Procedure

Clinton Vessel Interaction Project Environmental Monitoring

Endorsed: 15 January 2020

Brief description

The environmental monitoring and management of Clinton Vessel Interaction Project at the Port of Gladstone is essential to ensure that the potential environmental impacts of this activity are managed through the identification of sensitive environmental receptors, understanding environmental risks and employing measures and safeguards to mitigate potential environmental impacts. Specifically, this Procedure applies to the dredging and post dredging phase of the capital-dredging project to widen the Clinton Channel.

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Role	Position
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Custodians	Project Manager

Table of contents

Figures

Tables

Abbreviations

Term	Definition
BHD	Backhoe dredger
BPAR	Benthic photosynthetically active radiation
CSD	Cutter suction dredger
Cth	Commonwealth
CVIP	Clinton Vessel Interaction Project
DES	Department of Environment and Science
DMP	Dredge Management Plan
DO	Dissolved oxygen
DoEE	Department of Environment and Energy
EA	Environmental Authority
EM	Environmental Monitoring
EMP	Environmental Management Plan
EMS	Environmental Management System
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPP (Water)	*Environmental Protection (Water and Wetland Biodiversity) Policy 2019*
ERA	Environmentally Relevant Activity
ESMM	Environmental Specialist Monitoring and Measurement
EVs	Environmental values
EWMA	Exponentially weighted moving average
GHHP	Gladstone Healthy Harbour Partnership
GOC	Government owned corporations
GPC	Gladstone Ports Corporation Limited
JCU	James Cook University
LAT	Lowest astronomical tide
LMDMP	Long-term Maintenance Dredging Management Plan
m	Metre
m^3	Cubic metre
MD	Moderately disturbed
MCU	Material change of use
mg/L	Milligrams per litre
MP	Monitoring procedure
NTU	Nephelometric Turbidity Units
PAR	Photosynthetically active radiation

Term	Definition
PoG	Port of Gladstone
Project	Clinton Vessel Interaction Project
QE	Quality expert
QGC	Queensland Gas Company
RA	Rolling average
SD	Slightly disturbed
SPAM	Sediment plume-associated monitoring
TDP	Total daily PAR
TSHD	Trailing suction hopper dredger
TSS	Total suspended solids
WBDDP	Western Basin Dredging and Disposal Project
WBRA	Western Basin reclamation area
WICT	Wiggins Island Coal Terminal
WQ	Water quality
WQOs	Water quality objectives

1 Procedure statement

This Procedure has been developed to:

- Describe the Gladstone Ports Corporation Limited (GPC) system for monitoring and managing potential environmental impacts and risks associated with the dredging component and related activities of the Clinton Vessel Interaction Project (CVIP or the Project) in the Port of Gladstone (PoG);
- Describe the measures and safeguards to be implemented during the Project activities; and
- Address compliance requirements within the following Project environmental approvals as stated in the Environmental Management Plan (EMP) (Table 1 and eDOC #1501404).

2 Project and procedure scope

This Monitoring Procedure (MP) covers all aspects of the environmental monitoring (EM) undertaken prior, during and post the Project dredging activities within the PoG by GPC and engaged contractors. The EM detailed herein will be conducted starting three (3) months prior the Project operations commencement, it will continue throughout dredging operations and it will conclude two (2) months post dredging operations completion. The post dredging monitoring span will be adequate to cover tailwater discharge (see below).

This Procedure supports and is to be read in conjunction with the following:

- CVIP EMP (eDOC #1501404);
- Relevant GPC Environmental Management System (EMS) procedures as referenced in the EMP and MP;
- Dredging contractor Dredge Management Plan (DMP); and
- All relevant environmental approvals (Section 1).

Whenever deemed appropriate and/or required the present MP will be reviewed during the Project activities and updated.

The Project scope addressed by this Procedure includes:

- Capital dredging of 800,000 cubic metres (m^3) of seabed material (which includes an over dredging allowance) utilising one of the following approaches:
    - Approach 1: A medium size Cutter Suction Dredger (CSD) to break up rock and stiff clay and a Trailing Suction Hopper Dredger (TSHD) with a 6000 m^3 capacity to remove the sediment and pump it into the Wester Basin Reclamation Area (WBRA). The dredge duration is estimated to be 17 weeks. There will be a tailwater discharge from the WBRA which is estimated to commence 7.5 weeks after dredging has started and to continue until 4 weeks after dredging is completed (BMT 2018);
    - Approach 2: TSHD to dredge as much sediment as possible (estimated to be approximately 85%) and pump it into the WBRA. A Backhoe Dredger (BHD) to then dredge the remaining sediment/rock and load it onto barges, where it willbe transported to the WBRA. The dredge duration is estimated to be 32 weeks in total, with 24 weeks for the TSHD and 8 weeks for the BHD. There will be a tailwater discharge from the WBRA which is estimated to commence 7.5 weeks after dredging start and to continue until 4 weeks after dredging is completed; and
    - Approach 3: BHD to dredge all sediment/rock and load it onto barges from where it will be transported to the WBRA. The dredge duration is estimated to be 25 weeks. There will be no tailwater discharge from the WBRA as part of this approach. Approach 3 has been selected for the Project.

- Dredged material beneficially reused within the WBRA;
- Management of stormwaters from the WBRA. Note that modelling and calculations have showed that no tailwater will be generated using the BHD methodology (BMT WBM, 2019). The dredging contractor has also confirmed that due to the large area of the WBRA, there will be no tail water discharge.
- The removal of existing navigational aids and the installation of two new navigational aids at the new extent of the Clinton Channel and a land based swing pole; and
- The BHD dredging methodology requires a barge unloading facility to be constructed to facilitate the unloading of dredged material at the WBRA. The barge unloading facility will be a temporary structure (on spuds) and will not trigger any new approvals.

3 Procedure objective

The objective of this MP is to maintain compliance with the permits and approvals as detailed in the EMP. Moreover, this MP will ensure compliance to the relevant conditions by implementing adaptive management actions based on monitoring results to ensure no environmental harm occurs to the receiving environment and sensitive ecological receptors from dredging related plumes. Additionally, the program detailed in this MP will progressively build a better understanding of the Project dredging activities and will assists in quantifying and managing environmental risks.

The performance of this MP will be measured through internal and external audits as part of GPC's EMS. Permit non-compliances and other environmental incidents during the Project activities will be used as a measurement of the success of this MP and will trigger review whenever appropriate as mentioned in Section 2.

4 Background

4.1 Monitoring objectives

The monitoring program described in Section 5 of this MP has been developed to meet compliance with the Project EMP.

The EM detailed in this MP will protect the receiving environment as well as sensitive receptors within the predicted zone of plume influence and thus the areas outside it. These have been identified from hydrodynamic and plume modelling that informed the Project impact assessment (Section 4.4) (BMT WBM, 2018a) .The areas influenced by dredging operations highlighted by modelling have been used to identify appropriate monitoring site locations in order to protect the receiving environment and sensitive receptors through adaptive management (Section 5.10.1). Please note that the present MP has been prepared to be appropriate with turbidity levels displayed by modelling outputs run for Approach 1 (Section 1). This modelling is the most conservative as showing the highest levels of turbidity (Section 4.4). Additional modelling outputs have been undertaken for Approach 2 and 3 (Section 4.4. and Appendix 2) (BMT WBM 2019). Therefore, the monitoring locations selected for the Project are more than appropriate for the BHD methodology selected for the Project. Note that the closest sensitive receptors are several kilometres away from the dredging footprint. Monitoring of water quality (WQ) and light will be undertaken to:

- Measure WQ, specifically turbidity, and light levels near and at sensitive receptor sites within Port Curtis so that based on data and observations any expected environmental impact can be avoided; and
- Implement adaptive management and mitigation measures to avoid and minimise potential impacts of dredging activities on sensitive receptor sites within Port Curtis.

Additional to WQ and light, monitoring aspects such as sediment form part of the overall EM detailed in this MP.

4.2 Port Curtis water quality objectives

Water quality objectives (WQOs) are numeric measures to protect environmental values (EVs) such as aquatic ecosystems and human uses. WQOs specific to Port Curtis have been established and are detailed in the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water)). The latter are based on national and state WQ guidelines and objectives such as the ANZECC/ARMCANZ 2000, DERM 2009 and DEHP 2014.

Specifically, *The Curtis Island, Calliope River and Boyne River Basins Environmental Values and Water Quality Objectives* (DEHP 2014) have been formulated in accordance with the principles of the EPP (Water). These are listed under Schedule 1 of the EPP (Water which is the subordinate legislation to the *Environmental Protection Act 1994* and provides a framework for:

- Identifying EVs for Queensland waters and establishing WQOs to protect or enhance EVs (WQOs are long term goals for receiving waters rather than individual point source emission objectives); and
- Including the identified EVs and WQOs under Schedule 1 of the EPP (Water).

The relevant WQOs tables for the protection of aquatic ecosystems in the EPP (Water) include:

- Table 2A: Gladstone Harbour, The Narrows, adjacent coastal waters and estuaries – baseflow WQOs;
- Table 2B: Gladstone Harbour and The Narrows: time/flow thresholds for applying baseflow WQOs; and
- Table 2D: Gladstone Harbour and Boat Creek: event WQOs.

Figure 1 shows the EPP (Water) Port Curtis marine estuarine water types and Table 1 details the EPP (Water) WQO for the protection of aquatic ecosystems.

Table 1: Port Curtis and The Narrows EPP (Water) WQOs to protect aquatic ecosystem EVs under baseflow conditions (peak discharge < 100 m^3/sec).

EPP (Water) area/type	Parameter	Wet season (1 October to 31 March)			Dry season (1 April to 31 September)		
		20^{th} %ile	50^{th} %ile	80^{th} %ile	20^{th} %ile	50^{th} %ile	80^{th} %ile
MD2421 Western Basin	Turbidity (NTU)	7	13	29	4	8	17
MD2423 Mid Harbour	Turbidity (NTU)	4	9	16	2	4	7
SD2441 The Narrows	Turbidity (NTU)	8	15	30	4	7	12

Source: DEHP (2014).

The above-mentioned WQOs, despite being specific for Port Curtis and The Narrows, were not developed using long term continuous (telemetry) data. Moreover they have been developed using baseflow condition data and therefore may not reflect the natural variability of highly changeable environments such as Port Curtis.

Therefore for the purpose of this MP, specific WQ (turbidity) triggers based long term continuous data were established; details are reported in Section 4.3. Please note that in some instances (i.e. for some of monitoring sites) the below-mentioned triggers, which are tailored for the environmental management of CVIP dredging operations, are more stringent than the WQOs.

4.3 Baseline water quality monitoring

As mentioned in Section 4.1, monitoring sites for the protection of sensitive receptors and EVs during CVIP dredging operations were selected based on hydrodynamic and plume modelling outputs as well as impact assessment.

Seven (7) WQ monitoring sites (turbidity) and eight (8) light sites (Benthic Photosynthetically Active Radiation (BPAR)), spanning from The Narrows to Rodds Bay, have been selected for this purpose. A portion of these will be utilised as compliance sites whilst the remaining will act as support/reference sites to assist data interpretation and isolate potential dredging impacts on WQ and light.

In particular, four (4) of the six (6) WQ monitoring sites will function as compliance monitoring locations. One of the baseline monitoring locations C3 (intended for monitoring tailwater discharge) will be decommissioned prior to commencement of dredging, as there will be no tailwater discharge during CVIP. Additionally C3 represent a potential navigational hazard to the barges carrying dredge material to the WBRA. In the unlikely event of high rainfall requiring stormwater release (calculated as >1 m rain event), event based monitoring at C3 will be conducted for the duration of the discharge period. In this instance, in fact, C3 will be reinstated (following discussions regarding the safety and accessibility with DES, the Regional Harbour Master and the Dredge Contractor) and monitoring will commence once the WBRA reaches 80% stormwater capacity.

To establish appropriate turbidity triggers tailored to these locations continuous turbidity data were utilised together with standard physico-chemical parameters which were collected for thirteen (13) months (June 2014 to July 2015) by multiparameter sondes mounted on telemetered WQ buoys with a logging interval of 15 minutes. Within the baseline data collection interval three (3) maintenance dredging campaigns occurred at the PoG: 09 and 10 July 2014 (Queensland Gas Company (QGC) berth pockets only), 26 November 2014 to 03 January 2015 and 4 to 15 June 2015. In order to better represent the natural variability in turbidity within Port Curtis, data collected during the 2016, 2017 and 2018 maintenance dredging campaigns as well as pre and post Western Basin Dredging and Disposal Project (WBDDP) and Narrows Crossing have been included in the development of the triggers. The variation in turbidity during maintenance dredging is within the broader variation across the harbour over time; hence, it is reasonable to incorporate this data in the data set used to define triggers. Appendix 3 shows details of the datasets used for deriving the turbidity triggers. Maintenance dredging campaigns data include at least two (2) weeks of pre and post dredging monitoring. Moreover, during the maintenance dredging campaigns mentioned above, WQ monitoring including BPAR was undertaken in accordance with GPC's maintenance dredging permits and management plans. No exceedances were reported during the campaigns; specifically, turbidity levels in the harbour appeared to respond mainly to tidal fluctuations and other environmental factors rather than dredging activities, which seemed to have no effect on sensitive receptors and generally on EVs.

The 13 month WQ baseline and historical monitoring data set, after appropriate validation and QA/QC, has been used together with the Project WQ zones of impact from the initial modelling of CSD and TSHD dredging (Section 4.4) to develop turbidity trigger levels (Section 5.3.2) for compliance monitoring sites. Therefore, the triggers will be more than adequate for the selected BHD dredging methodology.

