PORT OF **WEIPA**

APPENDIX I

Onshore pond and reclamation assessment

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Port of Weipa: Sustainable Sediment Management Assessment

Onshore Pond and Reclamation Assessment

Report No. P022_R01F1

NORTH QUEENSLAND BULK PORTS CORPORATION

Technical Report
December 2019

Port of Weipa: Sustainable Sediment Management Assessment

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North Queensland Bulk Ports Corporation Ltd

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North Queensland Bulk Ports Corporation (NQBP) commissioned Port and Coastal Solutions (PCS) to undertake a series of studies as part of NQBP's long-term Sustainable Sediment Management (SSM) assessments at the Port of Weipa.

The aim of this study is to undertake a comparative assessment for placing maintenance dredge sediment within an onshore pond and a reclamation at the Port of Weipa.

As part of the assessment preliminary concept designs have been developed and costs, greenhouse gas (GHG) emissions and water quality impacts have been estimated for the two options. In addition, ongoing maintenance dredging and offshore placement at the existing Albatross Bay dredge material placement area (DMPA) has also been included in the comparative analysis for context.

The key findings from the comparative analysis are summarised below:

- the onshore pond option has been estimated to cost over three times more than ongoing maintenance dredging with offshore placement at the existing Albatross DMPA (difference of $130 M), while the cost of the land reclamation option is over $50 M more than ongoing maintenance dredging with offshore placement;
- the GHG emissions are approximately double for the onshore pond option compared to ongoing maintenance dredging with offshore placement at the existing Albatross DMPA, while for the land reclamation option the emissions are approximately 40% more than for maintenance dredging with offshore placement; and
- results from the water quality modelling have shown that although the spatial extent and peak concentration of the 95th percentile suspended sediment concentration (SSC) for the Albatross DMPA is greater than for the onshore pond option, the increased SSC at the sensitive receptors is comparable. In contrast, the results for reclamation option show consistently higher SSC at the sensitive receptors and the spatial map of the 95th percentile also shows the largest area of SSC between 5 and 10 mg/l.

This comparative analysis has shown that, from a cost, GHG emissions and water quality perspective, the existing practice of placing dredge sediment offshore (with the existing Albatross Bay DMPA used for comparative purposes) continues to be the most cost effective solution, providing lower GHG emissions and similarly low increases to SSC at the sensitive receptor locations compared to the onshore pond and reclamation site options assessed.

1. Introduction

North Queensland Bulk Ports Corporation (NQBP) commissioned Port and Coastal Solutions (PCS) to undertake a series of studies as part of NQBP's long-term Sustainable Sediment Management (SSM) assessments at the Port of Weipa. The scope of work for the studies being undertaken by PCS are as follows:

- Onshore pond and reclamation assessment: the aim of the study is to assess a single onshore pond option and a land reclamation option at the Port of Weipa. As part of the assessment, preliminary concept designs will be developed to allow a comparative analysis between the options and other options being considered as part of the SSM assessments to be undertaken;
- Sediment transport and dredge plume modelling: the aim of the study is to model the transport of suspended sediment released into the marine environment by maintenance dredging at the Port of Weipa. The modelling will include a number of offshore and onshore placement sites as well as a range of possible metocean conditions and maintenance dredging volumes;
- Thresholds analysis: the turbidity, deposition and benthic PAR data collected as part of the ambient water quality monitoring at the Port of Weipa will be analysed to understand the natural variability of these parameters in the environment. Based on this data and information available from the literature, relevant thresholds (using an intensity, duration and frequency approach) will be defined for the long-term monitoring sites at the Ports; and
- CO_2 emission calculations: the aim of this study is to undertake calculations to provide an estimate of Greenhouse Gas (GHG) CO_2 equivalent emissions for a number of placement options for the Port of Weipa.

This report details the onshore pond and reclamation assessment for the Port of Weipa.

1.1. Project Background

NQBP undertakes regular maintenance dredging of the channels and berths at the Port of Weipa to ensure there is sufficient depth for vessels to safely travel to and from the berths. The sediment that has historically been removed by maintenance dredging, has been relocated to an offshore dredge material placement area (DMPA) located in Albatross Bay.

NQBP has current State and Commonwealth approvals to support maintenance dredging and at-sea placement of the dredged sediment at the Port of Weipa. The current 10-year permit was issued in 2010. Since then, the process to obtain new long-term sea dumping permits in Queensland has become more onerous.

A Maintenance Dredging Strategy (MDS) has been developed for the ports that are situated within the Great Barrier Reef World Heritage Area (GBRWHA) (DTMR, 2016). The MDS provides a framework for the sustainable, leading practise management of maintenance dredging (Figure 1). Although the Port of Weipa is not located within the GBRWHA, NQBP has decided to adopt the MDS to ensure the same high standard is adopted at all of their Ports. It is a requirement of the MDS that each Port within the GBRWHA develop Long-term Maintenance Dredging Management Plans (LMDMPs). The LMDMPs are aimed at creating a framework for continual improvement in environmental performance. DTMR have provided guidelines to assist in the development of the LMDMPs (DTMR, 2018). The guidelines note that they should include, as well as other aspects, the following:

