PORT OF **WEIPA**

SUMMARY REPORT

Comparative analysis of dredge material placement options

Port of Weipa
Sustainable Sediment Management

Comparative Analysis of Dredge Material Placement Options

March 2020

ADAPTIVE STRATEGIES

Executive Summary

BACKGROUND

North Queensland Bulk Ports (NQBP) commissioned Adaptive Strategies Pty Ltd to undertake a comparative analysis of the various options for managing marine sediments and maintaining effective port operations at the Port of Weipa.

The comparative analysis is part of the Port of Weipa – Sustainable Sediment Management (SSM) Assessment for Navigational Maintenance ('The SSM Project') which is investigating:

- Where sediment at the Port comes from
- How it influences Port operations
- Whether it can be eliminated or reduced before it influences Port operations
- What options are available at the Port for the disposal of sediments that may have accumulated and need to be dredged.

APPROACH TO THE COMPARATIVE ANALYSIS

Undertaking a comparative analysis of the various options for managing marine sediments is a complex task. The analysis needs to consider:

- A series of questions about the actual need to manage sediment, the options for non-dredging management solutions, and the options for disposal of dredge material.
- Management issues over both the short term (next 12 months) and long term (next 10 years).
- A wide range of detailed and comprehensive technical information developed to inform the various elements of the project.
- A significant number of possible options for managing sediments. For example, a wide range of non-dredge solutions, as well as many options for beneficial reuse or disposal of dredge material.
- The diverse views of stakeholders about what was important to them in relation to the implications of managing sediment at the Port.
- A complex, dynamic environment comprising terrestrial, aquatic and marine areas.

To address these challenges, the consulting team adopted the principles of Structured Decision Making (Gregory *et al*, 2012) to help NQBP work through an organised and transparent approach for comparing options. This involved the following five steps:

1. Understanding the decisions that needed to be made as part of the SSM Project.
2. Identifying what is important to stakeholders in the form of a clear set of objectives and performance measures.
3. Developing a range of option approaches for managing sediments.
4. Understanding the performance of the options against the objectives.
5. Comparing options and selecting a preferred option.

One of the key benefits of the structured decision making approach was the fact that the analysis was quantitative and was based on detailed technical information to measure the performance of each option. The quantitative nature of the analysis enabled direct comparisons between different management solutions in a clear and transparent way. It also enabled various weightings to be applied to understand how options performed in different scenarios, and sensitivity analysis to be used to test the robustness of the results.

PURPOSE OF STUDY

The purpose of this study was to undertake a comparative analysis of the various options for managing marine sediments and maintaining effective port operations at the Port of Weipa.

The study was undertaken using the principles of Structured Decision Making (Gregory et al, 2012) and involved:

- Understanding the decisions that needed to be made as part of the SSM Project
- Identifying what is important to stakeholders in the form of a clear set of objectives and performance measures
- Developing a range of options to managing marine sediments
- Understanding the performance of the options against identified objectives
- Comparing option approaches and selecting a preferred option.

It is important to note, as the basis for this study, that previous technical reports undertaken as part of the SSM have established:

- Sediment at the Port of Weipa needs to be managed
- Traditional maintenance dredging is required as part of the management solution
- There are a discrete set of feasible options that have the potential to provide long term solutions for reuse or disposal of sediment that is captured as part of the dredging.

Given that annual maintenance dredging is required as part of the solution, the comparative analysis focussed in detail on how best to deal with the dredge material (relocation or disposal).

FINDINGS

Using a structured decision-making process, 9 objectives and 11 discrete measures were developed by a stakeholder advisory group. These spanned across a number of key categories or themes including:

- Environmental
- Cultural Heritage
- Port Operations
- Costs
- Health and Safety
- Social
- Cultural.

There were six discrete alternative options for reuse and disposal identified (1 x on-land, 1 x reclamations, 1 x reuse for beach nourishment and 3 x at-sea).

An initial analysis of these six options indicated:

- At-sea placement would be necessary to deal with both the immediate maintenance dredging needs at the Port as well as the long term volumes over 10 years
- Other options, if feasible, would take 2-3 years to implement
- Beach nourishment, if feasible, may only be a partial solution as the full volume and type of sediment cannot be used
- Disposing of dredged material within a constructed reclamation or onshore was found to be the poorer performing options across most themes and did not warrant further consideration.

The structured decision making process showed how each of the six options compared when considering equally. In addition, the structured decision-making process was able to show how the comparison would change if the outcomes were significantly weighted (75%) to any one particular theme.

Overall results of comparative analysis showing equal and weighted scores.

	Equal	Environment	Port Operations	Costs	Health & Safety	Social	Cultural
Albatross DMPA	77.00	79.92	84.96	93.80	84.74	46.81	84.74
Albatross West	75.00	75.58	84.17	85.06	84.11	46.95	84.11
Albatross South	75.00	78.89	83.94	92.45	83.92	30.56	92.99
Weipa Onshore	28.00	40.47	18.42	7.59	48.37	26.54	16.65
Weipa Reclamation	51.00	55.69	47.45	60.44	54.69	54.04	22.98
Beach Nourishment	63.00	82.11	43.08	75.66	76.14	54.53	53.48

The results identified that the at-sea options were higher performing options. Continued and ongoing at-sea disposal at the existing DMPA is a preferred solution.

A combination of continued at-sea disposal at the existing DMPA and beach nourishment at some time in the future (pending a range of additional studies and feasibility assessment) has merit and should be further investigated.

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Introduction

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 is within Albatross Bay with the wharves and berths located in the estuary and lower reaches of the Embley River.

The Port of Weipa handles approximately 40 million tonnes of commodities per annum, including bauxite (>95%), fuel, cattle and general cargo. Rio Tinto Alcan (RTA) currently operates most of the port facilities for the export of bauxite (aluminium ore) from their nearby mine.

North Queensland Bulk Ports (NQBP) are the port authority for the Port Of Weipa. Among other roles NQBP are responsible for maintaining safe navigational access to the Port. As part of this role NQBP are conducting an extensive assessment of the ongoing marine sediments management needs at the Port. The project is called the *Port of Weipa – Sustainable Sediment Management (SSM) Assessment for Navigational Maintenance* ('The SSM Project').

The aim of the SSM Project is to develop long term solutions for the management of marine sediments at the Port by investigating:

- Where sediment at the Port comes from (e.g. onshore sources, marine sources)
- How it influences Port operations (e.g. by reducing depth within the Port navigational areas)
- Whether it can be eliminated or reduced before it influences Port operations (e.g. through mitigation and management measures)
- What options are available at the Port for the disposal of sediments that might have accumulated and need to be dredged (e.g. beneficial reuse, onshore disposal, offshore disposal).

To support the SSM Project, NQBP commissioned *Adaptive Strategies Pty Ltd* to undertake a comparative analysis of the various options for managing marine sediments and maintaining effective port operations.

This report documents the methods and results of the comparative analysis for the SSM Project.

Structured decision making

Based on a similar and successful project at the Port of Hay Point (Adaptive Strategies 2018) it was decided that the Weipa SSM Project should adopt the principles of Structured Decision Making (Gregory *et al,* 2012) to help NQBP work through an organised and transparent approach for comparing options and making decisions as part of the SSM Project.

Structured Decision Making sets out a process for identifying a series of options and comparing them against a range of objectives. It provides a technical method for comparative analysis that is able to accommodate both quantitative science based and values based objectives and information.

It is defined by Gregory *et al* (2012) as an:

> *"organized, inclusive and transparent approach to understanding complex problems and generating and evaluating creative alternatives. It's founded on the idea that good decisions are based on an in-depth understanding of both values (what's important) and consequences (what's likely to happen if an alternative is implemented)".*

For the SSM Project, the process:

- Helped to scope the questions and decisions relevant to sediment management at the Port of Weipa
- Helped define the things that are important to stakeholders within this context
- Encouraged consideration of a broad set of options or alternatives for sediment management
- Helps decision makers and stakeholders to think explicitly about how to measure performance of each sediment management option, including identifying the various impacts of each option, how they influence objectives and how they can be measured or predicted
- Provided a set of results that can be queried according to differing stakeholder values and objectives in order to provide insight to decision makers and ultimately help inform their decisions.

The consulting team worked with NQBP to apply the following five steps of Structured Decision Making:

1. Understanding the decisions.
2. Identifying what is important.
3. Developing options.
4. Understanding the performance of options.
5. Comparing options and selecting a preferred option.

Figure 1: Steps in the Structured Decision Making Process (adapted from Gregory *et al*, 2012)

Step 1: Understanding the decisions

It is critical in a comparative analysis process to understand the context about the nature of the decision or decisions being considered. This understanding ensures any analysis of options is focused towards the appropriate decision making process and that stakeholders all have a similar if not identical expectation of what will ultimately transpire.

Step 1 involved framing the decision to clarify:

1. What decisions need to be made and what is the relationship between different decisions.
2. What is the temporal and spatial scope of the decisions.
3. Who are the decision makers.
4. Who are the stakeholders in the decisions.
5. What is the outcome or deliverable of the comparative analysis process.

Framing the decisions

WHAT DECISIONS NEED TO BE MADE?

The key decisions that need to be made for the SSM Project were identified as follows:

Within the context of maintaining port operations:

- Is it necessary to manage sediment at the Port of Weipa in the short and/or long term?
- If yes, what are the feasible ways to manage sediment within the context of needing to maintain port operations and meeting legal requirements?
- If dredging is required, what are the feasible options for use or disposal of the dredged material?

The first two questions were essentially higher order questions that needed to be addressed before more detailed analysis around short and long term options for managing dredge material could be considered.

WHAT IS THE TEMPORAL AND SPATIAL SCOPE OF THE DECISIONS?

It is recognised that the sediment management needs of the Port are different in the short term compared with the long term. Decision making in the context of maintaining port operations needs to accommodate both of these timeframes. In this instance:

- Short term relates to the management of sediment on an annual basis
- Long term relates to the management of sediment over the next 10 years to correspond with legislative approval processes.

The spatial scope of the decisions is defined by the port boundary and any onshore and offshore locations relating to the various sediment management options.

WHO ARE THE DECISION MAKERS?

NQBP is the decision maker for the Port of Weipa. The comparative analysis was used by NQBP as part of a process to develop a business case that defines (from their perspective) the best approaches to managing marine sediments at the Port of Weipa.

It is recognised in this process that the views and input of stakeholders are critical (discussed below) and that there will also be a range of future decisions (e.g. by regulators) in relation to the project. Appropriate flow on decisions (e.g. relevant environmental approvals) will be addressed prior to commencement of any works.

WHO ARE THE STAKEHOLDERS IN THE DECISIONS?

Structured Decision Making is particularly useful for understanding and incorporating the views of stakeholders. There are a wide range of people with interests in the SSM Project and the decisions around the management of marine sediments. They include Commonwealth, State and Local Government; port customers; conservation groups; local community including Indigenous and fishing groups; researchers; and tourism operators.

A stakeholder group was established that comprised representatives from these different groups to provide input into the SSM Project (refer to Appendix A for a list of members).

WHAT IS THE OUTCOME OR DELIVERABLE OF THE DECISION MAKING PROCESS?

The outcome of the decision making process for the SSM Project is a business case that NQBP proposes to take forward for the long term sustainable management of marine sediments at the Port of Weipa.

Initial analysis of the decisions

As described above, Structured Decision Making has provided a method for comparing options for managing marine sediments against a range of objectives relevant to the Port. In order to arrive at a relevant set of options and generally help to structure and clarify thinking, a number of technical studies were first needed to help answer the preliminary questions set out above. That is, is it necessary to manage sediment at the Port in the short and/or long term, and if yes, what are the feasible ways to do this?

A summary of the work and analysis around these first two decisions is presented below.

IS IT NECESSARY TO MANAGE SEDIMENT IN THE SHORT AND/OR LONG TERM?

Port navigational areas are areas that have been identified to allow the safe navigation, movement, loading and transit of ships trading at the Port. These areas include shipping channels, apron areas and berth pockets. Often these areas are deepened to ensure shipping movements can occur safely and efficiently.

Currently the Port of Weipa consists of:

- a main shipping channel in Albatross Bay called the South Channel (Figure 1)
- 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 (Figure 2).

In total the Port has approximately 622 hectares of channels, swing basins and berths where depths are maintained by maintenance dredging.

Currents, wave energy and tidal regimes are responsible for mobilising and transporting sediments into these deeper areas of the Port. The different depths and water movement can cause significant changes in the patterns of sediment scouring (erosion) and accumulation (accretion).

A number of technical studies (PCS 2019a, PCS 2019b) were commissioned as part of the SSM Project to understand the sediment management needs of the Port. These studies answered key questions around:

- The nature and sources of marine sediments that accumulate in the navigational areas at the Port
- What drives sediment dynamics at the local and regional scales
- Current and predicted rates of sediment accumulation
- Risks to operations from increased sedimentation at the Port.