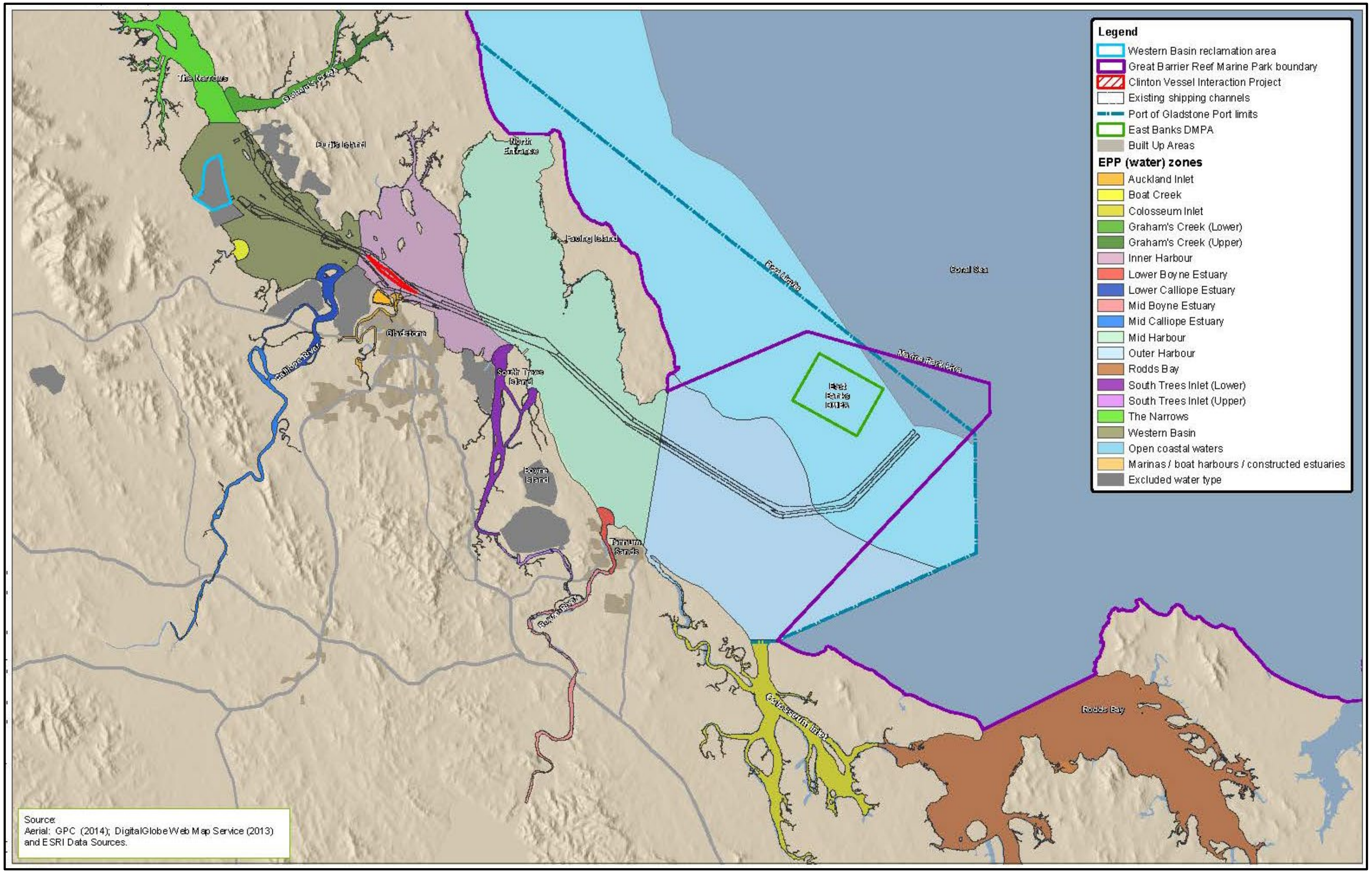

Figure 1: EPP (water) zones for Port Curtis, The Narrows and adjacent coastal waters.

4.4 Project WQ zones of impact

In order to derive the abovementioned triggers for the Project compliance WQ monitoring sites, spatial zones of predicted impact were developed using baseline WQ monitoring data in conjunction with the modelling outputs mentioned in Section 4.1 and 4.3 for the worst case scenario, Approach 1.

Therefore, turbidity baseline data was spatially interpolated across the study area, which was determined by the abovementioned modelling and impact assessment, producing three-dimensional (3D) threshold grids. The latter were overlaid onto a bathy-surface (esri grid) using GIS mapping software. This resulted in impact zone maps illustrating areas where modelled turbidity, from environmental conditions and dredging activities, could increase above interpolated baseline turbidity data (Figure 2). It is important to notice that based on the modelling results with Approach 1 there is no zone of moderate impact from the Project dredging activities.

Therefore, the resulting impacts zones were three (3) (Table 2):

- Zone of high impact being limited to the area to be dredged by the Project;
- Zone of low impact is limited to an area in the near vicinity of the dredging operation and does not extend into seagrass meadows and corals within the Port; and
- Zone of influence extending throughout large portions of the inner and middle harbour.

The abovementioned analysis was performed under different environmental conditions by running the models over fourteen (14) day spatial windows. The 14 days window was chosen as it is meaningful under a physical and hydrodynamic context representing the approximate duration of a consecutive spring and neap tidal cycle. The latter represents an important timescale in an ecological context and thus appropriate for assessing impacts to sensitive receptors in the study area such as seagrass meadows.

This analysis was repeated over the entire WQ baseline spatial range by incrementally moving the 14 day window by five (5) days which resulted in approximately 77 different 14 day windows. A range of turbidity percentiles were then calculated to represent and account for different environmental conditions similarly to the principle used within the WQOs (baseflow conditions, event conditions etc.) (Table 2):

- 20^{th} percentile: calm conditions with low wind and waves and neap tides;
- 50^{th} percentile: average conditions; and
- 80^{th} percentile: rough conditions with high wind and waves and spring tides.

Threshold values were developed for three (3) zones of impact and the zone of influence highlighted by the analysis described in this section (Table 2 and Figure 2). Please note that threshold values were developed for the zone of medium impact however this was not within modelling outputs for this Project. Turbidity triggers values were also established for each of these percentiles to take into consideration the natural variability of turbidity in Port Curtis and thus the study area. This ensures both short term and sustained dredging impacts are accounted for.

The abovementioned analysis and modelling has been undertaken with a series of values and assumptions relevant to TSHD dredging and Approach 1 (Section 2).

Please note that the modelling related to a medium size CSD and TSHD of 6000 m^3 capacity and Approach 1 is the most conservative one as is the one generating the highest levels of turbidity. In fact the same modelling described in this section has been undertaken for the other two approaches detailed in Section 2 (BMT WBM 2019). The current monitoring described in this MP is geared towards Approach 1 and therefore it would be adequate should one out of Approach 2 or 3 be selected.

The effectiveness of the zones of impact were tested utilising biological tolerances for Port Curtis seagrass meadows and coral reefs using a referential method with a function converting turbidity to light attenuation (BMT WBM, 2018a). Therefore, for each of the baseline WQ monitoring sites located by or in proximity to seagrass meadows, the site specific turbidity and BPAR as well as sedimentation for the abovementioned zone of influence and three (3) zones of impact were tested.

Modelling was considered appropriate and acceptable (BMT WBM 2018a) and has been used as the predictive tool for sensitive receptor monitoring locations within this MP.

Table 2: Description of impact assessment zone of impacts and related threshold values.

Zone of impact	Definition	Methodology
Zone of high impact	Excess turbidity from dredging activities most likely to cause WQ to deteriorate beyond natural variation	Excess turbidity greater than three standard deviations from the natural background mean at each percentile (i.e. 20^{th}, 50^{th} and 80^{th} percentiles)
Zone of medium impact	Excess turbidity from dredging activities likely to cause WQ to deteriorate beyond natural variation	Excess turbidity greater than two standard deviations from the natural background mean at each percentile (i.e. 20^{th}, 50^{th} and 80^{th} percentiles)
Zone of low impact	Excess turbidity from dredging activities may cause WQ to deteriorate beyond natural variation	Excess turbidity greater than one standard deviation from the natural background mean at each percentile (i.e. 20^{th}, 50^{th} and 80^{th} percentiles)
Zone of influence	Extent of detectable plume (as measured by instrumentation) but no predicted ecological impacts	Turbidity related to dredging activities exceeds: ▪ 1 NTU above 50^{th} percentile conditions ▪ 2 NTU above 80^{th} percentile conditions ▪ 5 NTU above 95^{th} percentile conditions ▪ 10 NTU above 99^{th} percentile conditions

The methodology selected for the Project will be Approach 3, BHD only. Modelling undertaken following the same methodology described above shows that in this scenario the only resulting zone of impact is the zone of high impact which corresponds to the dredging footprint (Figure 2 and Appendix 2) (BMT WBM, 2019).

Therefore, it is expected that this methodology will produce high turbidity (Table 2) only within the dredging footprint (zone of high impact), while outside the dredge footprint only ephemeral plumes with no ecological impact are being envisaged. Visual monitoring of the plume will be conducted as outlined in Section 5.3.5.

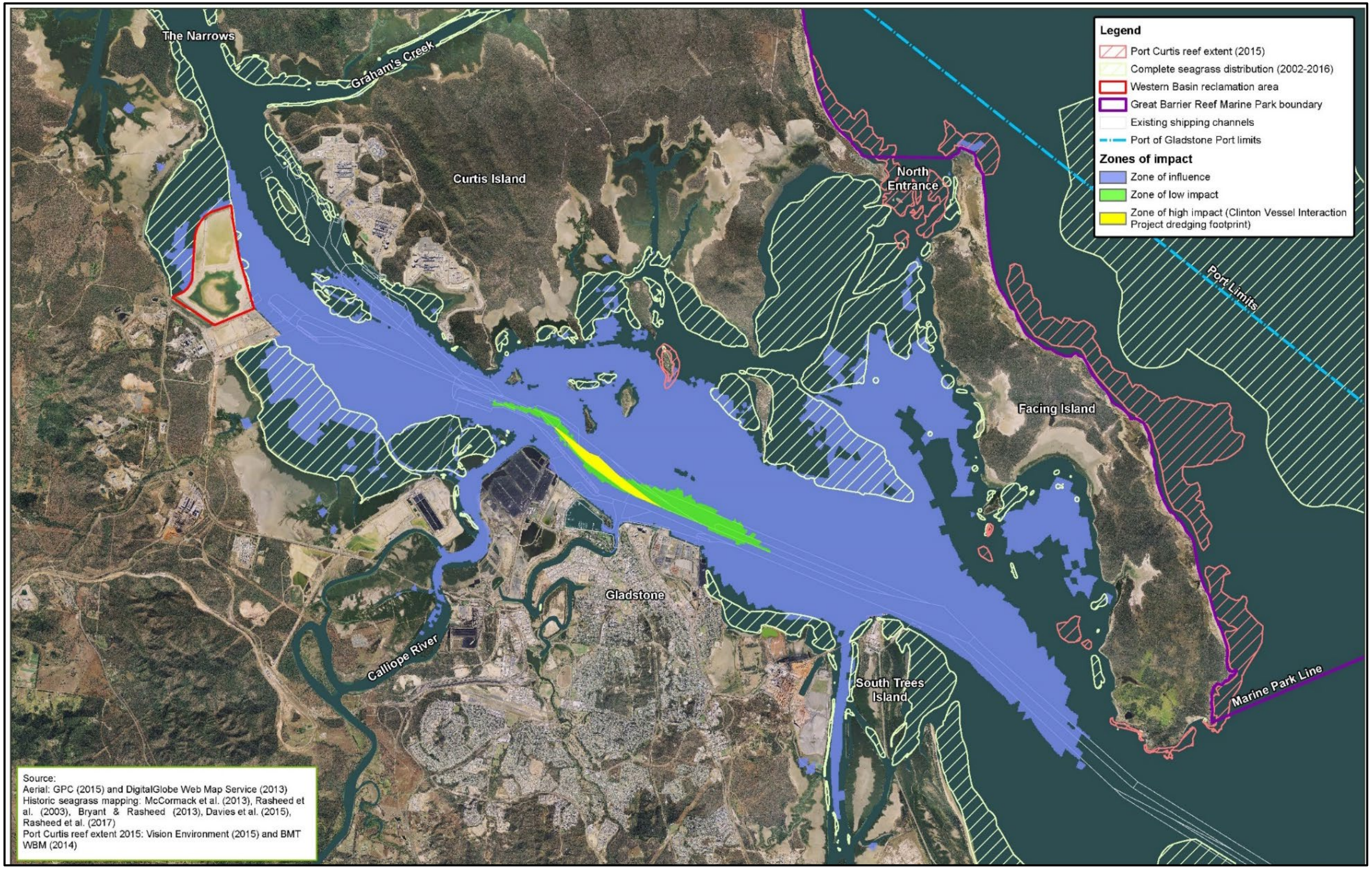

Figure 2: Water quality zones of impact for the Project resulting from modelling undertaken for Approach 1 (CSD and TSHD).

