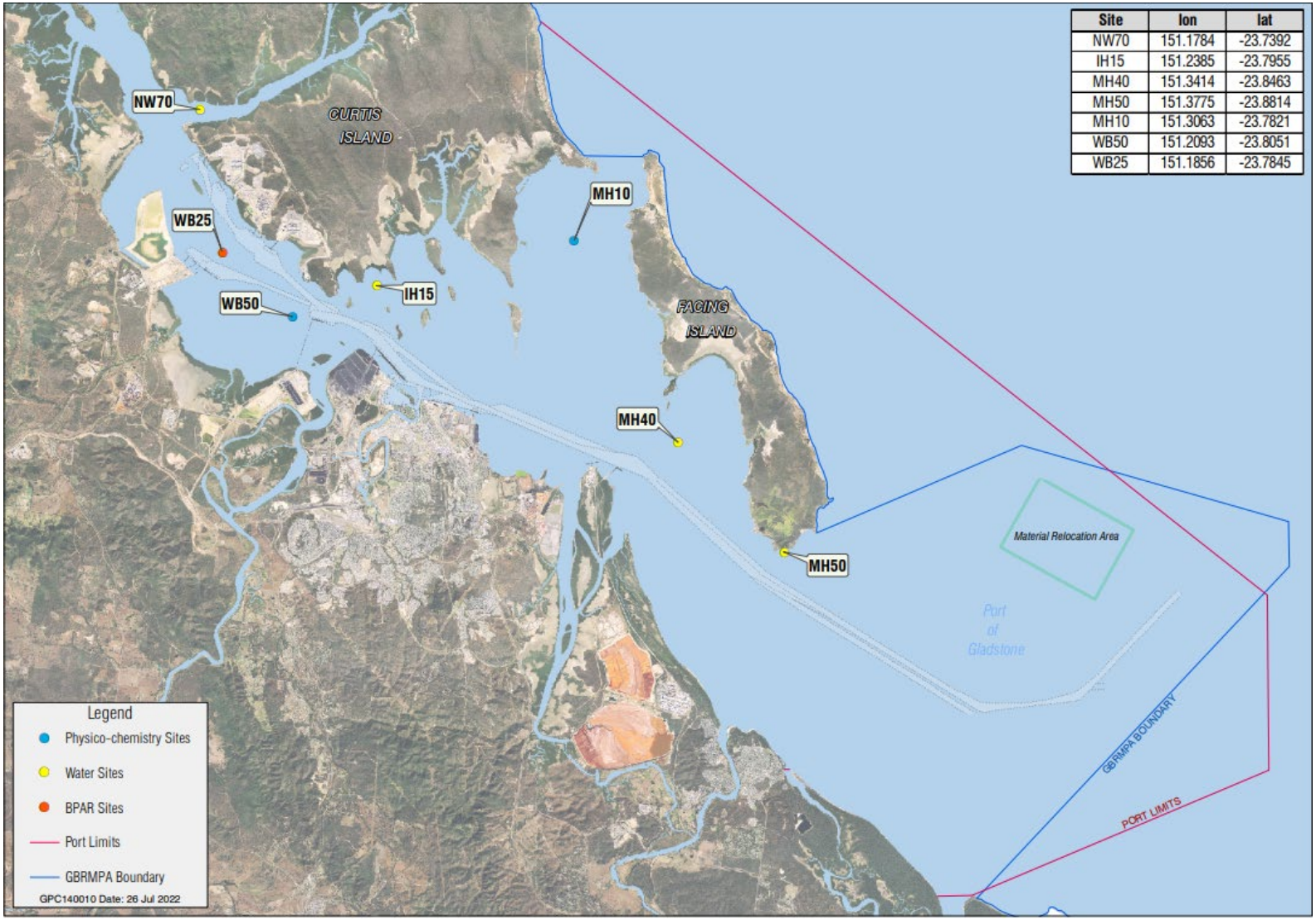

Figure 2: *PoG MD water quality monitoring stations.*

The internal alert and external notification trigger levels will be implemented based on the application of a 6 hourly EWMA to the raw turbidity data. The data collected via telemetry will undergo appropriate preliminary QA/QC procedures. The de-confounding process includes automatic algorithm and manual based validation processes. The EWMA is a smoothing technique developed by statistical experts that takes into consideration background levels so that readings increase and decrease gradually avoiding false readings and alarms (both on and off). Therefore when values exceed triggers or go below triggers they will not be expected to invert their trends suddenly. The 6 hour EWMA is calculated by using a 60:40 weighting system, where the current EWMA (Z_i) is computed by adding 60% of the mean turbidity readings during the preceding (just recorded) 6 hours (Xi) to 40% of the preceding 6 hour EWMA value (Z_{i-1}). Mathematically, 6-hourly values of the EWMA statistic are computed using the following equation:

$$Z_i = 0.6\ X_i + 0.4Z_{i-1}$$

Where i is the mean of the data for the ith period (in this case, the current 6 hour period).

