

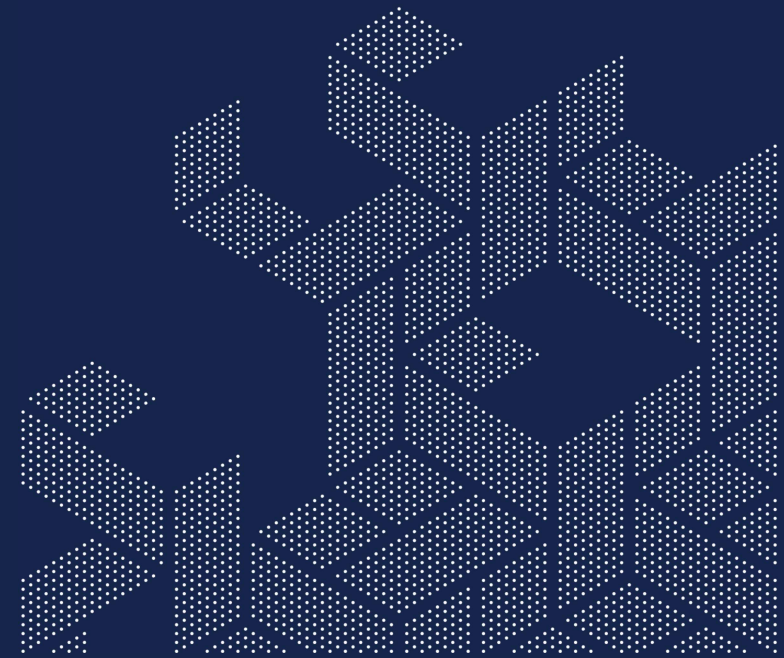
## Sustainable Marine Infrastructure Design and Construction

Luke Campbell  
PIANC APAC 24 - Sydney

**WGA**

We dare to be different

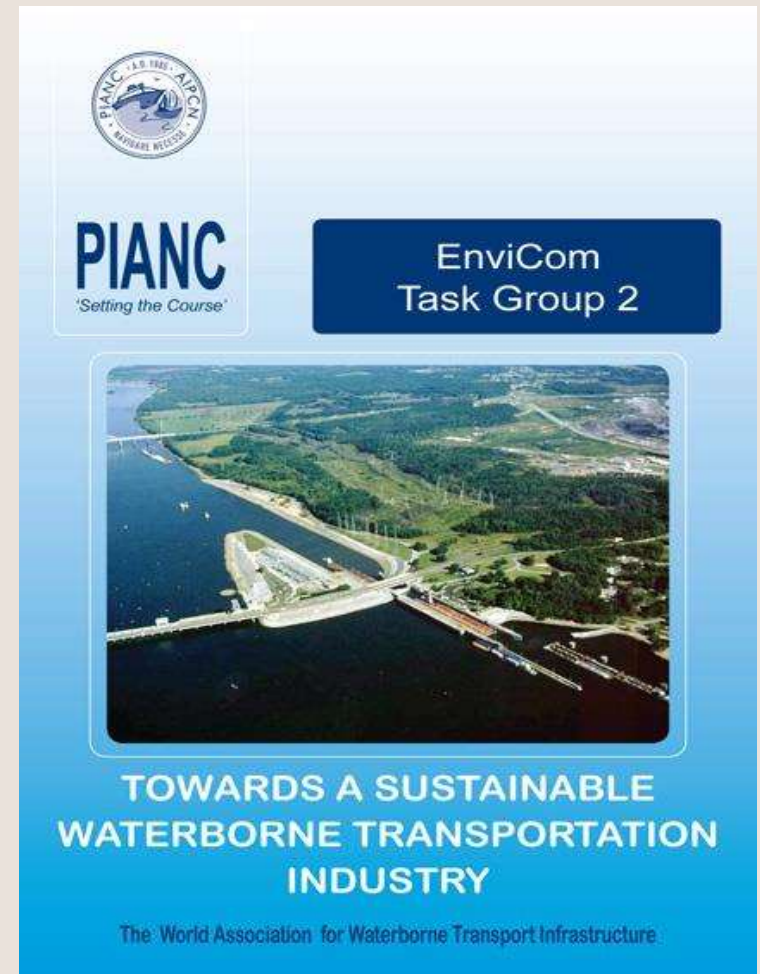
# **What is Sustainable Marine Infrastructure?**



## What is Sustainable Marine Infrastructure

### PIANC: EnviCom 2011

Targeted at non-technical stakeholders, such as shippers, policymakers and non-governmental organisations who have an interest in the choices to be made as the global transportation system evolves – not so relevant for the design of marine infrastructure specifically.





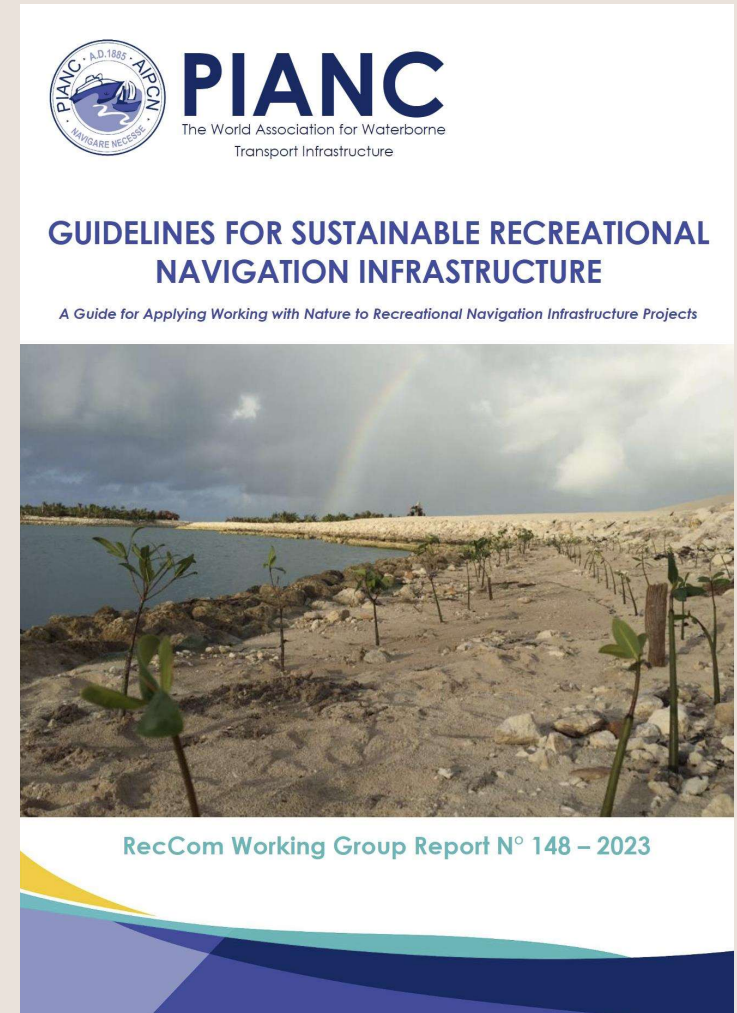
## What is Sustainable Marine Infrastructure

### PIANC: RecCom 148, 2023

I still need to digest the detail within this one.

Some great content, and certainly worth considering further.

I'm possibly using a more 'Marine Structures' definition of infrastructure.





# What is Sustainable Marine Infrastructure

## PIANC: RecCom 148, 2023

### In Practice, Most Common Approach:

- Preponderance of Economic
- Environmental is a Concern to “Manage”
- Regulatory Approach to Environmental Issues
- Limited Linkages / “Intersection” / Synergies

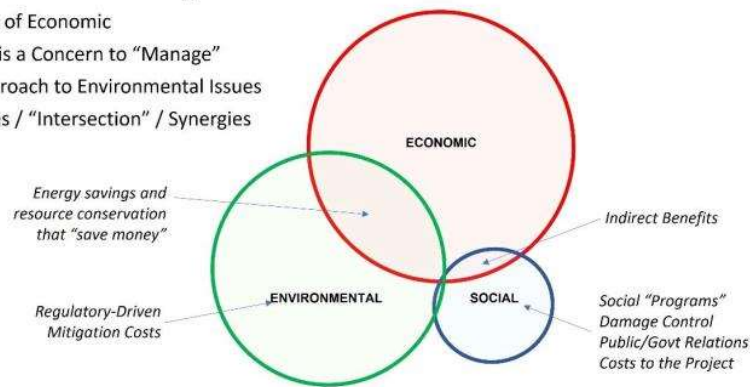


Figure 2.1: Sustainability planning approach practical challenges [Biondi, 2019b]

### New Paradigm

- Enhance Linkages
- Maximize the Intersection of the 3 Dimensions
- Seek More Balanced Outcomes
  - Proactive Environmental Design
  - Plan for Social Dimension
- Better / Smarter Design:
  - Work with Nature
  - Include Resiliency
  - Additional Value

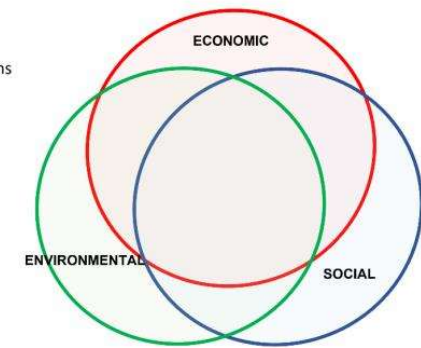
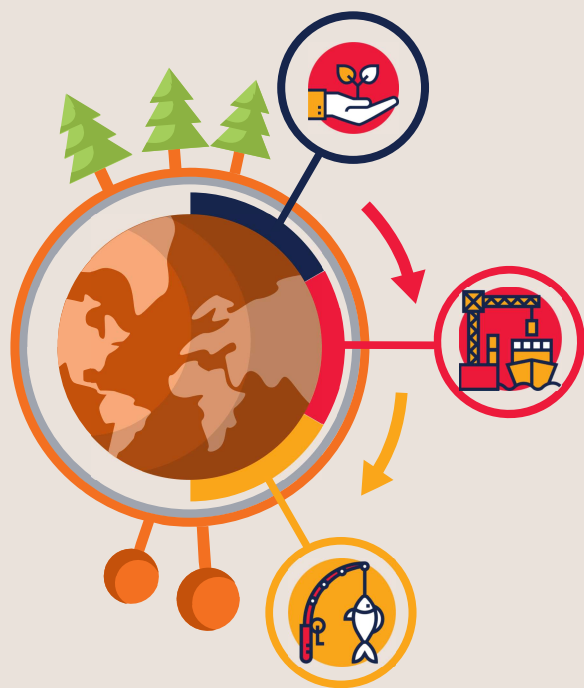


Figure 2.2: Sustainability planning approach new paradigm [Biondi, 2019b]

## What is Sustainable Marine Infrastructure

### Definition proposed by Infrastructure for 'sustainable infrastructure' (Infrastructure Australia)



- Sustainable infrastructure refers to the network and system, equipment and assets designed to meet the population's essential service needs, while adhering to sustainability principles. This results in infrastructure that is planned, designed, procured, constructed and operated to optimise social, economic, environmental and governance outcomes over an asset's life.
- Sustainable infrastructure protect's and preserves the ecological processes required to maintain human health, equity, diversity and the functioning of natural systems. It is not just about building new projects, but also about the rehabilitation, reuse or optimisation of existing infrastructure.
- Sustainable infrastructure enables economic development and the efficient use of financial resources, while enhancing quality-of-life and protecting natural resources. Sustainable infrastructure can reduce the life-cycle cost of infrastructure, while limiting negative effects on the environment.

# What is Sustainable Marine Infrastructure

## Maximise performance and minimise waste

### Three Key Themes



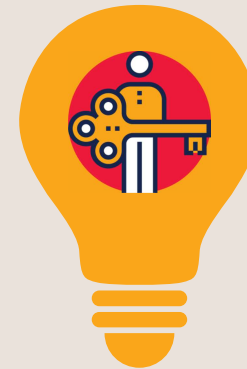
**One**

Good planning to optimise performance and outcomes over an asset's life.



**Two**

Re-use and optimisation of existing infrastructure.



**Three**

Value for money and maximum functionality.

A few examples for each  
Modest project size (\$\$\$ matter!)



## **Theme 1**

**Good planning to optimise performance  
and outcomes over an asset's life**



# What is Sustainable Marine Infrastructure

## Theme 1 - Good planning to optimise performance and outcomes over an asset's life

What future uses might be coming?

Do we even know?

How can we build additional capacity into the asset at minimal cost?

This is essentially future proofing.

Can we consider construction techniques that provide additional capacity at nominal (or perhaps no) additional cost?

What can we do with design so that further extensions of the design life will be relatively easy?