Figure 1: Port of Weipa navigational infrastructure (PCS 2019a)

Figure 2: Port of Weipa inner harbour navigational infrastructure (PCS 2019a)

Table 1 provides a summary of the key outcomes of this work.

From this work it was concluded that it is necessary to manage marine sediments in both the short and long term. This is due to the accumulation of marine sediments within the Port navigational areas, which will substantially impact port operations (ACIL Allen Consulting 2019) in the absence of measures to manage sediment. Current levels of marine sediment accumulation and predicted future rates necessitate a management approach that provides both short and long term solutions.

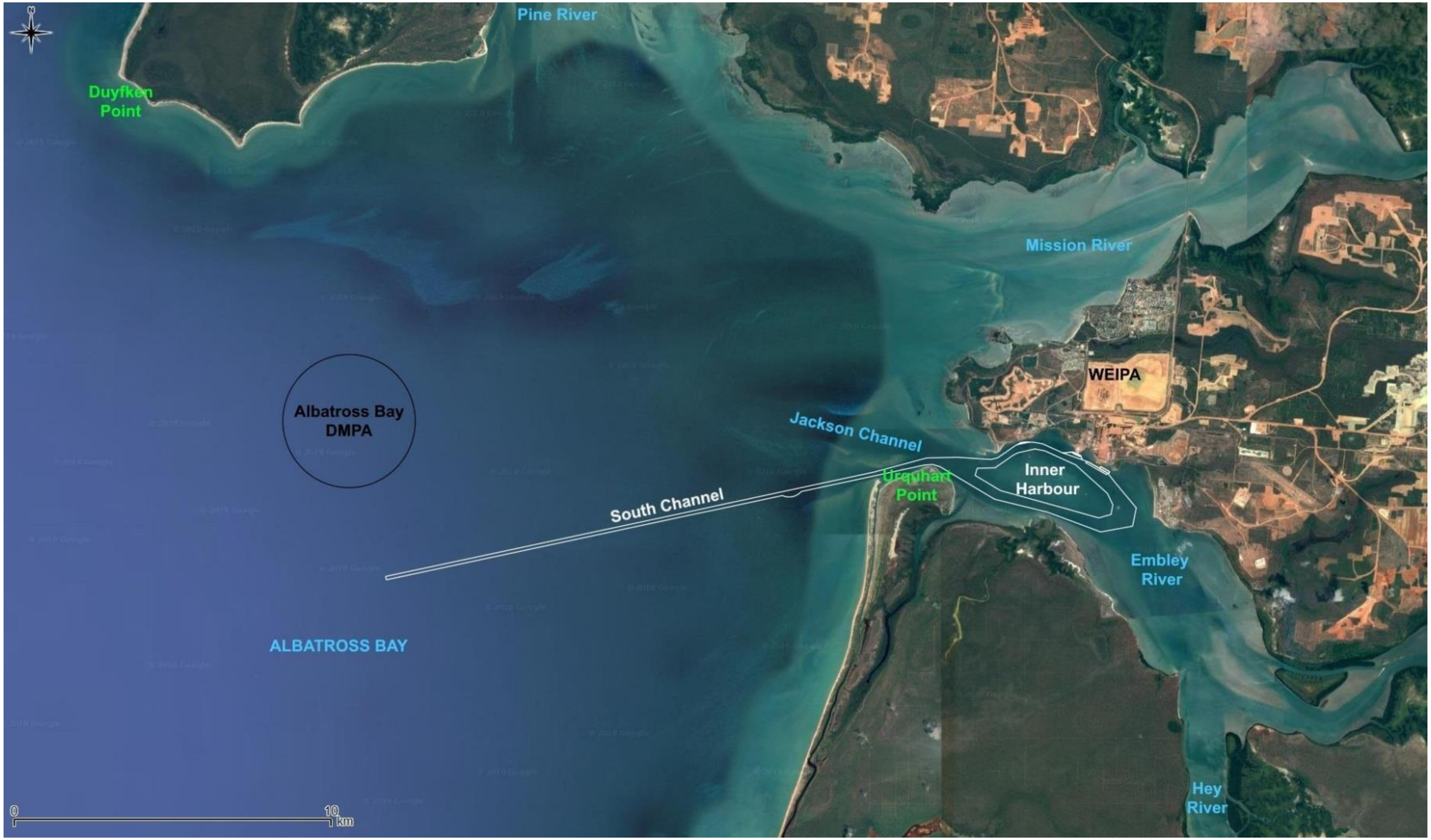


Figure 1: Port of Weipa navigational infrastructure (PCS 2019a)

Figure 2: Port of Weipa inner harbour navigational infrastructure (PCS 2019a)

Table 1: Summary of key issues and findings of studies commissioned to understand the sediment management needs of the Port (source Advisian 2018), PCS 2019a, PCS 2019b)

Issues considered	Key findings
Nature of marine sediments in the navigational areas	The Southern Channel sediments are characterised by silt (49%), sand (32%), clay (5%) and gravel (5%). The sampling locations closest to the mainland are characterised by high proportions of gravel, shell and coarse sand.
	The Approach Channel sediments are similar across all sites and contain very high proportions of sand (83%) compared to clay (8%), silt (6%) and gravel (5%).
	The Departure Channel sediments are characterised by high proportions of sand (64%), gravel (18%), clay (11%) and silt (8%).
	Lorim Point Berth sediments predominately contain sand (49%) and gravel (22%) with lesser amounts of clay (18%) and silt (11%). Humbug Berth sediments predominately contain sand (48%), silt (31%) and lesser amounts of clay (16%) and gravel (5%) Evans Landing sediments are consistent across the area and are dominated by gravel (43%) and sand (40%) with lesser amounts of clay (9%) and silt (7%). Tug Harbour Berth sediments are dominated by silt (42%) and clay (35%) with lesser amounts of gravel (14%) and sand (9%)
	Sediments have consistently been found to suitable for ocean disposal with contamination levels below screening levels.
Source and movement of marine sediments in the region	The dominant process which is resulting in sedimentation in the dredged areas at the Port of Weipa (and Amrun Port) is wave action. The wave conditions control the mass of sediment resuspended along the open coastline and within Albatross Bay and the tidal currents subsequently transport the suspended sediment.
	Sediment is transported until the bed shear stresses are sufficiently low for the sediment to be deposited (i.e. either the wave energy and tidal current speed have reduced or the sediment has been transported to a sheltered location). The tidal currents also appear to be an important driver within the Inner Harbour area of the Port of Weipa, driving transport by bed load or localised resuspension which can in turn result in localised accretion within the channel.
	Significant sedimentation occurs in the South Channel of the Port of Weipa, which is mainly due to the resuspension of existing fine-grained sediment within Albatross Bay due to wave action. The suspended sediment is then repeatedly transported backwards and forwards past the channel with 2 – 3% of the total (gross) suspended sediment becoming trapped.
	Fluvial sources of sediment contribute to sediment deposition in the Port in a minimal manner.
	Cyclones have the potential to resuspend and move large quantities of sediment in the region. These events can have significant impacts on navigation access to the Port.
Sediment accumulation within the Port	The sedimentation rates within the South Channel were determined based on the available bathymetric survey data. Sedimentation was found to be linearly correlated to the duration of time that wave height was above 2 m (i.e. the duration of large wave events). Sedimentation in the South Channel was found to predominantly occur over the wet season, with sedimentation rates ranging from

Issues considered	Key findings
	1,100 m3/day to 3,300 m3/day over this period, depending on the wave energy (low to high). Based on this it is expected that maintenance dredging will be required annually to ensure that the entire South Channel remains below the declared depths. In the Inner Harbour tidal currents are considered to be the dominant driver responsible for the mobilisation and transport of sediment in the Inner Harbour. Sediment sampling has shown that the sediment in the channels is predominantly sand and gravel, indicating that the current speeds are strong enough to prevent the build-up of fine-grained sediment in these areas. Maintenance dredging within the Inner Harbour is also expected to be required, with an estimated frequency of once every 2 to 5 years.
	The future predicted rates of sedimentation for the Port are: South Channel: annual sedimentation typically ranges from 200,000 to 600,000 m3, with the majority of this being above the design depths. The majority of the sediment is deposited in the middle 8 km of the 17 km long channel. Inner Harbour: the annual average volume of sediment above the design depths in the Inner Harbour is just under 25,000 m3 with an annual minimum of 3,500 m3 and an annual maximum of 105,000 m3. Of the average sedimentation of just under 25,000 m3, approximately 15,000 m3 is in the Departure Channel, 7,000 m3 in the Approach Channel and 2,000 m3 in the berths.
Maintenance dredging	The following two sediment management approaches have historically been used and are expected to continue to be adopted at the Port of Weipa: • Maintenance Dredging: this has been the main approach to remove sediment and maintain declared depths in the Port of Weipa. Since 2002, annual maintenance dredging has been undertaken at the Port, with volumes ranging from approximately 300,000 m^3 to over 800,000 m^3 per year. Over this period the TSHD Brisbane has undertaken the majority of the maintenance dredging. • In 2019 following extreme climatic conditions 2.4 million m^3 was removed and placed in the offshore DMPA. It is anticipated that this form of extreme sedimentation could occur once or twice a decade and should be incorporated into worst case management planning. • Bed levelling: bed levelling has routinely been undertaken following maintenance dredging to redistribute the sediment on the bed and remove any high spots.

WHAT ARE THE FEASIBLE WAYS TO MANAGE SEDIMENT?

A set of technical work was undertaken to fully explore the options available to manage marine sediment at the Port of Weipa.

Three broad strategies used to reduce siltation at ports and harbours were considered (PCS 2019c). These were:

- Keep Sediment Out – keeping sediment out of the area of interest that might otherwise enter and deposit.
- Keep Sediment Moving – raising flow velocities in quiescent areas to prevent sediment from settling as it passes through the area of interest.
- Keep Sediment Navigable – applicable to sites characterised by high turbidity near-bottom sediment regimes where navigability of fluid mud zones is permitted, thereby reducing the required dredged depth.

Within these strategies a set of options were examined to determine potential feasibility. Options that were considered included:

- Stabilise sediment sources
- Diverting sediment-laden flows:

- Trapping/Bypassing sediment
- Blocking sediment entry
- Habitat creation:
- Structural solutions to train natural flows
- Devices to increase bed shear stresses
- Alter nautical depth
- Traditional maintenance dredging

For each of these options a feasibility analysis was developed to get a high level understanding of environment impacts, operational impacts, ongoing maintenance requirements, the degree of confidence in achieving the desired outcomes and consideration of the regulatory pathways or approvals.

Due to the processes which control the sedimentation and the configuration of the dredged areas at the Port of Weipa, the assessment was not able to identify any feasible engineered or technical solutions which could significantly reduce the natural sedimentation at the Port of Weipa.

None of the alternative solutions are clearly preferable over ongoing maintenance dredging, however while the sustainable relocation solution may have potential merit but will require further feasibility testing.

The approach of sustainable relocation involves retaining sediment in the marine environment and within the natural sediment system. The aim of the sustainable relocation approach is to ensure that some sediment which is deposited/trapped within the dredged areas of the Port of Weipa is retained within the sediment system, to feed natural habitats such as mudflats (fine-grained sediment), mangroves (fine-grained sediment) and beaches (sand sized sediment).

FINDINGS

It was concluded through the initial consideration of the decisions that:

- It is necessary to manage sediment at the Port
- Maintenance dredging is required as part of the solution for managing sediment
- Sustainable sediment relocation (beach nourishment) is a potential partial option.

Step 2: Identifying what is important

The second step in the comparative analysis process identified what is important to NQBP and stakeholders.

If dredging is required, what are the feasible options for use or disposal of the material?

What is the best approach to provide for long term sustainable management of marine sediments at the Port of Weipa?

This step generated two key components of the comparative analysis process:

1. Objectives to consider in the decision making process. In other words, the things that really matter to NQBP and stakeholders when trying to make comparisons between sediment management options.
2. Performance measures for each of the objectives that provide a clear and transparent way of measuring how each of the sediment management options perform.

Approach

A workshop was held with the stakeholder advisory group in September 2019 to help define objectives and performance measures. Additionally, separate discussions were held with traditional owner and government stakeholders to obtain their views.

Through this process a range of values were identified as relevant to the Port. These values fall within the following six broad themes:

- Environment
- Port Operations
- Costs
- Cultural heritage
- Social
- Health and safety.

The objectives identified were aimed to be (Gregory *et al*, 2012):

- Complete – objectives were designed to capture all of the things that matter at the Port in the context of the decisions being made.
- Concise – unnecessary or similar objectives were removed to avoid double counting.
- Sensitive – objectives were developed that distinguish between the options, thereby helping to differentiate them to aid decision making.
- Independent – objectives were developed in a way that ensures that performance against an objective could be considered independently of any other objective.