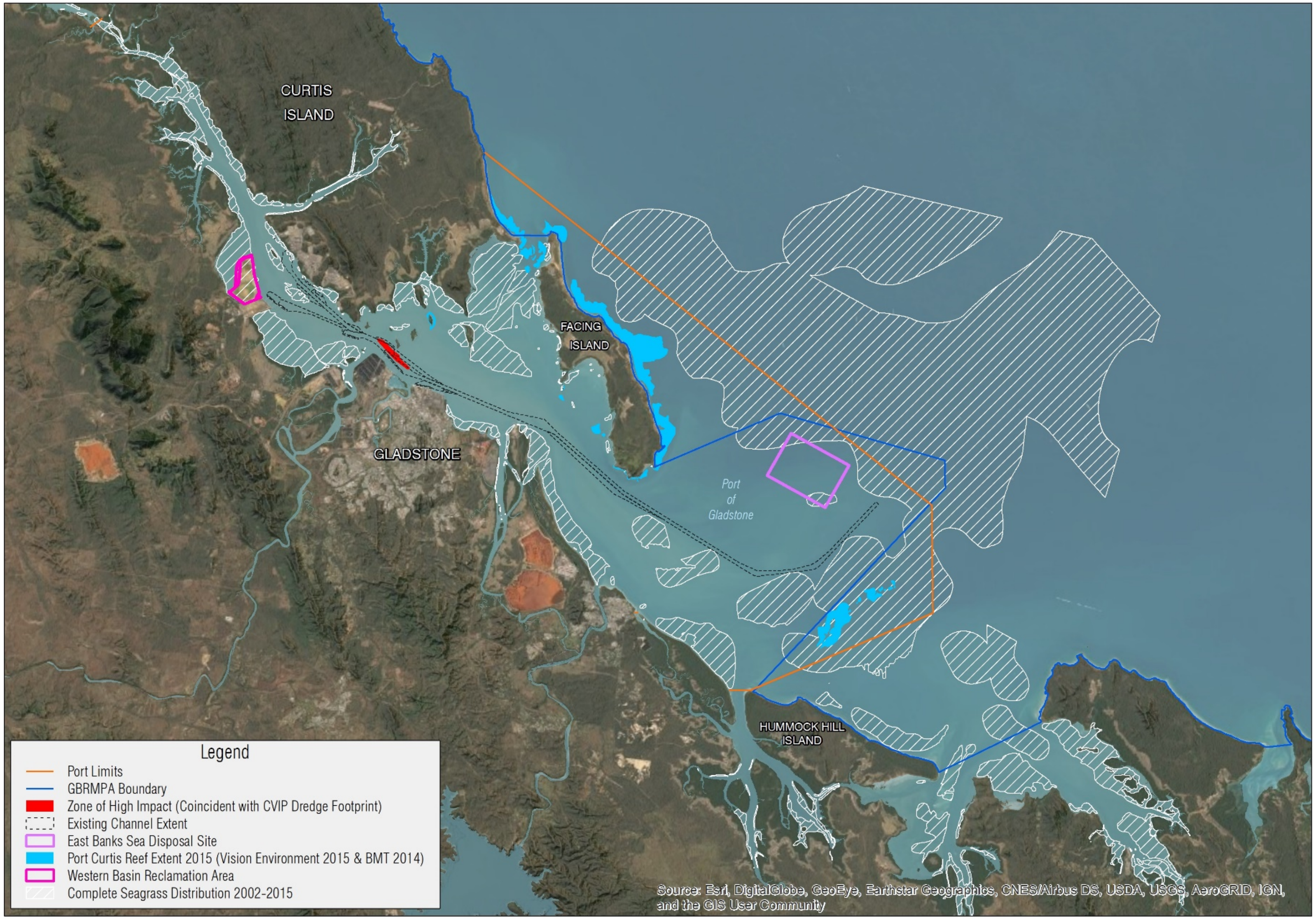

Figure 3: Water quality zones of impact for the Project resulting from modelling undertaken for BHD (See also Appendix 2).

5 GPC procedure

5.1 Roles and responsibilities

GPC staff 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* 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.*

Table 3 provides a summary of the responsibilities and accountabilities associated with implementation of this Procedure.

Table 3: Environmental roles and responsibilities for the Project.

Position (GPC)	Responsibility	Reporting to
Chief Executive Officer (CEO)	Ensure that systems are in place to manage environmental aspects and impacts at GPC.	GPC Board of Directors
Port Infrastructure Asset Manager	Responsible for ensuring the department operates within the EMS and is compliant with legislation.	CEO
Project Manager	Responsible for coordination and oversight of Project activities, approval and implementation of this document and associated management plans.	Port Infrastructure Asset Manager
Civil/Structural Supervisor	Coordination and oversight of Project dredging activities in the Port including adaptive management required by this document.	Project Manager
Navigational Aid Contract Manager	Oversight and implementation of contractor (GPC approved) EMP. Adhere to contractual arrangement and relevant conditions of GPC permits, this document and associated management plans.	Project Manager
Dredge Contractor Manager	Oversight and implementation of contractor (GPC approved) EMP. Adhere to contractual arrangement and relevant conditions of GPC permits, this document and associated management plans.	Project Manager
Environment Specialist – Monitoring and Measurement	Responsible for coordination of environmental monitoring and measurement in accordance with this document including adaptive management processes.	Environment Superintendent
Environment Specialist – Compliance	Provide assistance to the Project Manager to ensure compliance with Project EMP, this document and conditions of GPC permits, including reporting.	Environment Superintendent
Environment Superintendent	Operational line manager for Environmental Specialists. GPC operational interface for environmental monitoring and compliance matters.	Manager Planning and Development (Acting)
Environment Emergency Hotline (49761 617)	General and afterhours contact for the GPC environment team	Calls Environment Superintendent

5.2 Dredging monitoring and exceedance support

As due diligence and additional assurance that appropriate corrective actions and improvements will be implemented at the appropriate instances during the Project, GPC will engage a suitably qualified WQ expert to provide technical support to GPC ESMM.

The WQ expert will provide additional advice and support as required in case of any incidents or elevations and exceedances in WQ or BPAR values (Section 5.10).

5.3 Monitoring program

5.3.1 Water Quality

5.3.1.1 Water quality monitoring sites

As mentioned in Section 4.3 and 4.4, a range of WQ sites were selected to monitor physical-chemical parameters in real time (telemetry) (Figure 4 and Appendix 4). At the compliance sites, turbidity levels (as an Exponentially Weighted Moving Average (EWMA), refer to Section 5.3.1.2) will be assessed against trigger levels (Section 5.3.2) for compliance purposes. The support and reference WQ sites (Table 4), will not be assessed against triggers, but will help in the data interpretation and isolate potential dredging impacts on WQ.

At all WQ sites, buoys equipped with dual multiparameter sondes and telemetry equipment will be installed, commissioned and maintained. These will log readings every 15 minutes which will be transmitted in real time by the telemetry system. All equipment will be appropriately serviced and maintained.

WQ monitoring site locations is consistent with the Port Curtis Integrated Monitoring Program (PCIMP), a long-term ambient WQ program.

Table 4: Project WQ monitoring sites.

Site	Status	Description and water area	EPP (Water) management intent/ level of protection	Water quality zone of impact
MH60	Compliance	Outside the mouth of the Boyne River and adjacent to the South Trees inlet intertidal and subtidal seagrass habitats. Mid Harbour (MD2423).	Moderately disturbed	Outside of zone of high impact
WB50	Compliance	Outside the mouth of the Calliope River and adjacent to the Wiggins Island Coal Terminal (WICT) and Wiggins Island seagrass meadows. Western Basin (MD2421).	Moderately disturbed	Outside of zone of high impact
MH10	Compliance	Adjacent to Pelican banks seagrass meadows. Mid Harbour (MD2423).	Moderately disturbed	Outside of zone of high impact
QE3	Compliance	Adjacent to Worthington island in The Narrows (SD2442).	Slightly disturbed	Outside of zone of high impact
BG10	Support	Adjacent to the South-East end of Curtis Island and near Quoin Island. Adjacent to the Project dredging footprint will be used as early warning in case dredging generated plumes do reach sensitive receptors.	Moderately disturbed	Outside of zone of high impact
RB1	Reference	Adjacent to Colosseum inlet. Important wetland. Will be used as reference site to isolate potential dredging effects.	Slightly disturbed	Outside of zone of high impact

Site	Status	Description and water area	EPP (Water) management intent/ level of protection	Water quality zone of impact
C3	Support (Event based monitoring only)	Adjacent to the WBRA. Monitoring will commence when the WBRA reaches 80% capacity following storm event (>1 m rain). Monitoring will continue for the duration of the stormwater release.	Moderately disturbed	Outside the zone of high impact

Table notes:

- Compliance sites: Turbidity levels will be assessed against trigger levels (Section 5.3.2) for compliance purposes and adaptive management response.
  Support sites: Not be assessed against triggers or associated to any adaptive management action, but will help in the data interpretation and isolate potential dredging impacts on WQ.
- Reference site RB1: Located approximately 50 km from the Project dredging footprint and thus well outside of any potential effects that the Project might have on turbidity and WQ. Thus the reference site, will not be assessed against triggers levels or associated to any adaptive management action, but will help in investigations at the compliance sites by further isolating dredging impacts on WQ.
- C3: Event based monitoring will be conducted when stormwater release from the WBRA is envisaged following >1 m rainfall event. Monitoring will commence when the stormwater holding capacity of the WBRA reaches 80% and will continue for the duration of the discharge.

Monthly due diligence grab samples for metals and nutrients (Table 5) will also be undertaken at these sites pre, during and post dredging operations. Samples will be analysed by a National Association of Testing Authorities (NATA) accredited laboratory holding the accreditation for the analyses required. Results will be screened against the relevant abovementioned WQOs; it is important to note that for metals the WQOs, Schedule 1 of the EPP (Water) Curtis Island, Calliope River and Boyne River Basins Environmental Values and Water Quality Objectives (DEHP 2014) refer to the ANZECC/ARMCANZ guidelines. Moreover, for aluminium the threshold value of 24 µg/L will be adopted as the WQOs state that the marine guideline of 24 µg/L for aluminium developed by Golding *et al*. (2015) supersedes the existing previous low reliability guideline of 0.5 µg/L. The previous low reliability guideline was derived using very conservative and unrealistic margins and based on limited data. This is corroborated by the fact that 0.5 µg/L is below the laboratory detectable limit (limit of reporting) of 5 µg/L.

Grab sample results will be screened against the 95% and 99% protection of marine species threshold values for MD and SD water respectively (Table 5). Whilst this part of the monitoring program is not associated with specific permit conditions, in case of elevation GPC will do everything reasonable and practicable to investigate and determine the reason of such elevations.

Table 5: Analytes that will be tested for due diligence once a month before, during and after the Project. Table also shows relevant ANZECC/ARMCANZ guidelines for 95% and 99% protection marine species in MD and SD waters respectively. Please note only QE3 and RB1 are in SD waters. Source: ANZECC/ARMCANZ (2000/2018).

Analyte	Unit	ANZECC/ARMCANZ 95% protection marine species in MD waters	ANZECC/ARMCANZ 99% protection marine species in SD waters
TSS	mg/L	-	-
Total Nitrogen	mg/L	-	-
Total Phosphorous	mg/L	-	-
Chlorophyll *a*	µg/L	-	-

Ammonia (nitrogen)	µg/L	-	-
Aluminium (total and dissolved)	µg/L	24	24
Arsenic (total and dissolved)	µg/L	-	-
Cadmium (total and dissolved)	µg/L	5.5	0.7
Chromium (VI) (total and dissolved)	µg/L	4.4	0.14
Copper (total and dissolved)	µg/L	1.3	0.3
Lead (total and dissolved)	µg/L	4.4	2.2
Mercury (total and dissolved)	µg/L	0.4	0.1
Nickel (total and dissolved)	µg/L	7	7
Silver (total and dissolved)	µg/L	1.4	0.8
Zinc (total and dissolved)	µg/L	15	7
Tributyltin (TBT)	µg Sn/kg	0.006	0.004
TPH	mg/L	-	-

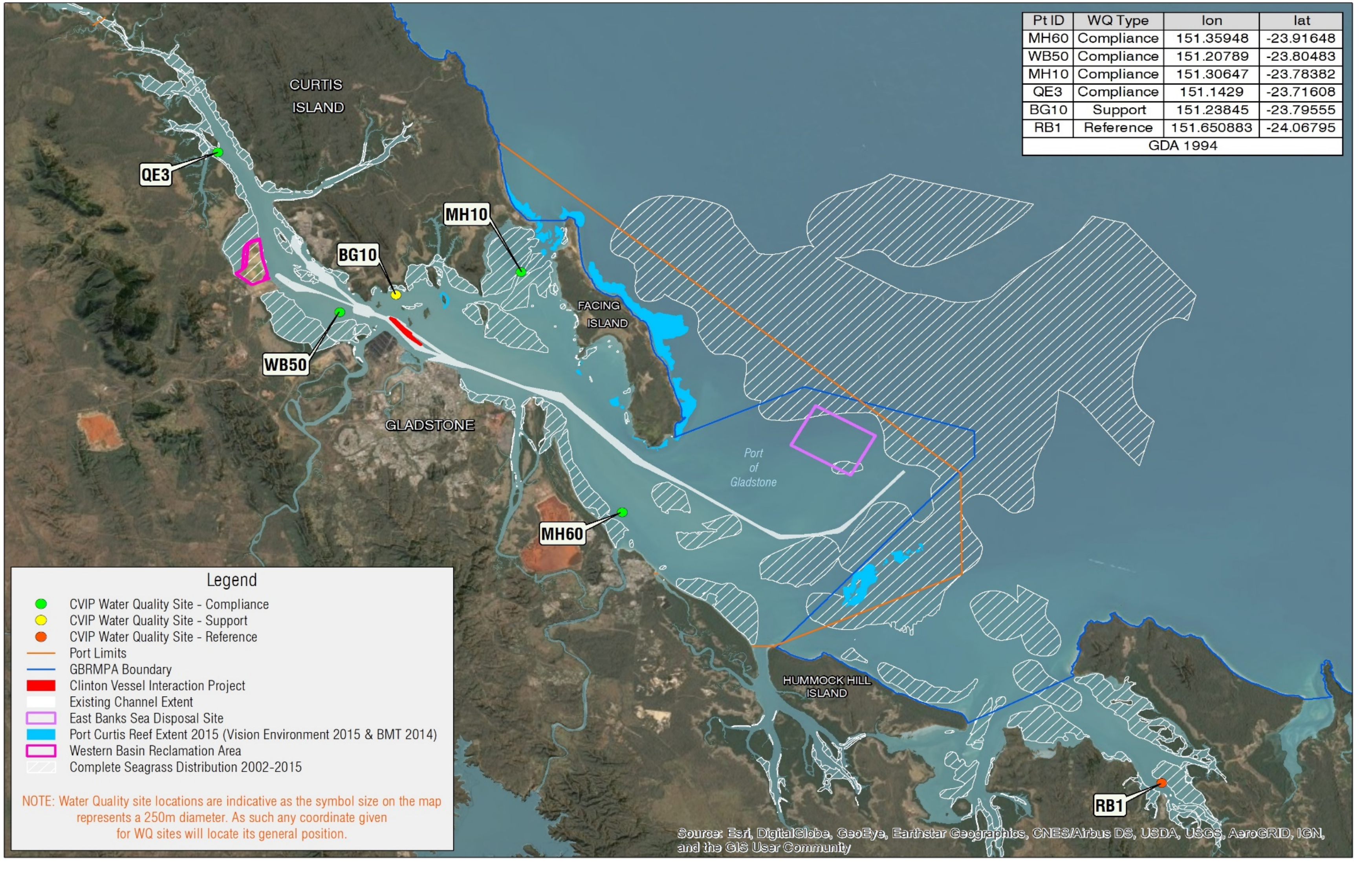

Figure 4: Water quality monitoring sites for the Project.