3.3.3 Turbidity Adaptive Management

Adaptive management steps (Figure 3) have been developed to ensure appropriate procedures and actions are undertaken when turbidity as EWMA at the WQ compliance site reaches the abovementioned percentiles (Table 4). When the turbidity, as 6 hours EWMA, at WB50 remains below the Internal Alert Levels (Alert Level 1 (internal)), no investigation into the cause of turbidity changes, if any are occurring, and dredging operational management will be undertaken.

The Alert Level 1 (internal) for turbidity, as 6 hours EWMA, is instead triggered when turbidity at WB50 exceeds the 80th percentile trigger continuously for more than 36 hours. This trigger is internal and proactive only, here GPC Environmental Monitoring Specialist will initiate the Response 1 conducting an investigation to determine the causes of the turbidity elevation. If it is deemed that the turbidity elevation is predominantly caused by MD activities, Response 1 will be initiated where GPC stakeholders and the dredging contractor will discuss and implement management measures to rectify dredging related impact on turbidity. If, instead, turbidity returns below the 80th percentile trigger or the abovementioned investigation shows that likely causes of elevation of turbidity are driven by environmental conditions no actions will be taken, WQ monitoring will continue and the status will go back to general monitoring.

When the Alert Level 2 (external) is triggered, in the instance turbidity as 6 hours EWMA exceeds the 95th percentile trigger continuously for more than 24 consecutive hours, GPC Environmental Compliance Specialist will notify the Department of Environment and Science (**"DES"**) and the Department of Climate Change, Energy, the Environment and Water (Commonwealth) (**'' DCCEEW''**) as per timelines detailed in the EMP (Section 5.14). The Environmental Monitoring Specialist will continue or open an investigation as per detailed above. Depending on the findings of the investigation appropriate stakeholders will be consulted and measures will be implemented or the investigation will be closed with status going back to general monitoring as detailed above in the instance of Alert Level 1.