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

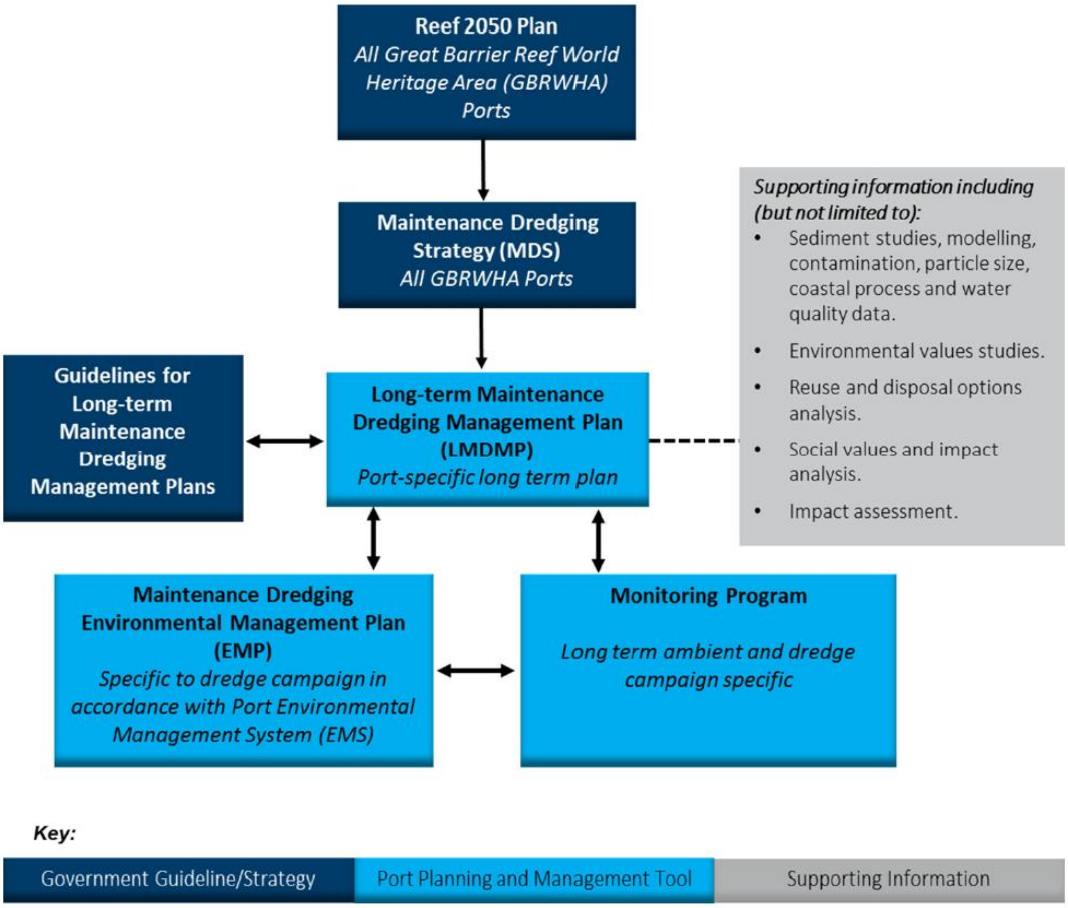

Figure 1. Planning and implementation mechanisms for maintenance dredging of Queensland ports (DTMR, 2018).

The requirement to investigate whether sedimentation at ports can be managed to avoid or reduce the need for maintenance dredging is derived from the London Protocol, which forms the basis for Australia's Sea Dumping Act 1981. Based on this, the environmental regulators are particularly focused on the following questions:

1. Can sedimentation be managed at the Port to avoid or reduce the need for maintenance dredging?
   - Where do sediments accumulate in the Port and at what volumes and rates?
   - What causes sedimentation in the Port?
   - Does sedimentation at the Port pose a risk to port operations and safety?
   - Why does the Port need to undertake maintenance dredging?
2. If maintenance dredging must occur, has there been a comprehensive assessment of whether the material can be beneficially reused?
3. If no beneficial reuse options are available, what would be the most suitable and feasible disposal or placement options?
4. Has a comparative analysis of options been undertaken, that considers human health, social values, environmental impacts and disproportionate costs?

To answer these questions, NQBP developed a framework as part of the SSM assessment at the Port of Hay Point. This framework was subsequently used to inform the framework that has been adopted at the Port of Weipa as well as the framework developed for the MDS, demonstrating that NQBP have been proactive at developing sound long-term maintenance dredging strategies. The studies included as part of the work currently being undertaken by PCS are aimed at answering the questions posed under point 4. The findings from all these SSM studies will feed into the development of a new LMDMP at the Port of Weipa.

1.2. Port Details

The Port of Weipa is located in the Gulf of Carpentaria, on the north-west coast of the Cape York Peninsula in Northern Queensland. The Port of Weipa is within Albatross Bay, a large embayment, with the wharves and berths located in the Embley River (Figure 2 and Figure 3). The Port of Weipa consists of:

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

The Port has approximately 622 hectares of channels, swing basins and berths where depths are maintained by maintenance dredging. Since 2002 maintenance dredging at the Port has been undertaken annually by the Trailing Suction Hopper Dredger (TSHD) Brisbane, with volumes ranging from approximately 300,000 m^3 to 2,400,000 m^3. The majority of the maintenance dredging requirement at the Port of Weipa is within the mid to outer sections of the South Channel where the sediment is predominantly fine-grained silt and clay. There is also some requirement for annual maintenance dredging within the Inner Harbour and inner area of the South Channel where the sediment has a higher proportion of sand.

The fact that the Port requires annual maintenance dredging indicates that regular natural sediment transport and sedimentation occurs in the region. In addition to the regular sedimentation, it has also been observed that extreme events such as tropical cyclones (TCs) can result in significant increases in the sedimentation and therefore increased maintenance dredging requirements at the Ports. TCs occur in the Gulf of Carpentaria in most years. Based on analysis of historical TCs, it follows that the region is influenced by tropical cyclones on average every other year, although the magnitude of this influence can vary significantly. To reduce the risk of increased sedimentation from a TC resulting in operational or safety issues at the Port, maintenance dredging at the Ports has typically been scheduled immediately after the wet season (when TCs occur).