5.3.2 Turbidity management trigger values

Turbidity triggers were specifically developed for the Project as detailed in Section 4.3. and 4.4. Two (2) turbidity percentiles of data ranges will be utilised during the Project to assess turbidity for compliance purposes:

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

The abovementioned triggers are detailed in Table 6 and will be implemented based on the application of a 6 hourly EWMA to the raw turbidity (de-confounded) data collected via telemetry. 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 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 (Zi) is computed by adding 60% of the mean turbidity readings during the preceding 6 hours (i) to 40% of the preceding 6 hour EWMA value (Zi-1). Mathematically, 6-hourly values of the EWMA statistic are computed using the following equation:

Zi = 0.6 i + 0.4Zi-1

Where i is the mean of the data for the ith period (in this case, the current 6-hour period). For more background information on EWMA and graph examples see Appendix 5.

To manage WQ, in particular turbidity during dredging operations adaptive management turbidity trigger flowcharts have been developed (Section 5.10) for the dry and wet season. These detail all steps that will be undertaken in case of turbidity levels exceeding the triggers detailed in Table 6. The flowcharts and actions are designed to and will prevent or reduce and manage any turbidity impacts to the PoG sensitive receptors and generally EVs.

Table 6: Turbidity triggers summary at all compliance WQ monitoring stations.

Site name	Status	Parameter	Wet season triggers (01 Oct – 31 Mar)	Dry season triggers (01 Apr – 31 Sep)	Data requirements
MH60	Compliance	Turbidity (NTU)	5 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	7NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Data logged every 15 mins. Real time (telemetry) feed. WQ automatically de-confounded data + 6 hourly EWMA plot feed for turbidity
			9 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
WB50	Compliance	Turbidity (NTU)	19 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	15 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Data logged every 15 mins. Real time (telemetry) feed. WQ automatically de-confounded data + 6 hourly EWMA plot feed for turbidity
			36 NTU (95th %ile of the 6 hr EWMA applied	23NTU (95th %ile of the 6 hr EWMA applied	

			to background turbidity data – external notification trigger)	to background turbidity data – external notification trigger)	
MH10	Compliance	Turbidity (NTU)	11NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	7 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Data logged every 15 mins. Real time (telemetry) feed. WQ automatically de-confounded data + 6 hourly EWMA plot feed for turbidity
			19 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
QE3	Compliance	Turbidity (NTU)	28 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	9 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Data logged every 15 mins. Real time (telemetry) feed. WQ automatically de-confounded data + 6 hourly EWMA plot feed for turbidity
			59 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	

Table notes:

- Site BG10 and RB1 are not included in this table as they are the support reference site respectively. For the compliance sites, internal alert is reached when 80th %tile trigger is exceeded > 36 hrs, whilst the external trigger is reached when 95th %tile trigger is exceeded >24 hrs.
- Wet season triggers for QE3, particularly the 95th percentile, is higher than the triggers for the other sites. This is due to QE3 being located in the Narrows, which is naturally a turbulent and turbid environment due to high current velocities and bedload transport resuspending and transporting sediments from intertidal areas such as mudflats particularly around spring tides as well as run-off and sediment loads during highflow events from the upstream catchment. The background data included a natural flood event.

5.3.3 BPAR monitoring

5.3.3.1 BPAR Monitoring Background

Seagrass meadows are an important primary producer in Port Curtis and have high economic and ecological value. These habitats play a key role in providing food resources and habitat for juvenile and adult fish species as well as turtles and dugongs. Due to their sensitivity to reduced light conditions, seagrass meadows are often chosen as a sensitive receiver for detecting dredging related plume impacts. Within Port Curtis, seagrasses are the sensitive habitat most commonly found adjacent to port facilities and shipping channels that are regularly dredged (Figure 5). Please note that in the instance of the PoG, despite being described as adjacent, seagrass meadows and shipping channels, and thus where dredging operations for the Project will take place, are separated by several hundreds of meters.

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

GPC and the James Cook University (JCU) seagrass ecology team developed light requirements values 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. The studies demonstrated that at intertidal locations, *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) (Table 7). This light requirement value, which will be adopted in this MP and related EM, is therefore the most conservative one. In fact, 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.

The light requirement for *Z. muelleri* in Port Curtis was established during the WBDDP for the growing season only (July to January for Port Curtis). It is important to note that the Project dredging activities will be conducted during the seagrass senescent season when seagrass light requirements are greatly reduced (February to June) and the BPAR trigger is not necessarily applicable (Chartrand *et al.* 2012, Collier *et al.* 2016).

The above-mentioned method for monitoring seagrass light requirements has been adopted and reported by several guidelines including DES Monitoring and Sampling Manual 2018.

Please note that the original method referenced by the DES Monitoring and Sampling Manual 2018 will be implemented to effectively monitor BPAR levels and thus protect seagrass meadows during the Project. However, the equipment utilised will be different as the original method employs Odyssey light sensors which are self-logging only. GPC instead will utilise Li-Cor light sensors which can be integrated into real-time systems; this is crucial for effectively and timely manage dredging operations to prevent and avoid any potential harm to seagrasses and other sensitive receptors. Employing different equipment and adaptation of Li-cor equipment in the methodology is acknowledged in the DES Monitoring and Sampling Manual 2018 (Page 252).

BPAR monitoring related to the Project will be undertaken to:

- Assess and measure impacts on light conditions at or adjacent to sensitive receptor sites within the PoG; and
- Determine the need and implement mitigation measures whether appropriate to prevent environmental harm to seagrass beds and generally EVs.

The results of this monitoring will test the impact hypotheses as follows:

> *Sediment generated during dredging and dredged material placement do not reach sensitive receptor areas causing harm and loss of habitat.*

5.3.3.1.1 Current Port Curtis seagrass meadows condition

Surveys of seagrass distribution and health within Port Curtis and Rodds Bay have been conducted since 2002. Fourteen (14) meadows (Appendix 6) are monitored yearly and their condition is assessed based on variations in three (3) key seagrass metrics: biomass, area and species composition.

These surveys have shown that seagrass meadows in Port Curtis and Rodds Bay are generally at their peak in distribution and abundance during the late spring/early summer (growing season), and decline during winter months (senescent season) (Bryant *et al.* 2014; Davies *et al.* 2013; Chartrand *et al.* 2012; Rasheed *et al.* 2012; Chartrand *et al.* 2011).

The initial mapping survey of seagrass meadows within the greater region from The Narrows to Rodds Bay was conducted in 2002 and found that coastal seagrass beds covered a total area of approximately 7,000 ha with deep water seagrass meadows covering a total area of 6,332 ha. This area was re-mapped in 2009 with 7,150 ha of coastal seagrass meadows and 4,890 ha of deep water seagrass meadows observed (Thomas *et al.* 2010). Throughout the years these surveys have shown that seagrass distribution is extremely variable especially for the deep water seagrass meadows. Seagrasses rapidly respond to a range of environmental factors such as river flow, climate events especially severe ones as well as sediment dynamics and grazing pressure. Whilst changes in seagrass meadow coverage do not seem directly linked dredging activities, it is extremely difficult to ascertain what, if any, impacts dredging may have on seagrass condition and recovery.

The overall condition of seagrass meadows within Port Curtis and Rodds Bay in 2018 was satisfactory, an improvement following several years of poor condition. The total area of seagrass mapped in the Port Curtis monitoring area continued to increase above the long-term average for the second year (Chartrand *et al.* 2019). In 2018, ten (10) monitoring meadows were in very good to satisfactory condition, and only four (4) remained in poor or very poor condition. GPC conducts this monitoring yearly with the addition of deep water seagrass meadows every 5 years in accordance with the long term monitoring schedule published in the PoG Long-term Maintenance Dredging Management Plan (LMDMP) on GPC's website.

5.3.3.1.2 Current Port Curtis reef condition

Together with seagrass meadows, reefs are another important ecosystem within Port Curtis. Based on mapping from GBRMPA (2009), Port Curtis contains 19 reefs made up of predominantly intertidal rocky shores or shallow subtidal reefs (BMT WBM 2014).

Field investigations by BMT WBM in 2014 showed dramatic reductions in hard and soft coral cover since 2009 in some parts of Port Curtis, particularly west of Facing Island (BMT WBM 2015). Coral cover was substantially lower in 2014 than 2009 at many sites in Port Curtis (e.g. Bushy Island, Manning, Oaks, Rat South, Rat North, Rocky Point South and Turtle Island reefs). East Point Ledge, located on the East side of Facing Island also had lower hard coral cover in 2014 than 2012.

The poor condition of coral communities in Port Curtis over the period from 2013 to 2014 was reported to be a result of the large freshwater influx caused by a flooding event in January 2013 (Thompson *et al.* 2015). This is corroborated by hydrodynamic modelling (BMT WBM 2015). Salinity thresholds derived by Berkelmans *et al.* (2012) were overlain on modelled plume outputs from the 2013 flood and these were consistent with areas of impact. In fact, coral genera *Acropora* and *Pocillopora*, which are sensitive to disturbances such as low salinity, were present in dead coral communities at most sites surveyed. It is quite typical of nearshore reefs of the Great Barrier Reef to experience low coral cover and macroalgal dominance following a severe disturbance such as a flooding event (Thompson *et al.* 2015).

It is likely that reefs west of Facing Island and Seal Rocks Reef are in a state of recovery after major freshwater plume impacts from 2013 (BMT WBM 2015). This is supported by 2015 surveys that found that whilst still quite low, the density and diversity of juvenile corals recorded indicates that recovery of coral communities is underway with *Acropora* and *Pocillopora* corals observed to be recruiting to most reefs (Thompson *et al.* 2015). GPC monitors reef conditions within Port Curtis every 5 years.

5.3.3.2 BPAR monitoring sites

The BPAR monitoring as per methods mentioned in Section 5.3.3.1 will be undertaken prior, during and post Project operations. This will be conducted at several sites which have been selected to cover a range of seagrass meadows with different dominant species (Table 7) (Figure 5). Furthermore, these sites were selected following the processes detailed in Section 4.3 and 4.4. Please note that no mapped seagrass meadows are located within the modelled zones of impact from the Project dredging operations. As mentioned in Section 5.3.3.1, in the PoG shipping channels and thus the Project dredging footprint are mostly located several hundreds of meters from seagrass meadows (Figure 5 and Appendix 4).

At BPAR monitoring sites, light (PAR) sensors mounted on benthic frames will be installed, commissioned and maintained. In order to minimise data loss the frames will be equipped with dual PAR sensors as detailed in the abovementioned methods. 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.

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. Such 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 monitoring sites.

A reference site, similar to the WQ monitoring methodology, will be established at Rodds Bay. This site is an important wetland located approximately 50 km from the Project dredging footprint and thus well outside of any potential effects that the Project might have on WQ or BPAR. Moreover this environment is similar and representative of environmental conditions within the PoG making it a suitable reference site. Rodds Bay was also used as a reference site during the WBDDP.

This will greatly help in the analysis and to isolate impact of dredging from environmental factors causing reduced light conditions. 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) (Section 5.3.3.1).

Table 7: Project BPAR monitoring sites.

Site name	Status	Description and water area	EPP (Water) management intent/level of protection	Zone of impact
CT	Control	Control site. PAR collected above the water at a land based station.	N/A	N/A
PBS	Compliance	Pelican Banks South. Coastal Intertidal *Z. muelleri* seagrass meadow between Curtis Island and Facing Island. Located outside of the Project zone of influence. There is a long history of BPAR monitoring at this site with continuous data collected from January 2013 until December 2016.	Moderately disturbed	Outside zone of high impact
QI	Compliance	Quoin Island. Coastal shallow sub-tidal to intertidal meadow dominated by *Halodule uninervis*. On the bank between Quoin Island and the shipping channel. The site is located adjacent to and outside of the Project zone of influence. Light threshold for H. uninervis is 5 mol/m^2/day with time to potential impact of 40 days.	Moderately disturbed	Zone of high impact
BS	Compliance	Black Swan. Intertidal *Z. muelleri* meadow in The Narrows region a relatively constant seagrass presence.	Slightly disturbed	Outside zone of high impact
WI	Compliance	Wiggins Island. Intertidal meadow adjacent to Wiggins Island dominated by *Z. muelleri*	Moderately disturbed	Outside zone of high impact
ST	Compliance	South Trees. Intertidal meadow between the shore and Gatcombe Channel near South Trees Inlet	Moderately disturbed	Outside zone of high impact

		dominated by *Z. muelleri*. Outside of the Project zone of influence.		
PB2	Compliance	Pelican Banks 2 located on the South-West tip of the meadow. Closest substantial occurrence of the shallow *Z. muelleri* seagrass species with the high light requirement, therefore will act as an early warning for the rest of the large intertidal area of dense seagrass on Pelican Banks.	Moderately disturbed	Outside the zone of high impact
RB104-1	Reference	Rodds Bay. Intertidal meadow located in Rodds Bay dominated by *Z. muelleri*	Slightly disturbed	Outside zone of high impact

5.3.3.3 BPAR management trigger values

The abovementioned light requirements and associated triggers (Section 5.3.3.1) have been implemented by GPC for a number of years for both capital and maintenance dredging and will be employed for the Project. The light triggers have been incorporated into an adaptive management plan which follows a multi staged approach (Figure 8) (Section 5.10). Following this staged approach, management response to reduced light conditions will occur well before environmental harm to sensitive receptors is potentially caused (28 days for *Z. muelleri* and 40 days for *H. uninervis*) (Table 8). It is important to note that management trigger and related responses will only be applied during dredging monitoring (not pre dredging operations).