# What is Sustainable Marine Infrastructure

## 1.1 – Flinders Ports Outer Harbor Berth, SA

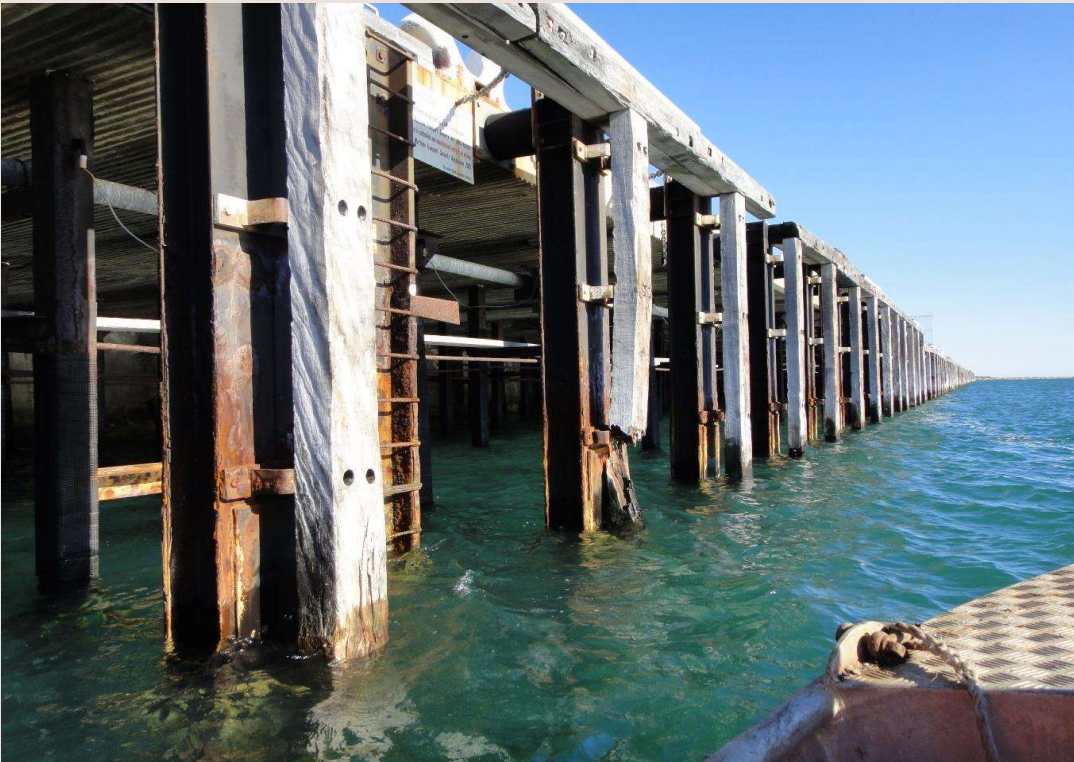


Theme 1- Good planning to optimise performance and outcomes of an asset's life

Outer Harbor – Berths 3 & 4



## What is Sustainable Marine Infrastructure Flinders Ports Outer Harbor Berth, SA

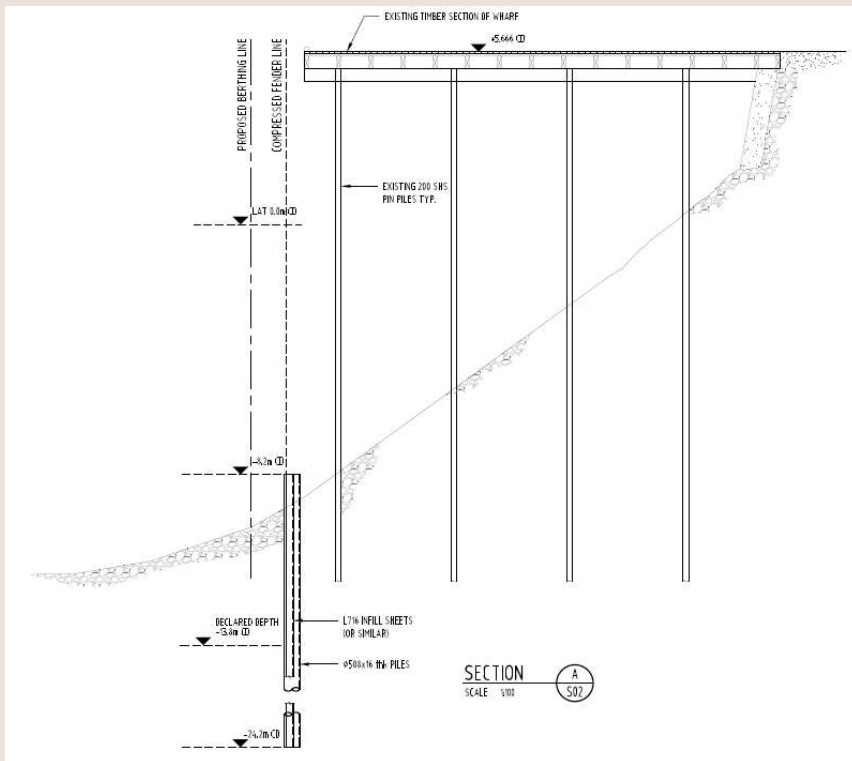


Theme 1- Good planning to optimise performance  
and outcomes of an asset's life

Original Wharf Structure

# What is Sustainable Marine Infrastructure

## Flinders Ports Outer Harbor Berth, SA

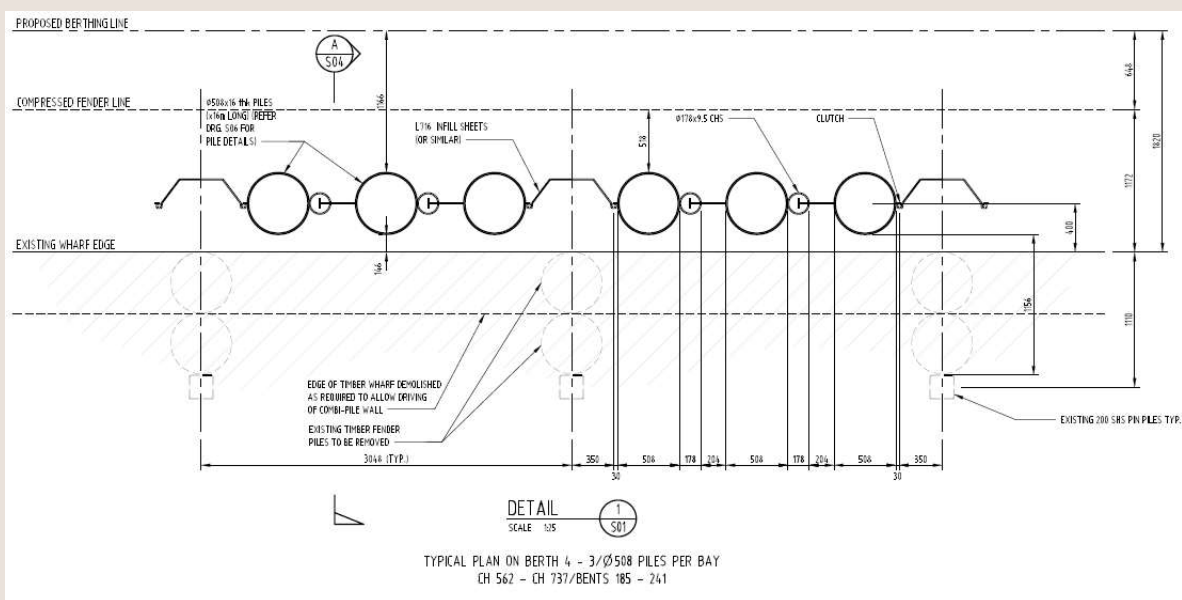


Theme 1- Good planning to optimise performance and outcomes of an asset's life

Wharf Arrangement

# What is Sustainable Marine Infrastructure

## Flinders Ports Outer Harbor Berth, SA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

Retaining Wall Detail



## What is Sustainable Marine Infrastructure Flinders Ports Outer Harbor Berth, SA



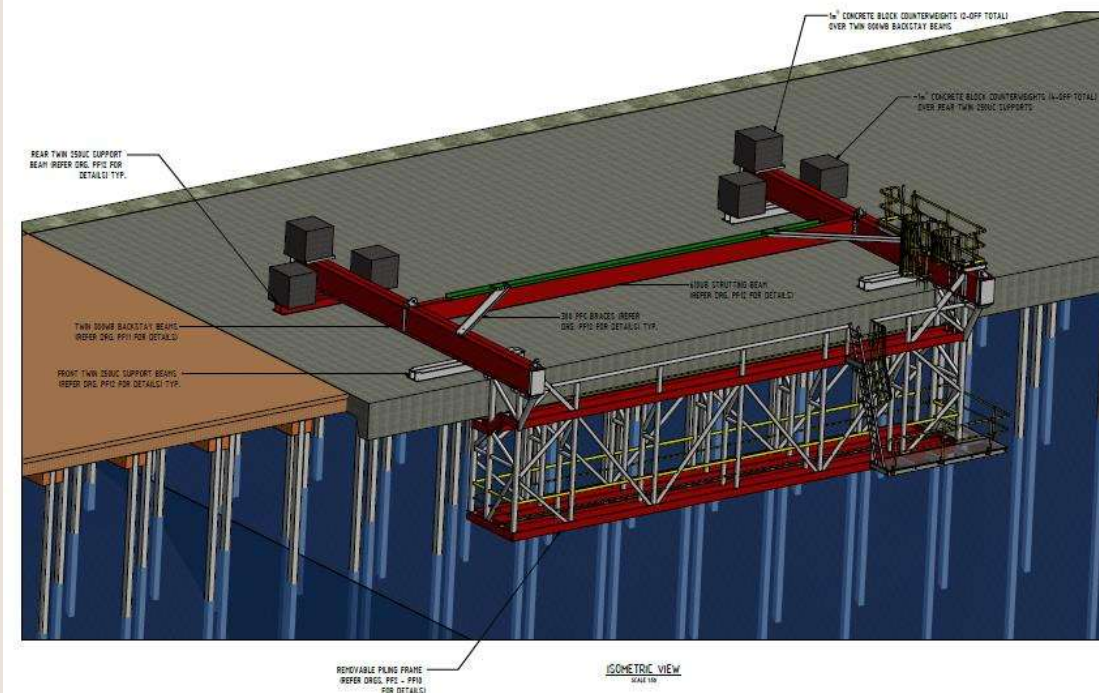
Theme 1- Good planning to optimise performance and outcomes of an asset's life

Pile Sections

# What is Sustainable Marine Infrastructure

## Flinders Ports Outer Harbor Berth, SA

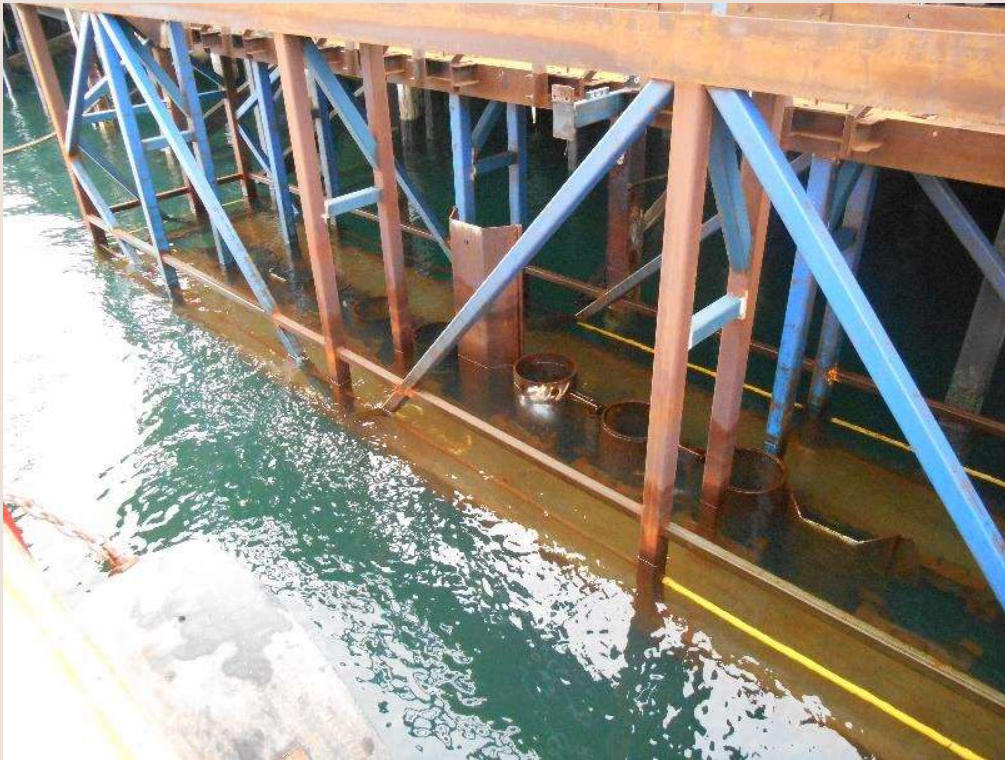
### OUTER HARBOUR - PILING FRAME FOR COMBI-PILE WALL



Theme 1- Good planning to optimise performance and outcomes of an asset's life

Piling Frame - Combi-Pile Wall

## What is Sustainable Marine Infrastructure Flinders Ports Outer Harbor Berth, SA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