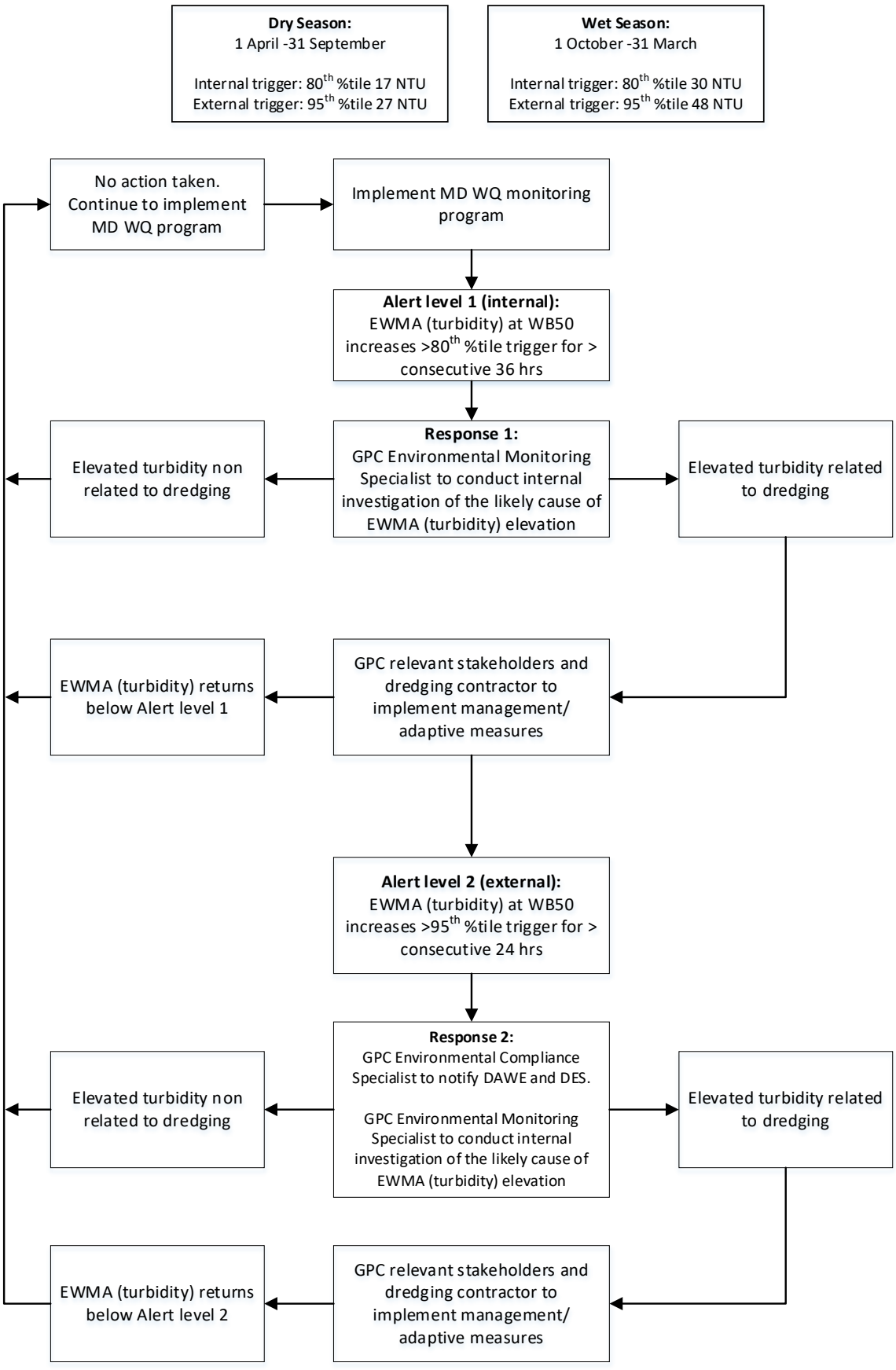

Figure 3: *PoG MD turbidity (EWMA) adaptive management flowchart for the dry and wet season.*

3.3.4 BPAR Monitoring

Seagrass meadows are an important primary producer in Port Curtis and have high economic and ecological value. In fact, seagrass beds play a key role in providing food resources and habitat for species of turtle and dugong as well as fish and invertebrates at both juvenile and adult life stages. Due to their sensitivity to reduced light conditions, the crucial ecosystem services they provide and widespread distribution within the Port Curtis region, seagrass meadows are adopted as the sensitive receptor for detecting potential PoG MD impacts.

Measurement of the light reaching seagrass (BPAR) is the key monitoring parameter to assess and determine whether sufficient light is reaching seagrass meeting its health and growth requirements. Levels of light reaching the benthos and thus the seagrass canopy can be affected by turbidity, but also by a range of other environmental factors such as cloud cover. Therefore BPAR monitoring will be undertaken to:

- Measure light levels at the sensitive receptor within the zone of influence that can be affected by MD operations to avoid and manage any potential impacts of MD on Port Curtis seagrass meadows and sensitive receptors within the zone of influence (Figure 1); and
- Implement mitigation measures to prevent environmental harm to seagrass beds and other sensitive receptors when appropriate.

The results of this monitoring will test the following impact hypothesis:

Maintenance dredging activities do not result in impact to sensitive receptors.

3.3.5 Seagrass Monitoring Background

Light is a crucial factor for seagrasses and thus BPAR is the key monitoring parameter to assess and determine whether sufficient light is reaching seagrass meeting its health and growth requirements. GPC and the James Cook University (JCU) seagrass ecology team developed light requirements thresholds specific to Port Curtis seagrass meadows. This was the result of laboratory and field studies undertaken for a number of years prior and during the WBDDP (Chartrand *et al.* 2012; 2016).

Such studies were initially undertaken for *Zostera muelleri* as it is the seagrass species with the highest light requirement occurring within the PoG as well as the most widespread. The studies demonstrated that *Z. muelleri* requires 6 mol/m^2/day on a fourteen (14) day rolling average (**''RA''**) of PAR (as Total Daily PAR (**''TDP''**) and management actions need to be considered after seven (7) days RA of low light availability (i.e. <6 mol/m^2/day). This light requirement value, which will be adopted in this MP and related Activity Based EM, is therefore the most conservative one. Further studies have confirmed that other seagrass species light requirements are lower; for example for *Halodule uninervis* the recommended value is 5 mol/m^2/day on a 14 day RA.