Performance measures were then defined for each objective. These measures provided a mechanism for predicting how well each of the options performed against the objectives. Similar to the objectives, the performance measures were developed with a set of principles in mind to ensure they were useful and appropriate. The key issues considered when defining a performance measure were (Gregory *et al*, 2012):

- Coverage - the measures addressed the range of relevant consequences of each option.
- Practicality – the measures needed to be predictable, which means the data required to assess them could be obtained or generated.
- Direct and specific – the measures reported directly on the relevant consequences and effectively highlight differences in the options to allow informed value comparisons.

The objectives and measures were refined and finalised following the workshop based on a review of the technical information that was available to conduct the analysis.

Objectives and performance measures

Nine objectives and eleven performance measures were defined. These are shown in Table 2.

Further discussion of each of the performance measures, including a rationale for their use and how they have been calculated and analysed is provided at Step 4 and Appendix B.

Table 2: Objectives and performance measures for the SSM Project

Theme	Objective	Measure
ENVIRONMENT	1. Avoid and minimise impacts to coastal ecosystems	A) Predicted performance in relation to avoidance and minimisation of impacts to coastal ecosystems
		B) Predicted risk on dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS)
	2. Minimise carbon emissions	C) Forecast Greenhouse gas emissions
CULTURAL HERITAGE	3. Minimise impact on cultural heritage	D) Nature and scale of any impact on cultural heritage
PORT OPERATIONS	4. Maintain effective and efficient port operations	F) Predicted lead time to dredge material placement
		F) Capacity to provide a long term solution for the port
	5. Avoid a loss of future port expansion opportunities	G) Predicted performance in terms of facilitating or constraining future port expansion
COSTS	6. Ensure solution is cost effective	H) Assessment of costs
HEALTH & SAFETY	7. Avoid or mitigate health and safety risks	I) Relative risk
SOCIAL[1]	8. Minimise interference to social activities	J) Scale and duration of any impacts on social activities
	9. Provide increased economic and social opportunities	K) Predicted number of FTE jobs created

[1] The social theme includes consideration of other industries such as fisheries, aquaculture and tourism. It also takes into account local recreational and commercial activities.

Step 3: Developing options for reuse or disposal of sediment

Following the analysis of sedimentation rates and options to avoid or reduce sedimentation in key port navigational areas (described under Step 1), it was concluded that maintenance dredging cannot be avoided and that it will be necessary to maintain effective port operations.

It is expected that at a minimum maintenance dredging in the order to 400,000 m^3 will be required annually; in addition to this historical data indicates that volumes in the order of 800,000 m^3 may need to be removed 2 or 3 times a decade and that following multiple cyclonic events a volume in excess of 2 million m^3 may need to be dredged to maintain safe port operations.

Accordingly, many of the performance measures were calculated to accommodate the following dredging volumes over a ten year period:

Standard volume – 400,000 m^3 removed 6 years out of every 10 years.

Large volume – 800,000 m^3 removed 2 years out of every 10 years.

Worst case volume – 2.5+ million m^3 removed 2 yeas out of every 10 years.

The full ten year volume may be in the order of 9 to 10 million m^3.

Having establishing the need to dredge marine sediments, the subsequent decision that needed to be addressed was:

If dredging is required, what are the feasible options for use or disposal of the material?

The third step in the structured decision making process worked through this question in order to identify a set of relevant, feasible options for consideration in the comparative analysis. This work aimed to consider as broad a range of options as possible and to not be limited by precedent or traditional thinking.

Analysis to identify feasible options for reuse or disposal of sediment

A number of studies were undertaken to help identify the most appropriate solutions for reuse or disposal of the maintenance dredge material. This work involved:

- Consideration of the sediment properties (Advisian 2018a).
- Identification and analysis of beneficial reuse options (Advisian 2018b).
- Identification and analysis of suitable material disposal/placement locations (PCS 2019d).

SEDIMENT PROPERTIES

The analysis of the geotechnical properties of the material to be dredged indicated that (Advisian 2018a):

- Naturally accumulating material encountered in the Port of Weipa navigational areas varied considerably between and within areas with typically high fines (clay and silt) content.
- The areas where coarse-grained sediments appear to prevail include most of the Approach and Departure Channel and the eastern portion of the Southern Channel.
- The fine-grained sediments may be suitable for low to medium load applications following adequate drying out and compaction, noting that this material may take many months to many years to consolidate. The coarser sediments may be suitable for medium to high loading applications following adequate compaction.
- The relatively high water and fines contents would limit the use of sediments in high end concrete products; however, the areas with relatively low fines, and high silica and sand content could be useful (with treatment) as an alternative source of fine sand in some concrete and concrete products.
- Potential Acid Sulphate Soil (PASS) was detected in all samples; however, analysis of the Acid Neutralising Capacity (ANC) of these samples indicated that if bought ashore, the marine sediments are unlikely to require treatment.
- All samples are considered highly saline and therefore if sediments are placed on land without treatment, salinity will degrade the quality of terrestrial soils and may impact the quality of receiving waters.

ANALYSIS OF OPTIONS FOR BENEFICIAL REUSE OF DREDGE MATERIAL

Advisian (2018b) identified eleven potential options for the beneficial reuse of dredge material (see Table 3). These options were selected based on the sediment properties and the views of an expert team with local, international and specific dredging and materials use experience.

Table 3: Beneficial reuse options considered for feasibility

Reuse category	Option
Reuse of dredge material as an engineering material	• Land reclamation • Construction fill • Road base • Lining material • Concrete products • Shoreline protection • Beach nourishment
Recycle of dredge material as an environmental enhancement	• Coastal (tidal) habitat rehabilitation • Deep water habitat creation
Reuse of dredge material as an agricultural application	• Topsoil for agricultural use

These options were analysed in detail to determine what may be feasible at the Port of Weipa. Advisian (2018b) considered a range of performance criteria when comparing options, including:

1. Sediment suitability.
2. Greenhouse gas emissions.
3. Opportunity or demand.
4. Conceptual cost.
5. Confidence in beneficial reuse process.
6. Duration from construction to use.
7. Environmental implications.
8. Socio-economic implications.
9. Environmental approvals.
10. Constraints.
11. Knowledge gaps (requiring research).
12. Longevity of the beneficial reuse option.

At the Port of Weipa about 80% of the dredge material is fine grained (silt/clay) and 20% is coarse material (sand/gravel). The coarse- grained sediments are typically more suitable for reuse in medium to high-load land reclamation, beach nourishment and use in concrete manufacture. The geotechnical properties of the fine- grained sediments (e.g. strength, plasticity, density, consolidation) are generally unsuitable for engineering applications and this material would require significant onshore processing and treatment to improve its suitability.

Comparative evaluation was applied to the identified beneficial reuse opportunities using the 12 performance criteria listed above (Figure 3). The highest ranked beneficial reuse opportunities for the Port of Weipa include: beach nourishment, land reclamation, shoreline protection, concrete products and deep-water habitat creation.

The amount of dredge material required for each of the top ranked reuse opportunities is between about 5,000 m^3/yr. (for concrete products) and 100,000 m^3/yr. (for land reclamation) and represents a relatively small part of the total annual dredging requirement. No single beneficial reuse opportunity provides a long-term solution to utilise the large volume of dredge material produced year after year. Several potential hybrid options exist to target a small portion of the dredge material for specific reuse with the balance of material managed, as it has been historically, through offshore placement.

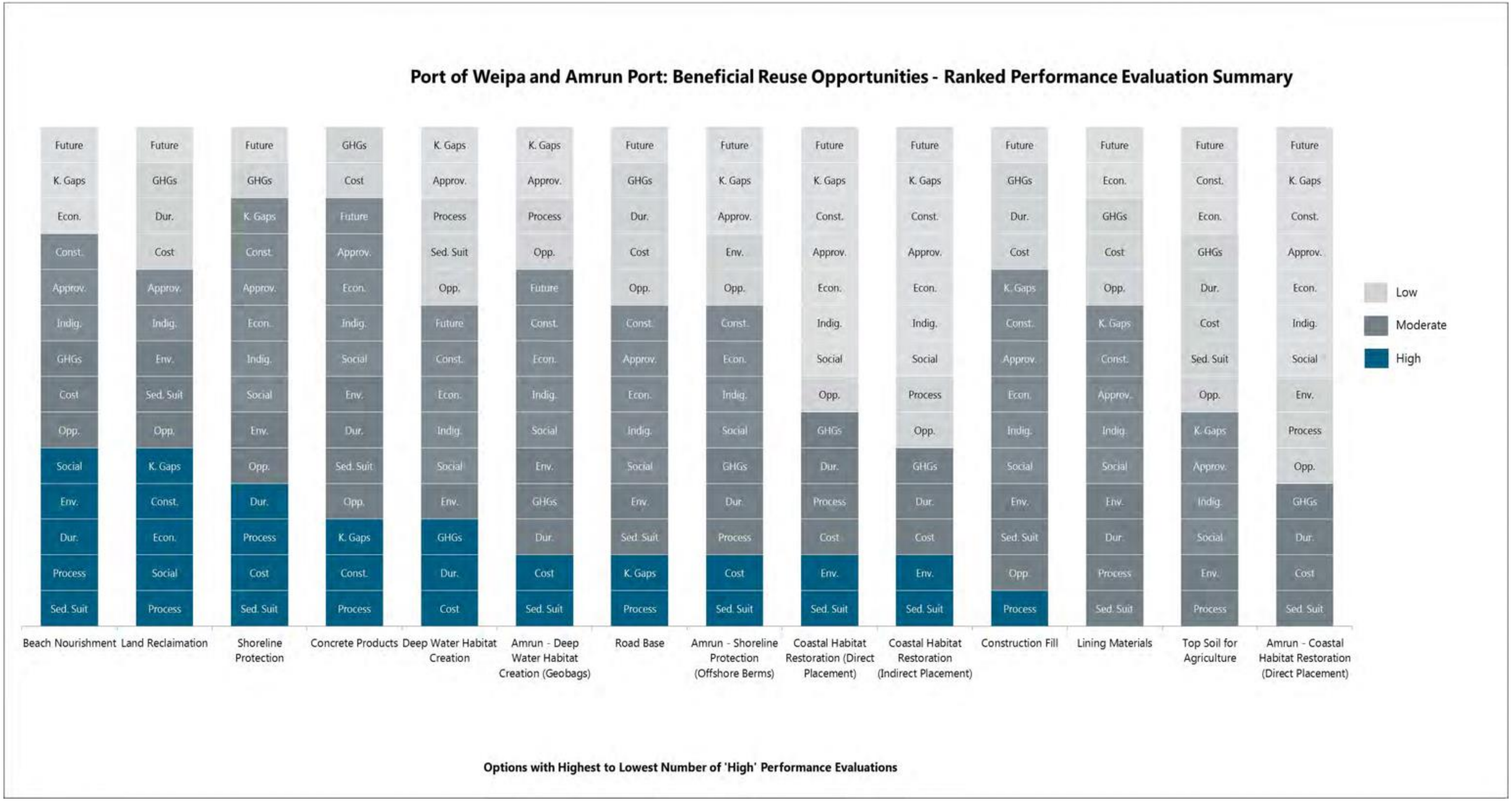


Figure 3: Beneficial reuse options performance summary

While maintenance dredge sediment derived from the ports may be suitable for a number of uses, the demand associated with reuse opportunities is very limited and the volume of material required for reuse opportunities (if any demand exists) is relatively small in comparison to the annual dredging requirement.

The analysis indicates that there is no clear preferred long-term beneficial reuse option for maintenance dredge material from the Port of Weipa. However, based on the analysis of feasibility, two options were selected for further consideration. These are beach nourishment and land reclamation. These options were selected as they were the higher-ranking options, they performed well against sediment suitability criteria and there is potential opportunity/demand in the Weipa area.

From these two beneficial reuses, two options were developed based on likely suitable locations. These are:

- Beach nourishment at Gonbung Point
- Land reclamation at Evans Landing.

It is important to note that a number of the beneficial reuse options identified in Figure 2 would require the material to be brought onshore for drying and processing. Although these options are not considered individually as feasible options, onshore disposal (as described below) is considered as part of the comparative analysis and essentially would provide some opportunity to recover and reuse the material should a demand arise.

SELECTION OF OPTIONS FOR DISPOSAL/PLACEMENT OF DREDGE MATERIAL

In addition to the two beneficial reuse options identified above, it was important to include a full range of disposal or placement options for comparison and consideration. Options were selected on the basis that:

- One is the existing placement area that has been used at the Port for a number of years with success, monitoring has shown very low levels of environmental impact
- A western offshore option in deeper water less influenced by tides and currents and well away from sensitive environments
- A third offshore option south of the shipping channel well away from sensitive environments, but also located to reduce potential for placed material to mobilise and return to the shipping channels
- One onshore option within reasonable pumping distances from the dredging vessel.

