The Sustainable Sediment Management story at the Port of Weipa

NORTH QUEENSLAND BULK PORTS

PORT OF WEIPA

What is sustainable sediment management (SSM)

From 2015 to 2017, North Queensland Bulk Ports (NQBP) undertook an extensive research project to investigate the most sustainable way to manage accumulated sediment in and around the Port of Hay Point. The result was a robust and transparent method to define sediment placement options that can be used across our ports.

Why is sustainable sediment management important?

Left unmanaged, natural sediment fills up port navigational infrastructure, impacting the depth necessary for safe loading, manoeuvring and transit of ships. A reduced ability to effectively load ships can have a substantial economic impact on the region that the port supports.

How our approach is different

A lot of previous sediment management research has focused on whether the sediment is clean of contaminants and where it can be safely placed.

Our sustainable sediment management study looked at this too, but also examined how and why sediment accumulates, and explored ways to reduce the build-up in navigational areas in the first place.

Additionally, we took steps to evaluate potential reuse of marine sediments. For each potential reuse or relocation option, we sought to demonstrate how environmental risks, human health, economics, and future challenges have been considered.

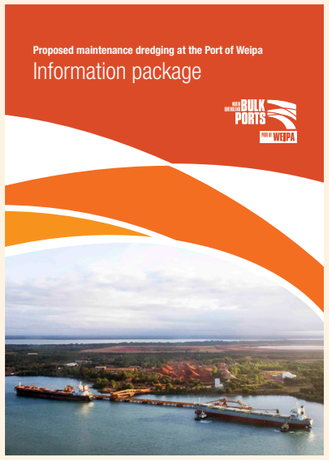
SSM at the Port of Weipa

In 2018-19, NQBP replicated its SSM research methodology at the Port of Weipa.

We worked with environmental scientists, consultants and technical experts to produce a series of reports that investigate conditions at and around Albatross Bay, on the north-west coast of the Cape York Peninsula.

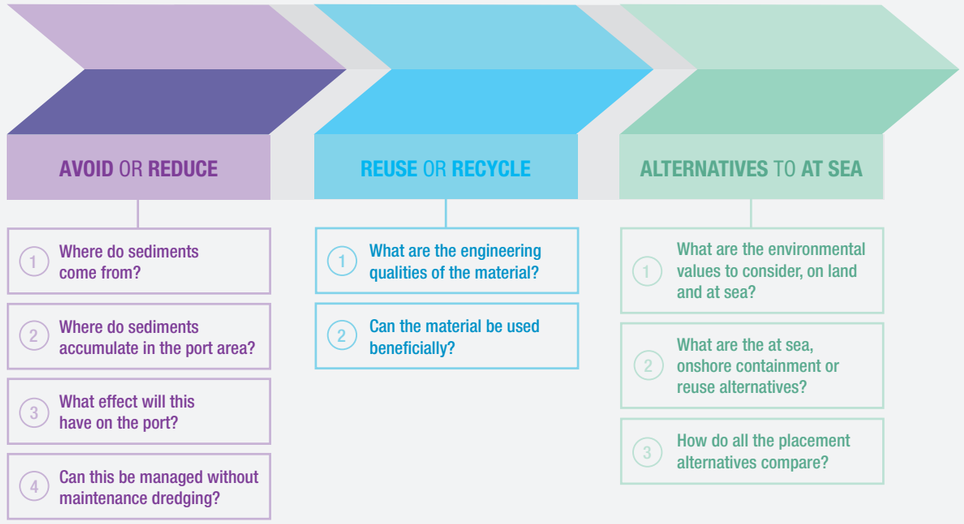
This document presents key findings from these reports. For details about maintenance dredging at Weipa, refer to our information package.

Download via www.nqbp.com.au



How we do it

Our methodology in action



- First, we ask, can sedimentation be managed at the port to **avoid or reduce** the need for maintenance dredging?
- If maintenance dredging must occur, we undertake a comprehensive assessment of whether material can be beneficially **reused or recycled.**
- If no beneficial reuse options are available we determine the most suitable and feasible placement option including **alternatives to at sea** placement.

About the Port of Weipa

North Queensland Bulk Ports manages the Port of Weipa, in the Gulf of Carpentaria on the north-west coast of the Cape York Peninsula.

Bauxite exports comprise more than 95% of the port's trade. Fuel and cargo are also imported to support mining operations and other trading activities.

The port is within Albatross Bay, a large embayment, with the wharves and berths located in the Embley River. It has approximately 622 hectares of channels, swing basins and berths, where depths are maintained by maintenance dredging.

The port consists of:

- A main shipping channel in Albatross Bay called South Channel
- An Inner Harbour, within the Embley River, which consists of the Approach and Departure Channels, as well as four shipping berths:
    - Lorim Point East
    - Lorim Point West
    - Humbug Wharf
    - Evans Landing.

AVOID OR **REDUCE**

1. Where do sediments come from?
2. Where do sediments accumulate in the port area?
3. What effect will this have on the port?
4. Can this be managed without maintenance dredging?

Where do sediments come from?

There are two main sources -

WAVE ACTION

Wave action is the dominant process resulting in sedimentation within the navigational areas at the Port of Weipa. 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.

TIDAL CURRENTS

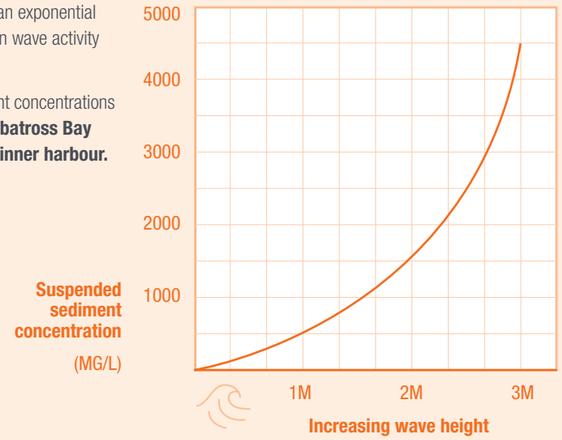
Tidal currents also appear to be an important driver of sediment by bed load or localised resuspension which can in turn result in localised accretion within the channel.

SEDIMENT SUSPENSION

We studied the relationship between **wave activity and turbidity** (water clarity) to better understand how sediment is suspended.

The results show an exponential relationship between wave activity and turbidity.