Seagrass in the Port Curtis region has two seasons, the Growing Season (July to December) and the Senescent Season (January to June). GPC have adopted a conservative approach of applying the trigger across the full year, Growing and Senescent Season, despite during the latter seagrass light requirements are greatly reduced and the BPAR threshold are not necessarily applicable (Chartrand *et al.* 2012, Collier *et al.* 2016). Adaptive Management for BPAR is applied using

the BPAR flowchart (Table 6). The flowchart has been developed to outline the steps to be undertaken for routine maintenance dredging in the event of BPAR result fall under the recommended 6 mol/m^2/day on a 14 day RA.

3.3.6 BPAR Monitoring Site

The BPAR monitoring site for MD operations was identified as per methods outlined in Section 3.2 and 3.3. In fact, the Passage Island seagrass meadows (WB25) (Table 5, Figure 1 and Figure 2) have been identified as the only significant receptor within the potential zone of influence during a simulated maintenance dredging campaign of 340,000 m^3. Therefore, at the BPAR monitoring site WB25, light (PAR) sensors mounted on a benthic frame will be installed, commissioned and maintained. In order to minimise data loss the frames will be equipped with dual PAR sensors. Moreover the light sensors will be set up within the boundaries of the meadows and mounted in line with the seagrass canopy to ensure BPAR measurement collected represent the actual amount of light received by the plants.

Table 5: *PoG MD BPAR monitoring sites.*

Site	Status	Site description and water area	WQ zone of impact
WB25	Compliance	Passage Island. Predominantly intertidal meadows dominated by *H. ovalis* followed by *Z. muelleri*	Zone of influence
CT	Control	Control site. PAR collected at a land based station to measure ambient light conditions highlighting the effect of factors such a cloud cover	N/A

A control site (CT) will also be set up on land in an appropriate elevated location to record daily ambient changes in total available PAR. This inclusion will allow for variations in daily ambient PAR due to factors such as cloud cover, assisting in the analysis and interpretation of BPAR levels at the compliance monitoring site. TDP and a 14 days RA will be calculated from the raw BPAR data collected via telemetry.

As per Collier *et al*. (2016) management triggers and related actions will be applied on a fourteen (14) day RA of PAR (TDP); during MD operations management actions will be considered after seven (7) days of 14 day RA <6 mol/m^2/day.

3.3.7 BPAR Adaptive Management

Adaptive management for BPAR will be implemented during MD operations following the overall general principles and rationale of the turbidity adaptive management framework (Section 3.3.3). The abovementioned light requirements and associated threshold have been successfully implemented by GPC for a number of years in both maintenance and capital dredging campaigns. The light threshold and related timelines have been incorporated into an adaptive management plan which follows a multi staged approach which will allow management responses to reduced light conditions to occur before potential environmental harm to sensitive receptors is caused (Table 6).

Table 6: *Adaptive management for BPAR to be implemented during PoG MD operations.*

Rule	Days < threshold	Adaptive management action
1 - Go	BPAR 14 day RA >6 mol m^{-2} d^{-1}	None required. Continue implementing the approved WQ program.
2 - Internal alert	BPAR 14 day RA <6 mol m^{-2} d^{-1} for 1 day	GPC Environment Monitoring Specialist increases surveillance (e.g. data scrutiny, equipment status, dredge operations check, environmental conditions check).
	BPAR 14 day RA <6 mol m^{-2} d^{-1} >3 but <5 continuous days	GPC Environment Monitoring Specialist reviews data for potential causal factors (e.g. equipment status, rainfall, wind, turbidity and physico-chemical, dredging activity etc.). Notify internal stakeholders.
3 - Investigate	BPAR 14 day RA <6 mol m^{-2} d^{-1} >5 continuous days	GPC Environment Monitoring Specialist reviews and investigate causal factors and document findings.
If significant weather event has been identified as causal factor, hold at 3 and continue monitoring light/seagrass*.		
4 - Action	BPAR 14 day RA <6 mol m^{-2} d^{-1} For 7 continuous days	Trigger meeting of internal stakeholders and dredging contractor to review findings of the investigation and determine potential actions for dredge management and seagrass protection.
	BPAR 14 day RA <6 mol m^{-2} d^{-1} For 10 continuous days	Implement agreed actions for dredge management and seagrass protection.
	BPAR 14 day RA <6 mol m^{-2} d^{-1} For 14 continuous days	GPC Environment Compliance Specialist to notify external regulator(s).