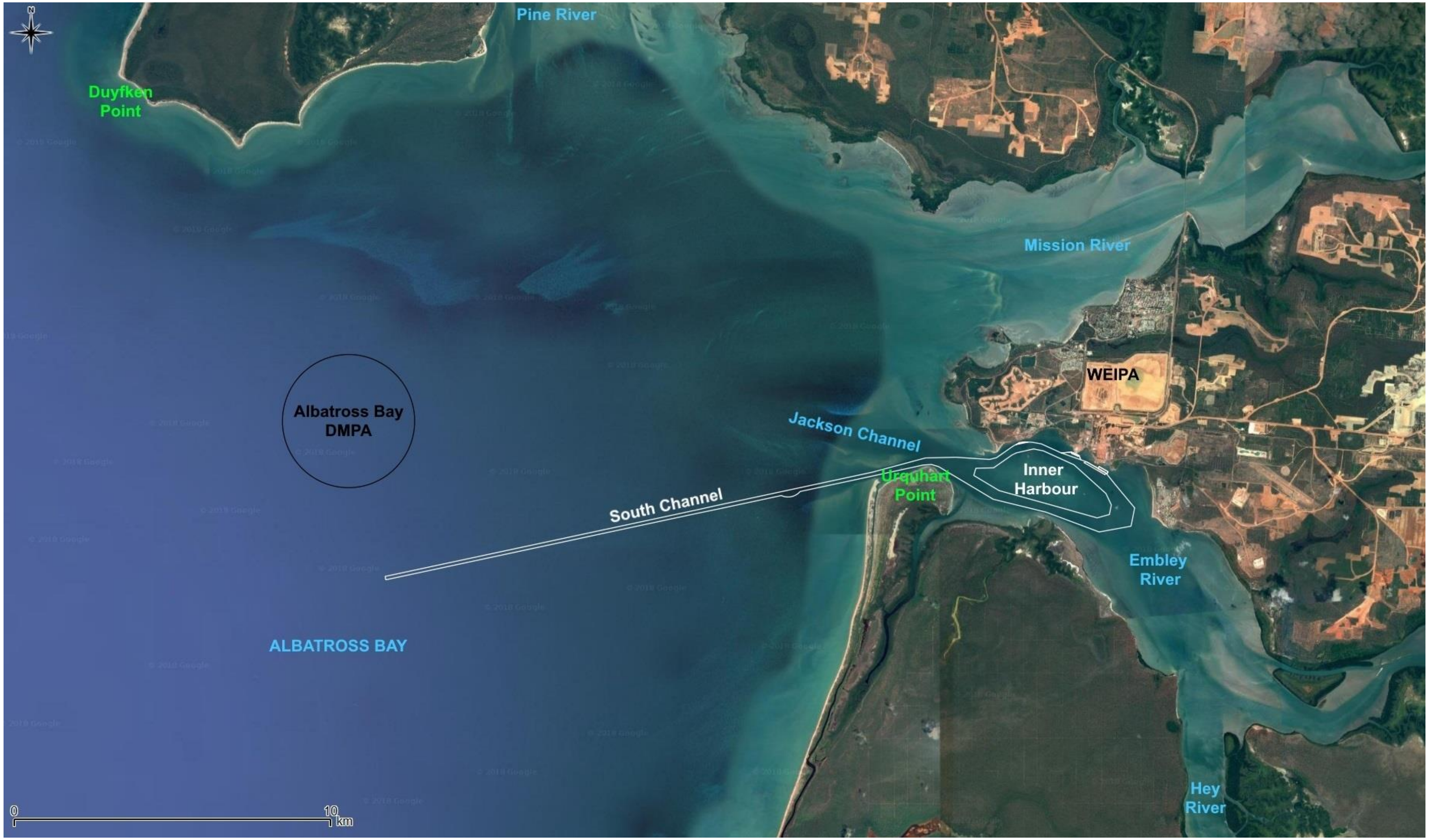

Figure 2. Location of the Port of Weipa.

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Figure 3. Close up of the Port of Weipa Inner Harbour area and berths.

1.3. Report Structure

The report herein is set out as follows:

- an introduction to the study is provided in **Section 1**;
- site considerations for the onshore pond and reclamation are presented in **Section 2**;
- the preliminary concept development for the two options are detailed in **Section 3**;
- the comparative assessment between the options is provided in **Section 4**, and
- a summary of the key findings is given in **Section 5**.

Volumes presented throughout are *in-situ* cubic metres.

2. Site Considerations

As part of the comprehensive beneficial reuse assessment for the Port of Weipa, a number of site-specific considerations were investigated (Advisian, 2018). This section provides an overview of the relevant site considerations based on information from beneficial reuse assessment as well as other relevant information.

2.1. Volume Requirements

Detailed bathymetric analysis has been undertaken at the Port of Weipa to better understand the natural sedimentation that has occurred (PCS, 2018). This analysis allowed the future sedimentation to be estimated which has allowed an economic assessment into the impacts of not dredging at the Port of Weipa to be undertaken (Acil Allen Consulting, 2019). The same sedimentation rates and assumptions have been adopted for the sedimentation rates assumed as part of this assessment, as were adopted for the economic assessment. It has been assumed that over the 10 year period being considered for this assessment there will be five years with typical sedimentation, three years with a single cyclonic event and two worst case years with multiple cyclonic events. Based on this, the assumed future sedimentation over 10 years for the Port was as follows:

- Port of Weipa: 5 x 400,000 m^3 (typical year), 3 x 800,000 m^3 (cyclonic year), 2 x 2,500,000 m^3 (worst case multiple cyclonic year) = 9,400,000 m^3 over 10 years.

2.2. Sediment Properties

Sediment samples were collected at the Port of Weipa as part of the beneficial reuse assessment to provide a better understanding of the geotechnical properties of the sediment (Advisian, 2018). A summary of the key results from the sampling is provided below:

- most of the maintenance dredging volume consists of fine-grained silt and clay within the South Channel. This sediment could be suitable for low to medium load applications following drying out and compaction (noting this could take months to years); and
- some coarser-grained sand and gravel accumulates in the Approach and Departure Channel and the inner area of the South Channel. This sediment could be suitable for medium to high loading applications following adequate compaction.

2.3. Onshore Pond Locations

For the beneficial reuse assessment at the Port of Weipa the option of placing all dredged sediment onshore was not considered as a realistic beneficial reuse option due to the sediment properties, relatively high future volumes and low demand for reconditioned dredge sediment. However, as part of the beneficial reuse assessment the availability of land was assessed for the creation of onshore ponds (for other beneficial uses such as construction fill) (Advisian, 2018). The key findings are summarised below:

- an inactive Tailings Storage Facility (TSF) located approximately 1 km north of Evans Landing wharf was identified as the most suitable location for the creation of any onshore ponds. The area of the inactive TSF, measuring 153.7 hectares, is on land associated with the Rio Tinto Alcan Mining Lease. The site was considered appropriate as it is located relatively close to the dredging area and is of a sufficient size to accommodate some onshore placement of sediment.