Suspended sediment concentrations were **highest in Albatross Bay** and **lowest in the inner harbour.**



99%
OF SEDIMENT
is **resuspended** from within Albatross Bay

1%
OF RESUSPENDED SEDIMENT
is **new** from cliff erosion and river discharges

10,000,000
TONNES / YEAR
of **suspended sediment** is transported back and forth past the South Channel

2-3%
OF THIS SEDIMENT
is **deposited within the navigation channel**

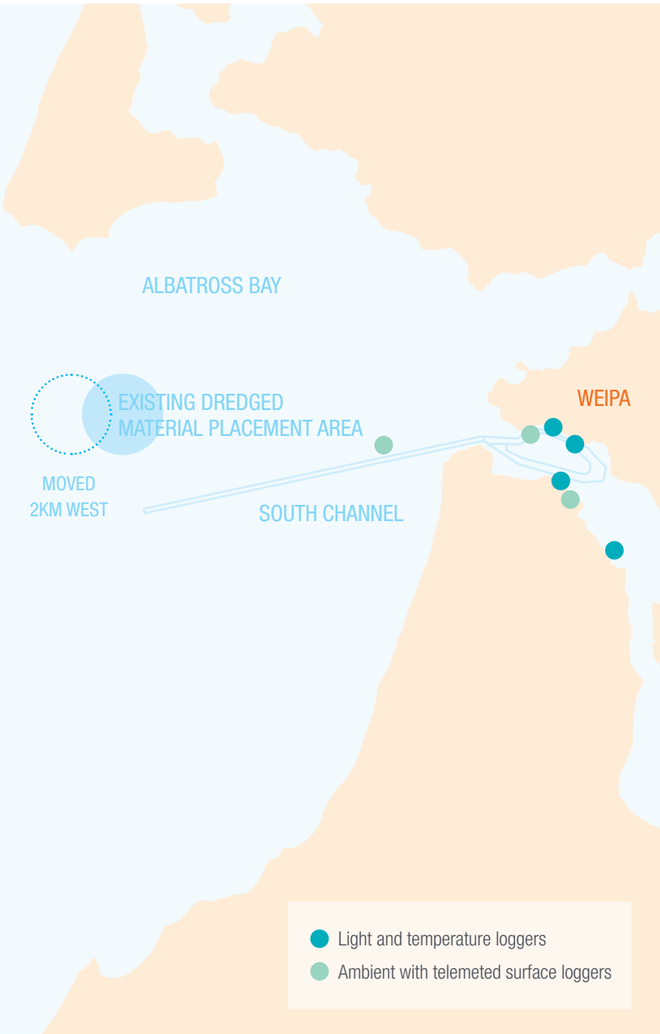
OVERALL

The **sediment budget** at the Port of Weipa local region is **generally balanced**

Suspended sediment is typically transported north and south along the open coastline

OR

East and west (onshore and offshore within Albatross Bay and the adjoining estuaries)



Resuspended sediments were studied on a regional scale at Albatross Bay.

45,000,000
TONNES / YEAR
resuspended during a **typical** year

70,000,000
TONNES / YEAR
resuspended during a **cyclonic** year

Annual resuspension in Albatross Bay is high and comparable to the Port of Cairns and

4X
MORE TURBID THAN PORTS OF

- MACKAY
- HAY POINT
- TOWNSVILLE

AVOID OR **REDUCE**

Where do sediments accumulate in the port area?

AND AT WHAT VOLUMES AND RATES?

Sedimentation volumes are directly correlated to the number of hours the significant wave height exceeds **2 metres.**

WEATHER AND SEDIMENT

Sedimentation typically occurs over the wet seasons (October-April) with rates depending on wave energy in that year. Typically we see volumes range between -

LOW		HIGH
1,100M³	per day	3,300M³
200,000M³	per year	600,000M³

WEATHER EVENTS

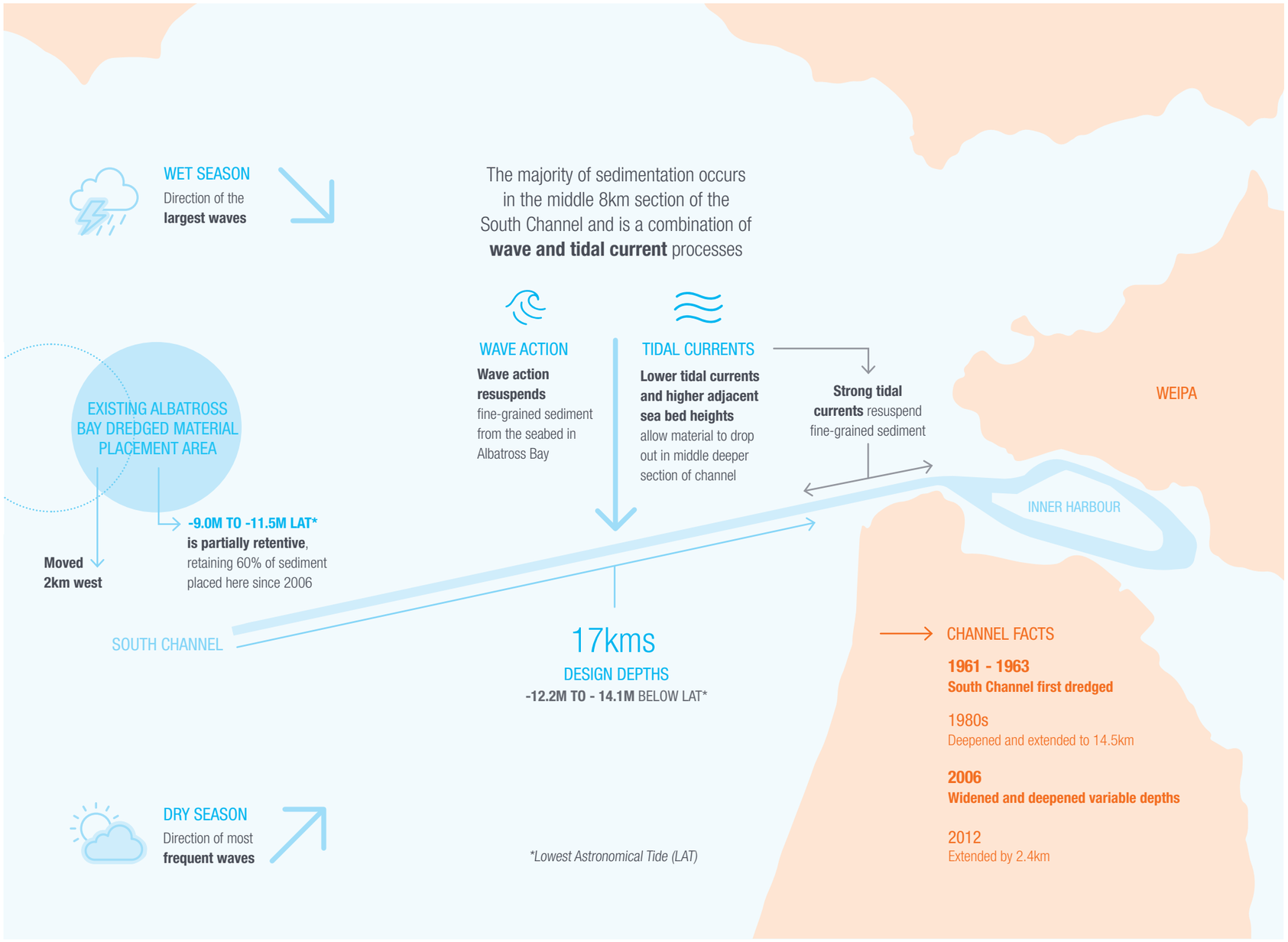
In addition to the wet and dry seasons influencing the direction, size and frequency of waves, **weather events like cyclones** also impact sediment volumes and movements.