** GPC to provide notification to the regulator(s) on the 14th consecutive day of 14 day rolling average PAR <6 mol m^{-2} d^{-1}. Notification will provide clarification that the low light conditions are a result of the significant weather event.*
*** Growing season based on Chartrand et al. (2012), Rasheed et al. (2017).*

Table note: Integration time for the RA is 14 days and will commence at the start of the monitoring program (14 days prior commencement of MD operations). Adaptive management actions will be implemented during MD operations only.

3.4 Dredge Data

In compliance with approvals, several parameters will be recorded by the dredging contractors around MD operations. All GPS coordinates recorded by the dredger must be to three decimal places. Key data collected by the dredger during the activity and reported to DES include:

- Areas being dredged;
- Volumes dumped at the spoil ground (in situ m^3);

- Dump run tracks, showing the spoil disposal track over the DMPA; and
- Any incidents in line with the requirements of the Environmental Authority ‘’**(EA)**’’.

Additional data to maintain compliance with approvals include:

- Time and date of each dump run;
- Marine megafauna observations log of each dump run i.e. date, time, direction, distance, species, presentation (single or group) and spotter details;
- Weekly plotting sheet or certified ship extract; and
- Vessel Log including responsible vessel person.

3.5 Reporting

Turbidity and associated EWMA, BPAR, metals monitoring and key dredger data described in Section 3.3 will form the content of GPC’s compliance report compiled for DES following MD dredging campaigns (Table 7). The EA requires a report to be submitted to DES within 40 business days of completion of all dredging related monitoring. Moreover the volume of material disposed at sea is reported annually to DCCEEW under the International Maritime Organisation (**“IMO”**) agreement, refer to Section 13 of the EMP.

Table 7: *PoG MD compliance report reporting requirements.*

Data	Locations
Dredged areas	All
Volumes (in situ m^3)	All
Dump run tracks	All
Incidents	All
Turbidity (as EWMA)	WB50 and MH10
BPAR	WB25
Metals	NW70, WB50, IH15, MH40 and MH50

3.6 Long Term Monitoring Programs

The LMDMP adopts impact hypotheses to test the long term impact of MD on Port of Gladstone environment and surrounding habitats. The LMDMP also seeks to understand baseline conditions through ambient monitoring programs. These impact hypotheses and ambient monitoring commitments are outlined in Table 15 of the LMDMP and described below.

3.6.1 Sediment Analysis Plan

The National Assessment Guidelines for Dredging (**“NADG”**) set out the framework for the environmental impact assessment and defining feasibility of dredge material to ocean disposal. The Sediment Analysis Plan (**’’SAP’’**) is undertaken in compliance with the NADG to provide a set of results that will allow a statistically valid evaluation of the physical and chemical properties of the

sediment in the proposed dredge footprint against appropriate thresholds to inform dredging and disposal decisions. In fact, this assessment determines if the dredge material is suitable for sea disposal.

The impact hypothesis to be tested by this exercise is:

Disposal of dredged material will not result in contaminant related impacts to the marine environment.

Learnings and recommendations for monitoring and management are included in monitoring and management plans for implementation and continuous improvement. As per NAGD, monitoring is to be conducted every five (5) years and was last conducted in 2022 and is scheduled for 2027.

3.6.2 Specialised Equipment

The impact hypothesis to be tested by this monitoring is:

Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.

To complement WQ monitoring adjacent to the MRA, GPC has purchased specialised sediment monitors to enable targeted investigations into sediment movement at MRA and in the inner harbour as required. These were deployed in several occasions in past years during and outside MD operations to collect all necessary data. These have provided a much better understanding of sediment movement and have been assessed against the impact hypothesis above. The reports interpreting the data considered that:

- It is unlikely that MD operations in the PoG will result in significant, widespread detectable adverse environmental impacts on the sensitive receptors (seagrasses and reefs) in the region around the port and MRA; and
- It is unlikely that the placement of sediment from MD at MRA and its subsequent resuspension would result in ecological impacts in the GBRWHA (excluding the MRA itself).