2.4. Future Demand

The beneficial reuse assessment identified land reclamation at the Port of Weipa as one of the top two options for the beneficial reuse of sediment from maintenance dredging, along with beach nourishment. However, one of the uncertainties associated with the option was related to the future demand as there is no current master plan for the Port of Weipa, although internal planning has occurred and as part of this reclamation has been considered.

Despite the lack of a master plan, the assessment determined that a realistic opportunity for a new reclamation at the Port of Weipa was in the Evans Landing region. It was noted that any future land reclamation in this area could potentially accommodate the heavy lift of materials, including break bulk cargo, to support future port operations (Advisian, 2018).

3. Preliminary Concept Development

This section describes the preliminary onshore and reclamation concepts which have been developed for comparative purposes as part of this assessment. For the concepts it has been assumed that any dredging would be undertaken by the Trailing Suction Hopper Dredger (TSHD) Brisbane. This is the dredger which has undertaken the majority of maintenance dredging at Queensland Ports since it was commissioned in 2000.

3.1. Onshore Pond

The location of the proposed 153.7 hectare Weipa Onshore pond at the inactive TSF is shown in Figure 4. The site is currently unused and located approximately 1 km to the north of the Evans Landing wharf. However, it is important to note that the size of the available land means that only some of the sediment removed by maintenance dredging over a 10 year period would be able to be contained at site.

As the available land is restricted at this location, an upper limit of 5 m has been assumed for the bund wall height for this concept development assessment (4 m depth of sediment/water and 1 m freeboard). This height is considered to represent a realistic upper limit for onshore pond bunds, with higher bund heights being achievable, but resulting in higher cost and additional safety and risk considerations. The bunds have assumed a slope of 1 in 3, a crest width of 3 m (to allow access along the bund wall) and a distance of 5 m between the toe of the bund and the land boundary (to allow drainage and access to the bund toe).

As the sediment will be placed into the pond over multiple years, which will allow the tailwater to be managed as well as some dewatering to be undertaken between years, a bulking factor of three has been assumed from the in-situ volume to the in-pond volume of the sediment.

Based on the assumptions detailed above, the area of land required to contain all the sediment predicted to require maintenance dredging at the Port of Weipa over 10 years has been estimated to be in the order of 750 hectares.

3.1.1. Sediment Capacity

As noted above, it is not considered realistic to develop a concept for an onshore pond at the Port of Weipa which could contain all maintenance dredged sediment over a 10 year period. Based on the assumptions regarding the bund height, slope and distance from the property boundary, the total area enclosed by the bunds would be approximately 135 hectares. Therefore, assuming an upper limit for the total depth of sediment/water in the pond of 4 m the total capacity for the pond would be 5.4 Mm^3. Based on the bulking factor of three this is equal to 1.8 Mm^3 of in-situ sediment, which is 4.5 typical years or 2 cyclonic years (or a combination of the two).

The onshore pond would not have sufficient capacity to contain all the sediment resulting from a worst case year with multiple cyclones. For a worst case year the bulked volume of the material would be 10 Mm^3 (a bulking factor of four has been applied as the sediment would be placed in a single year), which would require the pond bunds to be approximately 8.5 m high.

Over the 10 year period considered as part of this assessment it has been assumed that any additional sediment from maintenance dredging which the onshore pond does not have capacity for will be placed offshore at the existing Albatross Bay DMPA.

Figure 4. Locations of onshore pond and land reclamation for Port of Weipa. *Note: for comparative purposes only.*

3.1.2. Dredging and Placement

It is assumed that the TSHD Brisbane would pump the dredged sediment and water in the vessels hopper to the onshore pond from the Evans Landing wharf. The TSHD Brisbane has a pumping system which is capable of pumping dredge sediment at least 1,500 m from the mooring location and therefore it is assumed that the dredger could pump the sediment directly to the onshore pond.

To allow the cost and greenhouse gas (GHG) emission calculations to be undertaken the following assumptions about the dredging approach were made:

- 1,600 m^3 (in-situ volume) of sediment is dredged per load by the TSHD Brisbane;
- the vessel steaming speed is 10 knots when fully laden and 12 knots when empty and the average distance from the main dredge areas to Evans Landing are 11.5 km (South Channel) and 4.5 km (Inner Harbour);
- it takes 1 hour for the vessel to moor up, connect to the pipeline and to de-connect afterwards;
- it takes 1 hour for a full load to be pumped to the onshore pond;
- the vessel has an operational downtime of 10%.

Based on these assumptions it is estimated that it would take the TSHD Brisbane approximately 45 days to dredge and pump 400,000 m^3 of sediment to the Weipa onshore pond, compared to 23 days if the sediment was placed at the existing Albatross Bay Dredge Material Placement Area (DMPA). The majority of this increase in time is due to the additional time required to pump the sediment onshore.

3.1.3. Construction and Management

For the purposes of this analysis it has been assumed that approximately 445,000 m^3 of sediment will be required for the construction of the bund walls. This sediment is assumed to be from off-site sources and delivered by truck.

The construction stages are expected to be as follows:

- Site clearance and preparation;
- Delivery of sediment for bund walls and construction of walls and installation of drainage pipelines;
- Installation of geofabric liners; and
- Configuration and installation of onshore pipelines including tailwater discharge outlet point to connect the tailwater to a marine discharge outlet (assumed to be adjacent to Evans Landing wharf for the numerical modelling undertaken as part of this assessment).

It is estimated that the construction of the onshore pond would take between a year and a year and a half to complete depending on the machinery and workforce available. This assumes that the following would be working on the site throughout the majority of the construction phase as a minimum:

- Bulldozer x 2;
- Dump trucks x 3;
- Excavator x 2;
- assorted other plant for periods of time (trenchers, scarpers, rollers, water truck etc); and
- a total of 75 personnel (mix of skilled (20%) and general (80%)).

The ongoing management of the pond will primarily involve the tailwater discharge of excess water from the pond into marine waters. The pond would need to be configured to ensure that the suspended sediment concentration (SSC) of any suspended sediment present in the tailwater was below the threshold specified in any approval conditions. Between maintenance dredging programs it is possible that some additional dewatering could be undertaken to try and maximise the volume capacity of the ponds.

