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# JB Pacific – Extreme Weather Engineering
# Coastal Modelling 101 with the Australian Water School

jbpacific.com.au

JB Pacific

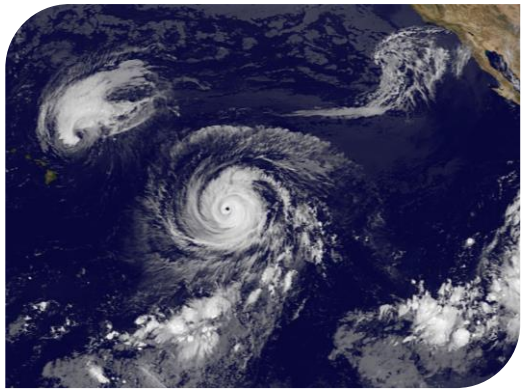
JBP scientists and engineers

# Agenda

1) Why model the coast and estuaries
2) Types of coastal modelling
3) The emerging field of Nature Based Resilience

# Why use coastal models

1) Coastal extremes studies - waves, storm surges, cyclones
2) Coastal processes – tides, currents, water levels
3) Sediment processes – sand estuarine dynamics, muddy coastlines,
4) Coastal designs and engineering
5) Nature based optioneering




# Types of coastal modelling

Wave models

- Phase (wave) averaging – spectral wave models like **SWAN**, MIKE SW
- Wave group resolving - **XBeach**
- Phase (wave) resolving – **Xbeach**, Mike Boussinesq wave, **CFD**
- Overtopping – **Neural Network, Xbeach, CFD**

Coastal processes and hydrodynamics

- Tuflow FV, Tuflow, **Delft3D**, Telemac, Mike 21

Sediment transport

- Tuflow FV, **Delft3D, Xbeach,** Mike 21, Telemac

Coastal Evolution

- UNIBEST, LITPACK, **GENESIS, Xbeach**

Beach erosion

- **Xbeach, SBeach**

Key

Commercial

**Free(ish)**

# Types of coastal modelling

## Wave models

- Phase (wave) averaging – spectral wave models like SWAN, MIKE SW

# Types of coastal modelling

## Wave models

- Phase (wave) averaging – spectral wave models like SWAN, MIKE SW

*Typically used for medium to large scale assessments*

*They calculate the overall wave energy*

*Computations based on energy balance equations*

*Requires little understanding! Models are text-based, and can be as little as 20 lines.*