Temporary Works – Pile Guide

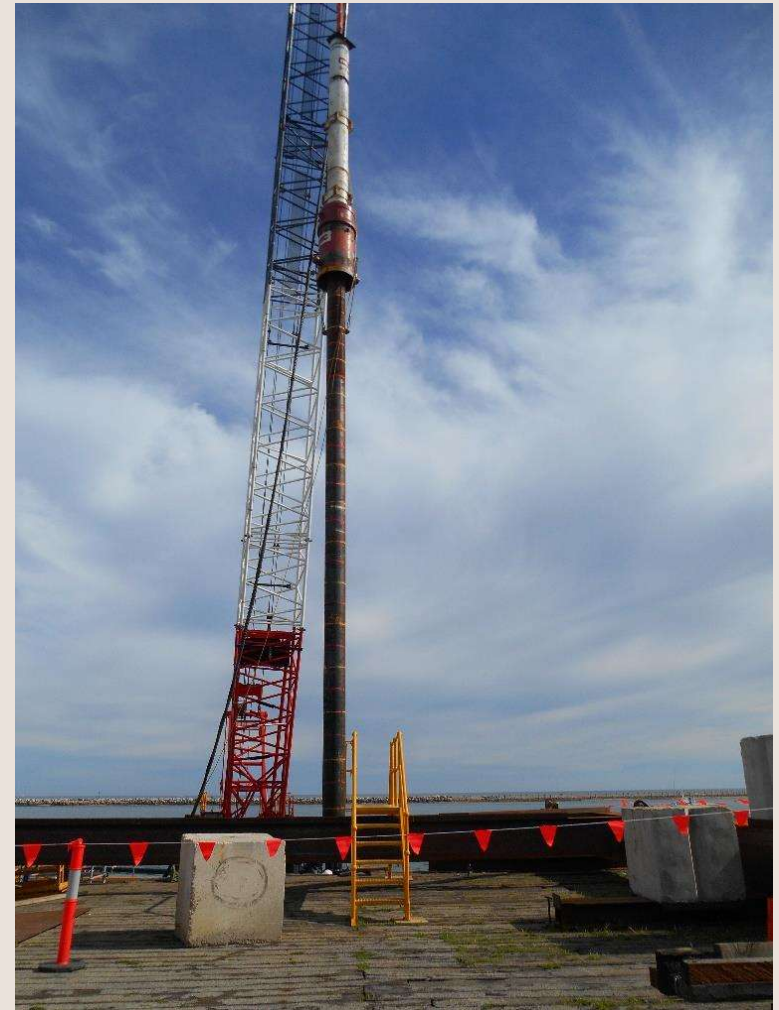


# What is Sustainable Marine Infrastructure

## Flinders Ports Outer Harbor Berth, SA

Theme 1- Good planning to optimise performance and outcomes of an asset's life

Piling



## What is Sustainable Marine Infrastructure

### Flinders Ports Outer Harbor Berth, SA

Theme 1- Good planning to optimise performance and outcomes of an asset's life

Completed Project



# What is Sustainable Marine Infrastructure

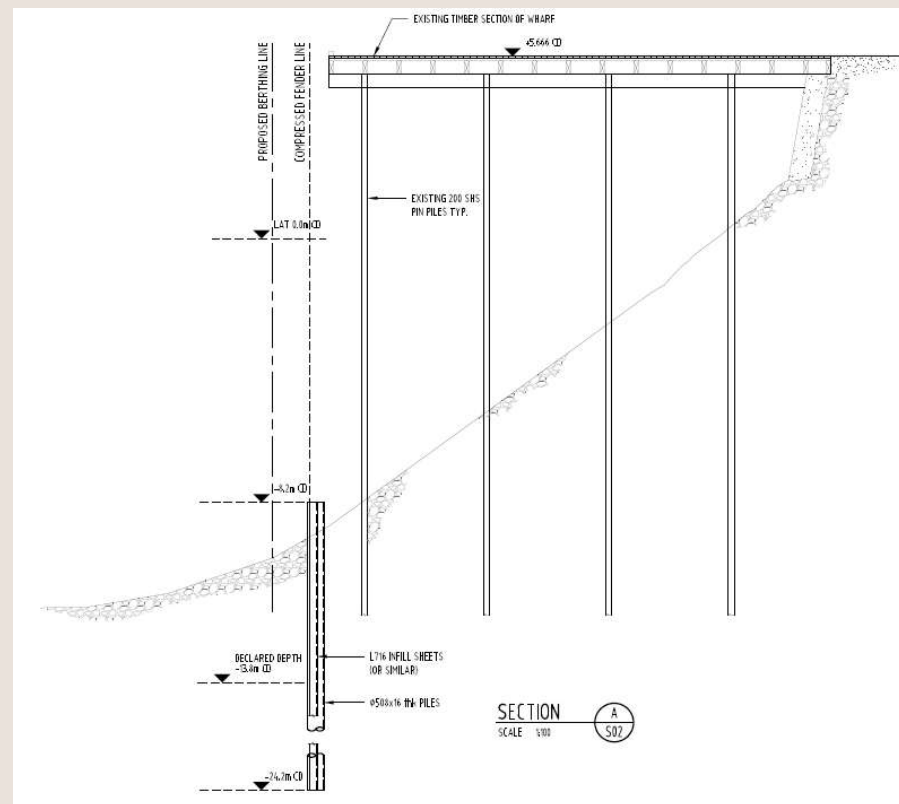
## Flinders Ports Outer Harbor Berth, SA

Theme 1- Good planning to optimise performance and outcomes of an asset's life

Not first berth deepening project for this wharf

Could the front piles have been deeper?

What will happen to vessels and berth requirements over the design life of wharf?



# What is Sustainable Marine Infrastructure

## 1.2 – Geraldton Berth 4, Shiploader Upgrade, WA

Theme 1- Good planning to optimise performance and outcomes of an asset's life

Life of shiploader vs design  
life of wharf asset





## What is Sustainable Marine Infrastructure

### Geraldton Berth 4, Shiploader Upgrade, WA

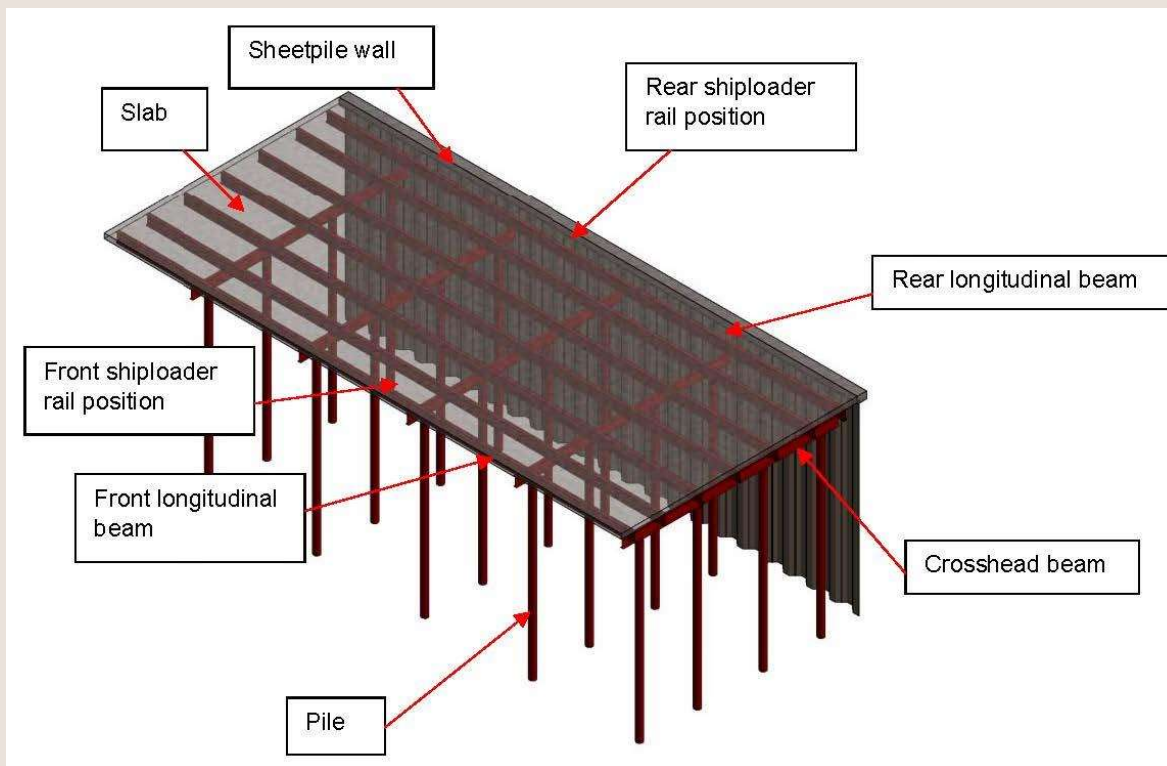


**Theme 1- Good planning to optimise performance and outcomes of an asset's life**



## What is Sustainable Marine Infrastructure

### Geraldton Berth 4, Shiploader Upgrade, WA



**Theme 1- Good planning to optimise performance and outcomes of an asset's life**

## What is Sustainable Marine Infrastructure Geraldton Berth 4, Shiploader Upgrade, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

## What is Sustainable Marine Infrastructure

### Geraldton Berth 4, Shiploader Upgrade, WA



Life of shiploader vs design  
life of wharf asset

Theme 1- Good planning to optimise performance  
and outcomes of an asset's life



## What is Sustainable Marine Infrastructure

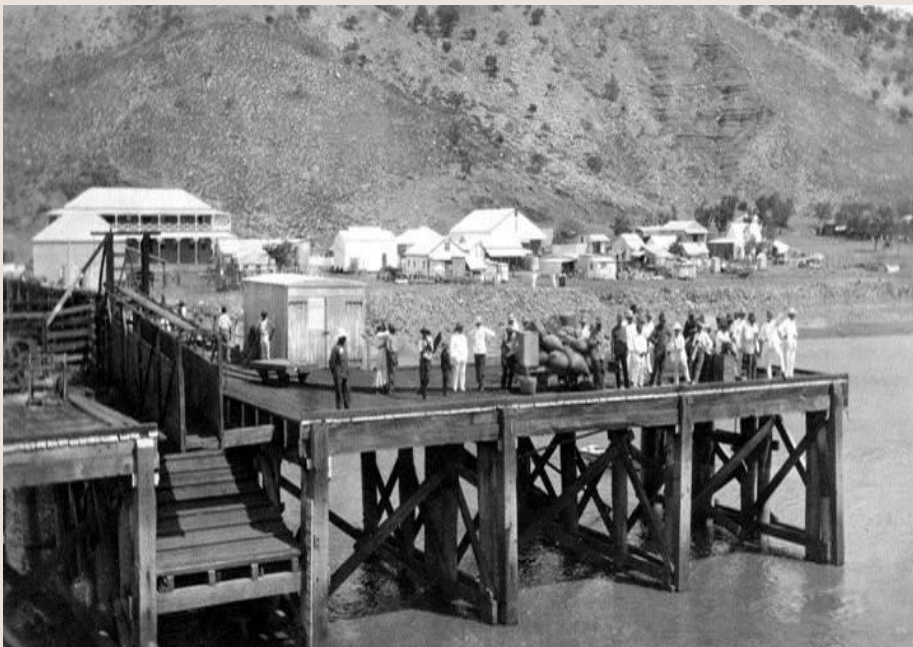
### 1.3 – New Community Jetty in the Kimberley - Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley - Anthon's Landing, Wyndham, WA