In all, two reuse, one onshore and three offshore placement options were selected as possible options for consideration in the comparative analysis. These are:

- Land reclamation at Evans Landing
- Beach nourishment at Gonbung Point
- Onshore pond at Weipa
- Existing Albatross Bay offshore dredge material placement area
- New west Albatross Bay offshore dredge material placement area
- New south Albatross Bay offshore dredge material placement area.

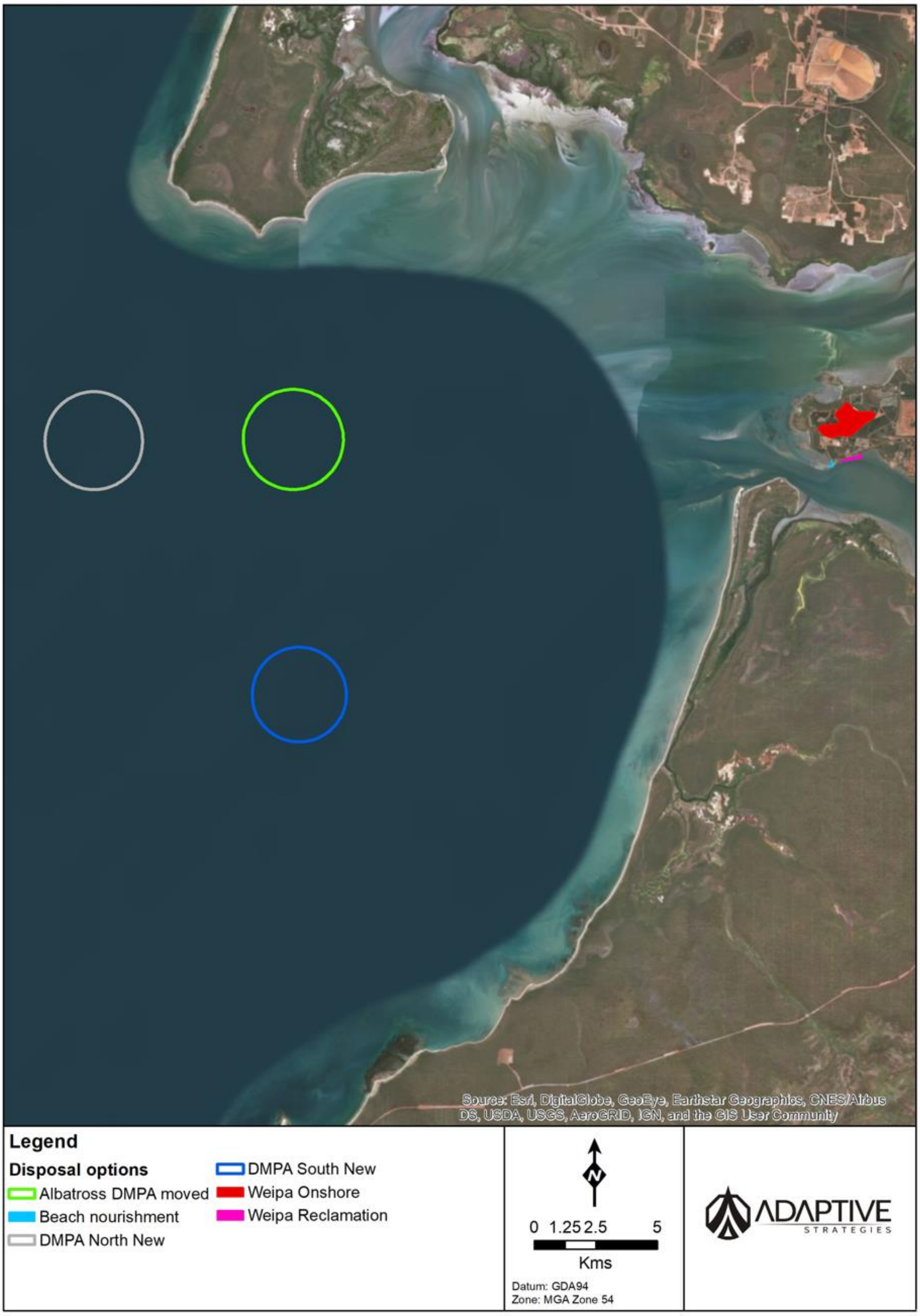


Figure 4: Location of the options for dredge material placement

Description of the options for reuse or disposal of sediment

As outlined above, the analysis of feasible options for the use or disposal of dredge material at Weipa arrived at six options to be considered in the comparative analysis. Following is a short description of each option and Figure 4 shows their respective locations.

RECLAMATION AT EVANS LANDING

One of the uncertainties associated with a reclamation option relates to the future demand as there is no current master plan for the Port of Weipa. 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 would potentially need to accommodate the heavy lift of materials, including break bulk cargo, to support future port operations (Advisian 2018b).

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 5.5 hectares 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 (PSC 2019d).

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. 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 m3 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.

BEACH NOURISHMENT AT GONBUNG POINT

Beach nourishment or sand replenishment is a process by which sediment (usually sand) lost through longshore drift or erosion is replaced from sources outside of the eroding beach. A wider beach can reduce storm damage to shoreline by dissipating wave energy and protecting from storm surges and unusually high tides. Beach nourishment is typically a repetitive process, since it does not remove the physical forces that cause erosion, but simply mitigates their effects.

The beach nourishment option for beneficial reuse of dredged material is heavily constrained by demand. It may have a single or limited application for only the suitable sand component of targeted dredged material. It is considered that targeted sand dredging volumes (estimated 100,000 m^3 annually) could provide a long-term suitable source of material for beach nourishment that significantly exceeds demand in the region (Advisian 2018b).

At this time no specific locations with significant demand for beach nourishment have been identified; however potential minor areas of erosion that may benefit from beach nourishment have been identified at Gonbung Point. The Gonbung Point area is at the mouth of the Embley River and is crossed by unformed vehicle and walking tracks. The area is used for fishing and recreation. Beach nourishment to increase the sand area and encourage stabilisation by vegetation is considered a potential enhancement to the area’s amenity and an opportunity to rehabilitate the environment.

The dredge spoil sand from areas such as the Approach Channel, Departure Channel and Southern Channel would need to be targeted and placed onshore.

ONSHORE POND AT WEIPA

An inactive Tailings Storage Facility located approximately 1 km north of Evans Landing wharf was identified as a possible suitable location for the creation of an onshore pond (Advisian 2018b). The area of the inactive Tailings Storage Facility, 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.

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. 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.

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 bulking factor of three this is equal to 1.8 Mm^3 of in-situ sediment, which is 4.5 standard years or 2 large (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 (PCS 2019d).

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.

EXISTING ALBATROSS BAY OFFSHORE DREDGE MATERIAL PLACEMENT AREA

The existing Albatross Bay DMPA is located approximately 2.9 km northwest of the seaward end of the South Channel. The spoil ground has a depth range of 8.4 – 11.2 m below LAT with depth increasing from east to west. It is proposed to shift the spoil ground slightly to the west to increase depth and capacity. Recent dredge material placement with a large dredge vessel was restricted by the depths of the DMPA. A 2 km shift westwards has been applied to the DMPA as per Figure 5.

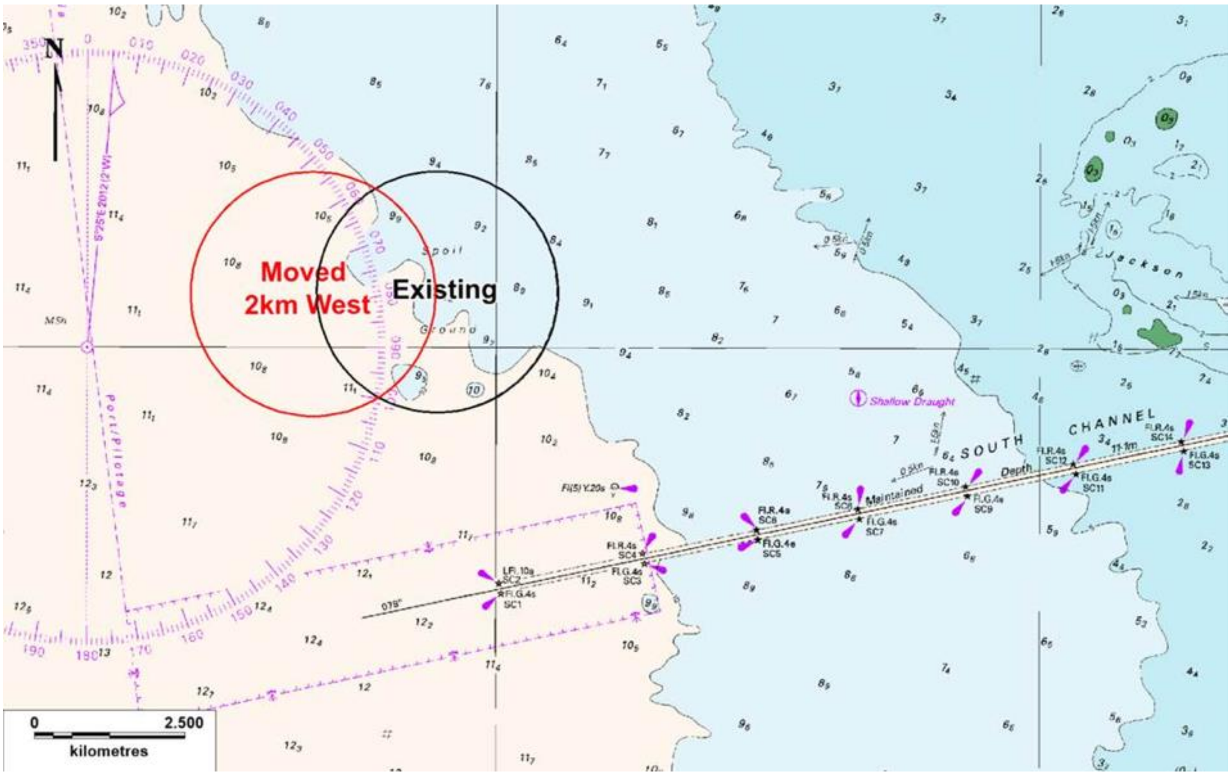


Figure 5: Adjustment of existing Albatross Bay DMPA

NEW ALBATROSS BAY WEST OFFSHORE DREDGE MATERIAL PLACEMENT AREA

Dredged material would be placed on the seabed at a new Albatross Bay placement area located 10.4 km northwest of the seaward end of the South Channel. The new placement area would be the same size as the existing DMPA. It is located in waters 12-13 m below LAT with depth increasing from east to west.

NEW ALBATROSS BAY SOUTH OFFSHORE DREDGE MATERIAL PLACEMENT AREA

Dredged material would be placed on the seabed at a new Albatross Bay placement area located 4.4 km south of the seaward end of the South Channel. The new placement area would be the same size as the existing DMPA. It is located in waters 12-14 m below LAT with depth increasing from east to west.

The location of all offshore options is shown in Figure 6.

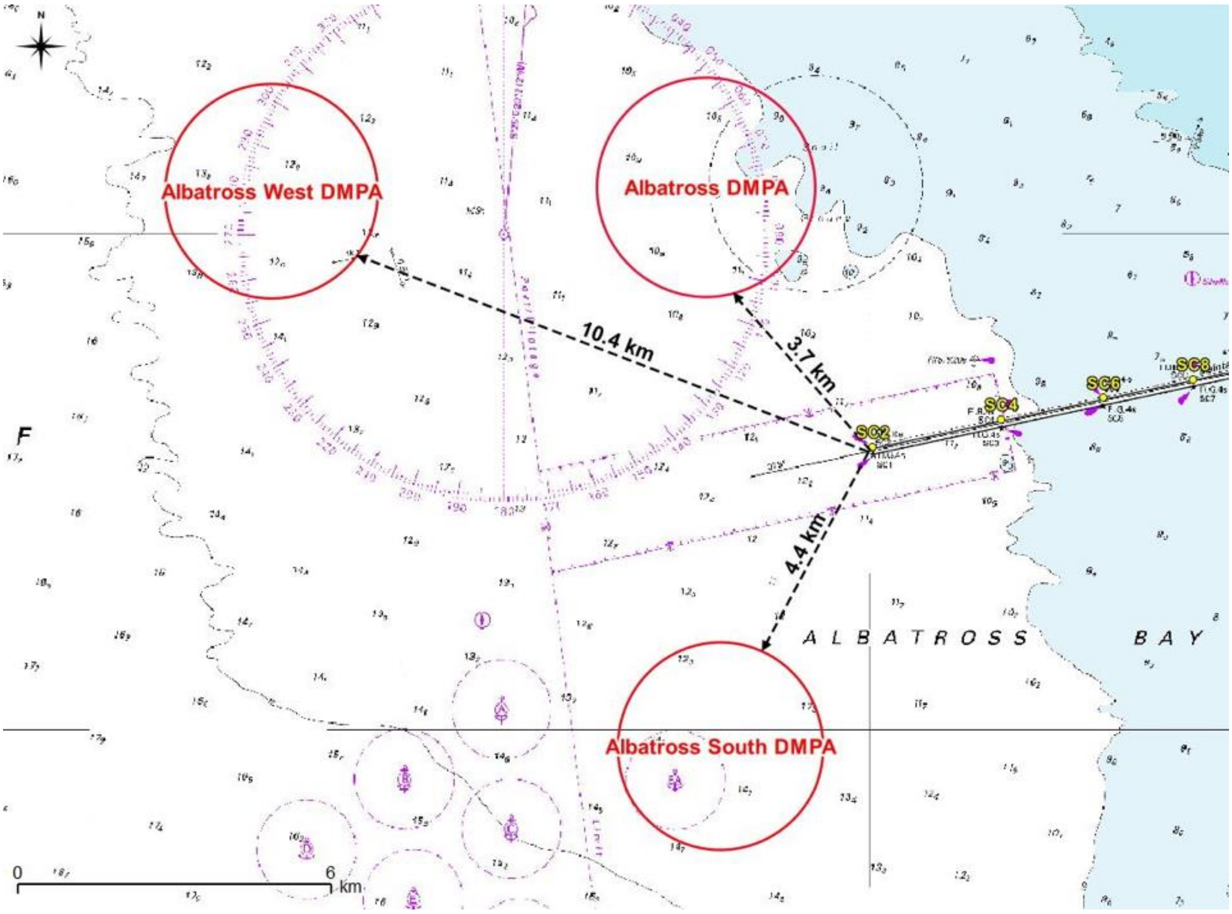


Figure 6: Respective position of the three offshore placement areas.