Defines the project details

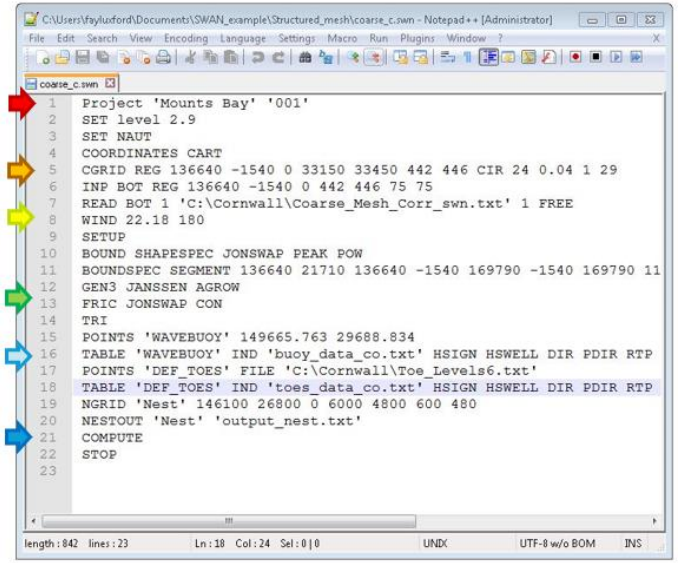
Defines the grid/bathy

Defines boundary conditions

Defines SWAN paramatres

Defines output points

Orders SWAN to run



# Types of coastal modelling

## Wave models

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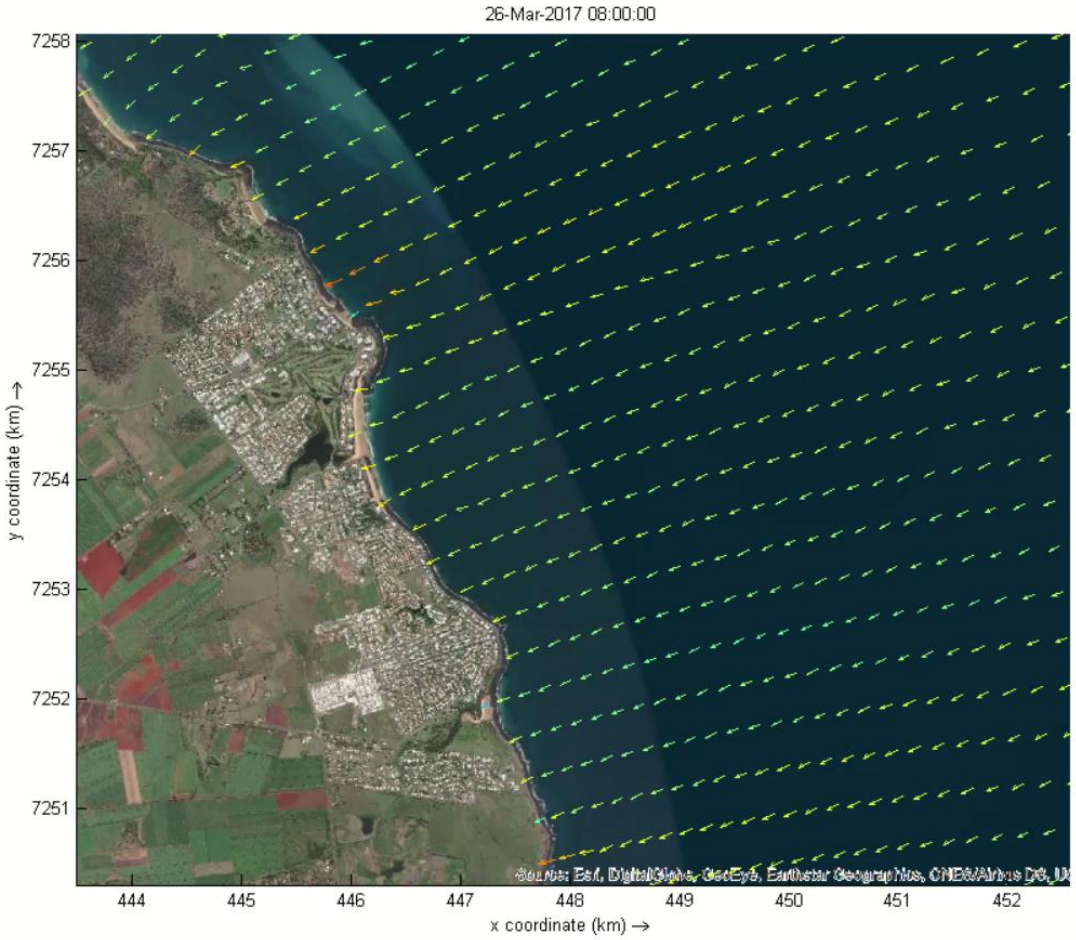



Defines the project details

Defines the grid/bathy

Defines boundary conditions

Defines SWAN paramatres

Defines output points

Orders SWAN to run

```
1  Project 'Mounts Bay' '001'
2  SET level 2.9
3  SET NAUT
4  COORDINATES CART
5  CGRID REG 136640 -1540 0 33150 33450 442 446 CIR 24 0.04 1 29
6  INP BOT REG 136640 -1540 0 442 446 75 75
7  READ BOT 1 'C:\Cornwall\Coarse_Mesh_Corr_swn.txt' 1 FREE
8  WIND 22.18 180
9  SETUP
10 BOUND SHAPESPEC JONSWAP PEAK POW
11 BOUNDSPEC SEGMENT 136640 21710 136640 -1540 169790 -1540 169790 11
12 GEN3 JANSSEN AGROW
13 FRIC JONSWAP CON
14 TRI
15 POINTS 'WAVEBUOY' 149665.763 29688.834
16 TABLE 'WAVEBUOY' IND 'buoy_data_co.txt' HSIGN HSWELL DIR PDIR RTP
17 POINTS 'DEF_TOES' FILE 'C:\Cornwall\Toe_Levels6.txt'
18 TABLE 'DEF_TOES' IND 'toes_data_co.txt' HSIGN HSWELL DIR PDIR RTP
19 NGRID 'Nest' 146100 26800 0 6000 4800 600 480
20 NESTOUT 'Nest' 'output_nest.txt'
21 COMPUTE
22 STOP
23
```