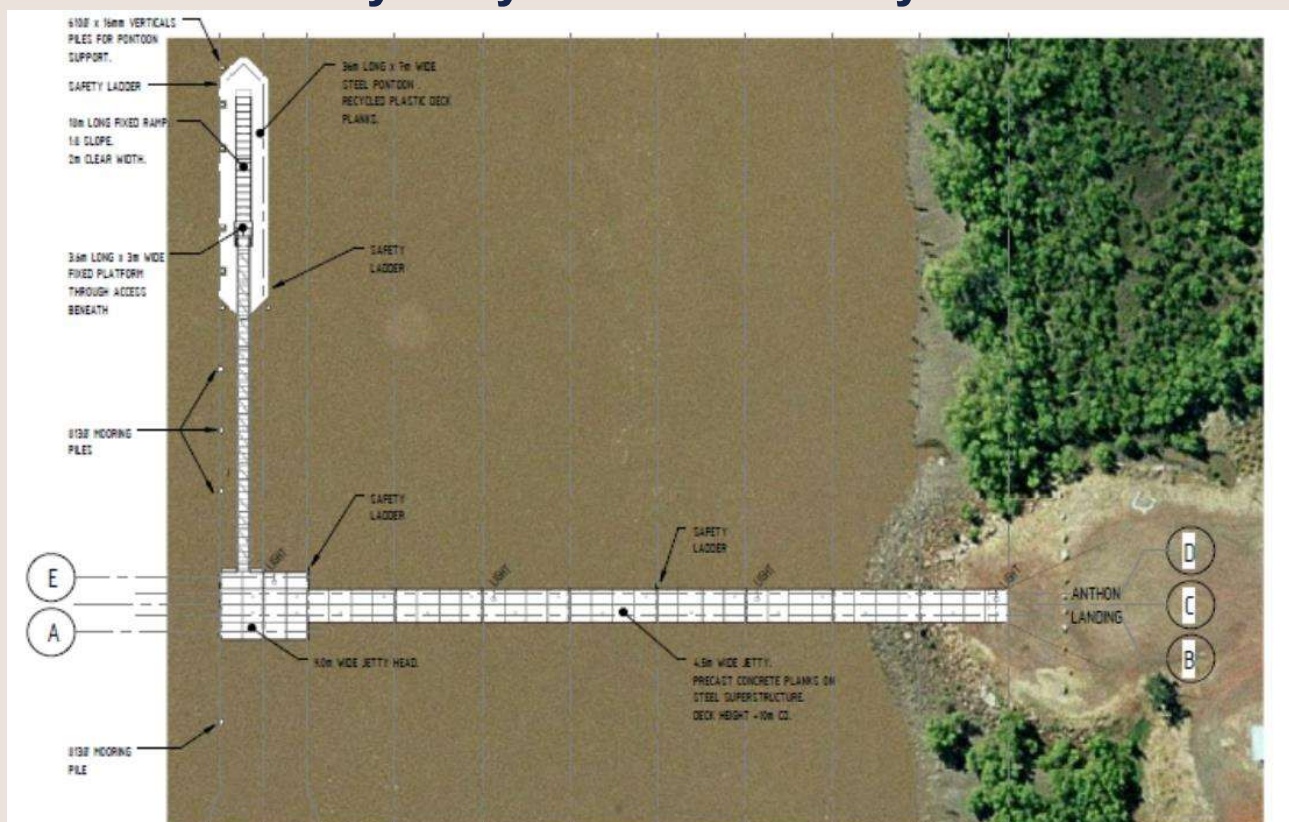


Theme 1- Good planning to optimise performance and outcomes of an asset's life



## What is Sustainable Marine Infrastructure

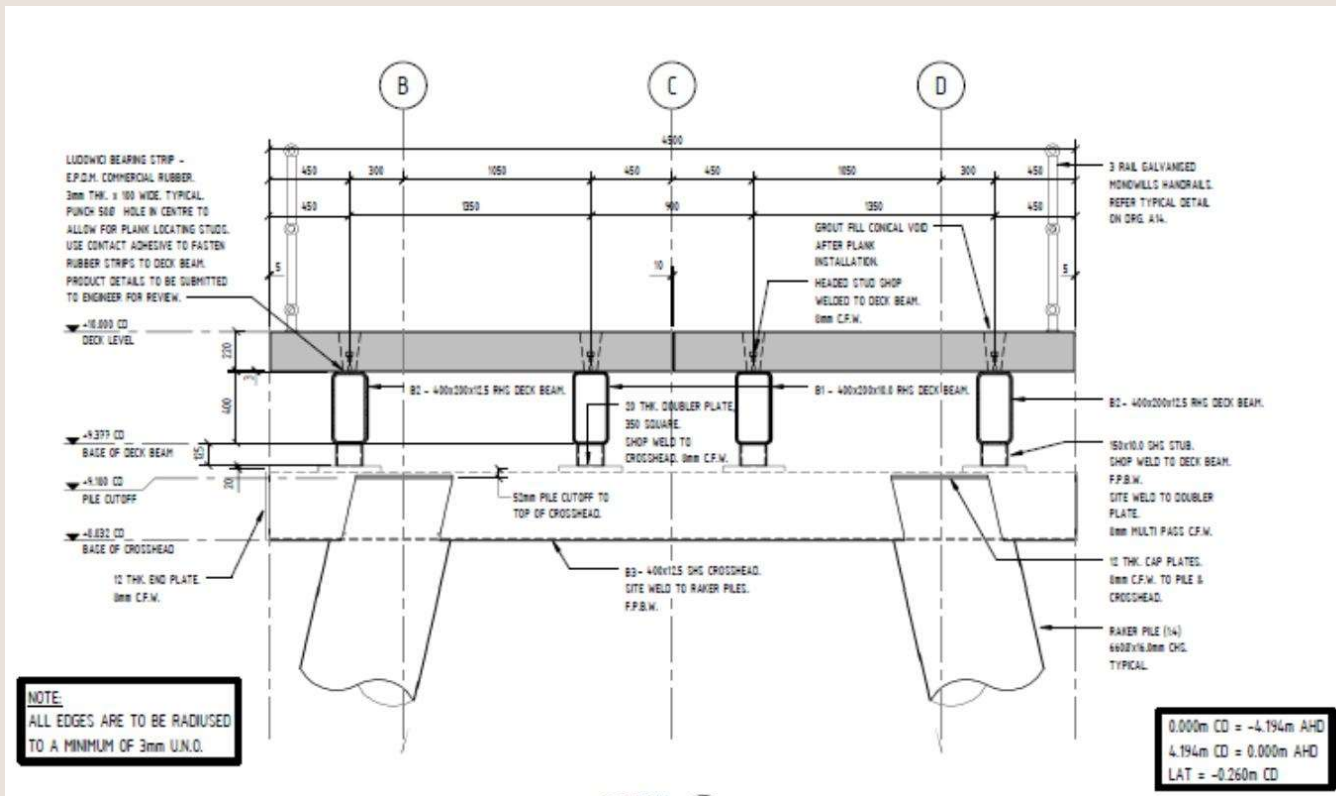
### New Community Jetty in the Kimberley - Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

# What is Sustainable Marine Infrastructure

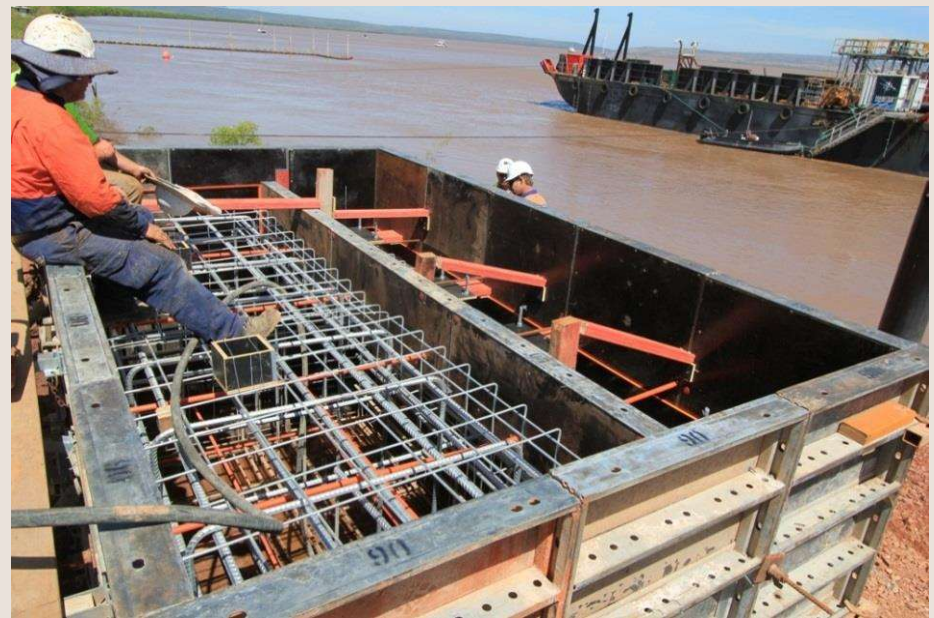
## New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life



## **What is Sustainable Marine Infrastructure**

### **New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA**



**Theme 1- Good planning to optimise performance and outcomes of an asset's life**

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life



## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA

#### INTRODUCTION

In July 1969 the Hydraulics Research Station was consulted by the Public Works Department, West Perth, Western Australia about the reasons for siltation at the meatworks jetty, Wyndham.

The original wooden jetty was built in 1919 and an extension, involving considerable reconstruction, was completed in 1961. Since that date it has been necessary to dredge at regular intervals to maintain depths of over 30 ft below I.S.L.W.D. (Indian Spring Low Water Datum, i.e. low water of ordinary spring tides), the average annual dredging rate between 1965 and 1969 amounting to 12 800 yd<sup>3</sup>.

After a preliminary consideration of the problem, the Station recommended that a field study and data analysis be undertaken to determine the cause of the siltation.

PORT OF WYNDHAM, W. AUSTRALIA  
SILTATION STUDY

September 1971

Crown Copyright

Report No  
EX 586

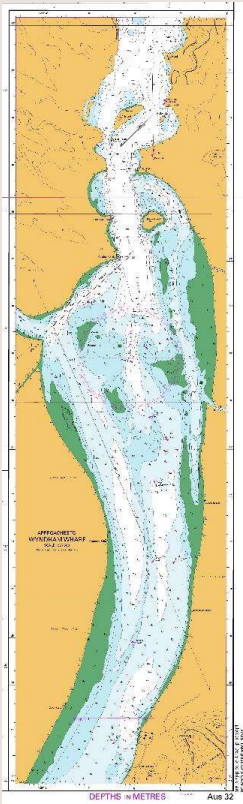
Hydraulics Research Station  
Wallingford  
Berkshire  
England

**Theme 1- Good planning to optimise performance and outcomes of an asset's life**

HR Wallingford Historical Report

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA

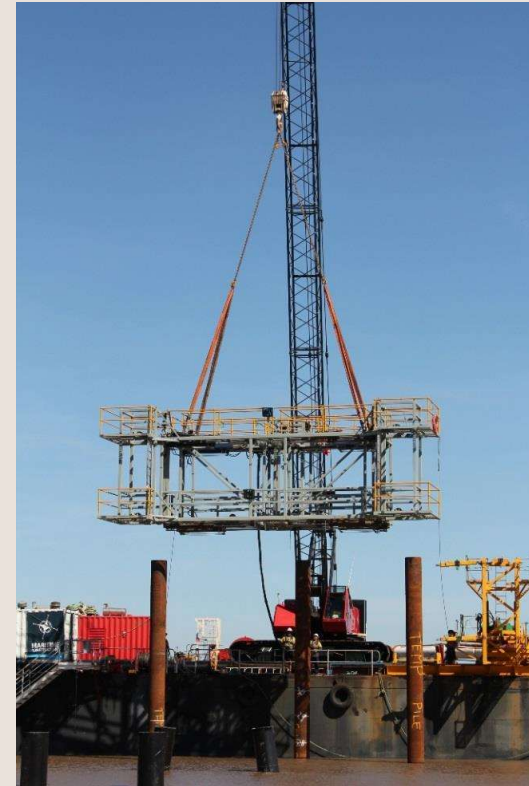


Theme 1- Good planning to optimise performance and outcomes of an asset's life



## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



**Theme 1- Good planning to optimise performance and outcomes of an asset's life**



## What is Sustainable Marine Infrastructure

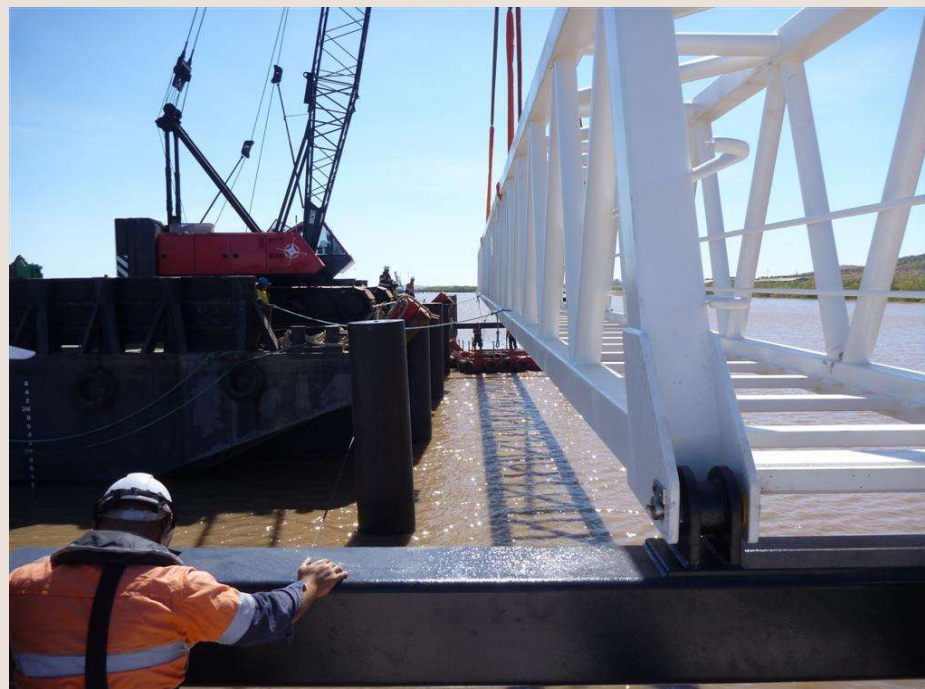
### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life