3.2. Reclamation

The beneficial reuse assessment at the Port of Weipa suggested that a potential land reclamation area in the Evans Landing region could be up to 20 hectares in size. However, this size of reclamation would require the reclamation to cover the shallow bay to the north-east of Evans Landing which is a known area of seagrass. As such, the extent of the potential reclamation considered as part of this assessment has been reduced in size to ensure it does not directly impact any areas of known seagrass or the sandy foreshore at Gonbung Point located to the south-west of Evans Landing. An outline of the concept design for the 5.5 hectare reclamation considered as part of this assessment is shown in Figure 4.

The reclamation would be constructed using a perimeter sheet pile wall, which would be up to 10 m in height to contain the reclamation. The outer sheet pile wall (total length = 1 km) is estimated to require approximately 12,000 m^2 face area.

3.2.1. Sediment Capacity

Water depths are variable across this reclamation area, with an average depth of approximately -5 m LAT. It has been assumed that the dredged sediment could be placed into the reclamation up to 3 m above LAT (approximately highest astronomical tide level), with specific construction fill used above this level. Based on this the reclamation would have a volume capacity of approximately 440,000 m^3. As the sediment to be placed into the reclamation would be predominantly sand and gravel sized limited bulking would occur.

Due to the limited capacity of the reclamation combined with the potential future use for Port operations, it has been assumed that the reclamation would be filled with predominantly coarse grained sediment from the Inner Harbour and inner South Channel regions. There could be between 50,000 and 100,000 m^3 of this type of sediment available each year and so the reclamation is likely to be able to contain in the order of four to five years of dredged sediment from this inner region. It has been assumed that the remaining finer-grained silt and clay sediment which makes up the majority of the annual maintenance dredging volume will be placed offshore at the existing Albatross Bay DMPA. In addition, for the years when no maintenance dredge sediment is placed in the reclamation over the 10 year period being considered, it has been assumed that all of the sediment would be placed at offshore at the existing Albatross Bay DMPA.

3.2.2. Dredging and Placement

It is assumed that the TSHD Brisbane would pump the dredged sediment and water in the vessels hopper to the reclamation from an adjacent mooring. The TSHD Brisbane has a pumping system which is capable of pumping dredge sediment at least 1,500 m from the mooring location and therefore the dredger could easily pump the sediment into the reclamation.

To allow the cost and greenhouse gas (GHG) emission calculations to be undertaken the following assumptions about the dredging approach were made:

- 1,600 m^3 (in-situ volume) of sediment is dredged per load by the TSHD Brisbane;
- the vessel steaming speed is 10 knots when fully laden and 12 knots when empty and the average distance from the Inner Harbour regions to Evans Landing is 4.5 km;

- it takes 1 hour for the vessel to moor up, connect to the pipeline and to de-connect afterwards;
- it takes 1 hour for a full load to be pumped to the onshore pond; and
- the vessel has an operational downtime of 10%.

Based on these assumptions it is estimated that it would take the TSHD Brisbane approximately 9 days to dredge and pump 100,000 m^3 of sandy sediment to the Weipa reclamation.

3.2.3. Construction and Management

The reclamation area would be constructed using a sheet pile driver and a barge, this process is expected to take approximately one year to complete. Following construction of the sheet pile wall a geofabric liner would be installed to prevent the loss of fine-grained sediment from the reclamation area by leaching through the voids between the sheet piles. The dredged sediment would then be pumped into the reclamation and contained by the geofabric liner and sheet pile walls.

The dredged sediment would need to be dewatered over time, with the dewatering requiring active management to ensure SSC levels are acceptable. It is likely that some dewatering would be required between the annual dredging programs.

Ongoing management of the reclamation would be required until the sediment is effectively consolidated and dewatered and therefore suitable for medium to high load bearing. This is likely to take numerous years to occur before the final engineering work on the reclamation can be undertaken.

4. Comparative Assessment

This section provides cost, GHG emission and water quality impact estimates for the two options. To allow a comparison with ongoing maintenance dredging, results from other components of this project (PCS, 2019a & 2019b) are also presented. The results from this assessment can also subsequently be used to compare the options to other options being considered as part of the SSM Project.

The cost and GHG emission estimates have been developed so they include the management of 10 years of sedimentation at the Port:

- Weipa Onshore: as the option is only able to contain 1.8 Mm^3 of the 10 years of sedimentation (in-situ volume) it has been assumed that the remaining 7.6 Mm^3 of sedimentation is dredged and placed at the existing Albatross Bay DMPA by the TSHD Brisbane; and
- Weipa Reclamation: as the option is only able to contain 440,000 m^3 of the 10 years of sedimentation (in-situ volume) it has been assumed that the remaining 9 Mm^3 of sedimentation is dredged and placed at the existing Albatross Bay DMPA by the TSHD Brisbane.

4.1. Cost

High-level cost estimates for managing 10 years of future sedimentation at the Port using the two options as well as ongoing maintenance dredging (denoted by the Albatross DMPA option) are provided in Table 1. The cost estimates also include the cost for the placement of the remaining volume of sediment that the options cannot accommodate to the existing Albatross Bay DMPA.

Table 1. High-level cost estimates over 10 years.