FOR EXAMPLE -

In the **2018/19 wet season** there were two tropical cyclones (TC Owen and TC Penny) and a monsoonal low resulting in sediment infill of approximately

2,400,000m³

UNDERSTANDING SEDIMENT ACCUMULATION IN WEIPA



AVOID OR **REDUCE**

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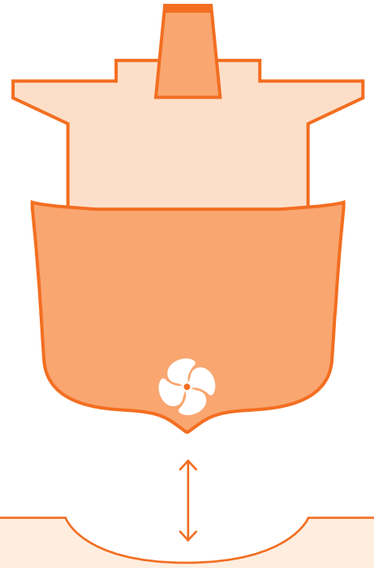
What effect will this have on the port?

ECONOMIC AND SOCIAL IMPACTS

The maintenance of navigational depths at ports is essential for an economy like Australia to bulk trade its goods efficiently.

As part of the Sustainable Sediment Management process, and to assist in evaluating various options, NQBP sought **an independent analysis of the economic impacts** if maintenance dredging were not to occur.



MODELLING

The report was modelled on two probable predictive sedimentation model scenarios with various year types.

Both scenarios included 'normal' and 'cyclonic' years. A **cyclonic year** is defined by a single cyclone event.

SCENARIO 1

One 'worst case' year is included in **Year 9 of the 16 year** assessment.

SCENARIO 2

Two 'worst case' years were modelled in **Year 3 and Year 9** assessment.

MODELLED OVER 16 YEAR PERIOD

WORST CASE YEAR

A 'worst case' year occurred in the **2018/19 wet season** when there were **two tropical cyclones (TC Owen and TC Penny)** and a monsoonal low resulting in large volumes of sediment infill.

In both scenarios, the analysis shows that a maximum reduced channel declared **depth loss from -11.7m to -6.5m** after 9 years of the 16 year assessment would lead to a loss of export volumes.

120.7

MILLION TONNES OF EXPORT VOLUMES IN SCENARIO 1

136.1

MILLION TONNES OF EXPORT VOLUMES IN SCENARIO 2

Local, regional and national economic impacts were explored with both direct and indirect effects identified.

REDUCED CAPACITY

Export capacity of the terminals will be decreased resulting in reduced export earnings.

Flow-on, indirect negative impacts on other industries, particularly bauxite supply chain industries will be experienced. The indirect impacts will flow through to the broader region and Queensland economies as the income losses by residents affect their spending on goods and services.

LOSS OF JOBS

Full time employment (FTE) levels across Far North Queensland will decrease due to a decline in economic activity in the region.

ROYALTY REVENUE

If no maintenance dredging occurs at the Port of Weipa, bauxite royalty revenue will fall.

AVOID OR **REDUCE**

1. Where do sediments come from?
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A constraints analysis was undertaken to assess each option

Can sedimentation be managed without dredging?

As part of our assessment we explored possible solutions, outside of maintenance dredging, to manage sediment in our port infrastructure areas including:

KEEPING SEDIMENT OUT — OR → KEEPING SEDIMENT MOVING — OR → KEEPING SEDIMENT NAVIGABLE

Both engineered and technological solutions were identified to possibly avoid or reduce future maintenance dredging and their feasibility considered based on the Weipa environment, port layouts and infrastructure design.

	Reduction strategy	Example
KEEPING SEDIMENT OUT	Stablise sediment sources	Reduce sediment input through better catchment management
	Diverting sediment-laden flows	Diverting river sediment inputs away from port
	Trapping sediment before it enters port	Sediment traps, insurance trenches and sediment bypass systems
	Blocking sediment entry	Pneumatic barrier, silt screen, barrier curtain
	Habitat creation	Seagrass, saltmarsh, mangroves to stabilse sediment/ promote accretion
KEEPING SEDIMENT MOVING	Structural solutions to train natural flows	Training walls/dikes to divert flow and prevent local deposition of sediment
	Devices to increase bed shear stresses	Hydraulic jets, vortex foil arrays, mechanical agitators
	Methods to reduce sediment flocculation	Adopting designs that reduce turbulence and therefore flocculation
KEEPING SEDIMENT NAVIGABLE	Adopt a 'nautical depth' navigation approach which includes fluid mud	Nautical depth is the distance from the water surface to a given wet density, typically in the range of 1100 to 1300 kg/m3

ON AVERAGE

95% of annual sedimentation

in the Port of Weipa dredged areas occurs within the South Channel

Due to the differences in sedimentation rates and coastal processes between the South Channel and Inner Harbour, each area was assessed separately. **We looked at:**

- ENVIRONMENTAL IMPACTS
- ONGOING MAINTENANCE
- LEGISLATIVE REQUIREMENTS
- OPERATIONAL IMPACTS
- EFFECTIVENESS OF SOLUTION
- COST
- GREENHOUSE GAS EMISSIONS

Here's what we found

						$	Co2e
SOUTH CHANNEL							
Maintenance Dredging	Low	Low	No*	High	Low	$79.7M	52,000
Sustainable Relocation	Low	Low	No*	Moderate/High	Medium/High	$74.7M	48,410
INNER HARBOUR							
Maintenance Dredging	Low	Low	No*	High	Low	$8.1M	4,210
Sustainable Relocation	Low	Low	No	Moderate/High	Medium/High	$6.3M	2,910
Drag Barring	Low	Low	No*	Low/Moderate	Low	$6.5M	4,460

FINDING

Due to the processes that 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 that could significantly reduce the natural sedimentation at the Port of Weipa.