Step 4: Understanding the performance of the options

As described under Step 2, objectives and performance measures were defined to allow the performance of each option to be measured and compared. A set of detailed, technical work was undertaken following identification of the options to generate the data and scores against each performance measure.

This work is summarised below and explained in full with relevant results in Appendix B.

Objective 1: Avoid and minimise impacts to coastal ecosystems

Stakeholders agreed that it was important to look for opportunities to avoid or minimise impacts on coastal ecosystems. Two performance measures were generated in relation to this objective:

a) Predicted performance in relation to avoidance and minimisation of changes to coastal ecosystems.

b) Predicted risk on dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS).

COASTAL ECOSYSTEMS

Theme:	Environment
Objective:	1. Avoid and minimise impacts to coastal ecosystems
Measure:	Predicted performance in relation to impacts to coastal ecosystems
Unit of measure:	Performance score ranging from 4-16

The coastal ecosystems performance measure examined potential impacts from each option in relation to the following coastal ecosystems (GHD 2019):

- Land based ecosystems: threatened ecological communities (TECs), endangered regional ecosystems (EREs) and other native vegetation
- Freshwater and estuary ecosystems: wetlands, estuaries and mangroves
- Habitat for threatened, rare or commercially important species including: marine turtles, prawns, inshore dolphins, saltwater crocodiles and sawfish
- Coastal landforms: salt marsh, saline coastal flats / swamp, beaches, and rocky headlands
- Marine ecosystems: coral reefs, seagrass and/or seabed.

Changes or losses to these coastal ecosystems or landforms can lead to a variety of adverse environmental impacts, as well as serious implications for industries dependent on these natural resources.

A performance score (higher score is better) was generated for each option based on a set of criteria that considered:

- Scale of change.
- Ecosystem impacts.
- Species habitat impacts.
- Duration of change.

Please note: more detailed environmental impact assessment will form part of any future assessment and approval processes.

MARINE WATER QUALITY

Theme:	Environment
Objective:	1. Avoid and minimise impacts to coastal ecosystems
Measure:	Predicted risk of dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS)
Unit of measure:	Performance score ranging from 0-63

Marine waters are the vector to disturbance of a range of receptors, including benthic communities (e.g. seagrass and coral), fishes, and a range of megafauna such as dolphins, turtles and whales. All stakeholders felt that the potential impacts on these waters was an important criteria to assess when considering the options for long term sustainable sediment management at the Port of Weipa.

To inform this measure hydrodynamic plume modelling was undertaken by Ports and Coastal Solutions (PCS 2019e) to compare each option. A performance score was generated for each option based on the predicted risk of dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS).

Objective 2: Minimise carbon emissions

Consideration of the potential Greenhouse Gas (GHG) emissions from the construction and operational activities of each option is an important component of comparing the options. Stakeholders agreed that understanding how each option performed in relation to forecast GHG emissions should form part of the decision making process.

GHG EMISSIONS

Theme:	Greenhouse Gas (GHG) emissions
Objective:	2. Minimise carbon emissions
Measure:	Forecast GHG emissions
Unit of measure:	Tonnes of CO2 equivalent (tCO2-e)

Calculating forecast GHG emissions was undertaken in accordance with the internationally recognised methodology outlined in the GHG Protocol. In accordance with the Protocol, the assessment considered the following emissions:

- Direct emissions – e.g. emissions associated with fossil fuel consumption by vessels/construction plant/vehicles during transport and construction. These are known as 'Scope 1' emissions in the GHG Protocol.
- Indirect emissions from supporting activities – e.g. emissions associated with the production of construction materials. These are known as 'Scope 3' emissions in the GHG Protocol. For this project high level estimates are used.

None of the options were considered likely to result in significant indirect emissions due to the consumption of purchased electricity (known as 'Scope 2' emissions in the GHG Protocol). Scope 2 emissions were therefore not part of this assessment.

Objective 3: Minimise impact on cultural heritage within the area

The sustainable sediment management project aims to further improve the management of port sediments while ensuring the continued operation of the port, ensuring social and cultural features are respected and that environmental and cultural heritage values are protected. Stakeholders wanted to ensure that the potential for impacts on cultural heritage arising from the various options were considered in the decision making process.

CULTURAL HERITAGE

Theme:	Cultural Heritage
Objective:	3. Minimise impact on cultural heritage within the area
Measure:	Nature and scale of any impact on cultural heritage
Unit of measure:	Performance score ranging from 4-12

A cultural heritage performance score was generated for each option based on a set of criteria that considered:

- The nature of any interaction with or disturbance to identified Indigenous cultural heritage or potential unknown sites and/or artefacts.
- The nature of any interaction with landscape/cultural connection of importance to Indigenous people.
- Impact on access for Indigenous people to culturally important places.

Objective 4: Maintain effective and efficient port operations

Stakeholders agreed that it was important to examine options that provided for effective and efficient port operations. Two performance measures were generated in relation to this objective:

a) Predicted lead time to dredge material placement.

b) Capacity to provide a long term solution for the port.

LEAD TIME

Theme:	Port Economics & Operation
Objective:	4. Maintain effective and efficient port operations
Measure:	Predicted lead time to dredge material placement
Unit of measure:	Years

Finding appropriate solutions that can be implemented within required timeframes is important (i.e. how long it will take to plan, get approval, and prepare works).

It is necessary to conduct maintenance dredging annually if port operations are to continue without serious restrictions. The lead time for each option was calculated based on industry experience in relation to the following key preparatory stages:

- Research/studies.
- Engineering design.
- Planning and approval.
- Construction.

LONG TERM SOLUTION

Theme:	Port Economics & Operation
Objective:	4. Maintain effective and efficient port operations
Measure:	Capacity to provide a long term solution for the port
Unit of measure:	Percentage of 10 year timeframe

A critical aspect to the project is providing a long term solution that can address the requirements of multiple dredging campaigns. A well designed and implemented long term solution will provide certainty for all stakeholders and the best outcomes across the various project themes.

The ability of each option to deliver a long term solution has been presented as a percentage in order to reflect the fact that some options only provide solutions for a portion of the dredge material and/or for a limited number of years.

100% represents the aim of providing a solution that delivers annual dredging for the maximum volumes over a 10 year period.

Objective 5: Ensure solution is cost effective

All stakeholders recognised that cost was an important criteria to assess when considering the options and that ensuring that solutions are cost effective is critical.

COST

Theme:	Port Economics
Objective:	5. Ensure solution is cost effective
Measure:	Assessment of costs
Unit of measure:	AUD in Present Value

High-level cost estimates for managing 10 years of future sedimentation at the Port was calculated for each option.

The differences in cost between the offshore options is generally due to the different locations of the offshore DMPA which results in a change in travel distance and therefore a change in dredge duration.

For the beach nourishment reclamation and onshore options there are additional cost associated with construction and pipeline infrastructure required to pump the sediment.

Objective 6: Avoid significant loss of future port expansion opportunities

Maintaining effective port operations and future port development opportunities is a critical component of the decision making process.

FUTURE PORT IMPLICATIONS

Theme:	Port Operation
Objective:	6. Avoid future loss of future port expansion opportunities
Measure:	Effect on future port expansion or operations
Unit of measure:	Performance score ranging from 2-8

Performance was measured against two key criteria:

- Impact on port land, whether the option provided an increase or decrease in port land, or was neutral.
- Ability for the option to facilitate or assist in future port expansions.

Objective 7: Avoid or mitigate health and safety risks

Risks to human health and safety was an important criteria to assess when considering the options for long term sustainable sediment management at the Port of Weipa.

HEALTH AND SAFETY

Theme:	Human Health and Safety
Objective:	7. Avoid or mitigate health and safety risks
Measure:	Relative risk
Unit of measure:	Performance score ranging from 8-24

To assess this component, a range of human health and safety measures were developed along with some simple performance criteria to rank them.

It is important to note the process was not intended to replicate a full risk assessment (based on unmitigated and mitigated risks derived from likelihood and consequences of various activities). Rather it took a high level approach around potential risk pathways and complexity. More detailed assessment will be considered for the preferred option as part of any future project planning and management. A performance score (lower score is better) was generated for each option based on a set of criteria that considered:

- Interaction with public areas.
- Dust and emissions.
- Duration of activity (influences likelihood of occurrence).
- Spills and contaminants.
- Heavy vessel / machinery interaction.
- Isolated areas – proximity to medical support.
- Weather exposure.
- Personnel requirements.

Objective 8: Minimise interference to social activities within the region

The coastal areas and waters in the Weipa region support a range of social and commercial activities, including: urban living, commercial fishing, recreational fishing, boating. People living in the area need to access a wide range of services in Weipa. Stakeholders wanted to ensure that the potential for impacts on social features and activities arising from the various options were considered in the decision making process.

SOCIAL

Theme:	Social
Objective:	8. Minimise interference to social activities within the region
Measure:	Scale and duration of any impacts on social activities
Unit of measure:	Performance score ranging from 3 - 9

A performance score was generated for each option based on a set of criteria that considered:

- The nature of any interaction with social or commercial features or activities.
- The length of time any interaction or disturbance will occur for.
- Number of people affected.

Objective 9: Provide increased economic and social opportunities

As part of the broader social theme, stakeholders recognised that a positive consideration would be to measure and compare the jobs created by each option. In particular regional job creation is seen as important as it will contribute to the regional economy and enhance the social fabric of the region. Jobs created at a broader level are also of value but for the purposes of comparison have been weighted at a lower factor.

EMPLOYMENT

Theme:	Social
Objective:	9. Provide increased economic and social opportunities
Measure:	Predicted number of FTE jobs created
Unit of measure:	Full Time Equivalent (FTE) jobs created

For each option the forecast number of part-time and full time jobs (if any) was determined to create an overall employment score.

Step 5: Comparing options and selecting a preferred option

The final step in the comparative analysis was the application of a process to compare the options against the objectives and performance measures.

The process was extensive and involved:

- Calculating raw scores for all measures and options
- Converting raw scores into normalised results to enable fair comparison
- Comparing options against the objectives and performance measures
- Ranking options using various methods (e.g. different weightings)
- Recommending a preferred solution based on the outcomes of the analysis.

RAW SCORES CONSEQUENCE TABLE

The raw scores from each performance measure (see Step 4 and Appendix B) were used to generate a consequence table. A consequence table is a matrix that illustrates and compares the performance of each option with respect to the objectives. Key elements of the table (Table 4) include:

- All of the objectives and performance measures identified in Step 2
- The table indicates which direction is better for each performance measure in the "Direction" column.
- The best scores for a performance measure are highlighted in green
- The worst scores for a performance measure are highlighted in red.

NORMALISED SCORES CONSEQUENCE TABLE

In order to compare options using different performance measures it is necessary to apply standard statistical methods to ensure the comparisons are valid and balanced. In particular this involves the process of normalisation whereby different measures and units of score are standardised to a score in a range from 0 to 1.

The formula that was used to normalise raw scores was:

$$\text{Normalised score} = \frac{\text{raw score} - \text{worst score}}{\text{best score} - \text{worst score}}$$

Table 5 shows the results for all measures and options converted into normalised scores. The 1 or the highest number closest to 1 indicates the best result.