A trial of in channel placement of dredge material is scheduled for the 2023 or 2024 MD campaign, which will use specialised monitoring equipment to test the impact hypothesis. This monitoring will be detailed in a trial validation plan developed for this specific task.

3.6.3 Bioavailability Studies

Bioavailability studies at the MRA were undertaken to:

- Assess pollutant concentrations at the relocation site to ensure these do not reach levels where toxic effects could occur.

The impact hypothesis tested was:

Pollutant concentrations *within dredge plumes at the loading and relocation sites do not reach levels where toxic effects or algal blooms could occur*.

The latest study was conducted in 2018 and confirmed that pollutant concentrations at loading and relocation sites did not reach levels where toxic effects or algal blooms could occur. The study showed that the plumes were short lived, did not reach sensitive receptors and dredge plumes remained within the main channels and were not expected to cause adverse environmental effects. The plume monitoring results have complemented the results of sediment studies and previous studies into monitoring of dredge and disposal plumes.

GPC have discussed with the Technical Advisory and Consultative Committee (**''TACC''**) acceptance that no additional bioavailability studies are required and will use the NADG to guide further investigations.

3.6.4 Water Quality (Plume Validation)

The plume validation monitoring is conducted to assist to:

- Determine the impact on sensitive receptors in relation to size of dredging campaign. This includes determining what is the zone of impact; zone of influence and what areas are outside the zone of influence.

The hypothesis to be tested by this monitoring is:

Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.

And/or:

Pollutant concentrations within dredge plumes at the loading and relocation sites do not reach levels where toxic effects or algae blooms could occur.

Validation of current modelling is complete and focused on a maximum of 340,000 m^3 dredging campaign, where WQ measurements and samples were conducted inside the plume. Further plume sampling will be scheduled in the event that the dredging activity or sediment characteristics change and/or new information for impact modelling is required.

3.6.5 Reefs Survey

Reefs condition monitoring will assist to:

- Determine the health of the reefs and if there is any environmental impact caused by MD on reef communities closest to the MRA.

The hypothesis to be tested by this monitoring is:

Maintenance dredging activities do not result in impacts to sensitive receptors.

Reef habitats occur outside the zone of influence within the Gladstone Harbour and on the eastern side of Facing Island. The reef survey is conducted on a five (5) yearly frequency to determine if MD activities are causing any discernible environmental impact. The last survey was conducted in 2023, and this survey will be conducted in 2028 to build upon previous studies.

3.6.6 MRA Benthic Habitats

Benthic communities, flora and fauna, condition assessment within and adjacent to the MRA is designed to highlight any differences and long term changes in communities and determine if dumping activities are causing any impact and long term change to communities outside the spoil ground. Monitoring is undertaken every five (5) years and was last conducted in 2021.

The hypothesis in line with the LMDMP is:

The deposited spoil does not result in long term changes to benthic communities outside MRA.

3.6.7 Hydrographic Survey

Hydrographic surveys are carried out following one (1) month of PoG MD completion. The post survey from a previous campaign is utilised as initial for the new campaign (as a pre dredging survey). Any high areas that could form navigation hazards should be identified and communicated to the Regional Harbour Master. GPC submits Hydrographic surveys to DCCEEW and the Hydrographic survey office at the beginning and end of the sea dumping approval in compliance with the Sea Dumping Permit. Refer to Section 13 of the EMP.

Hydrographic surveys will continue in order to:

- Assess dredged material deposition patterns within the zone of placement impact and; and
- Identify potential navigation hazards, and the capacity of the MRA for future disposal events.

The impact hypothesis to be tested in future surveys is as follows:

The deposited spoil does result in navigation hazards within and adjacent to the MRA.

3.6.8 Marine Pests

The aim of the marine pest surveys is to determine if translocation of MD equipment has resulted in new marine pests being introduced within the PoG. The survey will identify any presence and location of detection of marine pests within the port. GPC undertakes the marine pest survey every five (5) years, this was last conducted in 2020.

The hypothesis to be tested by this monitoring is:

Maintenance dredging does not result in the introduction of marine pests into new environments within the port area.