## What is Sustainable Marine Infrastructure

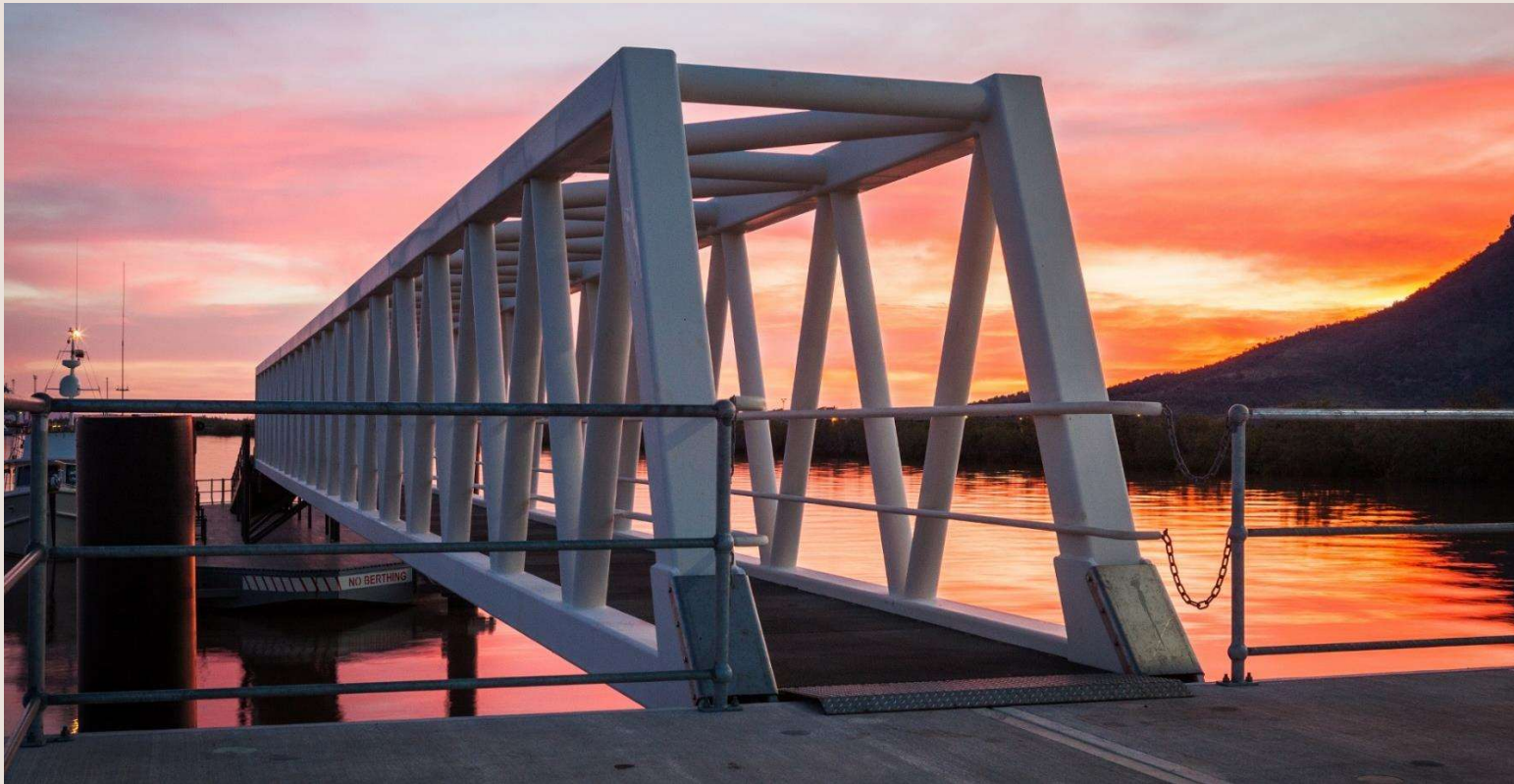
### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



**Theme 1- Good planning to optimise performance and outcomes of an asset's life**

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life



## What is Sustainable Marine Infrastructure

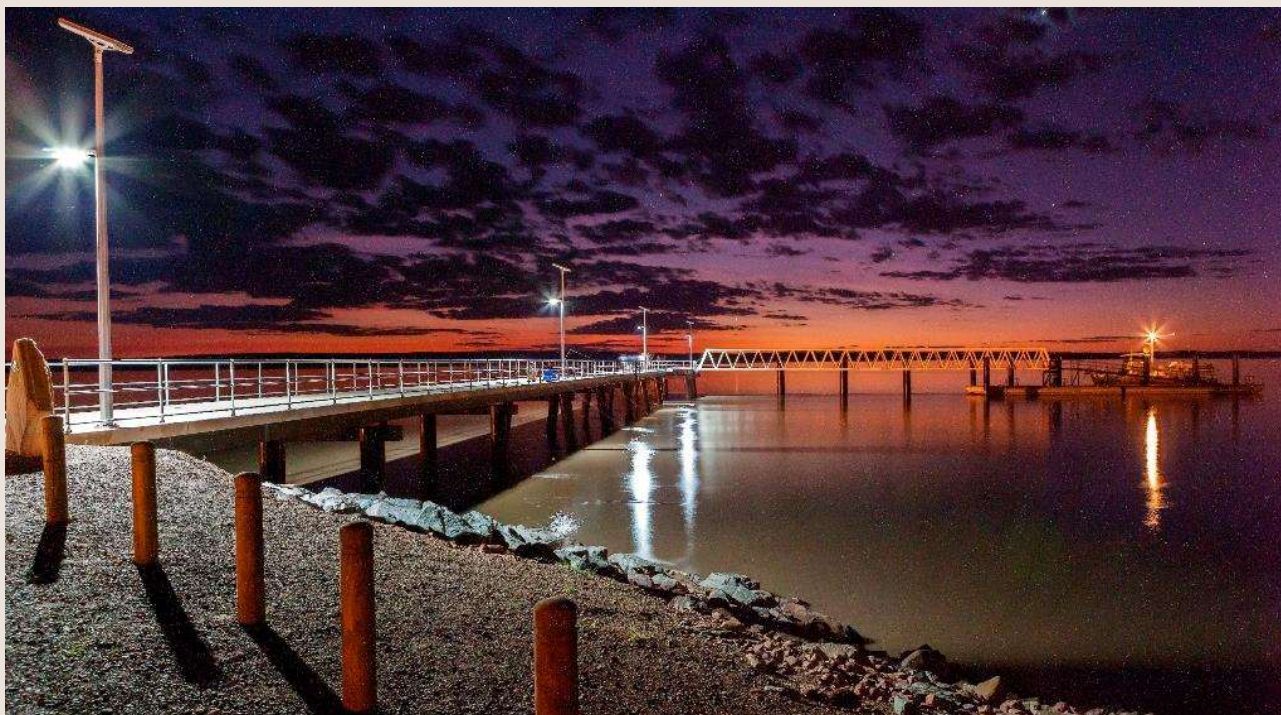
### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

## What is Sustainable Marine Infrastructure

### New Community Jetty in the Kimberley- Anthon's Landing, Wyndham, WA



Theme 1- Good planning to optimise performance and outcomes of an asset's life

Could have used thinner section with piles

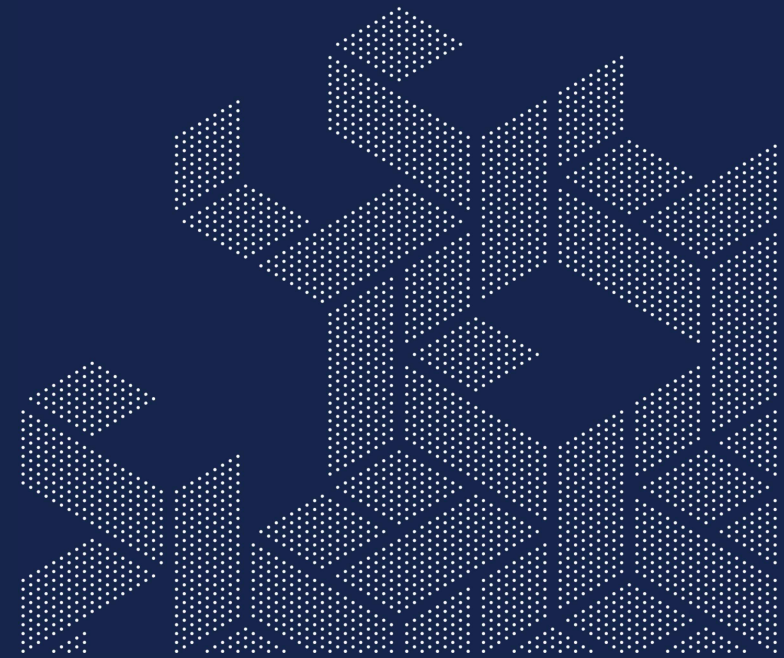
Cost negligible, benefits in construction

Benefit, could be extra 20 years or more!

Asset maintenance plans – will they survive!

## **Theme 2**

**Re-use and optimisation of existing  
infrastructure**



# What is Sustainable Marine Infrastructure

## Theme 2 – Re-use and optimisation of existing infrastructure

Can we make something of what's already there?

Or perhaps, what can we do with design of greenfields infrastructure projects to give future engineers and designers the best chance of being able to find a future use.

What information do we need to ensure is (and will be in the future!) available for this to be maximised?

Should temporary structures still be looked after and protected more carefully (at modest expense) to ensure that there is adequate reserve for repurposing?

Or can we simply achieve longer design lives than required with nominal changes?



## What is Sustainable Marine Infrastructure

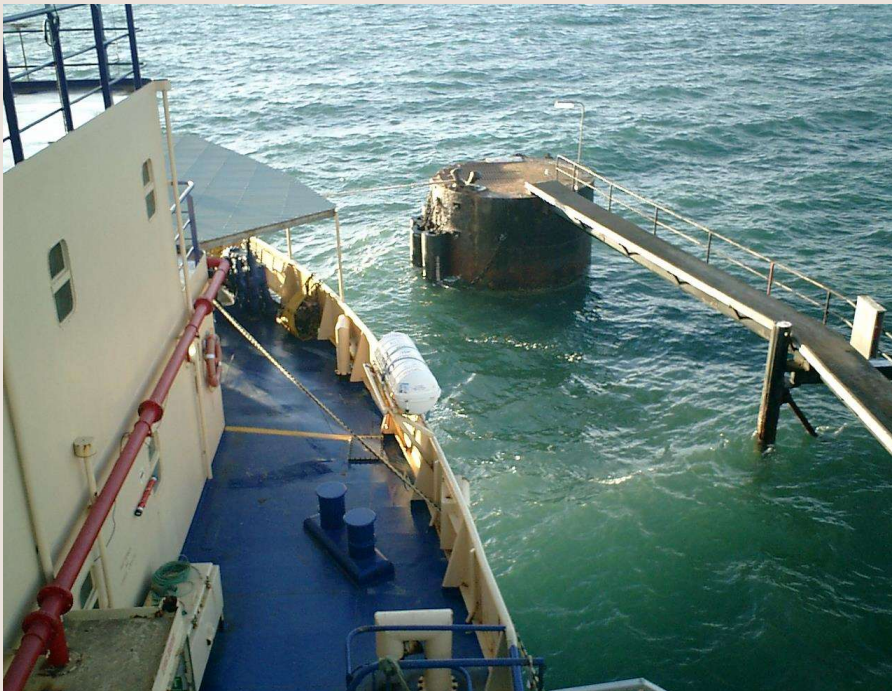
### 2.1 – Klein Point Berthing Caisson, SA