Option	Dredging ($M)	Pipeline Infrastructure ($M)	Onshore Construction ($M)	Total ($M)
Albatross DMPA	**$61 M**	-	-	**$61 M**
Onshore Pond	$72 M	$25 M	$98 M	**$195 M**
Reclamation	$62 M	$25 M	$22 M	**$109 M**

The cost estimates have been developed to ensure they are directly comparable to the estimates made as part of the previous beneficial reuse assessment (Advisian, 2018). The following assumptions were adopted when calculating the cost estimates in Table 1:

- the daily rate for the TSHD Brisbane is $80,000 and a mobilisation cost of $250,000 (costs based on information from the Port of Weipa 2019 maintenance dredging program);
- the bed leveller and survey vessel are required for the same duration as the maintenance dredging, with a daily rate of $10,000 and $12,500 respectively (costs based on information from the Port of Weipa 2019 maintenance dredging program);
- a mooring/connector and pipeline cost of $5M/yr is included for the mobilisation and demobilisation (same costs as assumed by Advisian (2018));
- the total cost for the onshore pond construction (bunds, drainage and geofabric liner) can be related to the volume of the bunds, with a total construction cost of $150/$m^3$. The volume of sediment required to construct the bund walls has been estimated to be 445,000 m^3 (same costs as assumed by Advisian (2018));
- the cost for the sheet pile wall is $700/$m^2$ and the cost for installation of the sheet pile wall is $300/hr (same costs as assumed by Advisian (2018)). It has been estimated that

12,000 m^2 of sheet pile wall would be required for the reclamation and the installation would take 3,000 hours; and

- costs for the ongoing management of the ponds/reclamation and dewatering of the dredged material have been assumed to be $1M/yr for the reclamation (same costs as assumed by Advisian (2018)) and $3M/yr for the onshore pond (due to its significantly larger size). These costs are only applied for the years when additional dredged sediment is placed into the ponds/reclamation.

Although the cost estimates for the dredging component of the options only differ by up to 20%, there is significant variation between the options due to the costs associated with the pipeline infrastructure and the onshore construction. The cost estimates indicate that the onshore pond option would cost over three times more than placing the sediment offshore at the existing Albatross Bay DMPA, with half of this cost being related to the construction of the onshore pond. Although the cost of the reclamation is over $80M less than the onshore pond option, it is almost $50M more than placing the sediment offshore at the existing Albatross Bay DMPA.

4.2. GHG Emissions

High-level GHG emission estimates for managing 10 years of future sedimentation at the Port using the two options as well as ongoing maintenance dredging (denoted by the Albatross DMPA option) are provided in Table 2. The table separates the GHG emissions associated with the dredging and the onshore infrastructure as well as providing both the Scope 1 and Scope 3 emissions associated with the infrastructure construction. The different scopes of emissions are defined by the internationally recognised GHG Protocol (GHG Protocol, 2015):

- Scope 1 emissions: these are defined as direct GHG emissions, which in this case will be a result of fossil fuel consumption by marine vessels and onshore plant;
- Scope 2 emissions: these are defined as indirect GHG emissions from the production of electricity used as part of the option. Based on the options considered the emissions for this would be minimal and so they have not been considered further; and
- Scope 3 emissions: these are defined as indirect GHG emissions from supporting activities (i.e. emissions associated with the manufacture of materials used for the options). In this case this will include the drainage pipes, steel sheet pile walls and the geofabric liners.

The results show that the Weipa onshore pond option results in the highest predicted GHG emissions, with almost double the emissions compared to ongoing maintenance dredging and placement at the Albatross Bay DMPA. The reclamation option is predicted to result in a 40% increase in GHG emissions relative to the ongoing maintenance dredging and placement at the Albatross Bay DMPA. The reason for the significant difference in predicted GHG emissions between the onshore pond and reclamation options is related to the amount of sediment being pumped ashore (higher GHG emissions) relative to the amount of sediment being placed at the Albatross Bay DMPA (lower GHG emissions). For the onshore pond option it has been assumed that 1.8 Mm^3 would be pumped onshore and 7.6 Mm^3 placed offshore at Albatross Bay DMPA, while for the reclamation option it has been assumed that 0.4 Mm^3 would be pumped into the reclamation and 9 Mm^3 placed offshore at Albatross Bay DMPA.

Table 2. High-level GHG emission estimates over 10 years.

Option	Dredging ($t\ CO_2\ e$)	Infrastructure		Total ($t\ CO_2\ e$)
		Scope 1 ($t\ CO_2\ e$)	Scope 3 ($t\ CO_2\ e$)	
Albatross DMPA	**28,000**	-	-	**28,000**
Onshore Pond	33,200	16,100	9,100	**58,400**
Reclamation	28,500	7,000	3,700	**39,200**

The GHG emission estimates have been developed based on the approach detailed in the previous engineering design assessment undertaken as part of the SSM Project at the Port of Hay Point (RHDHV, 2016). The number of hours activity for each vessel/plant was estimated (Table 3 and Table 4) and the corresponding load and emission factors detailed by RHDHV (2016) were applied to determine the total tonnes of CO_2 equivalent (e) Scope 1 emissions produced by the option. To estimate the total tonnes of CO_2 e Scope 3 emissions produced the total mass of the different material used in the construction were estimated (Table 5) and the emission factors detailed by RHDHV (2016) were then applied.

Table 3. Estimated hours of operation for the dredge vessel to manage 10 years of sedimentation.

Activity	Weipa Onshore (hrs)	Weipa Reclamation (hrs)
Steaming	4,000	3,600
Dredging	2,800	2,800
Pumping	2,500	800
Bed levelling	5,400	5,400

Table 4. Estimated hours of operation for plant associated with construction and management of infrastructure.

Plant	Weipa Onshore (hrs)	Weipa Reclamation (hrs)
Construction		
Bulldozer (D10 - D12)	3,300	3,300
Dump Truck (40t)	4,950	0
Excavators (40 - 60t)	3,740	13,200
Trenchers	2,970	0
Scraper	880	0
Grader	440	0
Roller Compactor	2,860	0
Water Truck	1,430	0
Piling Rig Plus Tug	0	3,000
Annual Management (processing, dewatering etc)		
Bulldozer (D10 - D12)	7,500	2,500
Excavators (40 - 60t)	7,500	2,500

Table 5. Estimated mass of construction materials for Scope 3 emissions.