Table 4: Raw scores for each Port of Weipa placement and reuse option

					Port of Weipa Placement/Reuse Options					
Objective	Unit	Score min	Score max	Direction is better	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Avoid and minimise impacts to coastal ecosystems	Coastal ecosystems	4	16	lower	10	10	10	11	14	6
	Water quality	0	63	lower	4	1	3	0	3	3
Minimise carbon emissions	GHG emissions	-	-	lower	28,000	34,400	28,500	58,400	39,200	28,500
Long term solution	Percentage	0	100	higher	100	100	100	12.3	37.4	8
Ensure solution is cost effective	Cost ($M)	-	-	lower	$61	$76	$62	$195	$109	$87
Lead time	Years	-	-	lower	0.5	0.5	0.5	3	4	2
Avoid a loss of future port expansion opportunities	Performance	2	8	higher	6	6	6	2	8	4
Avoid or mitigate health and safety risks	Relative risk	8	24	lower	10	10	10	15	15	11
Minimise interference to social activities	Performance	0	9	lower	3	3	7	7	8	0
Provide increased economic and social opportunities	Employment (FTE)	-	-	higher	0.65	0.85	0.67	3.15	9	0.81
Minimise impact on cultural heritage	Performance	4	12	higher	11	11	12	5	5	8

Table 5: Normalised scores for each Port of Weipa placement and reuse option

		Port of Weipa Placement/Reuse Options					
Objective	Unit	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Avoid and minimise impacts to coastal ecosystems	Coastal ecosystems	0.50	0.50	0.50	0.42	0.17	0.83
	Water quality	0.94	0.98	0.95	1.00	0.95	0.95
Minimise carbon emissions	GHG emissions	1.00	0.79	0.98	0.00	0.63	0.98
Long term solution	Percentage	1.00	1.00	1.00	0.12	0.37	0.08
Ensure solution is cost effective	Cost ($M)	1.00	0.89	0.99	0.00	0.64	0.81
Lead time	Years	1.00	1.00	1.00	0.29	0.00	0.57
Avoid a loss of future port expansion opportunities	Performance	0.67	0.67	0.67	0.00	1.00	0.33
Avoid or mitigate health and safety risks	Relative risk	0.88	0.88	0.88	0.56	0.56	0.81
Minimise interference to social activities	Performance	0.67	0.67	0.22	0.22	0.11	1.00
Provide increased economic and social opportunities	Employment (FTE)	0.00	0.02	0.01	0.30	1.00	0.02
Minimise impact on cultural heritage	Performance	0.88	0.88	1.00	0.13	0.13	0.50

ANALYSIS

The analysis of the six options shows how they each perform against the objectives and measures.

One of the critical findings is that only the offshore options have the potential to be implemented within the first year in order to achieve annual maintenance dredging.

The other critical objective to consider when looking at each option is the long-term sediment management requirements of the Port. There is a demonstrated need for ongoing maintenance dredging every year in the order of 400,000 m^3 up to 2.5 million m^3 (or potentially higher). Looking at Table 4 only the offshore options have the potential to provide this capacity over a 10 year period.

WEIGHTINGS

The next step involved weighting the normalised scores for each performance measure and calculating an overall performance score for each option out of 100. A score of 100 would mean that an option performs perfectly against every performance measure.

Weighting is an important step in the decision making process. It is a process that people often undertake subconsciously by placing more value on some objectives over others when trying to make a decision between options. The structured decision making process provides a transparent way of applying and testing weightings.

It is recognised that stakeholders value objectives differently and will therefore apply different weightings. Given this, no attempt was made to reach a consensus on how to apply weightings. Rather a number of different weighting scenarios were generated to see how each option would perform. The weighting scenarios (see **Error! Reference source not found.**) were:

- Equal weights - all performance measures were weighted equally.
- Environment - performance measures relating to the environment theme were attributed with 75% of the weightings.
- Port operations - performance measures related to the efficient ongoing and future operation of the Port were attributed with 75% of the weightings..
- Costs - performance measure relating to the cost of each option was attributed with 75% of the weightings.
- Health and Safety - performance measure was attributed with 75% of the weightings.
- Social - performance measures relating to the social theme were attributed with 75% of the weightings.
- Cultural - the performance measure relating to the cultural heritage theme was attributed with 75% of the weightings.

A summary of the overall performance of each option under the seven weighting scenarios is provided in Table 6. The best performing option under each scenario is highlighted in green and the worst performing is highlighted in red.

Table 6: Summary of weighted scores (max 100) for each option across the six weighting scenarios

	Equal	Environment	Port Operations	Costs	Health & Safety	Social	Cultural
Albatross DMPA	77.00	79.92	84.96	93.80	84.74	46.81	84.74
Albatross West	75.00	75.58	84.17	85.06	84.11	46.95	84.11
Albatross South	75.00	78.89	83.94	92.45	83.92	30.56	92.99
Weipa Onshore	28.00	40.47	18.42	7.59	48.37	26.54	16.65
Weipa Reclamation	51.00	55.69	47.45	60.44	54.69	54.04	22.98
Beach Nourishment	63.00	82.11	43.08	75.66	76.14	54.53	53.48

SUMMARY

Review of the scores led to the following observations:

- The three offshore options all perform relatively well across a range of measures and weighting scenarios. The existing offshore option generally outperforms the other offshore options, but only marginally.
- The Weipa onshore option performs worst on almost all measures and weighting scenarios, in short it is a poor option.

- The reclamation option preforms moderately in all scenarios, while it has positive elements in terms of future port expansion it is not a good long term option and it has a poor lead time.
- The beach nourishment option has good environmental and social elements but is poor in terms of being a long term solution. It may have merit if combined with an offshore option.
- The existing Albatross Bay DMPA ranked highest under four different weighting scenarios. This result implies that this option can be expected to respond well to a broader range of stakeholder values and factors that might influence decision makers.
- Reclamation and the onshore pond never ranked amongst the three highest performers under different weighting scenarios. They can therefore both be expected to respond poorly to the range of stakeholder values and factors that might influence decision makers.

ADDRESSING UNCERTAINTY

Uncertainty is an inherent component to the complex type of analysis and decision making involved with the SSM Project. There is a level of uncertainty in:

- The scores against each performance measure (e.g. the cost calculations for each option).
- The weightings that may be applied by different stakeholders and how influential those weightings are to the selection of a preferred solution.

To respond to these challenges, sensitivity analysis was undertaken at two levels:

- Analysis to understand how influential changes to the performance measure scores would be to overall performance.
- Analysis to understand how overall performance scores may change under different weighting scenarios.

Sensitivity analysis around performance measure scores

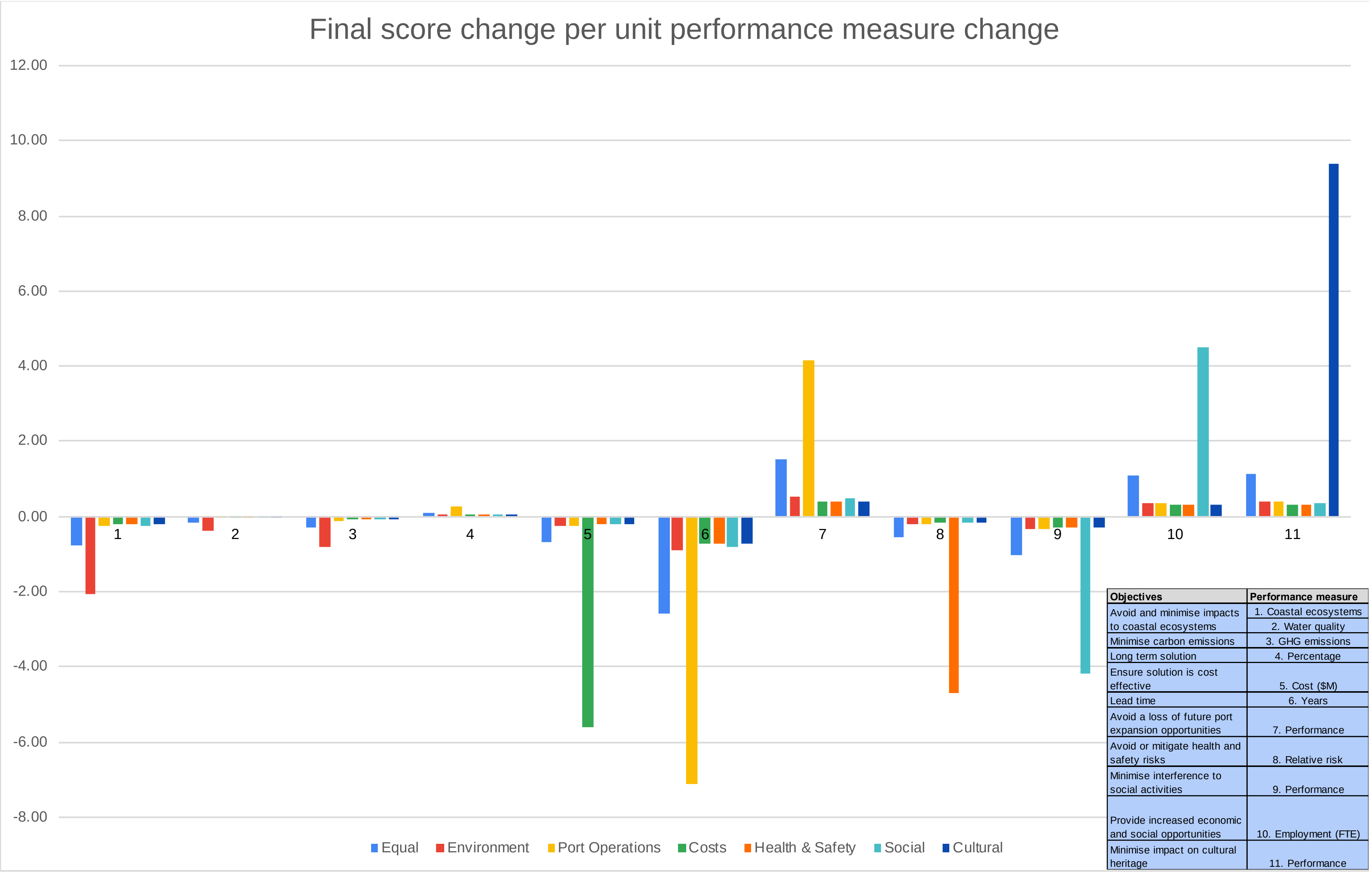
An analysis was undertaken to understand how influential changes to individual performance measure scores would be to overall performance scores. This was done for all measures under the six weighting scenarios. The process involved examining how much the overall performance score would change for every one unit of change in a performance measure. The method provides confidence in the performance measures by testing their sensitivity and it addresses any outliers.

Figure plots the result of that analysis.

The graph shows how the overall score for an alternative changes with an alteration of one unit score for each performance measure (under each weighting scenario). The greatest changes occur when the range in the performance measure is small (e.g. the cultural heritage performance measure) and when that measure is being weighted very heavily. The lighter blue columns show the unweighted scenario and a small scale of change in most measures; the largest change being in the lead time which is measured in years and has a scale of just 0.5 to 3. A one point change is therefore approximately a 25% alteration.

The results indicate that small changes to the performance measures will generally lead to very small changes in the overall performance of an option. This suggests that there is some margin for error in the scores assigned to each performance measure, which helps to address concerns around uncertainty in this aspect of the analysis.

The exception to this is where a performance measure is highly influential under a particular weighting scenario (e.g. the cultural heritage measure under the cultural focus weighting scenario). In this instance, small changes to the key performance measure(s) will have a much greater effect on the overall score. This result is to be expected given the method used in deriving the weighted scores.



Objectives	Performance measure
Avoid and minimise impacts to coastal ecosystems	1. Coastal ecosystems
	2. Water quality
Minimise carbon emissions	3. GHG emissions
Long term solution	4. Percentage
Ensure solution is cost effective	5. Cost ($M)
Lead time	6. Years
Avoid a loss of future port expansion opportunities	7. Performance
Avoid or mitigate health and safety risks	8. Relative risk
Minimise interference to social activities	9. Performance
Provide increased economic and social opportunities	10. Employment (FTE)
Minimise impact on cultural heritage	11. Performance

Figure 7: How changes in the 11 performance measure scores influence overall performance under each weighting scenario

Overall analysis and conclusion

The analysis in the Port of Weipa SSM Project has led to three key findings:

1. Sediment at the Port of Weipa needs to be managed.
2. Dredging is required as part of the management solution.
3. There are a discrete number of feasible options that have the potential to provide a long term solution for use or disposal of sediment.

Analysis of Options

The analysis of options for reuse or placement of dredge material looked at six discrete options against the objectives of the project. From that work it was clear that:

- Offshore disposal at the existing or potential one of the new DMPAs would be needed to deal with the full volume of dredged material over a 10 year period.
- Onshore placement at the Port of Weipa was the worst performing single option and does not warrant further consideration.
- Reclamation is a viable option for a partial volume, however it has environmental, social and cultural implications that would need to be addressed. Adoption of this option would only be feasible if there was a specific need or demand.
- Beach nourishment has some merit, particularly from an environmental and social aspect. This option would be worth examining in more detail as part of a combined solution with an offshore placement option.