Theme 2 - Re-use and optimisation of existing infrastructure

## What is Sustainable Marine Infrastructure

### Klein Point Berthing Caisson, SA



Theme 2 - Re-use and optimisation of existing infrastructure



## What is Sustainable Marine Infrastructure

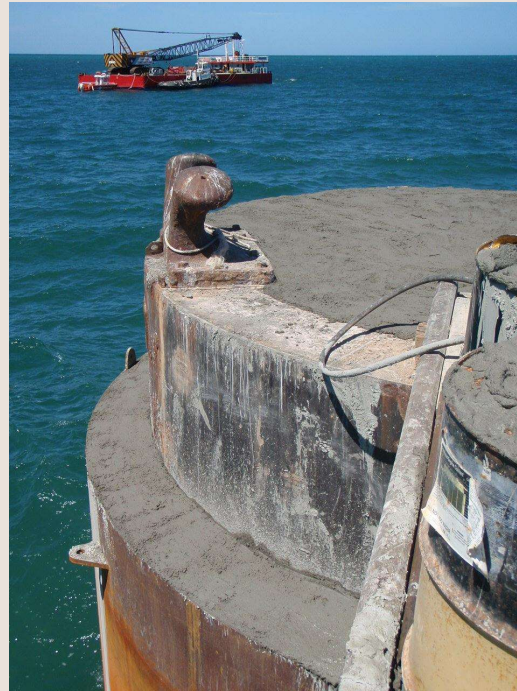
### Klein Point Berthing Caisson, SA



Theme 2 - Re-use and optimisation of existing infrastructure

## What is Sustainable Marine Infrastructure

### Klein Point Berthing Caisson, SA



Theme 2 - Re-use and optimisation of existing infrastructure



## What is Sustainable Marine Infrastructure

### Klein Point Berthing Caisson, SA



Theme 2 - Re-use and optimisation of existing infrastructure

## What is Sustainable Marine Infrastructure

### Klein Point Berthing Caisson, SA

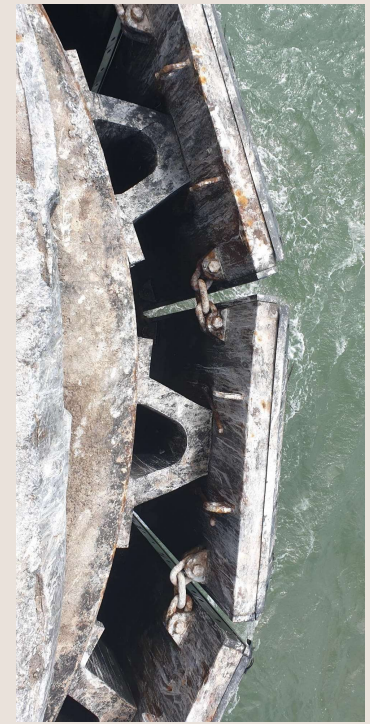


Theme 2 - Re-use and optimisation of existing infrastructure



# What is Sustainable Marine Infrastructure

## Klein Point Berthing Caisson, SA



Theme 2 - Re-use and optimisation of existing infrastructure

Should we limit design life to what scope / project brief asks?



## What is Sustainable Marine Infrastructure

### 2.2 – Rapid Bay Jetty

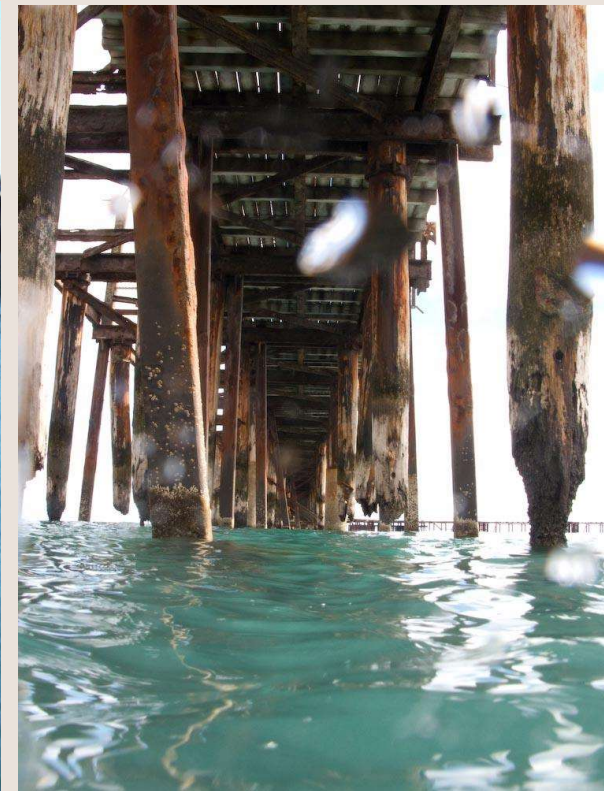


Theme 2 - Re-use and optimisation of existing infrastructure

Geotechnical Investigation

## What is Sustainable Marine Infrastructure

### Rapid Bay Jetty, SA



Theme 2 -  
Re-use and  
optimisation  
of existing  
infrastructure



## What is Sustainable Marine Infrastructure

### Rapid Bay Jetty, SA



Theme 2 - Re-use and optimisation of existing infrastructure



## What is Sustainable Marine Infrastructure

### Rapid Bay Jetty, SA



Theme 2 - Re-use and optimisation of existing infrastructure

## What is Sustainable Marine Infrastructure

### Rapid Bay Jetty, SA



Theme 2 - Re-use and optimisation of existing infrastructure

How much are historical piling records worth?

Should they be locked in a safe?

## What is Sustainable Marine Infrastructure

### 2.3 – “John Holland” (temp) Wharf – Port Hedland, WA



Theme 2 - Re-use and optimisation of existing infrastructure



## What is Sustainable Marine Infrastructure

### “John Holland” (temp) Wharf – Port Hedland, WA



Theme 2 - Re-use and optimisation of existing infrastructure

## What is Sustainable Marine Infrastructure

### “John Holland” (temp) Wharf – Port Hedland, WA

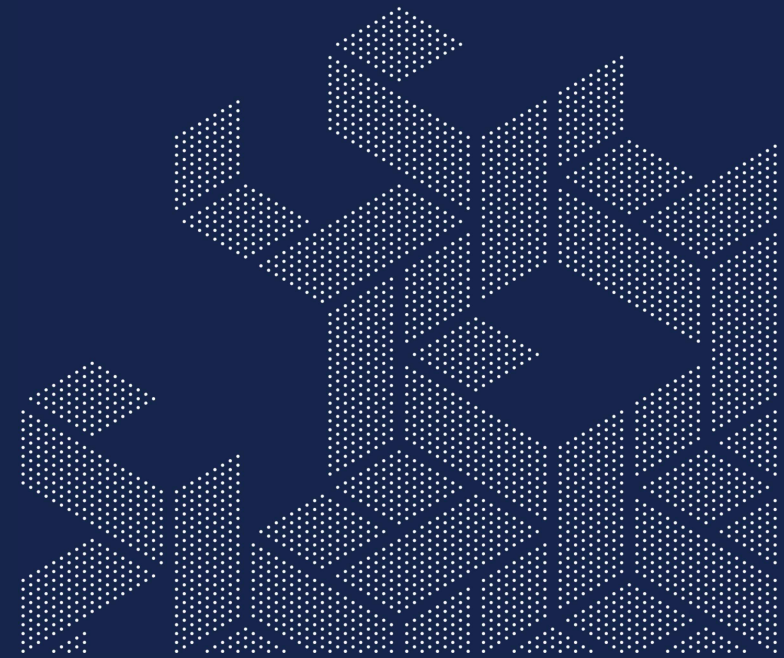


‘Temporary’ structures – define temporary!

Theme 2 - Re-use and optimisation of existing infrastructure

## **Theme 3**

**Value for money and maximum functionality**





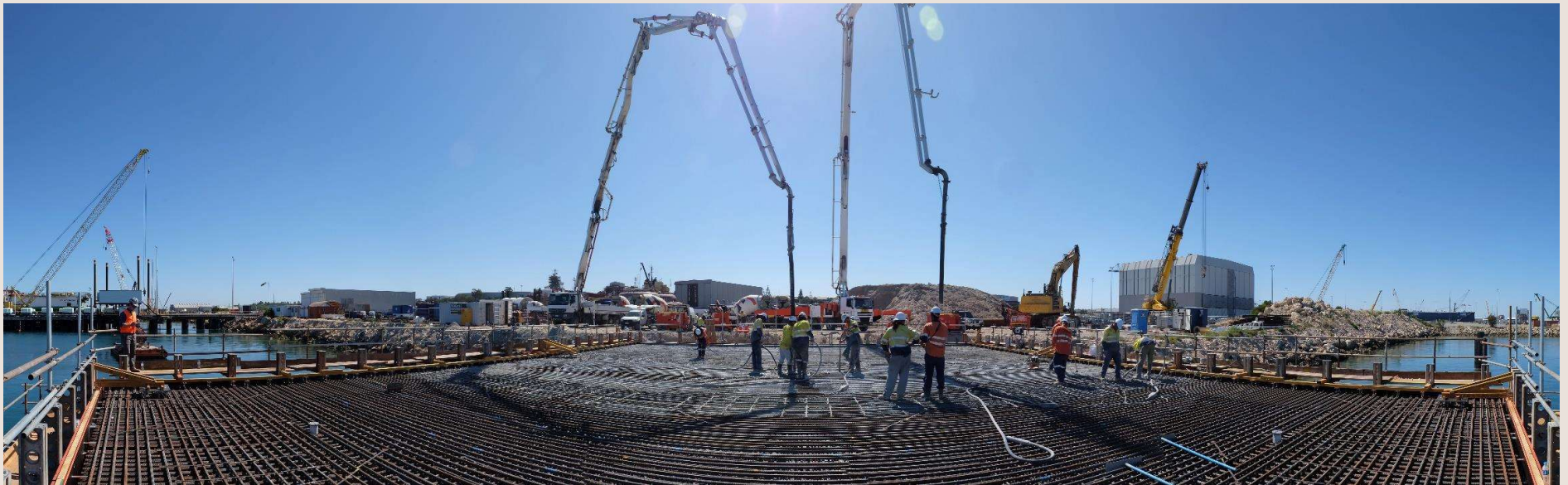
## What is Sustainable Marine Infrastructure

### Theme 3 – Value for money and maximum functionality

How do we get the most out of infrastructure projects to ensure that maximum value is derived from a single project, reducing the need for another future project that will further impact the local environment?