*Project: Bargara SEMP*

# Types of coastal modelling

## Wave models

- Wave group resolving - XBeach

*Typically used for small to medium scale assessments*

*They calculate wave groups (sets of waves) propagating.*

*Computations based on wave action (energy) equations*

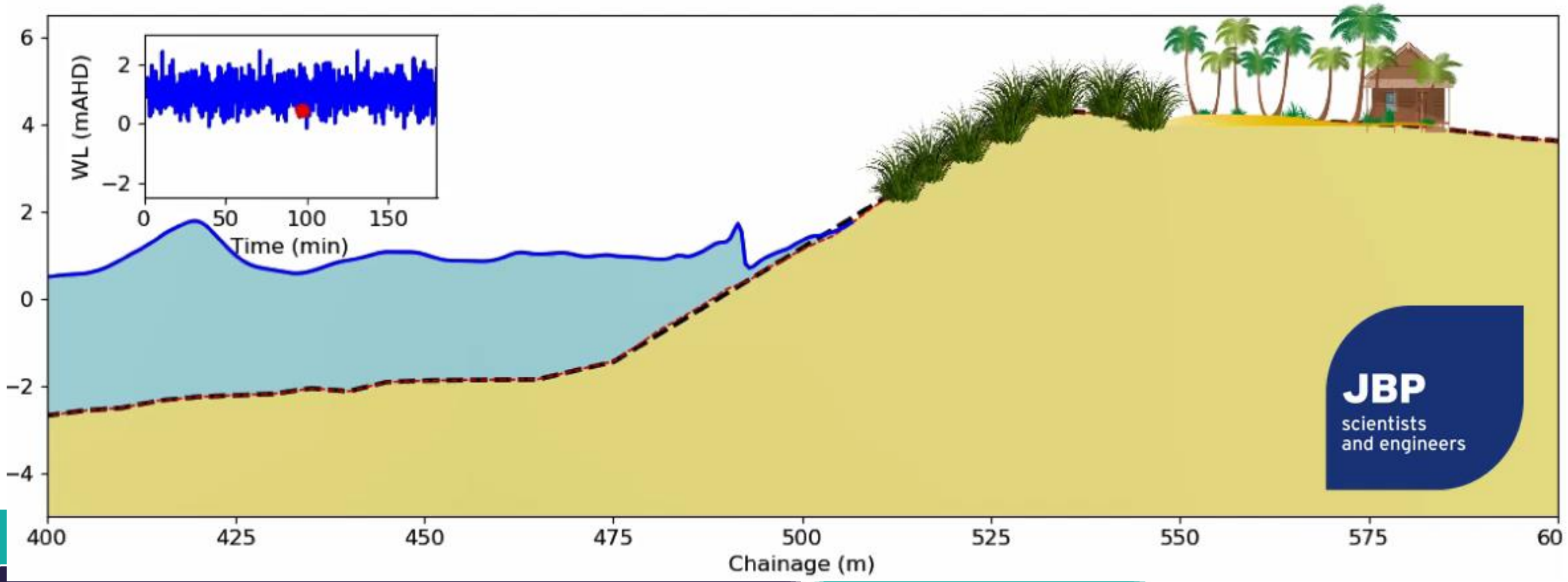
*Requires fairly detailed understanding, however the models are fairly stable*