Table 8: BPAR management light threshold for intertidal *Z. muelleri* (6 $mol/m^2/d$ over a 14 day RA) and *H. uninervis* (5 $mol/m^2/d$ over a 14 day RA) adapted from Collier *et al.* 2016 with related investigation and management actions at different consecutive days of 14 day RA below threshold. No management light threshold trigger are applicable to the control sites (CT and RB104-1).

Site name	Internal alarm and investigation (days)	Review of internal investigation results and implementation of initial corrective actions (days)	External notification (DES and DoEE). Review of initial corrective actions. Modification and/or addition of corrective actions (days)	Review of data and corrective actions. Modification and/or addition of corrective actions (days)	Review of corrective actions. Modification and/or addition of corrective actions. Time to potential impact (days)[a] ($mol/m^2/d$)
PBS	1 (equivalent to 14 days of low light)	3 (equivalent to 17 days low light)	7 (equivalent to 21 days low light)	10 (equivalent to 24 days low light)	14 (equivalent to 28 days low light)
PB2					
BS					
WI					
ST					
QI	1 (equivalent to 14 days of low light)	10 (equivalent to 24 days of low light)	15 (equivalent to 29 days of low light)	20 (equivalent to 34 days of low light)	26 equivalent to 40 days low light

Table note: This table is to be read in conjunction with Figure 8, Section 5.10.1. Integration time for the RA is 14 days and will commence at the start of the monitoring program, three (3) months prior to dredging operations commencement. Adaptive management actions will be implemented as appropriate and required to ensure dredging operations do not have additional effect on seagrass meadows. **a:** As per Collier *et al.* 2016, 28 days is the time by when health of *Z. muelleri* can start to deteriorate and 40 days for *H. uninervis* therefore adaptive management actions should be implemented before this time.

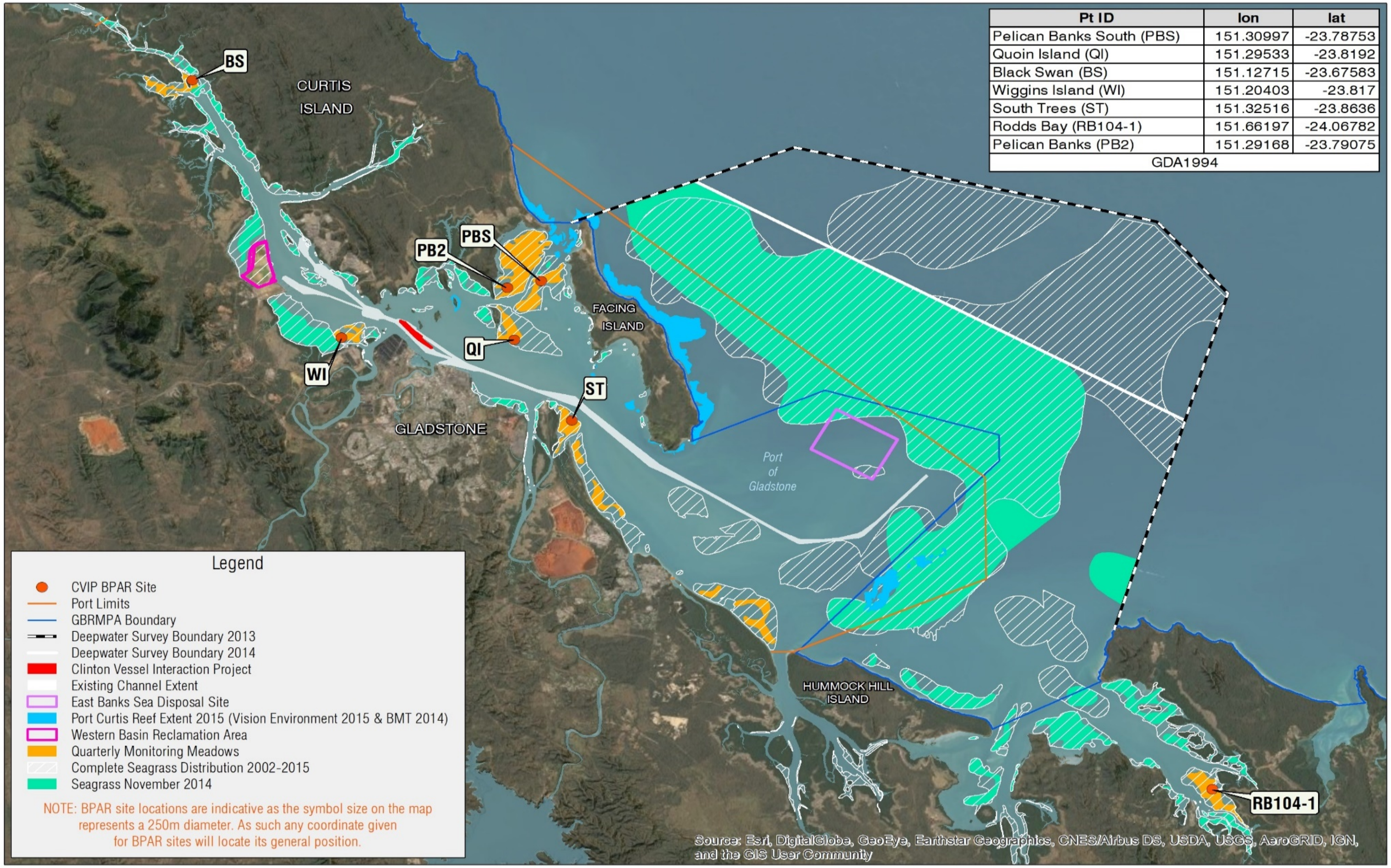

Figure 5: Seagrass meadows and BPAR monitoring locations for the Project.

5.3.4 Sediment flux and bed level change monitoring

Within proximity to two (2) of the BPAR monitoring locations specified in Table 5, PBS and ST, acoustic altimeters mounted on frames will be installed, commissioned and maintained in order to obtain sediment flux and bed level change data. These will be deployed on the benthos as close as possible to BPAR sensors. The exact locations of such instruments will have to be defined upon inspection as a suitable subtidal location, where the instruments can be submersed at all times without wave (bubbles) and other physical disturbances that can influence the readings, will have to be determined. These instruments will be set up to record instantaneous sediment change by logging at 15 minutes intervals. Cumulative bed level change from the original baseline reading will be calculated in order to obtain long-term sediment erosion or deposition patterns at these sites. Please note these instruments will not be telemetered thus data will be downloaded during maintenance and analysed at the end of the Project.

This monitoring component will be undertaken as due diligence and implemented during the three (3) phases of the project (pre, during and post dredging) as detailed in Table11 in order to allow comparisons in sediment flux and bed level change between phases. This will allow to determine if dredging is generating large amounts of sediments that deposit potentially on sensitive receptors, in particular seagrass meadows. This study will complement the fine-grained sediment validation monitoring (Section 5.7) as well as the interpretation of BPAR monitoring (Section 5.3.3) and seagrass surveys (Section 5.5).

5.3.5 WBRA tailwater discharge

Dredge material from the Project will be beneficially reused within the WBRA, this area is fit for purpose to receive dredge spoils and has been set up with two (2) tailwater (decant) discharge locations (Table 9 and Figure 6). This aspect and related monitoring, such as visual inspections of plumes during dredging operations, (Section 5.3.5.1) will be managed by the dredging contractor. It is important to consider that with the selected BHD (Approach 3) dredging there will be no tailwater discharge.

Rainfall in excess of 1m may require the release of stormwater. All monitoring and management measures will be in place to ensure the stormwater quality meets the discharge limits,

Table 9: Approved potential tailwater discharge locations at the WBRA to be utilised for the Project.

Discharge location no.	Coordinates (MGA56 GDA94)
1	312432.3 7370426.7
2	312494.2 7370473.1

The Project hydrodynamic and dredge sediment plume modelling undertaken by BMT WBM (2018a) has demonstrated that a decant water discharge TSS of 100 mg/L will not have a significant impact on Port Curtis EVs.

Figure 6: WBRA estimated flow path and potential tailwater discharge locations.

5.3.5.1 Tailwater discharge monitoring (only required for release of stormwater)

At the tailwater compliance discharge location a WQ telemetry (real-time) station equipped with dual multiparameter sonde will be installed, commissioned and maintained to collect readings at 15 minutes intervals. The full suite of physico-chemical parameters will be collected as well as grab samples to be analysed for various nutrients and metals (Table 10). Please note that whilst the full suite of physico-chemical parameters will be collected, turbidity, pH and dissolved oxygen (DO) readings will be screened against compliance purposes. The remaining parameters will be useful and utilised in the data analysis.

Whilst this aspect of the monitoring will be undertaken by the dredging contractor, GPC will be kept up to date with the data and analyses results. GPC will also provide support, whenever required and appropriate, to the dredging contractor so that every precaution is taken to manage and discharge tailwater appropriately avoiding any potential environmental harm. Release limits will be reviewed and updated, if appropriate and required, prior to the start of dredging operations to reflect any changes to the dredging methodology that might be proposed by the dredging contractor.

The proposed BHD methodology will not lead to any tailwater discharge, so this monitoring will only be triggered if stormwater needs to be released from the facility. Currently it is being envisaged that rainfall events in excess of 1m may trigger release of stormwater. GPC will ensure that all release limits (Table 10) are being adhered to prior to any discharge of stormwater.

Table 10: Compliance WQ monitoring parameters and relative limits for tailwater discharge at the WBRA.

Parameter	Release limit		Monitoring frequency
	Minimum	Maximum	
TSS	-	100 mg/L	Monthly or weekly during discharge events
NTU	-	62.5*	Logged every 15 minutes
pH	6.5	9.0	Hourly[1]
DO	-	100% sat[2]	Monthly or weekly during discharge events
Ammonia (nitrogen)	-	8 µg/L[2]	Monthly or daily if pH is outside release limits
Aluminium (filtered)	-	24 µg/L[6]	Monthly or daily if pH is outside release limits
Arsenic (III) (filtered)	-	2.3 µg/L[3]	Monthly or daily if pH is outside release limits
Arsenic (V) (filtered)	-	4.5 µg/L[3]	Monthly or daily if pH is outside release limits
Cadmium (filtered)	-	0.7 µg/L[5]	Monthly or daily if pH is outside release limits
Chromium (VI) (filtered)	-	4.4 µg/L[4]	Monthly or daily if pH is outside release limits
Copper (filtered)	-	1.3 µg/L[4]	Monthly or daily if pH is outside release limits
Lead (filtered)	-	4.4 µg/L[4]	Monthly or daily if pH is outside release limits
Mercury (filtered)	-	0.1 µg/L[5]	Monthly or daily if pH is outside release limits
Nickel (filtered)	-	7.0 µg/L[5]	Monthly or daily if pH is outside release limits
Silver (filtered)	-	1.4 µg/L[4]	Monthly or daily if pH is outside release limits
Zinc (filtered)	-	15 µg/L[4]	Monthly or daily if pH is outside release limits
TPH	-	10 mg/L	Monthly

Table notes:

1 While pH is to be sampled hourly, limits apply to pH as a 6 hour rolling average
2 Source: Table 2A MD2421 Western Basin, 80th percentile (DEHP 2014)
3 Source: Low reliability trigger value, Section 8.3.7 (ANZECC 2000 V2)
4 Source: ANZECC trigger values for marine waters 95th percentile (ANZECC 2000 V2)
5 Source: ANZECC trigger values for marine waters 99th percentile (ANZECC 2000 V2)
6 Source: Curtis Island, Calliope River and Boyne River Basins Environmental Values and WQOs Section 3.1
* While NTU is logged every 15 minutes, limits apply to NTU as a daily median

5.4 Monitoring program summary

Pre, during and post dredging phases are detailed in Table 11, dates are only approximate as dependant on dredging operations start. GPC will confirm such dates with as much notice as possible.

Table 11: Dredging phases details.

Phase	Duration (months)	Approximate start date
Pre-dredging/baseline	3	15/10/2019
During dredging including Navigational Aid Removal)	7	15/01/2020
Post dredging	1	31/08/2020

A summary of the WQ and BPAR as well all monitoring discussed in the previous sections to be undertaken prior, during and post dredging for the Project is provided in Table 12. The pre-dredging data collection for telemetered turbidity will be utilised as a second baseline in conjunction with data from existing monitoring programs such as PCIMP to review and update this procedure prior to Project dredging operation commencing if deemed appropriate and/or required.

Table 12: WQ, BPAR and sedimentation monitoring program summary for the Project. Please note that this table reports both compliance and due diligence aspect of the EM related to the Project as well as both compliance and support/reference telemetered WQ and BPAR sites. For full details on the different components of the EM please refer to the relevant sections.