FOOTNOTE

*No ongoing 'NQBP' maintenance would be required as dredging and drag barring vessel would be contracted from external parties

AVOID OR **REDUCE**

1

Following the sediment analysis, maintenance dredging was deemed necessary to maintain effective port operations.

REUSE OR **RECYCLE**

2

With the sediment analysis complete, we explored alternative options for the use or placement of sediment material.

REUSE OR **RECYCLE**

1. What are the engineering qualities of the material?
2. Can the material be used beneficially?

What are the engineering qualities of the material?

AND CAN THE MATERIAL BE USED BENEFICIALLY?

At the Port of Weipa sediment to be dredged consists of **fine grained** (silt/clay) and **coarse** material (sand/gravel).

FINE GRAINED
80%
silt + clay

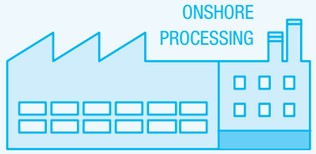
COARSE
20%
sand + gravel

ASSESSMENT

Once sediment properties are known, we identify potential beneficial reuse options.

FINE GRAINED

The **strength, plasticity, density and consolidation of fine grained sediment** means it's generally unsuitable for engineering applications.

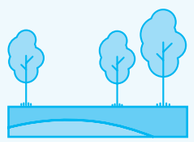


Significant onshore processing and treatment would be required to improve its suitability.

For this reason, fine grained sediments are more suitable to habitat creation options and potentially for reuse in shoreline protection if placed in geotextile bags.

COARSE

Coarse sediment, such as sand, is typically **more suitable for reuse in medium to high-load:**



LAND RECLAMATION

BEACH NOURISHMENT

CONCRETE MANUFACTURE

? WHAT ARE THE BENEFICIAL REUSE OPTIONS FOR THE **2** MATERIALS

HOW WE ASSESS

All beneficial reuse opportunities are analysed by a multidisciplinary team using the below criteria.

11 beneficial reuse options were identified by the team across three categories.

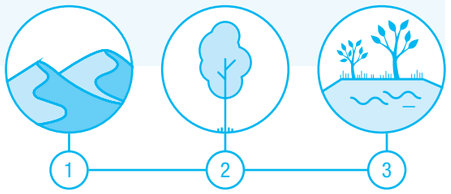
CRITERIA

- Sediment suitability (Sed Suit.)
- **Demand for the opportunity (Opp.)**
- Conceptual cost estimate (Cost)
- **Confidence in reuse process (Process)**
- Duration from construction use (Dur.)
- **Greenhouse gas emissions (GHGs)**
- Environmental implications (Enviro.)
- **Socio-economic implications (Social)**
- Indigenous community implications (Indig.)
- **Economic implications (Econ.)**
- Environmental approvals and permits (Approv.)
- **Constraints (Constr.)**
- Knowledge gaps requiring research (KGaps.)
- **Longevity and future considerations (Future)**

RECYCLE
ENGINEERING MATERIAL
Land reclamation
Construction
Road base
Lining material
Concrete products
Shoreline protection
Beach nourishment

REUSE
ENVIRONMENTAL ENHANCEMENT
Coastal (tidal) habitat creating including **direct and indirect** placement

REUSE
AGRICULTURAL APPLICATION
Topsoil



RANKING PERFORMANCE

Beach nourishment, land reclamation and shoreline protection were ranked the top three most beneficial opportunities.

1. BEACH NOURISHMENT

Sed Suit	Process	Cost	Enviro	Social	Opp	Cost	GHGs	Indig	Approv	Constr	Econ	KGaps	Future

2. LAND RECLAMATION

Process	Social	Econ	Constr	KGaps	Opp	Sed Suit	Enviro	Indig	Approv	Cost	Dur	GHGs	Future