3.6.9 PCIMP

PCIMP consists of representatives from Gladstone industry, research institutions and other stakeholders. GPC is a founding member of PCIMP which was first established in 2001. Currently GPC contributes financially to the program and its participation within PCIMP will continue during the permit period. The broad objective of this program is to assess the ambient mid to far-field water and sediment quality in the Port Curtis region to determine trends over time. The

program is designed to identify any potential areas for concern. The key objectives of the program are to:

- Quantify concentrations of various indicators within the Port Curtis region to establish a long term baseline dataset;
- Engage and involve stakeholders to adopt adaptive management practices, if required; and
- Collect and collate high-quality data from sites within the Port Curtis region for PCIMP members and the Gladstone Healthy Harbour Partnership (**"GHHP"**).

Trends on water and sediment quality are available on the PCIMP website http://www.pcimp.com.au. PCIMP information is now collated for the public in GHHP report cards and technical reports (Section 3.6.10).

3.6.10 GHHP

The GHHP is a forum bringing together several parties (including community, industry, science, government, statutory bodies and management) to monitor and where necessary try improve the health of Port Curtis. GHHP undertakes annual reporting on the health of the Gladstone Harbour advising on management recommendations and action based on rigorous science and strong stakeholder engagement to ensure the ongoing and continuous improvement in the health of Port Curtis.

GPC is a member of the GHHP management committee. The program is currently reviewing existing monitoring programs and investigating opportunities for further monitoring. The GHHP annual report card for the health of the Port Curtis is provided at: http://ghhp.org.au/report-cards.

3.6.11 Seagrass Surveys

Seagrass monitoring at the PoG is conducted to:

- Assess seagrass meadows health and broad-scale changes over time; and
- Develop knowledge and a long-term record of seagrass condition in the PoG.

Most coastal seagrass meadows in the PoG occur outside the zone of influence and are not predicted to be affected by any potential turbid plume from MD. The exception is the Passage Island seagrass meadow (WB25) which is located in the zone of influence. Moreover, in the Zones of Influence turbid plumes are predicted to be short lived and not likely to cause environmental harm. Monitoring of MD activities has supported this to date.

As seagrass meadows are crucial for the health of the PoG with several fauna species relying on them for habitat provision and/or food source, seagrass monitoring has been undertaken since 2002 and at an annual frequency since 2004. The program has been adapted and changed over the years following requirements and developments with the current program in line with GPC commitments and obligations under the PoG LMDMP as well as discussion and

recommendations from the TACC. This includes yearly monitoring and mapping of fourteen (14) coastal seagrass meadows and five (5) yearly mapping of all coastal and deep water seagrass within the Port Curtis region.

3.7 Data Management

Data shall be managed in accordance with the Environmental and Resource Use Data Management Procedure (#1101368). This procedure outlines GPC processes for recording and managing environmental and resource use data. The purpose of this Procedure is to document the processes used by GPC to:

- Collect, store and report on environmental and resource use data;
- Report trends and exceedances to internal and external parties for compliance and due diligence purposes or to help identify efficiency opportunities;
- Ensure processes are in place to monitor the quality and accuracy of data; and
- Describe how GPC meets the requirements of AS/NZS ISO 14001:2015.

3.7.1 Data Validation

Environmental data validation in line with LMDMP is achieved by the following processes:

- **Quality Control / Quality Accreditation:** Quality control of laboratory analysis is controlled through the use of laboratories that hold current NATA Accreditation, where possible. GPC conducts audits on external providers that undertake environmental monitoring on a periodic basis to:
    - Assess the level of conformance of the external providers with the requirements of AS/NZS ISO 14001:2015, relevant Australian standards for sampling and standard test methods;
    - Assess the Contractor's level of conformance with GPC contract requirements, which includes qualifications, technical experience and previous direct experience with the scope of works requirements; and
    - Provide GPC with feedback regarding the operation and compliance of monitoring and reporting activities undertaken by external parties.
- **Peer review of reports:** Reports are peer reviewed internally to ensure that reports align with scope of works and delivers required objectives and contain no technical or referencing errors and is to the required standard.

3.7.2 Access to Reports and Data

GPC publishes the current approved version of the LMDMP and MP on the GPC website for public access. In accordance with Principal 16 of the Maintenance

Dredging Strategy, GPC also provides a WQ and adaptive management report prepared in accordance with statutory approval requirements for the most recent dredging campaign on GPC's website (Maintenance Dredging Gladstone - Gladstone Ports Corporation (gpcl.com.au) along with all monitoring reports related to the PoG LMDMP.

In addition, GPC keep a register of documents and reports (current and archived) including access to reports and data on the GPC website; the process is outlined in Section 3.16.3 of the EMP.