Monitoring aspect	Monitoring details	Data/sample collection details	Sites	Dredging phases to be monitored	Monitoring interval
WQ - telemetry	Dual multiparameter sondes WQ buoys. EWMA to be applied to turbidity data set and screened against triggers (Table 6)	Full physical-chemical parameters suite. Continuous real-time data, 15 mins logging interval	MH60 WB50 MH10 QE3 C3 (event monitoring only) BG10 (Support) RB1 (Reference)	Pre During Post	Continuous (telemetry)
WQ – grab samples (due diligence)	Sub surface pole sampler. Results screened against ANZECC 95% and 99% (MD and SD areas) protection marine species and WQOs for Gladstone Harbour Zones	Water samples to be analysed by NATA accredited laboratory for TSS, nutrients, chlorophyll, metals and TPH (Table 5)	MH60 WB50 MH10 QE3 C3 (event monitoring only) BG10 RB1	Pre During Post	Monthly
BPAR	Supply, install, commission and maintain benthic frames with dual PAR sensors and dual loggers. TDP and 14 days RA to be applied to the data set	Continuous real-time data, 15 mins logging	CT (Control) PBS QI WI BS ST PB2 RB104-1 (Reference)	Pre During Post	Continuous (telemetry)
Sediments (due diligence)	Acoustic altimeters deployed sub tidally in proximity (where suitable) of PBS and ST BPAR monitoring sites	Sediment flux and bed level change. Instantaneous sediment change and cumulative bed level change	PBS ST	Pre During Post	Continuous (data downloaded routinely and instrument re-deployed)
*WQ – telemetry (tailwater)	Dual multiparameter sondes WQ telemetry station. pH, NTU and DO to be screened against limits (Table 9)	Full physical-chemical parameters suite. Continuous real-time data, 15 mins logging	WBRA tailwater discharge location (Table 8)	During Post	Continuous (telemetry)
*WQ – grab samples (tailwater)	Pole sampler. Results screened against ANZECC 95% and 99% protection marine species (Table 9)	Water samples to be analysed by NATA accredited laboratory for TSS, nutrients, metals and TPH (Table 9)	WBRA tailwater discharge location (Table 8)	During Post	Monthly or daily whenever pH is outside range (Table 9)

Table notes: Telemetry compliance sites will be screened against related turbidity or BPAR triggers. Support and reference sites are not related to any management action or regulatory limit, but will be closely monitored and used as early warnings and will be of great help in the analysis of data and to determine potential dredging impact on sensitive receptors and EVs. *No Tailwater monitoring will be conducted as there will be no discharge, if stormwater needs to be discharged from the WBRA following high rainfall event (>1 m), the above monitoring will be triggered.

5.5 Seagrass surveys and monitoring

In addition to the BPAR monitoring detailed in Section 5.3.3.2, yearly seagrass monitoring referred to and following the same methodologies mentioned in Section 5.3.3.1.1 will be conducted. This monitoring will assess seagrass distribution and condition and will be conducted to gain additional information and continue GPC's yearly ambient monitoring program committed in GPC's LMDMP which is published on GPC's website.

Specifically, this program will assist to:

- Assess broad-scale changes in seagrass meadow extent and condition over time; and
- Provide information on seagrass condition before and post Project activities.

The hypothesis to be tested by this monitoring is:

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

The Project seagrass monitoring will build on established ambient seagrass monitoring conducted by JCU for GPC since 2002 (Section 5.3.3.1.1).

Monitoring methods will follow those established as part of the long term seagrass monitoring for Port Curtis and Rodds Bay to allow direct comparisons with previous year's meadow distribution and health assessments (Rasheed *et al.* 2017; Carter *et al.* 2014). The monitoring will therefore measure seagrass meadow area, biomass and species composition.

5.6 Dredger data

Data to be collected by the dredging contractor during the Project dredging activity and reported to DoEE and DES (Section 5.8) include:

- Daily record of dredge data
- Areas being dredged, including dates when dredger(s) were operational;
- Volumes placed at the WBRA (in situ m^3); and
- Any dredger incidents in line with the requirements of Sections 7.14 and 7.16 of the Project EMP, and the Project Environmental Authority, Tidal Works permit, allocation of quarry material, and EPBC Act controlled action conditions.

Additional data to be recorded to maintain compliance with approvals includes:

- Marine megafauna species observations log from the dredger operations (i.e. date, time, direction, distance, species, presentation (single or group) and marine fauna spotter details); and
- Vessel log, including responsible vessel person (Master).

5.7 Fine-grained sediment validation monitoring

Following the Project campaign, GPC will have to provide offsets for the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of dredging activities (dredging and tailwater discharge). The figure has been estimated and assessed through preliminary documentation. However, DoEE also requested GPC develop a monitoring plan to validate the estimated figure through field sampling and final calculations derived by the data collected. Fine-grained Sediment Validation Monitoring Plan (PCS 2019), has been approved by DoEE and it will be implemented as detailed in its content.

The plan is publicly available and displayed within GPC's website:

https://www.gpcl.com.au/SiteAssets/Development/CVIP_Plan_Port_and_Coastal_Solutions_CVIP_Monitoring_Plan_2019-DOCSCQPA1504080v3.pdf

Together with all EM detailed in the previous sections of this MP, the abovementioned plan will be implemented and results will be discussed in a report that will be submitted to DoEE as detailed in the Federal state approval (EPBC no. 2017/7976), condition 5 of Part A.

5.8 Hydrographic survey

Hydrographic surveys will be undertaken post dredging in order to confirm the Clinton Channel has achieved the design depth.

GPC will submit the hydrographic surveys of the Clinton Channel to the DoEE, DES and the hydrographic survey office at the end of the Project dredging in compliance with the Project environmental approval conditions.

5.9 Reporting requirements

The EM detailed in this MP will form the content of GPC's compliance report which will be for submitted to DoEE and DES following the Project dredging operations and all associated monitoring completion. For full details of reporting requirements refer to the Project EMP (Section 4.19).

5.10 Environmental management procedure during the Project dredging activities

Figures 7 and 8 show the adaptive management processes and procedures that will be undertaken if turbidity (as EWMA) and BPAR levels exceed the internal alert and/or external trigger levels (Section 5.10.2) for the durations specified in Section 5.3.2 and 5.3.3.3 respectively.

To protect the receiving environment including seagrass and other sensitive receptors during the Project activities, a WQ (turbidity) and BPAR trigger flowchart (Figure 7 and 8 respectively) has been developed to outline the steps that will be undertaken to adaptively manage the elevations and avoid impacts.

5.10.1 General monitoring (no adaptive management required)

Turbidity (as 6 hourly EWMA referred in this Section as ''smoothed turbidity value'') and BPAR levels will be monitored and assessed for compliance purposes (excluding support and reference sites) with all related data managed according to Section 5.3.

While the smoothed turbidity value for each compliance WQ monitoring site remains below the specified Internal Alert Levels (alert level 1 (internal) trigger) for less than 36 hours, no investigation into the cause of turbidity changes (if any) and no dredging operational management intervention is required.

Similarly, while BPAR (as a 14 day RA of TDP) levels remain below the thresholds detailed in Table 7 and 8, no investigation into the cause of BPAR changes (if any) and no Project operational management intervention is required.

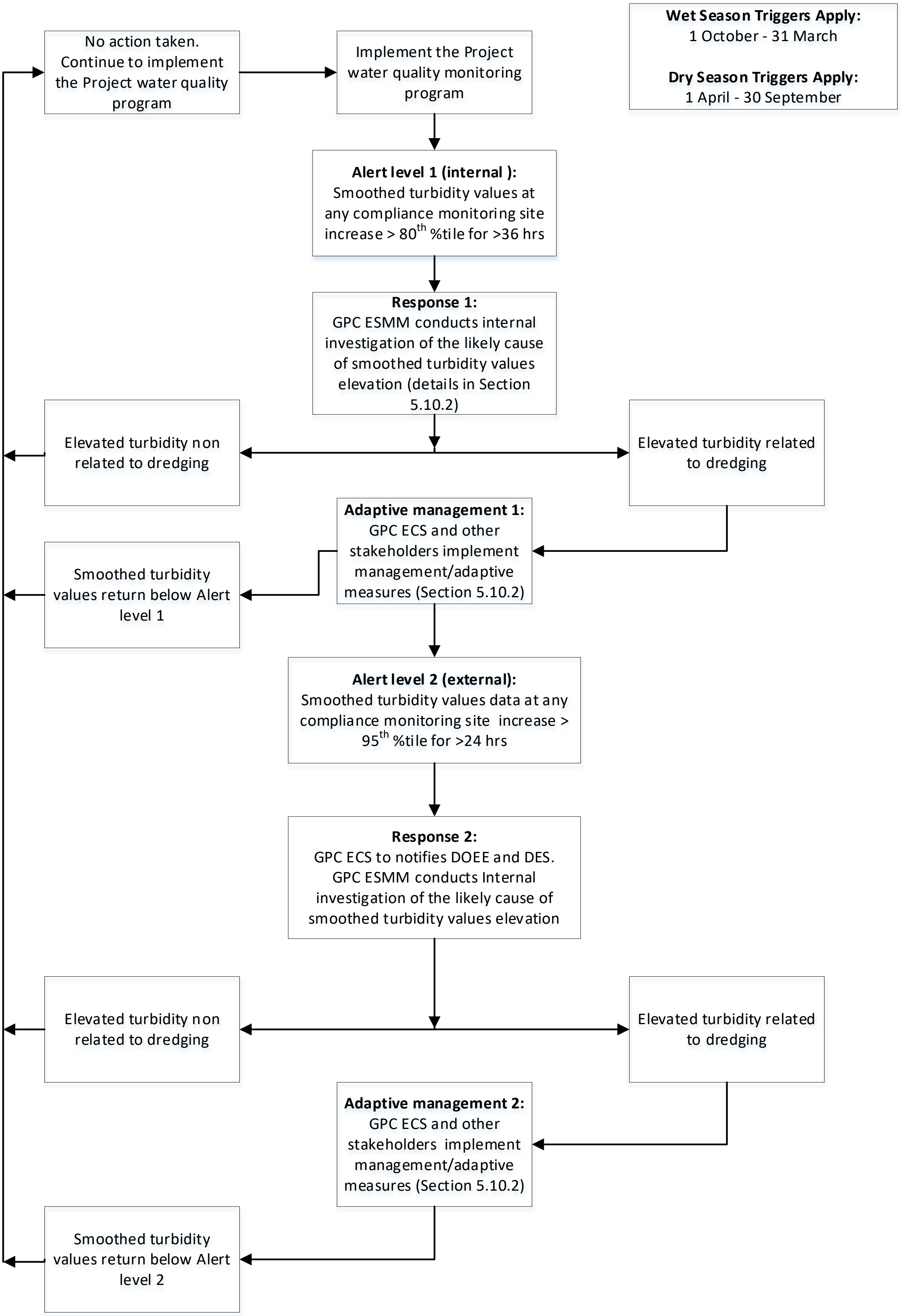

Figure 7: Adaptive management flowchart for WQ (turbidity) that will be implemented during the Project.

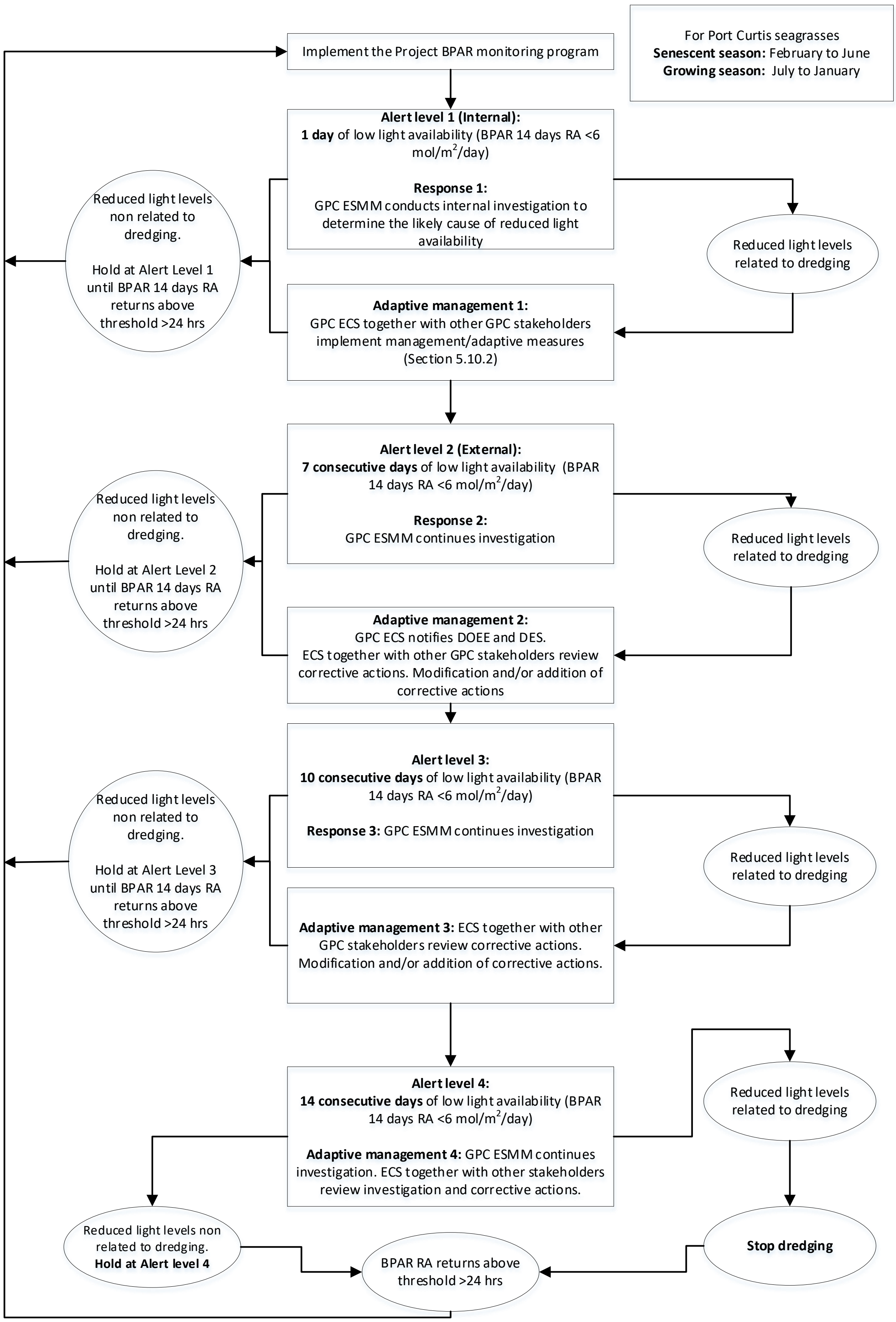

Figure 8: BPAR adaptive management flowchart to be implemented during the Project, seagrass senescent and growing season. **Note:** At the BPAR site QI, the light threshold will be 5 mol/m^2/day on a 14 day RA and the timeline will follow Table 8 with time to potential impact of 40 consecutive days of BPAR 14 RA below 5 mol/m^2/day.