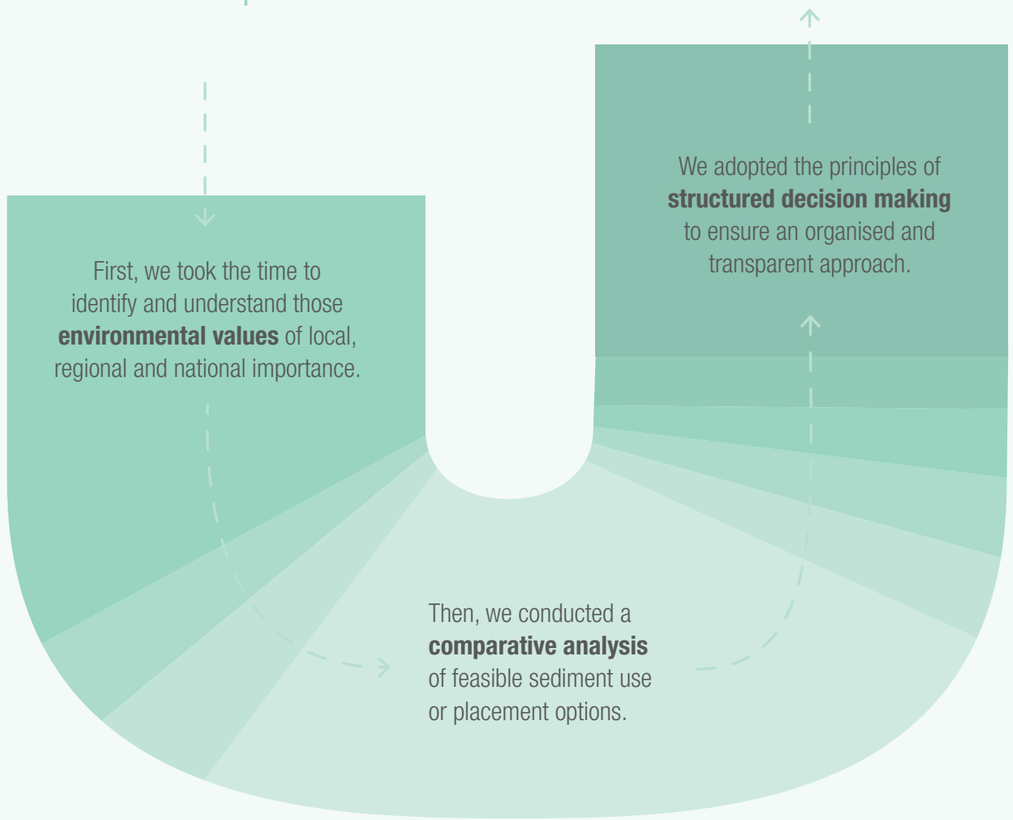
3. SHORELINE PROTECTION

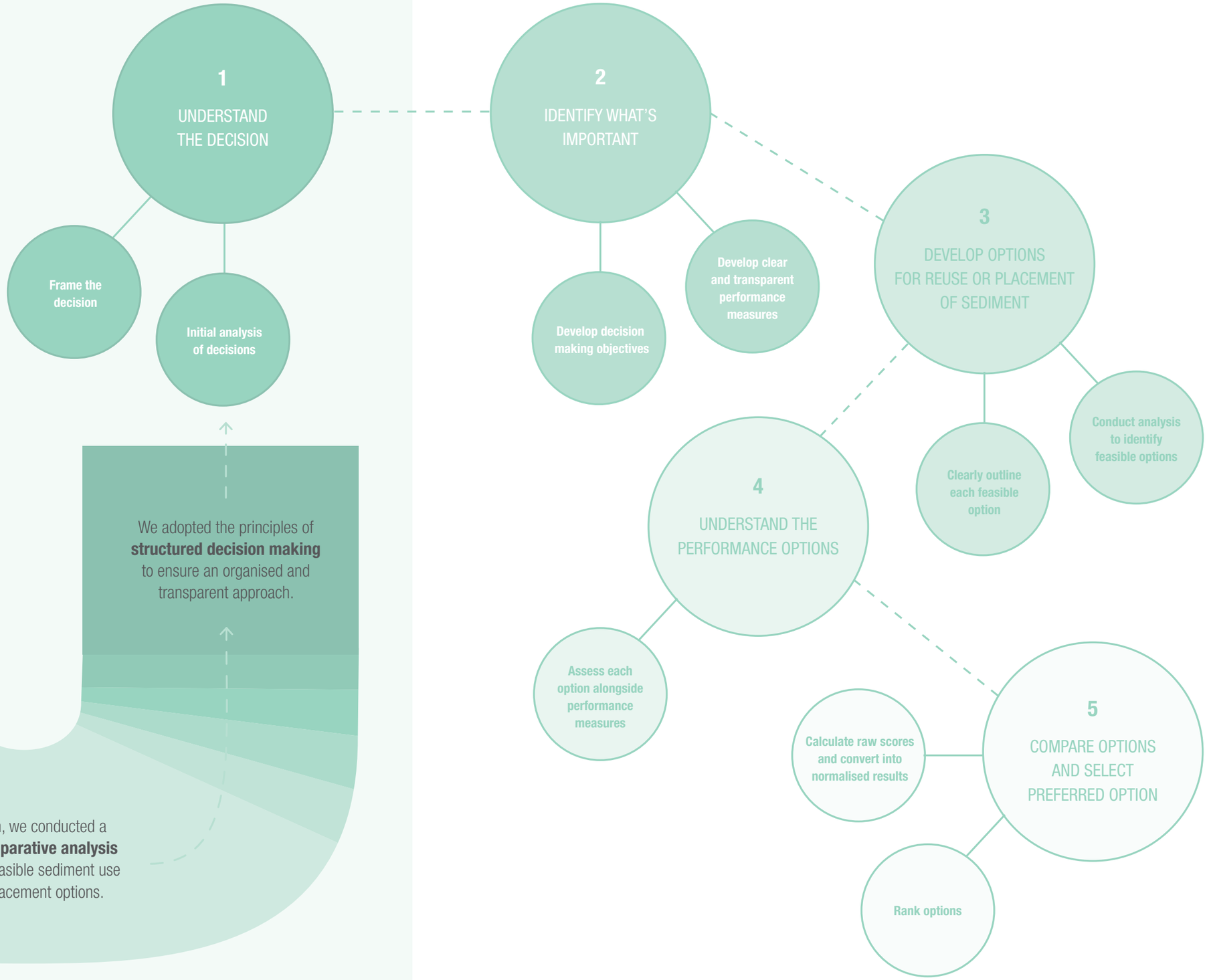
Sed Suit	Cost	Process	Dur	Opp	Enviro	Social	Indig	Econ	Approv	Constr	KGaps	GHCs	Future

HIGH ← MODERATE — LOW

3

A comparative analysis explored alternative options for the use or placement of sediment material. The analysis draws on existing research and independent technical reports.





What are the environmental values to consider

ON LAND AND AT SEA?

The environmental values assessment evaluated what was considered to be important for Weipa across **four headline categories.**