Preferred long term solution

Based on the detailed comparative analysis, offshore disposal at the existing DMPA consistently performed the best. It was the strongest of the three best performers and achieved the best score across four weighting scenarios (equal, port operations, cost and health and safety). It also performed strongly under the environment weighting, just 4 percentage points behind beach nourishment which is a not a feasible long term solution on its own.

On balance, offshore disposal at the existing DMPA is considered to be the preferred solution. It provides both a short and long-term solution, is well understood, and performs strongly in a range of scenarios.

It should be noted that beach nourishment is also considered to have merit. It is an option that can provide a positive environmental benefit and it is recommended that it should be examined in more detail as part of an integrated solution with offshore disposal at the existing DMPA.

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Appendix A – Port of Weipa Stakeholders (incl Technical and Consultative Committee Members)

Commonwealth Science and Industrial Research Organisation (CSIRO)

Department of Agriculture, Fisheries and Forestry (Qld)

Department of Environment and Energy (Clth)

Department of Environment and Science (Qld)

Department of Transport and Main Roads (Qld)

James Cook University – TropWATER

Maritime Safety Queensland

North Queensland Bulk Ports Corporation

Port of Brisbane (dredge operator)

Rio Tinto Alcan (RTA)

Traditional owners

- Mokwiri Corporation
- Wik-waya People

Appendix B: Performance Measures

The following performance measures and results were used to compare placement/reuse options.

Coastal ecosystems performance

Theme: **Environment**

Objective: **1. Avoid and minimise impacts to coastal ecosystems**

Measure: **Predicted performance in relation to avoidance and minimisation of changes to coastal ecosystems**

Unit of measure: Performance score ranging from 4-16

Which direction of the measure is better? Higher

Coastal ecosystems and landforms are areas where the land and water meet in a distinct environment of high diversity, connectivity and flow. They provide a range of ecological services including water distribution, food and habitat, nutrient and chemical cycling, as well as important links between land, freshwater and marine environments and breeding grounds for many coastal species. There are a range of coastal ecosystems and landforms that are relevant to the assessment of options for long term sustainable sediment management at the Ports of Weipa. They include:

- Land based ecosystems: endangered regional ecosystems (EREs) and threatened ecological communities (TECs).
- Threatened species habitats, notably for marine turtles, inshore dolphins and sawfish.
- Freshwater and estuary ecosystems: wetlands, estuaries, and mangroves.
- Coastal landforms: salt marsh, saline coastal flats / swamp, beaches, and rocky headlands.
- Marine ecosystems: coral reefs, seagrass and/or seabed.

Changes or losses to these coastal ecosystems or landforms can lead to a variety of adverse environmental impacts.

Please note that a more detailed environmental impact assessment will form part of any future assessment and approval process for the selected option.

METHOD OF CALCULATION

The performance of each option in relation to avoiding and minimising changes to coastal ecosystems and landforms was determined through the application of a set of criteria that considered:

- The scale of predicted direct changes to coastal ecosystems and landforms
- Relative significance of effects to ecosystems in terms of statutory listing status
- Relative significance of changes in terms of species habitat
- Duration of changes
- Any positive contributions to coastal ecosystems and landforms.

PERFORMANCE CRITERIA

Coastal ecosystem and landform performance criteria

Measure	Performance Criteria			
	Very High (Score = 1)	**High (Score = 2)**	**Medium (Score = 3)**	**Low (Score = 4)**
Scale of change	Increase in extent of ecosystem	Small or no area affected (<25 ha)	Moderate area affected (25-100 ha)	Large area affected (> 100 ha)
Ecosystem status	Positive contribution to ecosystem	No changes OR Changes to least concern or unlisted ecosystem+	Changes to of concern or vulnerable ecosystem+	Changes to critically endangered or endangered ecosystem+
Species habitat status	Positive contribution to species habitat	No changes OR Changes to habitat used by unlisted or near threatened species*	Changes to habitat used by vulnerable or commercially import species*	Changes to habitat or habitat used by critically endangered, endangered species; or breeding/nursey areas for commercially important species*
Duration of change	No changes	Short term changes (recovery within natural/seasonal variations 6-12 months)	Medium term changes (recovery expected within 10 years)	Permanent changes

+ Applies to ecosystems listed under Queensland or Commonwealth legislation. Predominately applies to land based ecosystems.

* Relevant to species listings under Queensland or Commonwealth legislation and economically important species such as commercial prawn stocks.

RESULTS

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Scale	4	4	4	4	3	1
Status	2	2	2	2	3	1
Species Habitat	2	2	2	3	4	2
Duration	2	2	2	4	4	2
Total	**10**	**10**	**10**	**11**	**14**	**6**

Marine water quality performance

Theme: Environment

Objective: 1. Avoid and minimise impacts to coastal ecosystems

Measure: Predicted risk of dredge material placement plumes and/or tailwater discharge exceeding ambient variation (occurrence above median ambient TSS) at nearest sensitive receptors

Unit of measure: Performance score ranging from 0-63

Which direction of the measure is better? Higher

Marine waters are the vector to disturbance of a range of receptors, including benthic communities, fishes and a range of megafauna such as dolphins, turtles and whales. Waters of the eastern Gulf are naturally high in turbidity however changes in water quality above normal levels may impact nearshore environments. Using ambient monitoring data and turbidity modelling at various sensitive receptor sites the predicted change in water quality can be determined.

Changes in total suspended solids (TSS) can provide a good indicator of water quality and also provide a useful surrogate for potential impacts on receptors such as fringing corals and seagrasses, particularly in the context of differentiating between options for dredge material relocation.

Elevated TSS can reduce the amount of light reaching the seafloor and impact on photosynthesising organisms such as hard corals and seagrasses (Erftemeijer and Lewis 2006; Erftemeijer et al 2012). Extended period of greater than 15mg/l TSS may lead to sub-lethal biota, depending on the sensitivity of individual organisms, whereas extended periods of greater than 100mg/l has been shown to reduce the Surface Irradiation (SI) reaching the seafloor to below 1% in some environments, which can lead to mortality of some species.

Hydrodynamic modelling has been undertaken for each of the placement options to determine if TSS will exceed natural variation levels at seven sensitive receptor locations. .

METHOD OF CALCULATIONS

To assess the performance of each option a number of performance criteria were developed to compare the modelled TSS data associated with potential plumes from each of the options, which compares the summary results against natural median TSS concentrations.

Onshore options – a tailwater outflow of 50mg/l at the proposed tailwater discharge site has been assumed.
Reclamation option – a failure event has been modelled and assumes a significant failure in the lining.
Beach nourishment option – has used the same failure criteria as for the reclamation options.
At-sea options – have used modelled outputs from plume modelling for the disposal of:

- Standard volume – 400,000 m^3
- Large volume – 800,000 m^3 (incorporating a single cyclonic event)
- Worst Case Volume – 2.5 million m^3 (incorporating two cyclonic events)

PERFORMANCE CRITERIA

For each option a water quality performance score was determined by comparing predicted changes in TSS against natural variability at the nearest sensitive receiver locations.

Marine water quality performance criteria

Measures	Performance Criteria			
	Very High (Score 0)	High (Score = 1)	Medium (Score = 2)	Low (Score = 3)
Total Suspended Solids (TSS)	TSS concentrations not shown to occur above natural median concentration	TSS concentrations occur above natural median concentrations between 5% and 20% of the time	TSS concentrations occur above natural median concentrations for 20% to 80% of the time	TSS concentrations occur above natural median concentrations greater than 80% of the time
Assessed at 7 sites with three volumes at Weipa – minimum score = 0, maximum score = 63				

RESULTS

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Standard Volume						
20th	0	0	0	0	0	0
80th	0	0	0	0	0	0
95th	0	0	0	0	1	1
Large Volume						
20th	0	0	0	0	0	0
80th	0	0	0	0	0	0
95th	0	0	0	0	1	1
Worst Case Volume						
20th	0	0	0	0	0	0
80th	2	0	1	0	0	0
95th	2	1	2	0	1	1
Total	**4**	**1**	**3**	**0**	**3**	**3**

GHG emissions

Theme: Environment

Objective: 2. Minimise carbon emissions

Measure: Forecast GHG emissions

Unit of measure: Tonnes of CO_2 equivalent (tCO_2-e)

Which direction of the measure is better? Lower

Consideration of the potential Greenhouse Gas (GHG) emissions from the construction and operational activities of each option is an important component of comparing the long term sustainable sediment management options.

Forecast GHG emission estimates are provided for each option in relation to the 10-year dredging forecast of 9.4 million cubic metres.

METHOD OF CALCULATION

Calculating forecast GHG emissions was undertaken in accordance with the internationally recognised methodology outlined in the GHG Protocol. In accordance with the Protocol, the assessment considered the following emissions:

- Direct emissions – e.g. emissions associated with fossil fuel consumption by vessels/construction plant/vehicles during transport and construction. These are known as 'Scope 1' emissions in the GHG Protocol.
- Indirect emissions from supporting activities – e.g. emissions associated with the production of construction materials. These are known as 'Scope 3' emissions in the GHG Protocol. For this project high level estimates are used.

None of the options were considered likely to result in significant indirect emissions due to the consumption of purchased electricity (known as 'Scope 2' emissions in the GHG Protocol). Scope 2 emissions were therefore not part of this assessment.

Total in-situ volume of sediment assumed to require maintenance dredging over the 10 year period is 9.4 million cubic metres (Mm^3).

Onshore option assumes that all sediment from five typical dredge campaigns will be placed onshore (2 Mm^3) at which point the pond would be full. For remaining years it was assumed sediment placed at existing Albatross Bay DMPA.

Reclamation/beach nourishment assumes 100,000 m^3 of sandy sediment would be pumped from Evans Landing to reclamation/nearby beach during each typical year (total = 500,000 m^3). Assumed remaining sediment would be placed at existing Albatross Bay DMPA.

It has been assumed that for the onshore, reclamation and beach nourishment options the TSHD Brisbane would pump while moored at the Evans Landing wharf.

The reclamation option assumes that a sheet pile wall approach would be adopted for the reclamation

RESULTS

Results for the GHG assessment are:

Objectives	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Carbon emissions (tCO2-e)	28,000	34,400	28,500	58,400	39,200	28,500

Cultural heritage performance

Theme: Cultural Heritage

Objective: 3. Minimise impact on cultural heritage within the area

Measure: Nature and scale of any impact on cultural heritage

Unit of measure: Performance score ranging from 4 - 12

Which direction of the measure is better? Lower

Many indigenous cultural heritage values have been identified in the Weipa region, primarily in the coastal zone.

Stakeholders wanted to ensure that the potential for impacts on cultural heritage arising from the various options were considered in the decision making process.

METHOD OF CALCULATION

The performance for each option was calculated based on a set of criteria that considers:

- The nature of any interaction with or disturbance to identified Indigenous cultural heritage or potential unknown sites and/or artefacts.
- The nature of any interaction with landscape/cultural connection of importance to Indigenous people.
- Impact on access for Indigenous people to culturally important places.

PERFORMANCE CRITERIA

Cultural heritage performance criteria

Measure	Performance Criteria		
	High (Score = 3)	Medium (Score = 2)	Low (Score = 1)
Nature of interaction or disturbance – site/artefact	None	Potential risk to identified site but can be mitigated or avoided, or Potential risk to unknown site/artefact but can be adequately managed	Destruction, loss of identified or unknown site or artefact
Nature of interaction or disturbance - landscape/cultural connection	None or positive	Connection and identified value lost due to change in environment on site specific scale	Connection and identified value lost due to change in environment on regional scale
Impact on access to culturally important places	None or positive	Access lost or disrupted temporarily	Access lost permanently
Distance from Shore	10+ km	1-10 km	0-1 km

RESULTS

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Disturbance	3	3	3	1	1	2
Connection	3	3	3	2	2	3
Access	3	3	3	1	1	2
Distance	2	2	3	1	1	1
Total	**11**	**11**	**12**	**5**	**5**	**8**

Lead time

Theme: Port Economics & Operation

Objective: 4. Maintain effective and efficient port operations

Measure: Predicted lead time to dredge material placement

Unit of measure: Years

Which direction of the measure is better? Lower

Maintaining effective port operations is a critical component of the decision making process for sustainable sediment management. One of the factors to consider around this objective is the implementation time for each of the options (i.e. how long it will take to plan, get approval, and prepare works).

It is necessary to conduct maintenance dredging annually if port operations are to continue without serious restrictions.