## What is Sustainable Marine Infrastructure

### 3.1 – ‘Super’ Heavy Duty Wharf Design – 100 kPa and beyond



Theme 3 - Value for money and maximum functionality

## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA

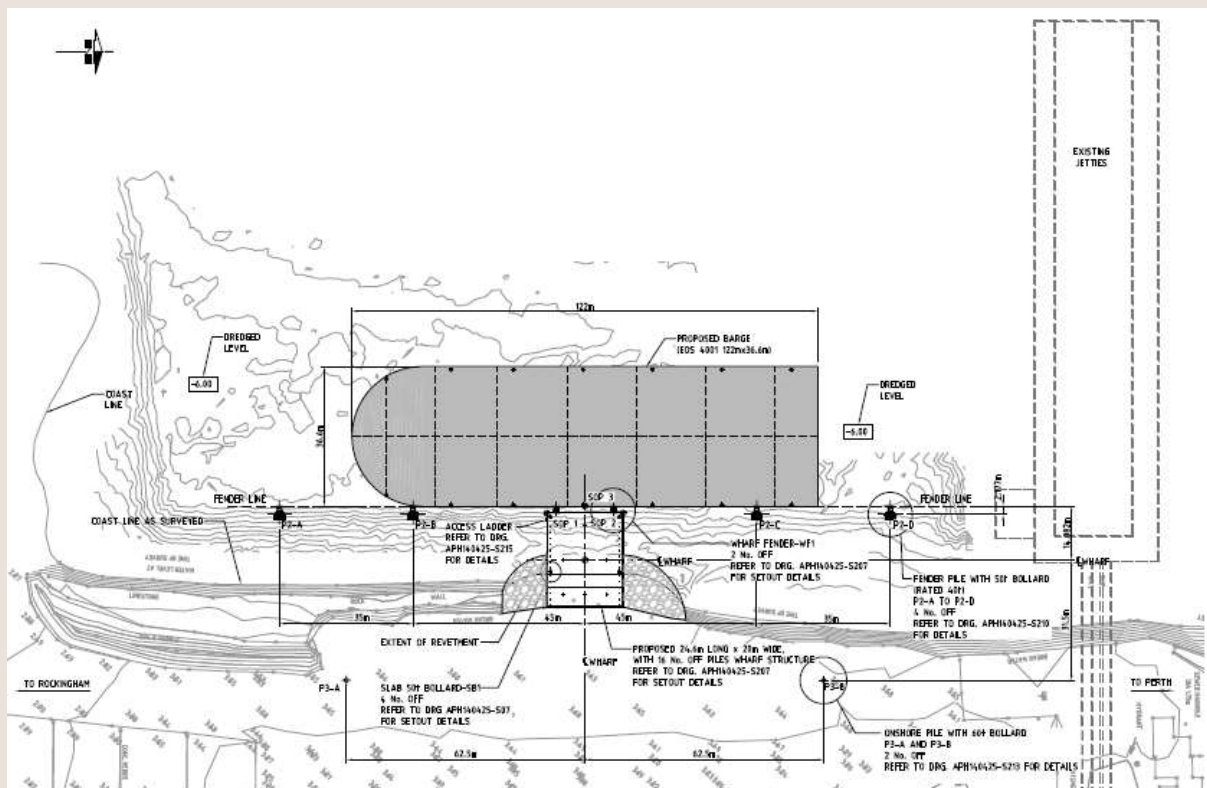


Theme 3 - Value for money and maximum functionality



# What is Sustainable Marine Infrastructure

## New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

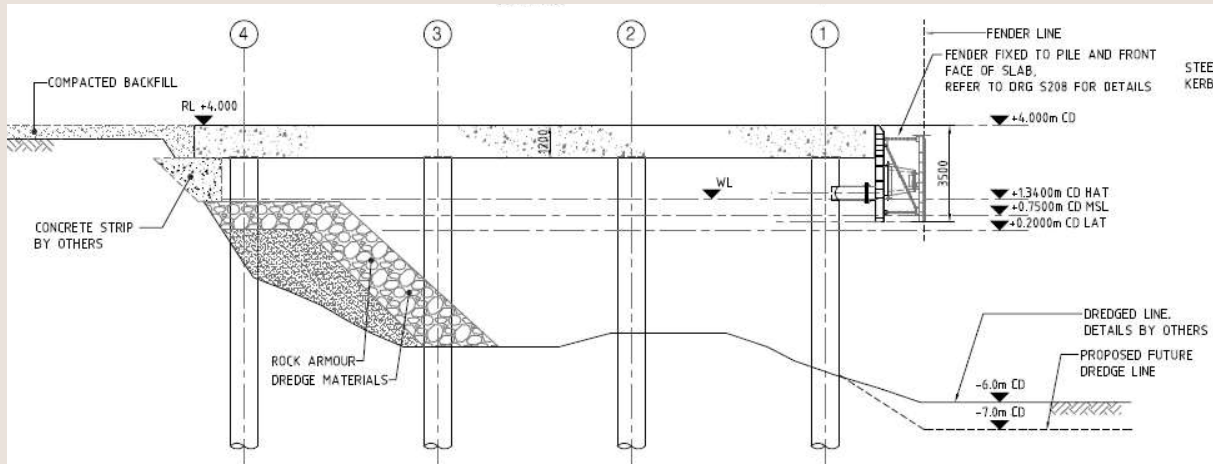
Main Wharf: 20m wide x 30m long

Berth Length: 160m

Concrete Deck Piles

# What is Sustainable Marine Infrastructure

## New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

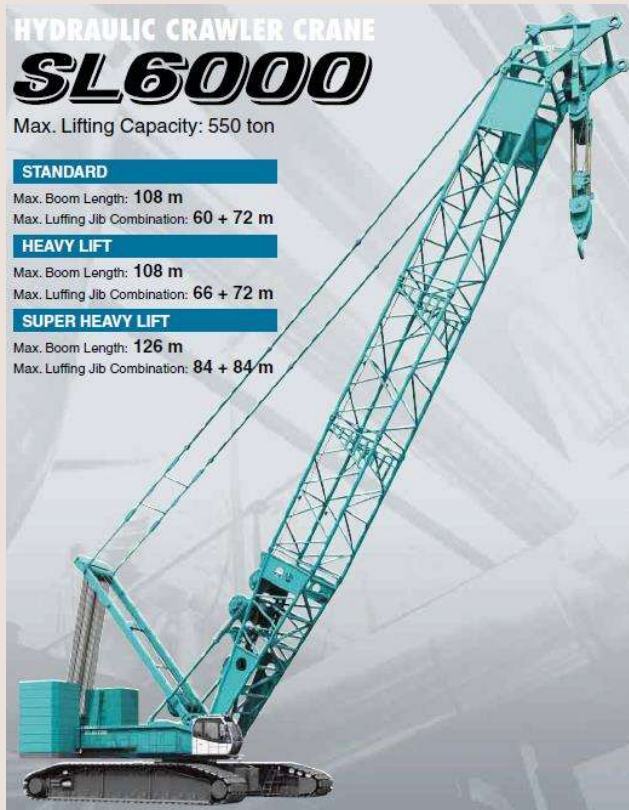
Typical Section

Wharf Deck Level +4.0m CD

Dredge Depth -7.0 CD

# What is Sustainable Marine Infrastructure

## New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

Design Loads – Wharf Decks

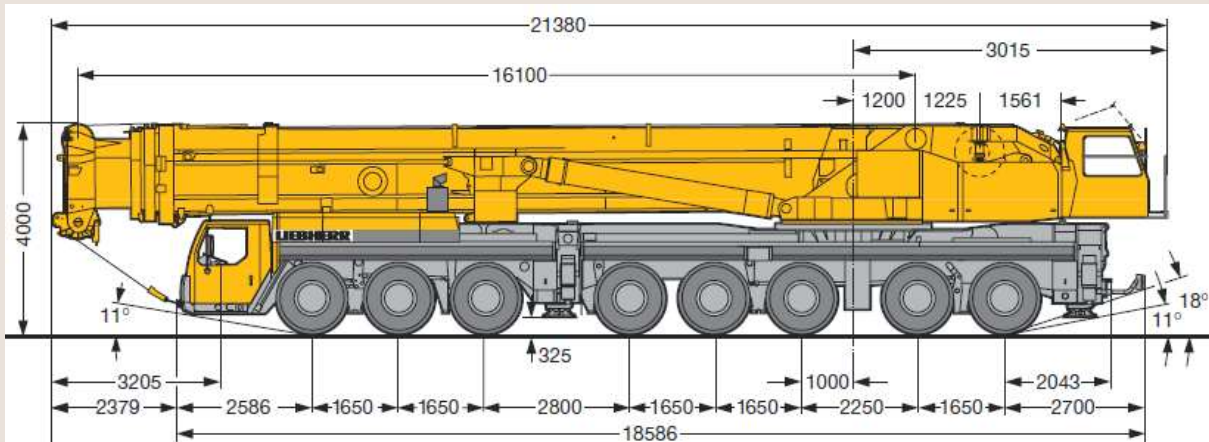
80kPa Distribution Load

450t Crawler Crane



# What is Sustainable Marine Infrastructure

## New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

400t Mobile Crane

## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

SPMT's  
Self-Propelled Modular Transport

## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

1,600 Crawler Crane



## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Wharf Deck Reinforcement

Theme 3 - Value for money and maximum functionality

## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money  
and maximum functionality

Formwork



## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money  
and maximum functionality

Formwork



## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

Temp works + Access

## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

Piling

## What is Sustainable Marine Infrastructure

### New Heavy Lift/Loadout Wharf, Henderson, WA



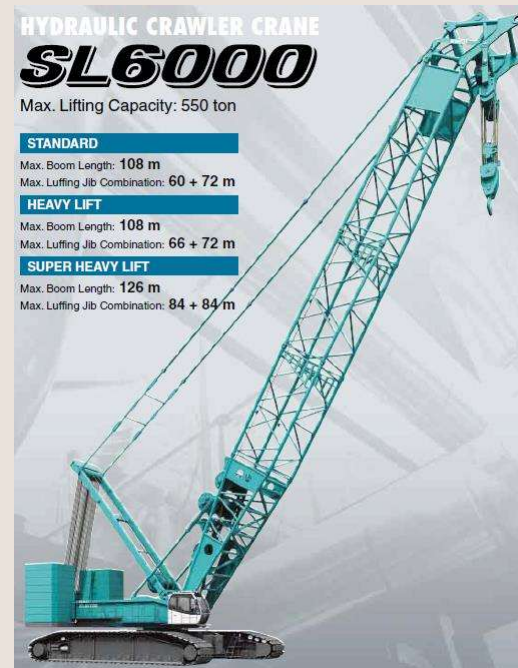
Theme 3 - Value for money and maximum functionality

Piling



# What is Sustainable Marine Infrastructure

## New Heavy Lift/Loadout Wharf, Henderson, WA



Theme 3 - Value for money and maximum functionality

Piles: 1200 => 1350

Slab: 1m => 1.2m

## What is Sustainable Marine Infrastructure

### 3.2 – Monkey Mia Jetty, WA



Theme 3 - Value for money and maximum functionality

## What is Sustainable Marine Infrastructure Monkey Mia Jetty, WA



Theme 3 - Value for money and  
maximum functionality



## What is Sustainable Marine Infrastructure

### Monkey Mia Jetty, WA



Theme 3 - Value for money and maximum functionality

## What is Sustainable Marine Infrastructure

### Monkey Mia Jetty, WA



Wider

Higher Capacity

Less Cost!