5.10.2 Turbidity (as smoothed turbidity value) adaptive management actions description

5.10.2.1 Turbidity (smoothed value) alert level 1 (internal) and Response 1

The Alert Level 1 (internal) for turbidity (as smoothed turbidity value) is triggered when turbidity (as smoothed turbidity value) at a designated compliance WQ monitoring site is exceeded continuously for a 36 hour period (Figure 7).

This does in turn trigger the Response 1 where GPC ESMM or delegate will initiate an investigation to determine the causes of the elevation. Please note whenever deemed appropriate and required the GPC ESMM will obtain support from the suitably qualified WQ expert who will be engaged for the duration of the Project (Section 5.2).

This investigation will commence within 24 hours of becoming aware of the elevation and will include, but will not be limited to, the following:

- Review telemetry data from WQ (and BPAR) monitoring contractor to ascertain that there has been an elevation-exceedance. Moreover automated emails and alarms will be set up so that elevations in data are not missed;
- Contact WQ (and BPAR) monitoring contractor to check the monitoring equipment status to determine if any interference or malfunction has occurred (e.g. particles/debris lodged within the sensors);
- Contact dredging contractor to gather information such as visible plumes, their extent and direction;
- Analyse data against environmental conditions such as tides, rainfall and wind;
- Check anthropogenic influences (outside the direct Project activities) occurring within Port Curtis;
- Determine the spatial distribution of exceedances in relation to unaffected sites;
- Determine the position of the dredger(s) and in general dredging equipment in relation to the exceedance location;
- Determine the production rate and type of material currently being dredged, including any changes over the previous 48 hours; and
- Determine production rate and type of material to be dredged over the next 2 to 5 days.

All elevations and investigations will be recorded within GPC's systems together with a briefing explaining the likely causes of elevation of turbidity (as smoothed turbidity value).

5.10.2.2 Turbidity (smoothed value) adaptive management 1

If the ESMM, with the aid of the WQ expert whenever required or appropriate, deems the elevation in turbidity (as smoothed turbidity value) to be predominantly due to dredging and/or placement activities (e.g. tailwater discharge) GPC ECS and other GPC stakeholders such as the Project Manager, GPC Dredge Contractor Manager and the dredging contractor will be consulted. This consultation will deliberate what management measures are to be implemented to rectify dredging related impacts on turbidity.

If, instead, the abovementioned investigation shows that likely causes of elevation of turbidity (as smoothed turbidity value) are driven by environmental conditions no actions will be taken, WQ monitoring will continue and the status will go back to general monitoring.

Management measures will be implemented and remain in place until the dredging activities related turbidity (as smoothed turbidity value) no longer triggers the Internal Alert Level values. The measures may include, but will not be limited to the following:

- Reduction in the average rate of dredging and/or placement to reduce the amount of turbidity released into the water column;

- The material being dredged will be assessed and where practical the dredger will be relocated or sequenced to dredge coarser material to allow finer sediments to settle out of the dredge plume; and
- The dredging contractor will implement alternative adaptive management actions to reduce turbidity and/or improve light conditions such as aligning feasible maintenance activities.

If the turbidity (as smoothed turbidity value) returns to acceptable (below triggers) limits for a period of/or greater than 24 hours, no further management measures will be taken and dredging will resume and continue its normal operations. WQ monitoring will continue and the status will go back to general monitoring.

5.10.2.3 Turbidity (smoothed value) alert level 2 (external) and Response 2

When the External Notification Trigger Level at a designated compliance monitoring site for turbidity (as turbidity smoothed value) is exceeded continuously for a 24 hour period, GPC ECS will notify DES and DoEE within one business day of becoming aware of the elevation.

The ESMM, with the aid of the WQ expert whenever required or appropriate, will conduct another internal investigation as detailed in Section 5.10.2.2.

5.10.2.4 Turbidity (smoothed value) adaptive management 2

If the ESMM investigation shows that the elevation in turbidity (as smoothed turbidity value) to be predominantly due to dredging and/or placement activities (e.g. tailwater discharge), GPC ECS and other stakeholders such as the project manager and Dredging Contractor Manager will consider the need for implementation of management measures to rectify dredging related impacts on turbidity as detailed in Section 5.10.2.2. Elevations of turbidity (as smoothed turbidity value) at compliance sites will be analysed together with BPAR levels at compliance sites. In fact, if such smoothed turbidity value elevations occur concurrently with prolonged periods of low BPAR levels, e.g 14 days of continuous 14 days RA <6 mol/m^2/day and/or 24 days of continuous 14 days RA <5 mol/m^2/day for QI, management actions will be deliberated accordingly (Section 5.10.3)

If the abovementioned investigation shows instead that likely causes of elevation of turbidity (as EWMA) are driven by environmental conditions no additional actions will be taken, the process detailed in these sections will not be escalated further. WQ monitoring will continue and the status will go back to general monitoring.

Moreover, if the turbidity (as smoothed turbidity value) returns to acceptable (below triggers) limits for a period of/or greater than 24 hours, no further management measures will be taken and dredging will resume and continue its normal operations. WQ monitoring will continue and the status will go back to general monitoring.

5.10.3 BPAR (as 14 day rolling average of TDP) adaptive management actions description

5.10.3.1 BPAR alert level 1 (internal) and response 1

The BPAR alert level 1 is triggered when BPAR at any compliance BPAR site (as 14 days RA of TDP) falls below the 6 mol/m^2/day, or 5 mol/m^2/day for QI, threshold for 24 hrs (in the growing season equalling to 14 days of seagrass not receiving adequate light) (Figure 8). This will in turn trigger Response 1 where GPC ESMM or delegate will initiate an investigation to determine the causes of the reduced BPAR conditions. Please note whenever deemed appropriate and required the GPC ESMM will obtain support from the suitably qualified WQ expert who will be engaged for the duration of the Project (Section 5.2).

This investigation will commence within 24 hours of becoming aware of the reduced BPAR levels as per Figure 8 and will include, but will not be limited to all details, including record keeping, described in Section 5.10.2.1. The investigation will continue if the BPAR (as 14 days RA of TDP) levels remain below the 6 mol/m^2/day, or 5 mol/m^2/day for QI, threshold. If instead the above-mentioned BPAR 14 day RA returns above the threshold for a period of/or greater than 24 hours the investigation will be closed.

Moreover, if the investigation shows that likely causes of decreased BPAR levels (as 14 day RA of TDP) are driven by environmental conditions no actions will be taken, BPAR monitoring will continue and the status will go back to general monitoring.

5.10.3.2 BPAR adaptive management 1

If the ESMM, with the aid of the WQ expert whenever required or appropriate, deems the low BPAR levels (as 14 day RA of TDP) to be predominantly due to dredging and/or placement activities (e.g. tailwater discharge) and the low BPAR levels extend are experienced for 3 consecutive days the Adaptive Management 1 phase will be triggered. Here the GPC ECS and other GPC stakeholders such as the Project Manager, GPC Dredge Contractor Manager and the dredging contractor will be consulted to deliberate what management measures are to be implemented to rectify dredging related impacts on BPAR.

Management measures will be implemented and remain in place until the dredging activities related BPAR (no longer triggers the Internal Alert Level values. The management measures implemented will be as per Section 5.10.2.2.

If the BPAR returns to acceptable levels (>6 mol/m^2/day or >5 mol/m^2/day for QI only) for a period of/or greater than 24 hours, no further management measures will be taken and dredging will resume and continue its normal operations. BPAR monitoring will continue and the status will go back to general monitoring.

5.10.3.3 BPAR alert level 2 (external) and response 2

When the External Notification Trigger Level at a designated compliance BPAR monitoring site is triggered and thus BPAR (as 14 day RA) levels at any compliance BPAR site are below the 6 mol/m^2/day, or 5 mol/m^2/day for QI, threshold for 7 consecutive days, GPC ECS will notify DES and DoEE within one business day of becoming aware of the reduced BPAR conditions as per Figure 8.

Please note that as detailed in Section 5.10.3.1 in this instance the ESMM (and WQ expert whenever required or appropriate) will still be in progress. If the BPAR 14 day RA returns above the threshold for a period of/or greater than 24 hours the investigation will be closed and BPAR monitoring will continue with status going back to general monitoring.

Moreover, if the investigation shows that likely causes of decreased BPAR levels (as 14 day RA of TDP) are driven by environmental conditions no actions will be taken, WQ monitoring will continue and the status will go back to general monitoring.

5.10.3.4 BPAR adaptive management 2

If the ESMM, with the aid of the WQ expert whenever required or appropriate, deems the low BPAR levels (as 14 day RA of TDP) to be predominantly due to dredging and/or placement activities (e.g. tailwater discharge) the GPC ECS and other GPC stakeholders such as the Project Manager, GPC Dredge Contractor Manager and the dredging contractor will be consulted to deliberate what management measures are to be implemented to rectify dredging related impacts on BPAR.

Management measures will be implemented and remain in place until the dredging activities related BPAR no longer triggers the Internal Alert Level values. The management measures implemented will be as per Section 5.10.2.2. In this instance, however, the management measures implemented during the Adaptive Management 1 phase will be reviewed and modified or new measures will be added if deemed appropriate.

5.10.3.5 BPAR alert 3,4 and adaptive management 3 and 4

The BPAR alert 3 and 4 will be triggered if BPAR levels at compliance sites (as 14 day RA of TDP) remain below the 6 mol/m^2/day, or 5 mol/m^2/day for QI, threshold for 10 and 14 consecutive days respectively (Figure 8).

The processes described in the above sections will be repeated (Figure 8). During both Senescent and Growing Season, if the Alert Level 4 is reached due to the Project operations and the implementation of management measures does not improve BPAR levels being received at seagrass monitoring sites the Project activity will stop until BPAR level returns to acceptable levels. Instead, if the investigation shows that reduced light conditions are due to environmental conditions (e.g. heavy rainfall and/or spring tides, cloud cover, haze from bushfires, strong winds) dredging operations will continue to maximise dredging time during senescent season where seagrasses are in natural decline with a likely much reduced light requirement as well as likely to experience regular natural low light periods.

5.10.3.6 Reporting

All exceedances during the dredging operations (see relative trigger and guidelines) for turbidity and BPAR compliance sites as well as metals and contaminants due diligence and compliance tailwater discharge point will be reported according to incidents reporting as specified in the EMP (Section 4.19).

6 Procedure monitoring and review

This MP, its operation and implementation will be reviewed whenever appropriate and required during the Project activities 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 Hummingbird and will be communicated to all relevant GPC staff.

Any changes to the monitoring program that potentially increase the risk of environmental harm or are inconsistent with the GPC commitments and/or environmental approval conditions will be approved by DoEE and DES prior to implementation. Changes of a minor administrative nature will not require resubmission of the Procedure to administering authorities.

7 More information

This Procedure will be available to all employees, contractors and consultants to which it applies. This document is uncontrolled when printed.

If you require any further information contact the Port Infrastructure Asset Manager.

8 Document version control

Version	Date	Author	Change description
1	05/09/18	S Cole	Draft for GPC review
2	21/09/18	S Cole	Final draft for GPC review
3	28/09/18	S Cole	Final to support approval applications
4	20/02/19	S Cole	Revised final to address preliminary DES comments
5	30/07/19	F Pastorelli	Final submission to DES for approval
6	09/10/2019	F Pastorelli	Revised to address DES' outstanding issues
7	14/10/2019	F Pastorelli	Final Submission (pre dredging only)
8	15/10/2019	DES	Approved
9A	17/10/2019	F Pastorelli	Final submission (dredging and post dredging)
10	15/10/2020	F Pastorelli	Final submission (dredging and post dredging)
10A	03/06/2020	F Pastorelli	Minor administrative changes
10B	29/07/2020	F Pastorelli	Minor amendment remove table 9 (seagrass growing season flowchart) and change to Table 8 (QI days)

9 References

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10 Appendices

10.1 Appendix 1 – Related documents

10.1.1 Legislation and regulation

Key relevant legislation and regulation, as amended from time to time, includes but is not limited to:

Type	Name
Commonwealth legislation and guideline	*Environment Protection and Biodiversity Conservation Act 1999* *Great Barrier Reef Marine Park Act 1975* *ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000*
State legislation	*Environmental Protection Act 1994* *Environmental Protection Regulation 2019* *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* *Coastal Protection and Management Act 1995* *Planning Act 2016* *Aboriginal Cultural Heritage Act 2003* *Fisheries Act 1994* *Marine Parks Act 2004* *Transport Operations (Marine Safety) Act 1994* *Transport Operations (Marine Pollution) Act 1995*
Other	ISO AS/NZS 14001:2015 Environmental Management Systems

10.1.2 Guiding principles

The guiding principles below relate to this Procedure.

Type	Details
GOC principles	**Principle 7** – Recognise and manage risk
GPC principles	**Sustainability** - We preserve the inherent worth of Port assets for future generations. We protect the health and safety of our people, the environment and our community. We engage with and contribute to the communities in which we operate. **Teamwork** - We are one company, one team. We work together to achieve our objectives.

10.1.3 Gladstone Ports Corporation documents

The documents below relate to this Procedure.