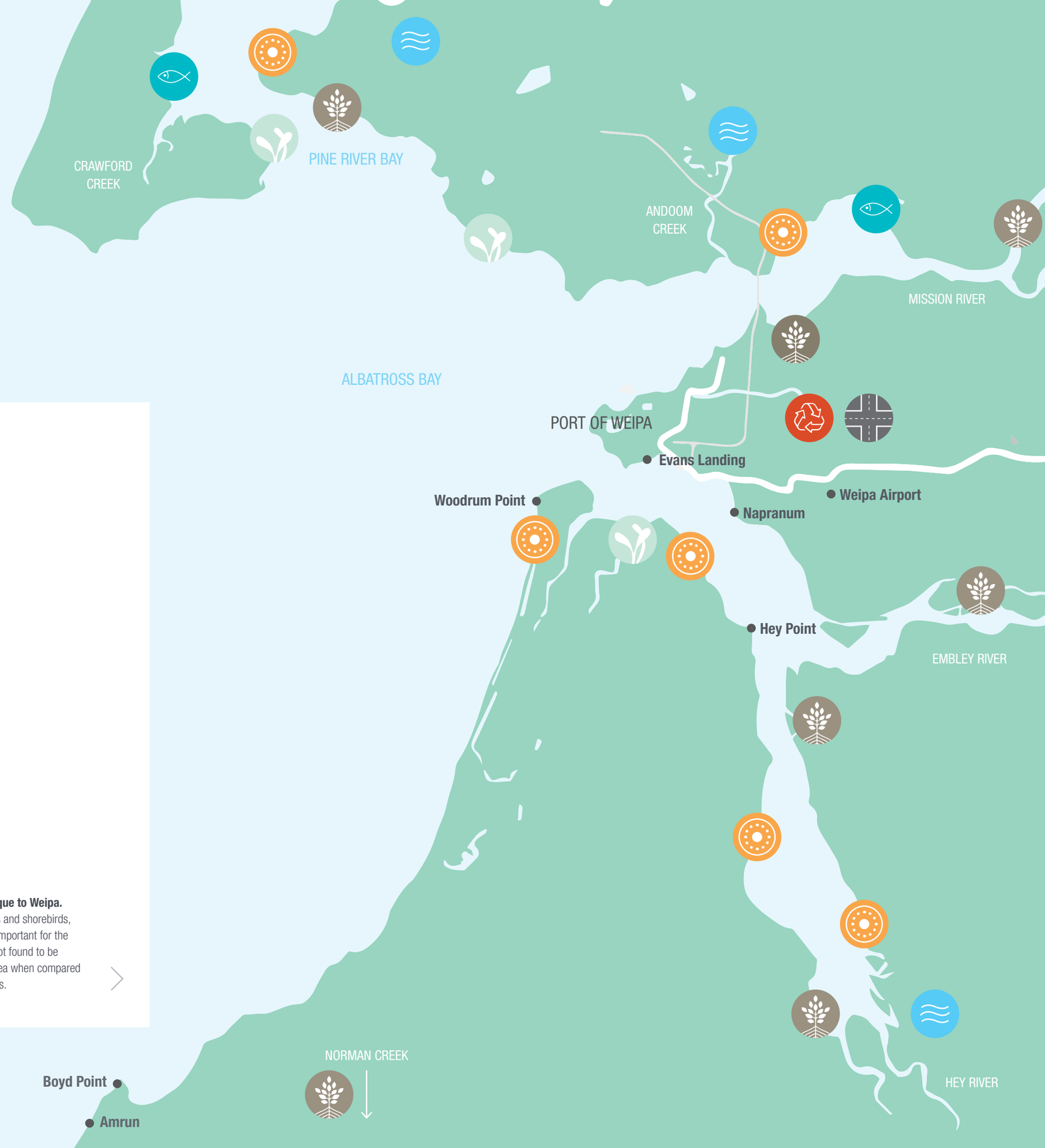
HEADLINE CATEGORIES

- SOCIAL
- AQUATIC ECOSYSTEMS
- LANDFORM AND BIOTA
- AIR QUALITY

Using robust methodologies the assessment explored how each value was considered important at a national, regional and local level. Data from field investigations and online portals, including government databases, were used to determine the specific values for the project:

- TRAFFIC MANAGEMENT
- SEAGRASS
- FISHERIES
- MANGROVES
- WASTE MANAGEMENT
- CATCHMENTS & STREAMS
- INDIGENOUS CULTURAL HERITAGE

These values are unique to Weipa. Some values, like corals and shorebirds, were recognised to be important for the region, however were not found to be unique to the project area when compared with surrounding regions.



ALTERNATIVES TO AT SEA

1. What are the environmental values to consider, on land and at sea?
2. What are the at sea, onshore containment or reuse alternatives?
3. How do all the placement alternatives compare?

What are the at sea, onshore containment or reuse alternatives?

AND HOW DO THEY COMPARE?

As part of the **structured decision making** framework, the following values were identified by stakeholders as relevant and important to the local area and region.

A workshop was held with the Weipa Technical Advisory and Consultative Committee (TACC) and additional conversations had with traditional owners and government stakeholders. From this, nine objectives and 11 performance measures were established.

ENVIRONMENT | CULTURAL HERITAGE | PORT OPERATIONS | COST | HEALTH & SAFETY | SOCIAL

THEME	OBJECTIVE	MEASURE
	Avoid and minimise impacts to coastal ecosystems	Predicted performance in relation to avoidance and minimisation of impacts to coastal ecosystems
		Predicted risk on dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient)
	Minimise carbon emissions	Forecast Greenhouse gas emissions
	Minimise impact on cultural heritage	Nature and scale of any impact on cultural heritage
	Maintain effective and efficient port operations	Predicted lead time to dredge material placement
		Capacity to provide a long term solution for the port
	Avoid a loss of future port expansion opportunities	Predicted performance in terms of facilitating or constraining future port expansion
	Ensure solution is cost effective	Assessment of costs
	Avoid or mitigate health and safety risks	Relative risk
	Minimise interference to social activities	Scale and duration of any impacts on social activities
	Provide increased economic and social opportunities	Predicted number of full-time equivalent 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.*

6 discrete alternative options for reuse and placement were identified across four categories (at sea, onshore, land reclamation and beach nourishment) and an analysis of the performance of these options found:

READING THE DATA

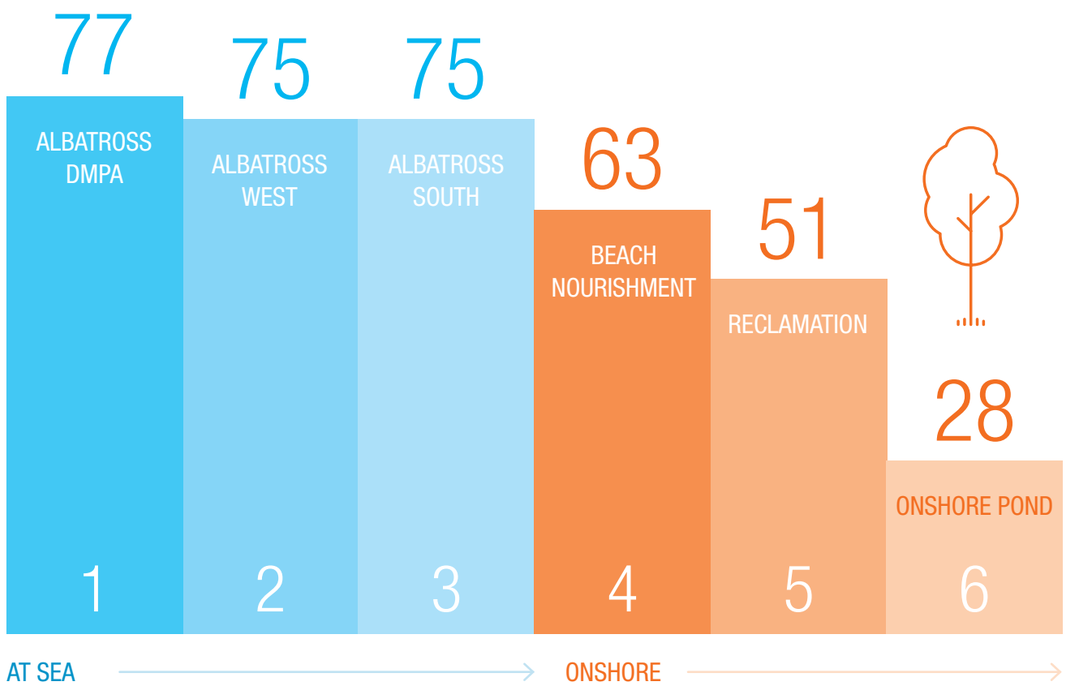
This table summarises the **weighted scores** (max 100) for each option across the six weighting scenarios. For the 'Equal' weighting column all performance measures were compared on an equal weighting.

For the five other weighting columns, **a 75%** weighting was given to performance measures in a particular theme/value, i.e. the 'Environment' weighting gave a 75% weighting for the environment performance measures (coastal ecosystems, dredge plumes/tailwater discharge and greenhouse gas emissions).

	EQUAL						
At sea (Albatross DMPA)	77.00	79.92	84.96	93.80	84.74	46.81	84.74
At sea (Albatross West)	75.00	75.58	84.17	85.06	84.11	46.95	84.11
At sea (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

COMPARING OVERALL PERFORMANCE SCORES

Offshore placement at the existing Dredged Material Placement Area (DMPA) consistently performed the best. It was the strongest of the three best performers and on balance, 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.



ALTERNATIVES TO **AT SEA**

1. What are the environmental values to consider, on land and at sea?
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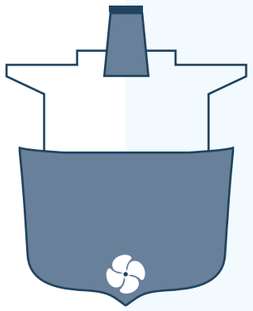
A closer look at the preferred solution

AT SEA

At sea placement at the existing or newly identified DMPA is necessary to deal with both the immediate maintenance dredging needs at the Port as well as the long term volumes over 10 years.



For the comparative analysis the existing Albatross Dredge Material Placement Area (DMPA) has been shifted 2-kilometres west into deeper water.

This is to assist with:

MAINTAINING A SAFE UNDER KEEL CLEARANCE

Sufficient depth (or under keel clearance) if a larger hopper dredger is required (such as in 2019) must be maintained.

PROVIDING SUFFICIENT CAPACITY

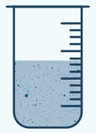
For placement of future dredged material for the next 10 years.

ENVIRONMENTAL ASSESSMENT

The benthic infauna at the proposed new 'shifted' DMPA is well known as benthic samples have been collected, and analysed at

1km + 2km

outside of the current DMPA



SEDIMENT VOLUMES IN CONTEXT

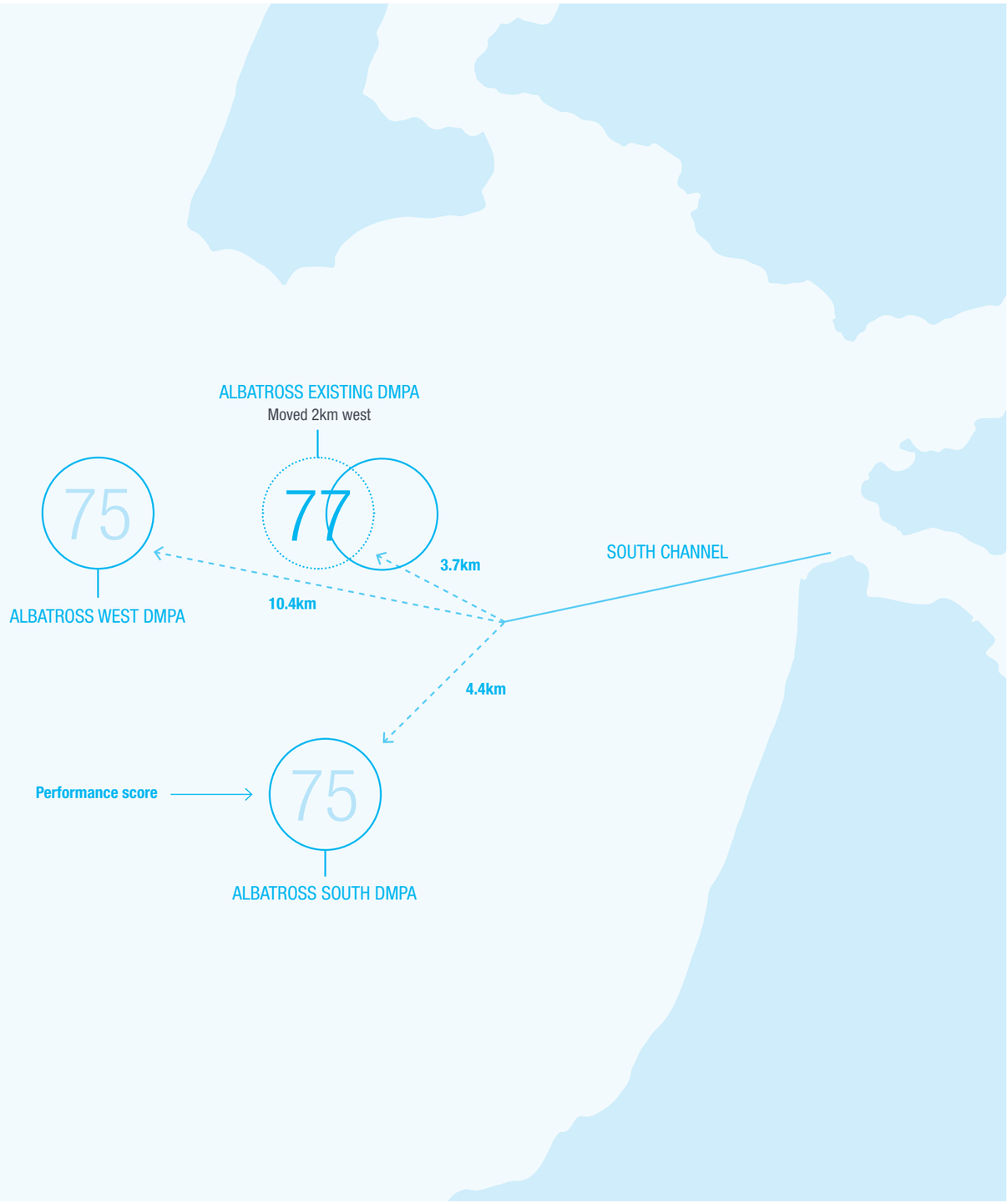
Performance measures were calculated to accommodate the following dredge volumes over a 10 year period (based on annual requirements, historical data and taking into account cyclonic weather events):