Activity	Weipa Onshore (kg)	Weipa Reclamation (kg)
HDPE Pipeline (200mm diameter)	105,000	0
HDPE Pipeline (800mm diameter)	680,000	0
Concrete	35,000	0
Steel	1,000	1,800,000
Geofabric liner (heavy)	1,200,000	0
Geofabric liner (light)	1,000,000	12,000

4.3. Water Quality

The potential impact of the two options to marine water quality, as well as ongoing maintenance dredging and placement at the existing Albatross Bay DMPA, has been assessed using the existing PCS numerical model of the region (see PCS (2019b) for further details regarding model setup and calibration/validation). The modelling has been used to predict the relative increase in SSC due to the following:

- Albatross DMPA: modelling has been undertaken for a typical dredge volume (400,000 m^3) with all of the sediment being placed at the existing Albatross Bay DMPA;
- Onshore Pond: modelling has been undertaken for a typical dredge volume (400,000 m^3) assuming that all of the sediment was pumped to the onshore pond. The modelling included the dredging activity and a tailwater discharge (assumed to be a constant 50 mg/l with a flow rate of 0.93 m^3/s) released adjacent to the Evans Landing wharf; and
- Reclamation: modelling has been undertaken for a typical dredge volume (400,000 m^3), assuming that 100,000 m^3 of the sediment was pumped into the reclamation (the sandy sediment from the Inner Harbour and inner South Channel) while the remaining sediment was placed at the existing Albatross Bay DMPA. The modelling included the dredging activity along with a worst-case assumption of a partial failure in the reclamation liner resulting in a constant release of 1,000 mg/l during the simulation (in line with the previous reclamation modelling undertaken for the Port of Hay Point SSM Project (RHDHV, 2016)).

The modelling was undertaken for a dry season period (June to July) as this is when maintenance dredging typically occurs. The 95th percentile SSC (the SSC which is only exceeded for 5% of the time over the duration of the dredging program) is shown for the three options in Figure 5 to Figure 7 along with locations of sensitive receptors. The sensitive receptors are as follows:

- AB1: closest area of extensive seagrass meadows to the South Channel in Albatross Bay (based on GHD (2019));
- AB2: closest rocky reef to the South Channel in Albatross Bay (based on GHD (2019));
- IH1: nearest area of seagrass to the location of the tailwater discharge/reclamation failure (and area which is regularly surveyed by JCU (McKenna & Rasheed, 2019)); and
- IH2: area of widespread seagrass on the southern bank of the Embley River which is regularly surveyed by JCU (McKenna & Rasheed, 2019).

Percentile results at the sensitive receptor sites for the dredge plume modelling simulations are shown in Table 6. The values represent the predicted increase in SSC due to the maintenance dredging activity in addition to the natural SSC.

The results show that although the spatial extent and peak concentration of the 95th percentile SSC for the Albatross DMPA is greater than for the onshore pond option, the increased SSC at the sensitive receptors is comparable. In contrast, the results for reclamation option show consistently higher SSC at the sensitive receptors (except for AB2 where all options show 0 mg/l) and the spatial map of the 95th percentile also shows the largest area of SSC between 5 and 10 mg/l. However, it is important to note that the partial failure scenario modelled represents a conservative assumption to highlight the potential risk of the option to the sensitive receptors as opposed to the likely impacts of the option (which are what the other two options show). For reference, the results of the reclamation without any failures would be expected to be comparable to the results for the Albatross DMPA and onshore pond options.

Table 6. SSC percentile results at sensitive receptors for the dredge plume modelling simulations.

Site	Albatross DMPA (mg/l)			Onshore Pond (mg/l)			Reclamation (mg/l)		
	20th	80th	95th	20th	80th	95th	20th	80th	95th
AB1	**0.0**	**0.1**	**0.2**	0.0	0.2	0.3	0.0	0.8	1.0
AB2	**0.0**	**0.0**	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
IH1	**0.0**	**1.1**	**2.7**	0.1	0.7	2.6	1.3	5.2	7.1
IH2	**0.0**	**0.6**	**2.3**	0.0	0.9	1.7	0.6	2.3	4.8

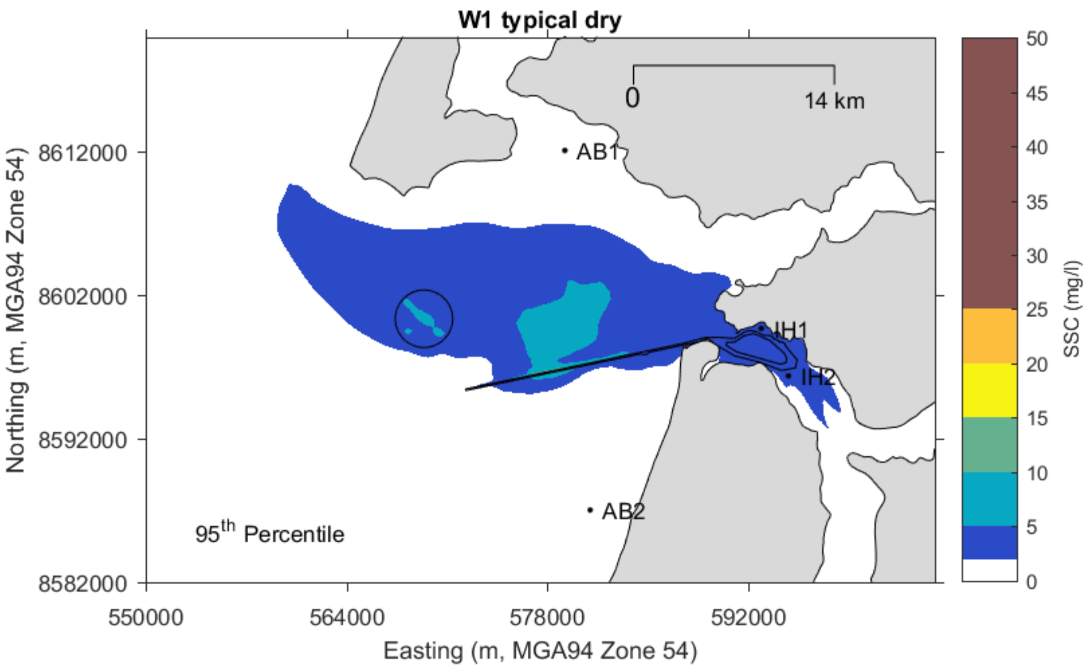

Figure 5. 95th percentile SSC for the Albatross DMPA option for a typical dredge volume.