METHOD OF CALCULATION

The lead time for each option was calculated based on industry experience in relation to the following key preparatory stages:

- Research/studies: prior to commencing or planning an action it may be necessary to gather additional information, scientific data, knowhow or develop technology. This may include background research, field/ocean studies, feasibility, environmental constraints and management, and design.
- Engineering design: Detailed design work.
- Planning and approval: For example, work required to prepare management plans (e.g. environment, health and safety) and apply for regulatory approvals (applications, assessment processes).
- Construction: Construction works required to prepare each option for dredge material placement (e.g. site preparation, construction of bunds, etc).

The following assumptions were made in calculating lead times:

- Where time periods might overlap subsequent time estimates are based on the additional time period required to complete the stage. Accordingly time periods are cumulative not overlapping.
- Options that involve new approaches, have significant environmental risks or involve locations where little environmental information is available will require considerable time to work through the earlier three stages (research, design, planning and approval).

RESULTS

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Years	0.5	0.5	0.5	3	4	2

Long term solution

Theme: Port Economics & Operation

Objective: 4. Maintain effective and efficient port operations

Measure: Capacity to provide a long term solution for the port

Unit of measure: Percentage

Which direction of the measure is better? Higher

A critical aspect to sustainable sediment management is providing a long term solution that can address the navigational requirements of the Port.

METHOD OF CALCULATION

The ability of each option to deliver a long term solution has been presented as a percentage in order to reflect the fact that some options only provide solutions for a portion of the dredge material and/or for a limited number of years.

100% represents the aim of providing a solution that delivers annual dredging for the maximum volumes.

The maximum potential timeframe that each option could operate was determined based on:

a. A long term solution being a timeframe of 10 years.
b. Annual dredging of a volume up to 2.5 Mm^3 to maintain effective and safe operation of the port.
c. Total volume of 9.4 Mm^3 of material is required in the 10 year period.
d. No lead time for any of the options (e.g. related to planning and approvals) was applied as lead time is addressed specifically in performance measure E.
e. For reclamation, onshore and beach nourishment options the size and scale of the solution was based on availability of land/locations and feasible, safe infrastructure size. Duplications or enlargements may be possible but were considered unlikely or unnecessary for the purposes of comparison.

RESULTS

Status	Albatross DMPA	DMPA West	DMPA South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Normal	100	100	100	100	20	10
Large	100	100	100	12	12	12
Worst case	100	100	100	1	1	1
# years	10	10	10	3	5	2
Total	**310**	**310**	**310**	**116**	**38**	**25**
%	**100**	**100**	**100**	**37.4**	**12.3**	**8**

Cost

Theme: Port Economics

Objective: 5. Ensure solution is cost effective

Measure: Assessment of costs

Unit of measure: AUD millions

Which direction of the measure is better? Lower

All stakeholders recognised that cost was an important criteria to assess when considering the options for long term sustainable sediment management. Ensuring that solutions are cost effective is critical.

METHOD OF CALCULATION

It is important to note that the assessment of cost used here does not attempt to provide a full, detailed costing of each option. Rather it takes a high level approach to determine the order of magnitude costs for each option using present dollar values. Calculations are based on:

Total in-situ volume of sediment assumed to require maintenance dredging over the 10 year period is 9.4 million cubic metres (Mm^3).

Onshore option assumes that all sediment from five typical dredge campaigns will be placed onshore (2 Mm^3) at which point the pond would be full. For remaining years it was assumed sediment placed at existing Albatross Bay DMPA.

Reclamation/beach nourishment assumes 100,000 m^3 of sandy sediment would be pumped from Evans Landing to reclamation/nearby beach during each typical year (total = 500,000 m^3). Assumed additional sediment would be placed at existing Albatross Bay DMPA.

Dredging costs for the onshore, reclamation and beach nourishment options include allowance for the mooring station and pipeline for each year that sediment would be pumped to the associated location. It has been assumed that for all three options the TSHD Brisbane would pump while moored at the Evans Landing wharf.

The reclamation option assumes that a sheet pile wall approach would be adopted for the reclamation. In addition, costs for finalising construction of the reclamation following dredge material placement have not been included.

RESULTS

Objectives	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
$ millions	$61	$76	$62	$195	$109	$87

Port Development

Theme: Port Economics & Operation

Objective: 6. Avoid a loss of future port expansion opportunities

Measure: Effect on future port expansion or operations

Unit of measure: Performance score ranging from 4-8

Which direction of the measure is better? Higher

Maintaining effective port operations and opportunities for future port development is a critical component of the decision making process.

METHOD OF CALCULATION

The impact on future port development and operations was assessed based on a set of performance criteria. Each option is assessed against the performance criteria and graded. A total performance score for each option is then derived from the sum the of performance criteria.

PERFORMANCE CRITERIA

Port Development criteria

Measures	Performance Criteria			
	Poor (Score = 1)	Neutral (Score = 2)	Positive (Score = 3)	Very Good (Score = 4)
Port Land	Result in a reduction in port/industrial land in the vicinity of Weipa/Amrun	No impact	Enable improved port operations	Increase available port/industrial land and/or berth areas
Facilitate future capital development/dredging	Potentially limit future port /industrial development	No impact	Enable improved port efficiency of existing infrastructure	Enable new infrastructure or increased capacity (e.g. larger vessels)

RESULTS

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Port Land	2	2	2	1	4	2
Future development	4	4	4	1	4	2
Total	6	6	6	2	8	4

Human health and safety

Theme: Human Health and Safety

Objective: 7. Avoid or mitigate health and safety risks

Measure: Relative risk

Unit of measure: Performance score ranging from 8-24

Which direction of the measure is better? Lower

All stakeholders felt that potential impacts on human health and safety was an important criteria to assess when considering the options for long term sustainable sediment management.

METHOD OF CALCULATIONS

It is important to note the process is not intended to replicate a full risk assessment (based on unmitigated and mitigated risks derived from likelihood and consequences of various activities). Rather it takes a high level approach around potential risk pathways and complexity. More detailed assessment will be considered for the preferred option as part of any future project planning and management.

For each option, each measure is assessed against the performance criteria and graded. A total performance score for each option is then derived from the sum of performance criteria.

PERFORMANCE CRITERIA

Human health and safety measures and performance criteria

Measures	Performance Criteria		
	Low (Score = 1)	Medium (Score = 2)	High (Score =3)
Interaction with public areas	Remote from public areas or is in an area of low public usage	Regular interaction with public areas but is able to be easily managed	High use public area requiring ongoing management
Dust and emissions	No dust or emissions expected above natural air quality variants	Dust or emissions expected but is able to be managed easily	Dust or emissions requiring ongoing management
Duration of activity (influences likelihood of occurrence)	0 - 4 weeks	4 weeks – 8 weeks	> 8 weeks
Spills and contaminants	Limited sources of spills or contamination in easily contained environment	Multiple sources of spill or contamination over single onsite area	Multiple sources of spill or contamination extending to multiple offsite areas
Heavy vessel / machinery interaction	Single vessel or machinery only	Multiple vessels or machinery with limited interaction with each other	Multiple vessels or machinery with regular interaction with each other
Isolated areas – proximity to medical support	Access to medical support similar to normal regional services	Short delays (hrs) in obtaining normal regional medical support	Long delays (days) in obtaining normal regional medical support
Weather exposure	Able to easily retreat in adverse weather	Short delays (hrs) in seeking retreat in adverse weather	Long delays (days) in seeking retreat from adverse weather
Personnel requirements	Small (<15) workforce in single location	Small to medium (up to 30) workforce working across multiple locations	Medium to large (>30) workforce operation across multiple locations

RESULTS

Health and Safety risk scores:

Objectives	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Risk score	10	10	10	15	15	11

Social performance

Theme: Social

Objective: 8. Minimise interference to social and commercial activities within the region

Measure: K) Scale and duration of any impacts on social or commercial activities

Unit of measure: Performance score ranging from 3 - 9

Which direction of the measure is better? lower

Western Cape York including Weipa supports a range of social and commercial activities, including: retail, commercial fishing, charter sports fishing, recreational fishing, boating, sports and informal recreation. People living in the area need to access a wide range of services locally and remotely.

The sustainable sediment management project aims to further improve the management of port sediments while ensuring the continued operation of the port, social and cultural features are respected and that environmental values are protected.

Stakeholders wanted to ensure that the potential for impacts on social and commercial features and activities arising from the various options were considered in the decision making process. Likely interactions with fishing activities, commercial and recreational have been included. Fishing considerations include vessel launch and operation, fishing locations and potential for impacts on fishing stocks.

Impacts on port and mining operations have been assessed separately.

METHOD OF CALCULATION

The performance criteria for each option was calculated based on:

- The nature of any interaction with social or commercial features or activities.
- The length of time any interaction or disturbance will occur.
- Number of people affected.

PERFORMANCE CRITERIA

Social performance criteria

Measure	Performance Criteria			
	Positive (Score = 0)	Good (Score = 1)	Medium (Score = 2)	Poor (Score = 3)
Nature of interaction or disturbance	Positive	None	Results in a need for alteration or relocation of an area or activity	Activity must cease and/or will results in a loss of revenue or commercial opportunity
Duration of interaction	Positive	None	Short to medium term – life of the dredging campaign.	Permanent or long-term
Number of people affected	Positive	None	Small numbers of participants, single interest group (1 to 10 people)	Larger numbers (+10) or multiple interest groups, whole community.

RESULTS

Social performance results

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Nature	1	1	2	1	2	0
Duration	1	1	3	1	3	0
# people	1	1	2	1	3	0
Total	**3**	**3**	**7**	**3**	**8**	**0**

Employment

Theme: Social

Objective: 9. Provide increased economic and social opportunities

Measure: Predicted number of FTE jobs created

Unit of measure: Full Time Equivalent (FTE) jobs created

Which direction of the measure is better? Higher

As part of the broader social theme, all stakeholders recognised that a positive consideration would be to measure and compare the jobs created by each option. In particular local job creation is seen as important as it will contribute to the regional economy and enhance the social fabric of the region. Jobs created at a broader level are also of value but for the purposes of comparison have been weighted at a lower factor.

METHOD OF CALCULATION

For each option the forecast number of part-time and full time jobs (if any) has been determined to create an overall jobs score. All jobs created have been included in the comparative analysis, however a different multiplier has been applied to the jobs in the Weipa region (x1) at a national level (x 0.5) and internationally (x 0.25). Indirect jobs supported or created beyond the region (such as work for regulatory agencies, consultants etc.) are not included as they are too intangible for inclusion.

Full-time Equivalent (FTE) is a unit equivalent of a full-time employee's workload. It represents a business's total number of full-time equivalent employees by summing the total hours worked by employees, both full and part-time, then dividing by the number of working hours available in a given period (days, week or year). In this way, it is used to determine the number of full-time equivalents regardless of the number of actual employees and variations in the number of hours worked during a period.

The formula used is:

number of employees X number of hours worked / number of available working hours.

e.g. 3 x 20/(3 x 40) = 0.5

In this instance the formula has been based on a yearly period to account for full time, part time and contract personnel who may work full time for a period of weeks rather than a full year. A worked example is shown in the table below.

Employment profile	# of personnel	FTE
Full time all year	1 person	1
Part time all year	2 people x 2 days a week (2 x 2/5 = 0.8)	0.8
Full time part year (e.g. 3 months)	20 personnel x 12 weeks (20 x 12/52 = 4.6)	4.6
Totals	**23 individuals**	**6.4 FTE**

The calculations for the mixed options over the 10 year period are based on an annual FTE multiplied by the weightings as follows.

- Local by 1.0; National by 0.5.

RESULTS

Option	Commentary
Reclamation	• Place core material (14 people for 19 weeks), geotextile installation (2 people for 12 weeks), armour material – upper reaches (14 people for 6 weeks) and armour material – lower reaches (5 people for 12 weeks).
Beach Nourishment	• Site preparation (2 people for 2 weeks), shaping (2 people for 2 weeks).
Onshore Weipa	• Site preparation (7 people for 2 weeks), earthworks (12 people for 4 weeks), bund formation (12 people for 4 weeks), liner installation (2 people for 3 weeks).
Albatross DMPA	• Employment restricted to onboard dredge vessel crew (TSHD Brisbane = 13 crew for five weeks).
Albatross West	• Employment restricted to onboard dredge vessel crew (TSHD Brisbane = 13 crew for 6.8 weeks).
Albatross South (Weipa)	• Employment restricted to onboard dredge vessel crew (TSHD Brisbane = 13 crew for 5.3 weeks).

The raw FTE results are:

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Local					8.35	0.15
National	1.31	1.71	1.34	1.31	1.31	1.31
Total	**1.31**	**1.71**	**1.34**	**1.31**	**9.65**	**1.46**

When the local and national weightings are applied the FTE results are:

	Albatross DMPA	Albatross West	Albatross South	Weipa Onshore	Weipa Reclamation	Beach Nourishment
Local				2.50	8.35	0.15
National	0.65	0.85	0.67	0.65	0.65	0.65
Total	**0.65**	**0.85**	**0.67**	**3.15**	**9.00**	**0.81**