Type	Document number and title
Policy	Environment Policy (#366016)
Standard	Environmental Standards (#809151)
Specification/Procedure	Environmental Management System Manual (#146256)

10.2 Appendix 2 – Additional modelling and resulting zones of impact for Approach 2 and 3

10.2.1 Zones of impact for Approach 2 (TSHD and BHD)

10.2.2 Zones of impact for Approach 3 (BHD)

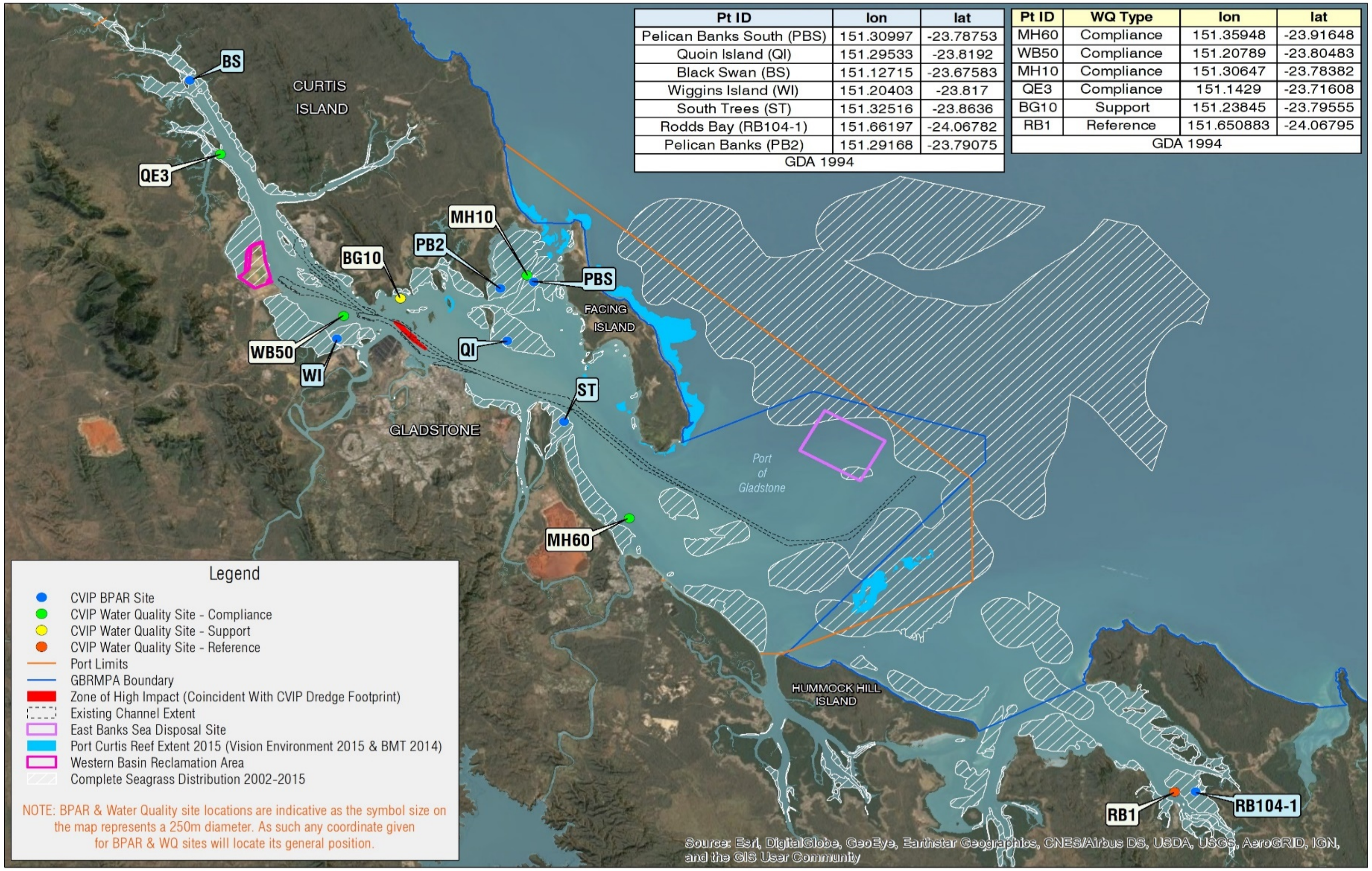
Source: BMT WBM, 2019.

10.3 Appendix 3 – Frequency distributions showing number of 15-minutes turbidity readings (NTU) at each monitoring location broken down by season and campaign. Number in parenthesis are number of 6-hourly EWMA values.

campaign	SITE								Campaign Totals
	QE3		MH10		WB50		MH60		
	season		season		season		season		
	dry	wet	dry	wet	dry	wet	dry	wet	
2014_2015 MD	0	0	0	6432 (267)	0	6432 (262)	0	0	**12,864 (529)**
2015 MD	0	0	2784 (116)	0	2784 (116)	0	0	0	**5,568 (232)**
2015_2016 MD	0	0	0	7820 (327)	0	7585 (314)	0	0	**15,405 (641)**
2016 MD	0	0	4328 (181)	2177 (87)	4328 (181)	2177 (91)	0	0	**13,010 (540)**
2017 MD	0	0	5881 (246)	0	5881 (244)	0	0	0	**11,762 (490)**
2018 MD	0	0	0	5860 (241)	345 (14)	6035 (251)	0	0	**12,240 (506)**
CD EIS	6164 (259)	10738 (449)	20802 (863)	16150 (674)	20736 (852)	16474 (689)	20488 (854)	15166 (633)	**126,718 (5,273)**
Jan 2011 to May 2011	1419 (59)	11480 (439)	0	0	0	0	0	0	**12,899 (498)**
Oct 2010 to April 2011	1807 (96)	14369 (592)	0	0	0	0	0	0	**16,176 (688)**
WBDDP Post-Dredge	0	0	7104 (292)	17374 (721)	4088 (156)	2920 (121)	0	0	**31,486 (1,290)**
WBDDP Pre-Dredge	0	0	16992 (707)	17263 (702)	16123 (664)	17377 (709)	0	0	**67,755 (2,782)**
Site / Season Totals	**9,390 (414)**	**36,587 (1,480)**	**57,891 (2,405)**	**73,076 (3,019)**	**54,285 (2,227)**	**59,000 (2,437)**	**20,488 (854)**	**15,166 (633)**	**325,883 (13,469)**

Source: Fox, 2019.

10.4 Appendix 4 – WQ and BPAR monitoring locations with superimposed WQ zones of impact for the Project



Pt ID	lon	lat
Pelican Banks South (PBS)	151.30997	-23.78753
Quoin Island (QI)	151.29533	-23.8192
Black Swan (BS)	151.12715	-23.67583
Wiggins Island (WI)	151.20403	-23.817
South Trees (ST)	151.32516	-23.8636
Rodds Bay (RB104-1)	151.66197	-24.06782
Pelican Banks (PB2)	151.29168	-23.79075
GDA 1994		

Pt ID	WQ Type	lon	lat
MH60	Compliance	151.35948	-23.91648
WB50	Compliance	151.20789	-23.80483
MH10	Compliance	151.30647	-23.78382
QE3	Compliance	151.1429	-23.71608
BG10	Support	151.23845	-23.79555
RB1	Reference	151.650883	-24.06795
GDA 1994			

10.5 Appendix 5 – Example of EWMA application and background information

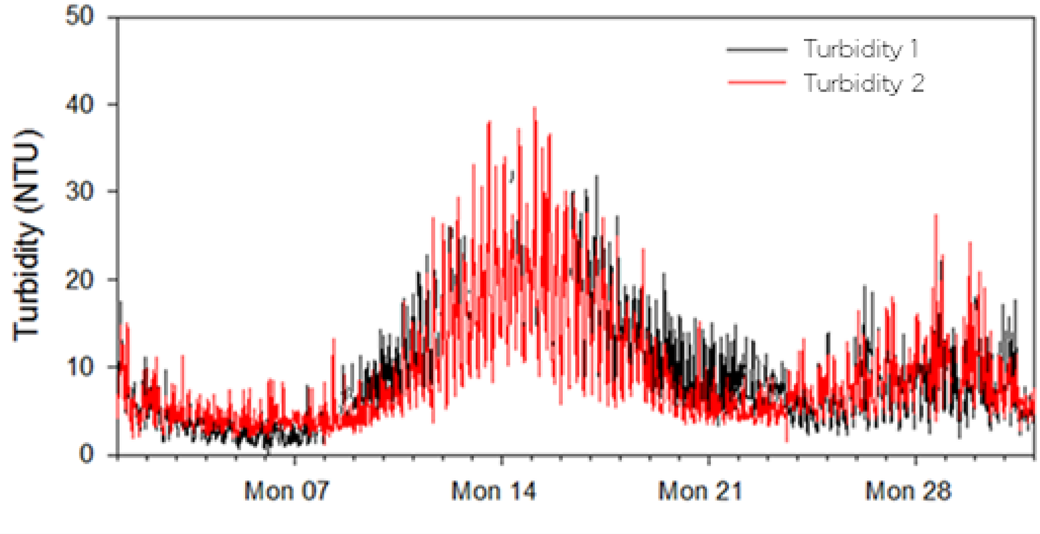


Figure A5-1: Validated turbidity (NTU) data from sonde 1 and 2.

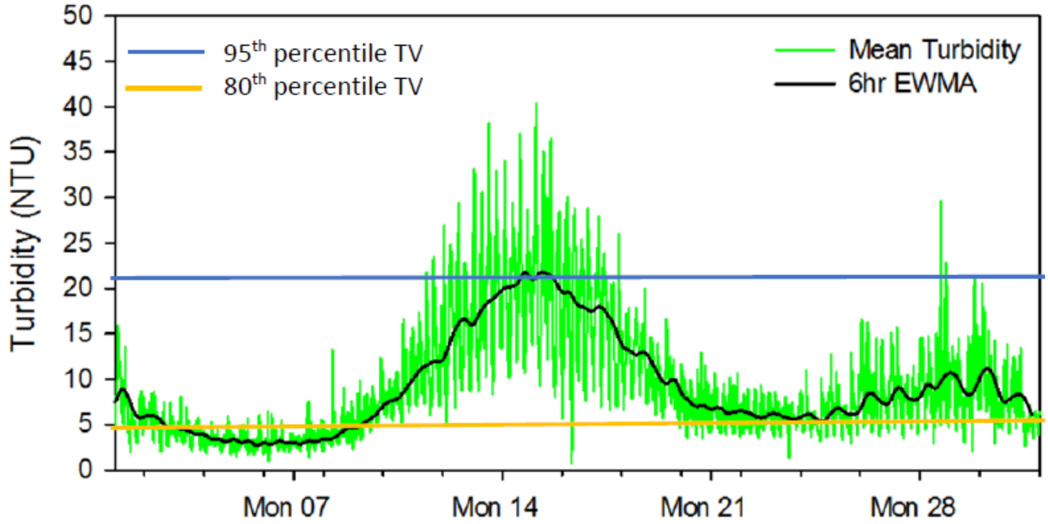


Figure A5-2: Mean of sonde 1 and 2 (green line), 6hr EWMA calculated from the mean turbidity and trigger values (TVs). Application of the "smoothing technique" EWMA evens out high and low values. The graphs demonstrates of how the 80th and 95th percentile triggers will serve as alerts and implementation of adaptive management response.

Exponentially Weighted Moving Average (EWMA) is appropriate for implementation based on the following:

• When collecting high frequency water quality data, such as 15 minute physicochemical data, data smoothing techniques are recommended due to the variability of natural ecosystem processes. The high natural variation within an ecosystem tends to mask overall trends in water quality parameters and reduces the ability to extract a signal from the background noise.

• Smoothing techniques generally consist of moving averages. For example, the Exponentially Weighted Moving Average (6h EWMA) proposed for use utilises in its calculations the average of the last six hours of turbidity data collected (in addition to the six hours collected previously). This permits smoothing to take place of the last 12h of data which minimises the impact of any outlying data or potentially missing data.

• The 6h windows were selected as that amount of time typically incorporates a tidal window (e.g. low tide to high tide), with the 12h period encompassing an entire tidal cycle.

• The 60/40% weighting was successfully used in the Port of Melbourne Channel Deepening Project, and the Western Basin Dredging and Disposal Project (WBDDP) and has undergone rigorous, independent scientific review during both of these projects.

• Trigger values (TV) for individual sites within the monitoring program have also been derived using previously collected 6h EWMA smoothed data gained for sites QE3, WB50, MH10 and MH60 during previous baseline (non-capital dredge period but including maintenance dredging periods from 2014 to 2018) monitoring programs. These programs include the WBDDP, Narrows Crossing, Channel Duplication EIS and maintenance dredge monitoring (2014 to 2018).

• Trigger values for each site will be set at the 80th percentile (internal) and 95th percentile (external) of the previously collected EWMA data. It is expected that 20% of the 6h EWMA smoothed data obtained during the monitoring program at each site will naturally exceed the 80th percentile TV, providing a sensitive early warning system when turbidity is increasing, and thus permitting GPC to prepare potential management actions. Similarly, 5% of the 6h EWMA smoothed data obtained during the monitoring program will exceed the 95th percentile TV.

• The use of the EWMA process to both develop TV and remove noise from the field collected data to determine the underlying trend will meet the purposes and intent of the EPP (Water and Wetland) Policy. Identification of the environmental values and management goals/water quality objectives for protecting waters will be undertaken by using previously collected 6h EWMA smoothed data to calculate sensitive TV for varying management actions. These TV and their associated management actions will provide a framework for making consistent, informed and equitable decisions about water quality at each site. Monitoring of the waters at each site and regular reporting of the 6h EWMA against set TV will enable GPC to determine whether policy objectives are being achieved.

• The previous use of the 6h EWMA proposed for this project has been shown to successfully balance of the risk of falsely triggering an early warning alarm with the risk of not detecting an environmentally significant event, meeting the intent of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 at each monitoring site.

10.6 Appendix 6 – 2018 seagrass distribution and monitoring meadows within Port Curtis and Rodds Bay