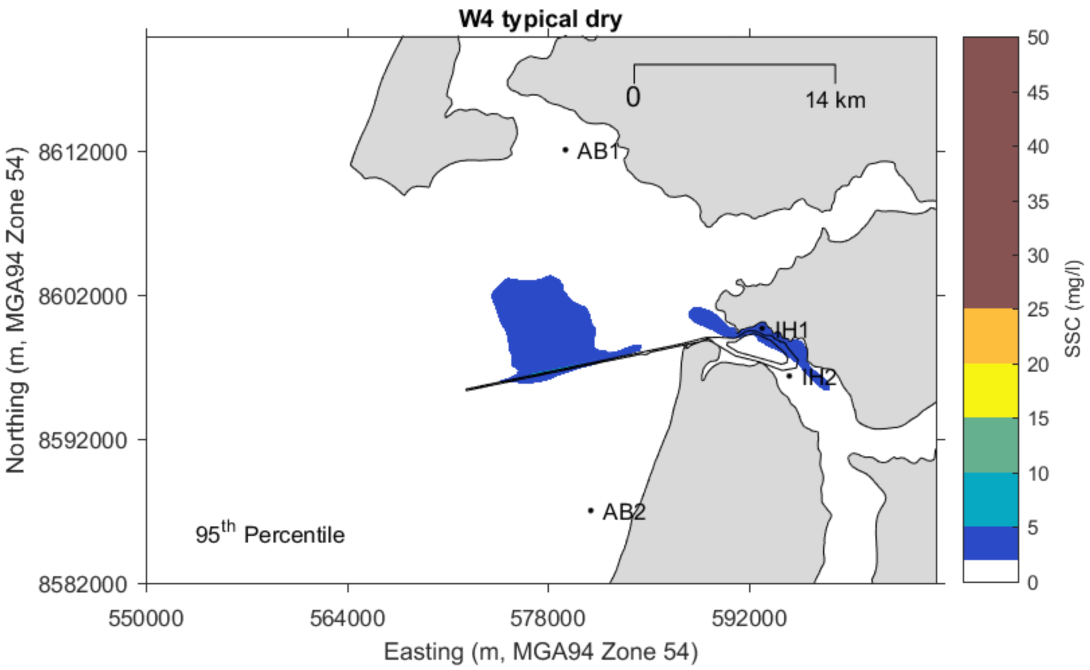

Figure 6. 95th percentile SSC for the Onshore Pond option for a typical dredge volume.

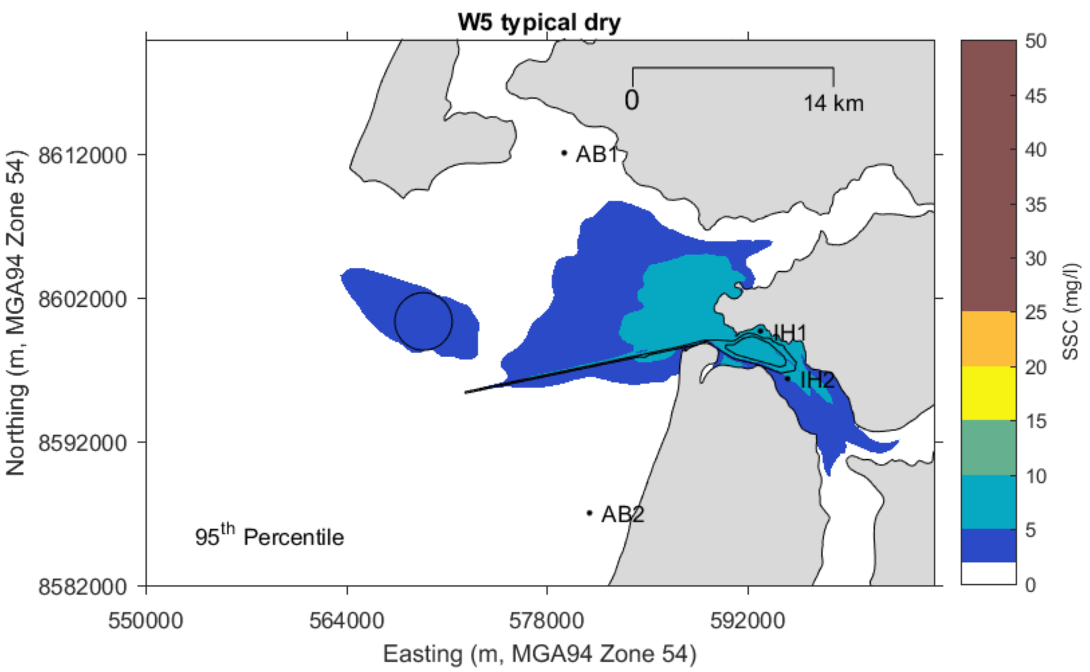

Figure 7. 95th percentile SSC for the Reclamation option for a typical dredge volume.

5. Summary

This report has presented a comparative assessment for placing maintenance dredge sediment within an onshore pond and a reclamation at the Port of Weipa. The assessment has also presented cost, GHG emission and water quality impacts for ongoing maintenance dredging and offshore placement at the existing Albatross Bay DMPA for context.

The key findings from the comparative analysis are summarised below:

- the onshore pond option has been estimated to cost over three times more than ongoing maintenance dredging with offshore placement at the existing Albatross DMPA (difference of $130 M), while the cost of the land reclamation option is over $50 M more than ongoing maintenance dredging with offshore placement;
- the GHG emissions are approximately double for the onshore pond option compared to ongoing maintenance dredging with offshore placement at the existing Albatross DMPA, while for the land reclamation option the emissions are approximately 40% more than for maintenance dredging with offshore placement; and
- results from the water quality modelling have shown that although the spatial extent and peak concentration of the 95th percentile SSC for the Albatross DMPA is greater than for the onshore pond option, the increased SSC at the sensitive receptors is comparable. In contrast, the results for reclamation option show consistently higher SSC at the sensitive receptors and the spatial map of the 95th percentile also shows the largest area of SSC between 5 and 10 mg/l.

This comparative analysis has shown that, from a cost, GHG emissions and water quality perspective, the existing practice of placing dredge sediment offshore (with the existing Albatross Bay DMPA used for comparative purposes) continues to be the most cost effective solution, providing lower GHG emissions and similarly low increases to SSC at the sensitive receptor locations compared to the onshore pond and reclamation site options assessed.

6. References

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