# Types of coastal modelling

## Wave models

- Wave group resolving - XBeach

*Project: Burdekin Dune Management Plan*

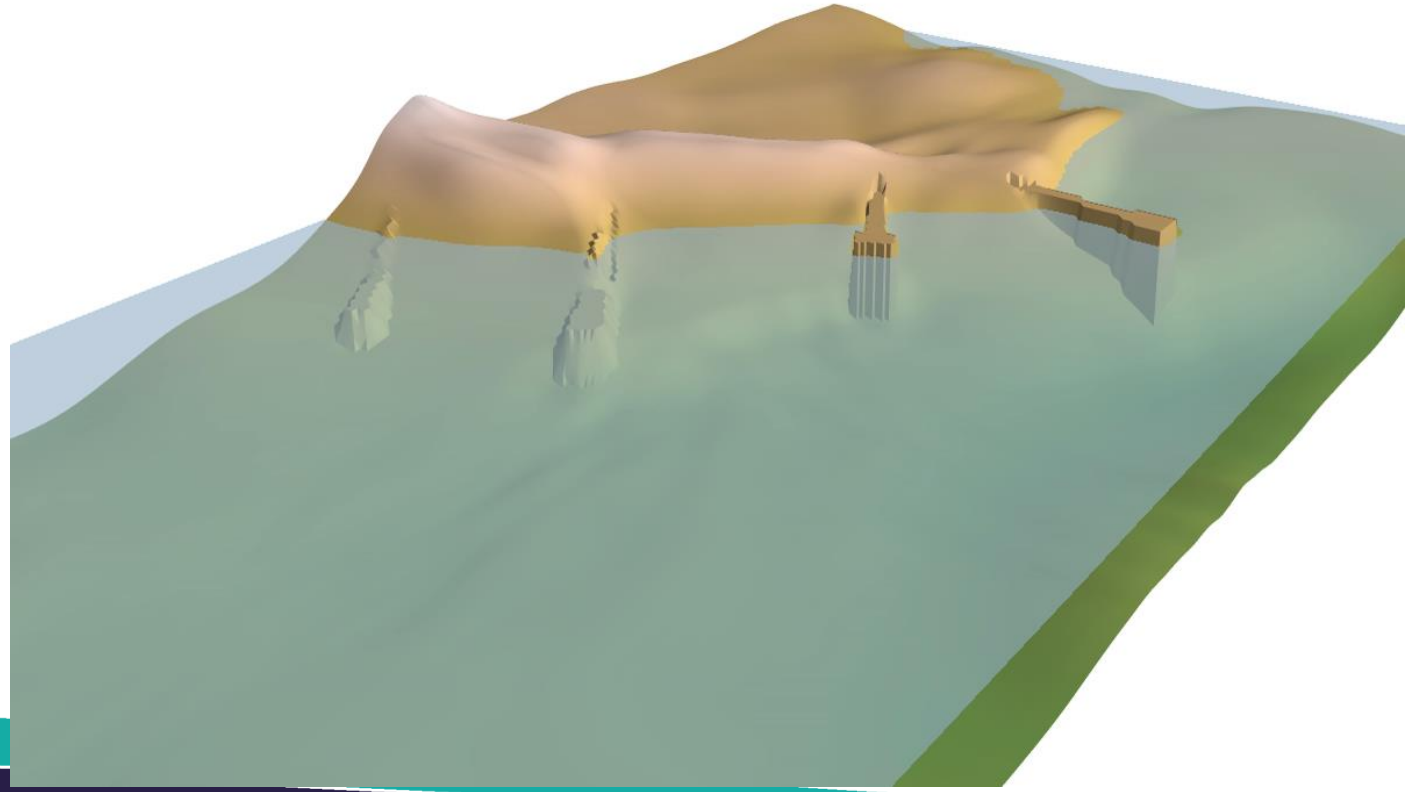


# Types of coastal modelling

## Wave models

- Wave group resolving - XBeach

*Project: Maroochy Groynes Renewal*