**Theme 3 - Value for money and maximum functionality**

## What is Sustainable Marine Infrastructure

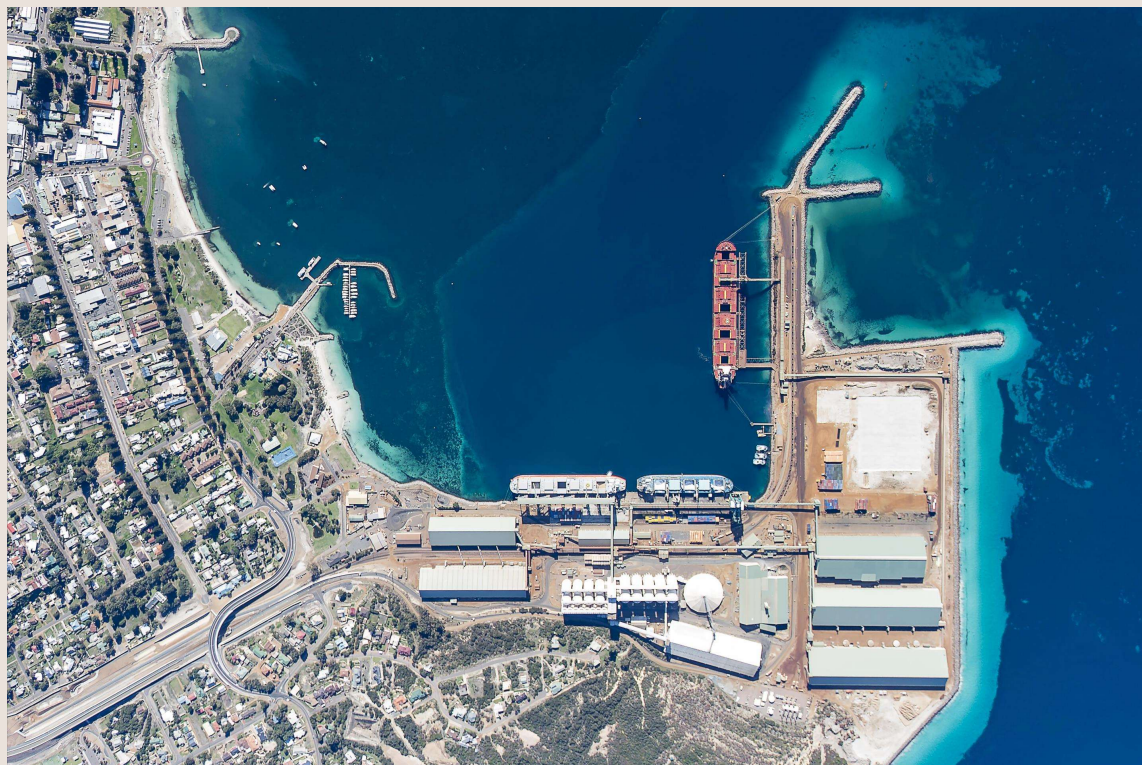
### 3.3 – Esperance Port, Berth 3, WA

Port Layout

3 Main Berths

Berth 3 completed in 2002

Cape-size vessels



Theme 3 - Value for money and maximum functionality



# What is Sustainable Marine Infrastructure

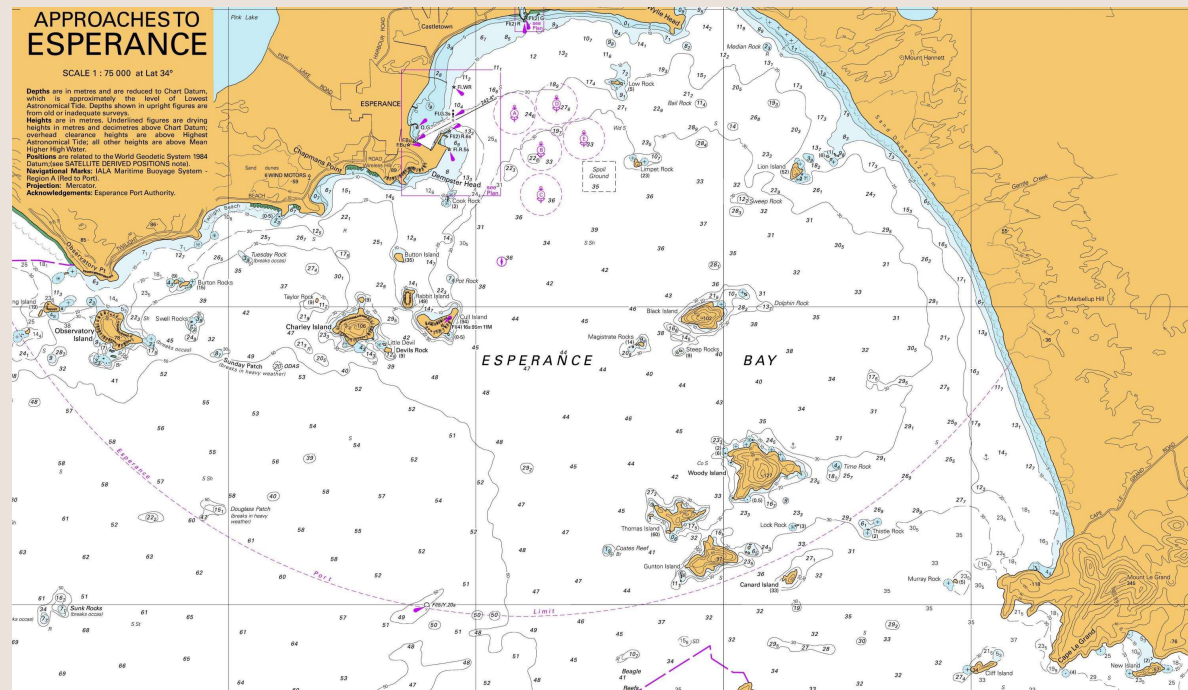
## Esperance Port, Berth 3, WA

Long Period Waves

Reflected from beach

Diffraction of swell at breakwater

General E-W direction at port



Theme 3 - Value for money and maximum functionality

## What is Sustainable Marine Infrastructure

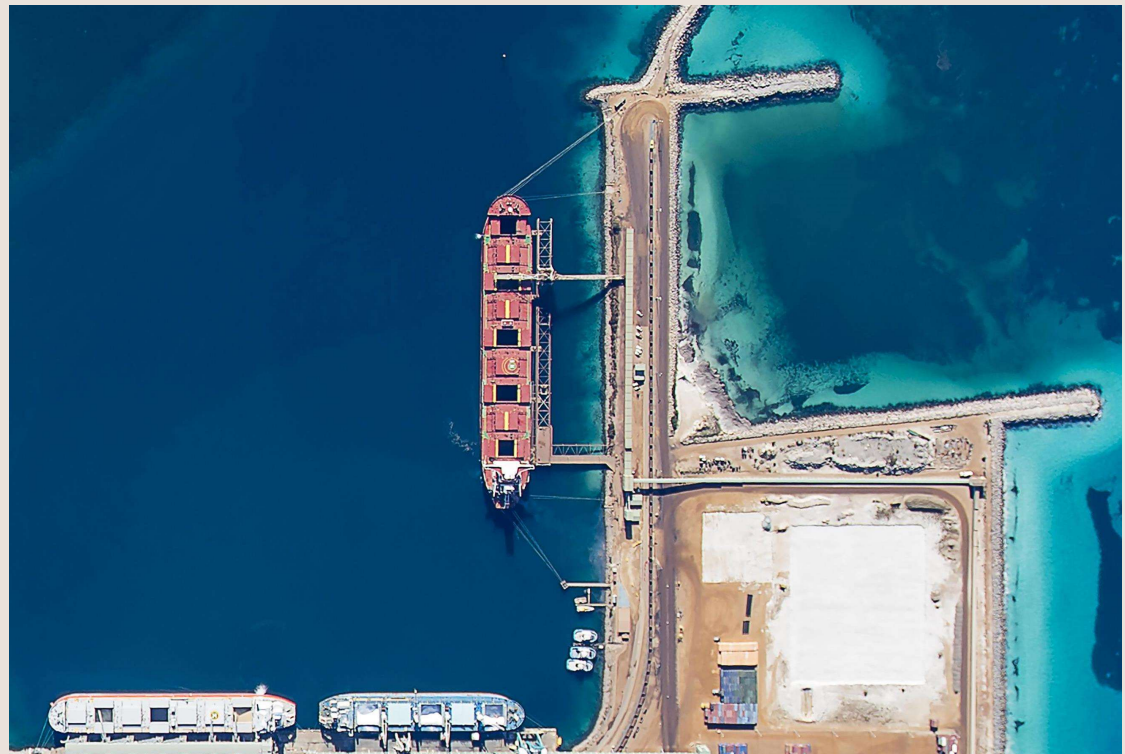
### Esperance Port, Berth 3, WA

#### Berth 3 Layout

5 breasting dolphins

Iron ore export

Cape-size vessels



Theme 3 - Value for money and maximum functionality

## What is Sustainable Marine Infrastructure Esperance Port, Berth 3, WA

Berth 3

Dolphins independent to shiploader

No continuous walkway

Pedestrian access only



Theme 3 - Value for money and  
maximum functionality



## What is Sustainable Marine Infrastructure Esperance Port, Berth 3, WA

Berth 3

Original design mainly for Panamax



Theme 3 - Value for money and  
maximum functionality

## What is Sustainable Marine Infrastructure

### Esperance Port, Berth 3, WA

Central Dolphin (BD3)

Original single hook

Preference to use for springs in both directions



Theme 3 - Value for money and maximum functionality

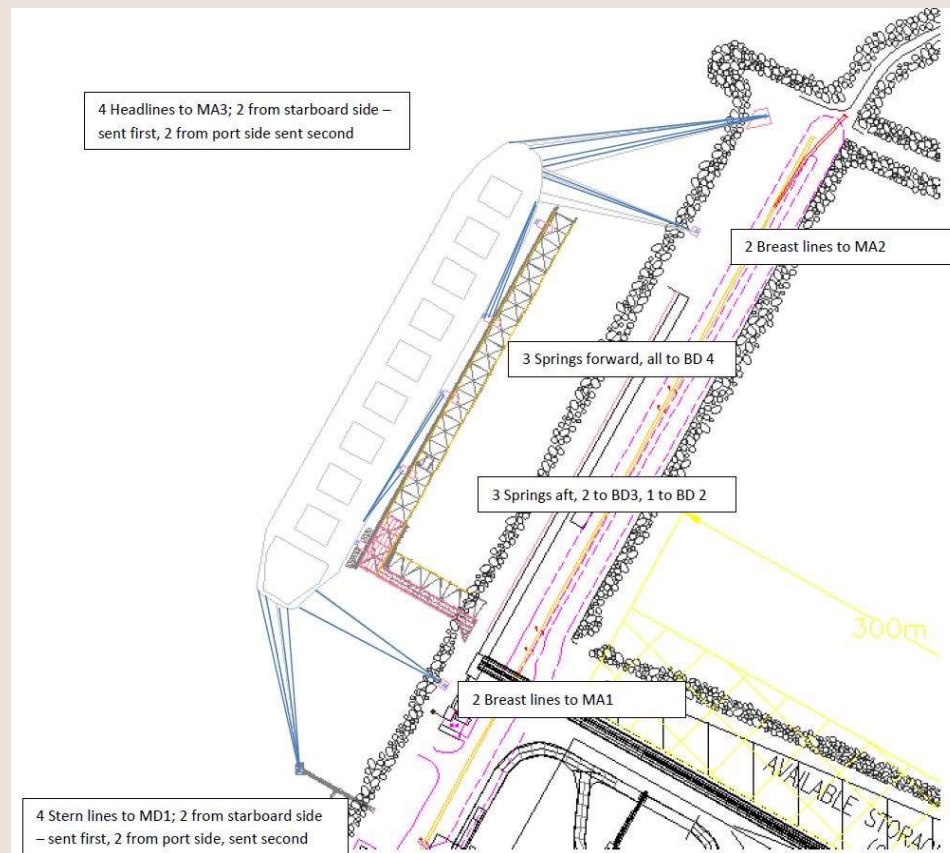
# What is Sustainable Marine Infrastructure

## Esperance Port, Berth 3, WA

### Mooring Line Arrangement

Aft springs only to central dolphin, BD3

Theme 3 - Value for money and maximum functionality





## What is Sustainable Marine Infrastructure

### Esperance Port, Berth 3, WA

Central Dolphin (BD3)  
New Quad Hook

Custom design, spring lines only

Allows 2 spring lines in each direction

Retrofitted to maximise rework to  
dolphin structure

Additional platform for work area

100t hooks

Theme 3 - Value for money and  
maximum functionality



## What is Sustainable Marine Infrastructure Esperance Port, Berth 3, WA

### Berth 3

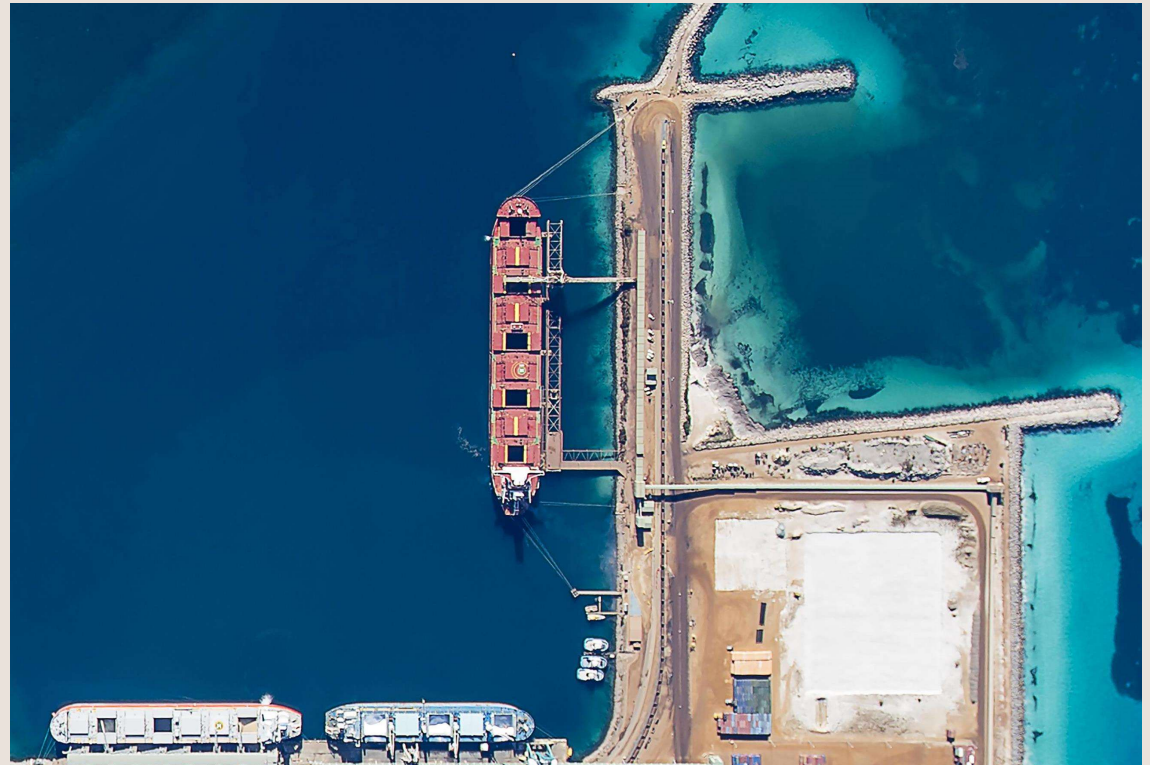
Optimised design – fit for purpose

Key wharf asset – deep water berth

Should the Port Authority have stepped in  
to deliver asset with future proofing?

What role/responsibility does the  
designer have?

Theme 3 - Value for money and  
maximum functionality



**WGA**

## **Conclusion**





## What is Sustainable Marine Infrastructure

### Conclusion – broad topic



## What is Sustainable Marine Infrastructure

### Conclusion – why should we expect the brief to be perfect?

- D+C Model
- Contractor experience
- Collaborative environment with client

### Klein Point Berthing Caisson





# What is Sustainable Marine Infrastructure

## Conclusion

It isn't always pretty!