Standard volume
400,000M^3 - removed 5 out of every 10 years

Large volume
800,000M^3 - removed 3 out of every 10 years

Worst case volume
2,500,000M^3 - removed 2 out of every 10 years

Including 15% contingency, the 10 year volume may be in the order of 10,810,000M^3



A closer look at alternative solutions

ONSHORE

A combined at sea and onshore option may warrant further exploration in the future

BEACH NOURISHMENT AT GONBUNG POINT

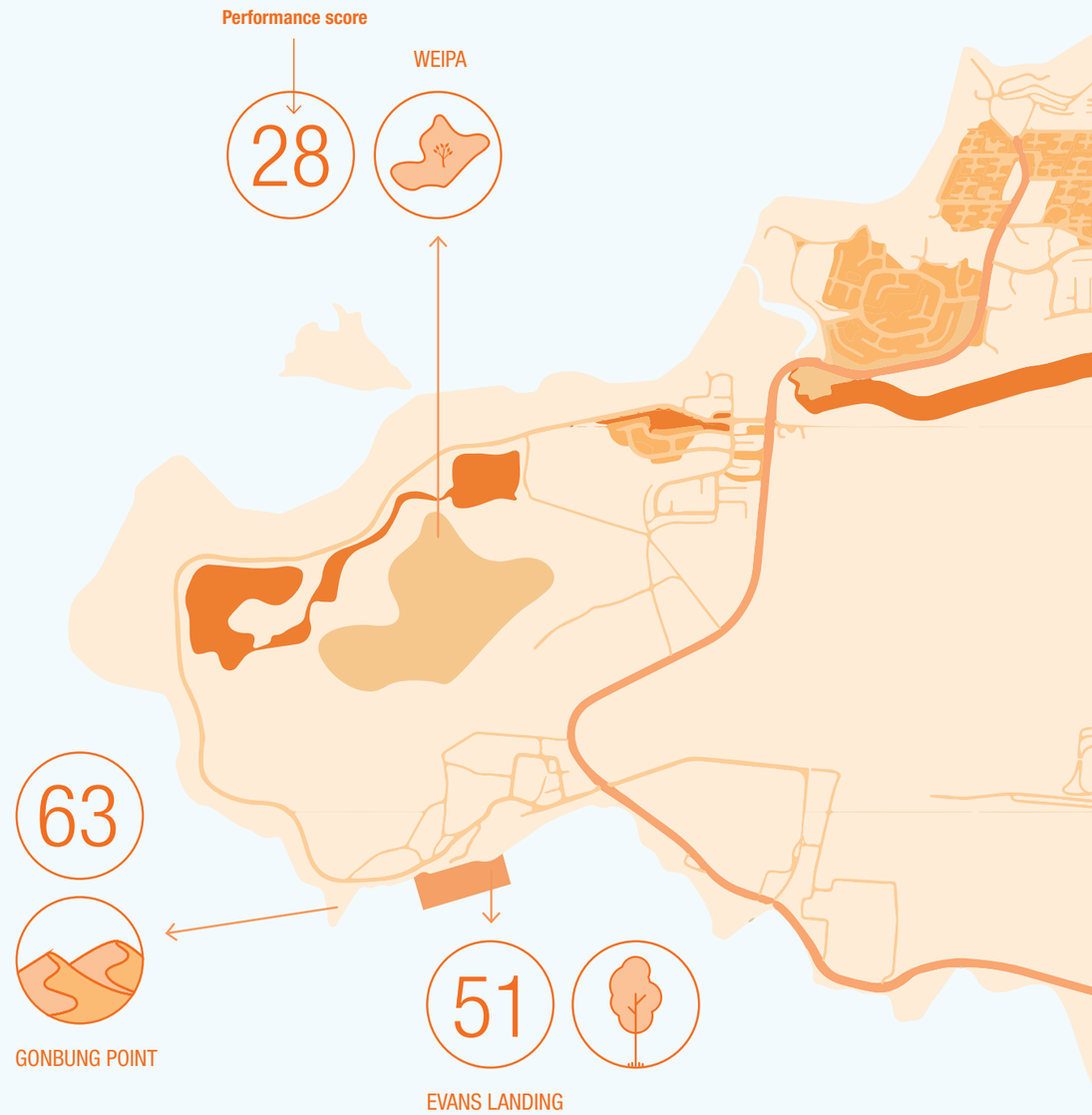
Beach nourishment has some merit particularly from an environmental and social aspect. This option would be worth examining in more detail as part of a combined solution with an offshore placement option. This option, however, is heavily constrained by demand and may only have a single or limited application.

RECLAMATION AT EVANS LANDING

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.

ONSHORE POND AT WEIPA

Onshore placement at the Port of Weipa was the worst performing single option and does not warrant future consideration. The available land, suitable for use, is limited and does not have the capacity to contain the sediment volumes over the 10 year period.



NORTH QUEENSLAND BULK PORTS CORPORATION

Mackay Office
Level 1, Waterfront Place,
Mulherin Drive
Mackay Harbour, QLD 4740
PO Box 3340,
North Mackay, QLD 4740
Phone: 07 4969 0700

Brisbane Office
Level 4, 175 Eagle Street
Brisbane, QLD 4000
GPO Box 409, Brisbane, QLD 4001
Phone: 07 3011 7900

Phone: 1300 129 255
Email: info@nqbp.com.au
Website: nqbp.com.au