4 MP Review

This procedure will be reviewed prior to each dredging campaign as required/appropriate or as a result of:

- Findings of internal and external inspections and/or audits;
- Changes in legislation or approvals;
- Incident and/or complaint investigations; and
- The review of monitoring results.

The review process is necessary to ensure currency, relevance and accuracy. Revisions are kept as a new version in GPC's document management system and are communicated to all relevant GPC Employees. For protocols on document management and review for this procedure refer to Section 5.18 of the EMP.

5 References

BMT WBM, 2017. Port of Gladstone Maintenance Dredging Assessment of Potential Impacts, December 2017. BMT WBM Pty Ltd, Brisbane, Australia.

Chartrand, K.M. and Ralph, P.J. and Petrou, K. and Rasheed, M.A., 2012. Development of a light-based seagrass management approach for the Gladstone Western basin dredging program. Fisheries Queensland, Department of Agriculture Fisheries and Forestry, Cairns, pp. 126.

Chartrand K.M., Bryant C.V., Carter A.B., Ralph P.J. and Rasheed M.A., 2016. Light Thresholds to Prevent Dredging Impacts on the Great Barrier Reef Seagrass, *Zostera muelleri* ssp. *capricorni*. Front. Mar. Sci. 3:106. doi: 10.3389/fmars.2016.00106

Collier, C.J., Chartrand, K., Honchin, C., Fletcher, A. Rasheed, M., 2016. Light thresholds for seagrasses of the GBR: a synthesis and guiding document. Including knowledge gaps and future priorities. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns (41pp.).

Rasheed, M., Wells, J. and Carter, A., 2017. Seagrasses in Port Curtis and Rodds Bay 2016: Annual long-term monitoring. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 17/02, James Cook University, Cairns.

6 Related Documents

The following documents relate to this MP:

Type	Document number and title
Tier 1: Policy	#366016 Environment Policy
Tier 2: Standard/Strategy	#809151 Environmental Management Framework Standard
Tier 3: Specification/ Procedure/Plan	#146256 Environmental Management System Plan #1385321 Port of Gladstone Long Term Maintenance Dredging Management Plan #879363 Port of Gladstone Maintenance Dredging Environmental Management Plan
Tier 4: Instruction/Form/ Template/Checklist	#1621179 GPC Corporate Glossary Instruction

7 Revision History

Revision date	Revision description	Author	Endorsed by	Approved by
16/12/13	v1 Procedure development	T.Tobin		
06/10/14	v2 Addition of due diligence monitoring	P.Rose		
08/01/14	v3 Addition of compliance site BG10 and edits from DES review.	T.Tobin		
10/01/14	v4 Addition of further edits following DES review and dry season triggers and flowchart	A.Bennett, P.Rose		
16/06/14	v5 Change to EIS monitoring regime for July dredging campaign	T. Tobin, A. Bennett		
16/08/14	v6 Update of document for December 2014 – December 2015 dredging period.	A. Bennett		

Revision date	Revision description	Author	Endorsed by	Approved by
16/03/15	v7 Update of document for December 2015 – December 2016 dredging period.	A. Bennett		
17/08/16	v8 Removal of expired EIS monitoring regime and general administration review and formatting.	T. Tobin		
09/03/2018	v9-17 Review for 2018 dredging campaign and Addition of Deed of Agreement Implementation Strategy commitments / links and LMDMP requirements.	T. Tobin		
23/11/2018	v17a Administrative (not requiring re-authorisation). Added BPAR adaptive management flowchart.	F. Pastorelli		
31/05/2019	v17b Administrative (not requiring re-authorisation). Update in alignment with LMDMP, the 2019 conditions register review and the annual administration document review.	F. Pastorelli, T Tobin	K. Lockwood	
09/09/2020	V19 Administrative (not requiring re-authorisation). Procedure update and streamlining.	F. Pastorelli	K. Lockwood	
30/06/2021	V23a Administrative (not requiring re-authorisation). Procedure update and streamlining.	F. Pastorelli	K. Lockwood	
18/05/2022	V24 review, includes: - Administrative (not requiring re-authorisation). Procedure update and streamlining.	T Tobin	F Horner	K Lockwood
09/06/2023	V25 review - Administrative (not requiring re-authorisation).	T Tobin	F Horner	DES DCCEEW
24/11/2023	V25a – Administrative (not requiring re-authorising)	T Tobin	F Horner	DCCEEW