# Types of coastal modelling

## Wave models

- Phase (wave) resolving – Xbeach, Mike Boussinesq wave, CFD

*Typically used for small scale assessments*

*They calculate individual waves propagating.*

*Computations based on conservation of mass and momentum*

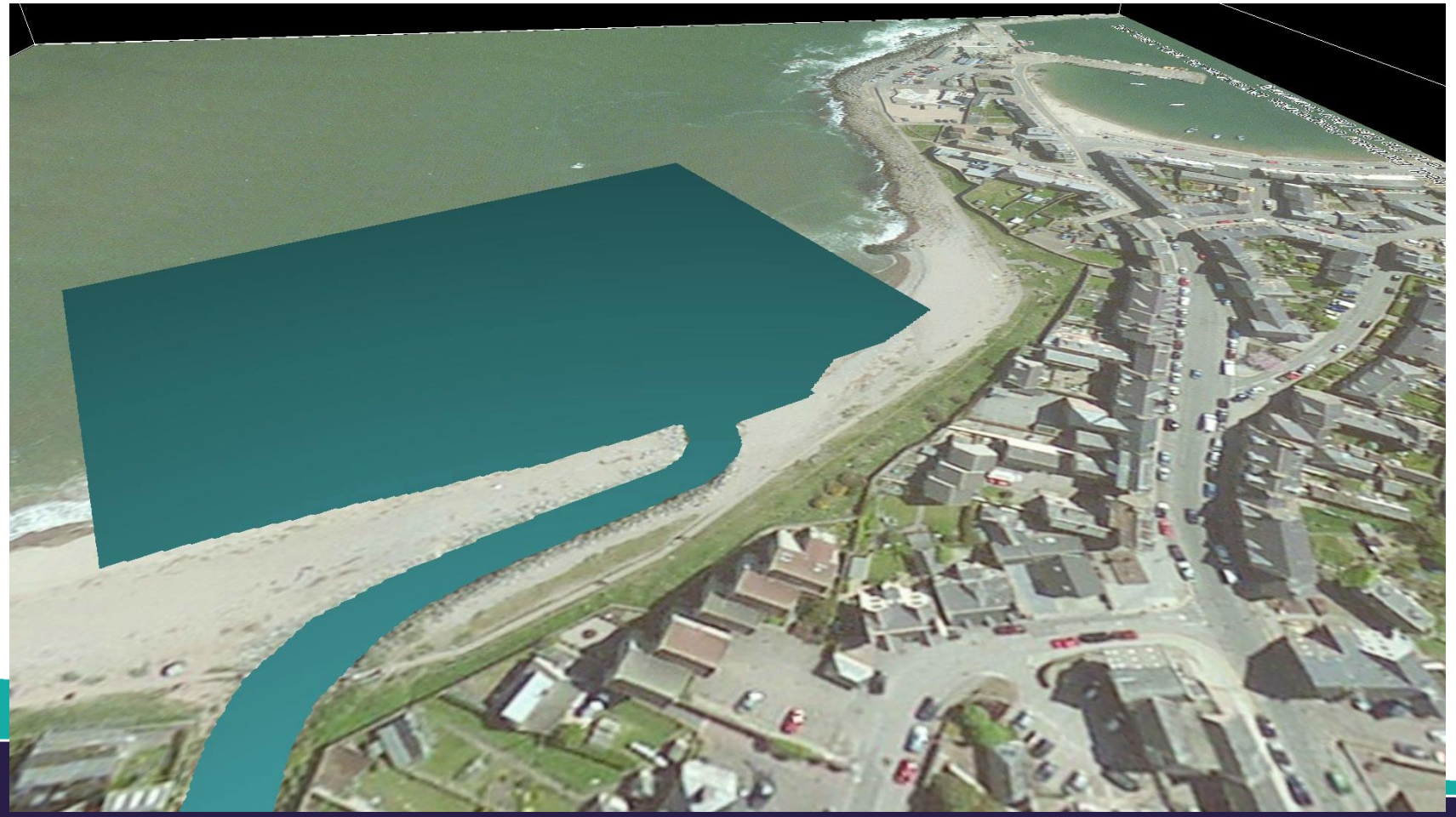
*Time consuming, traditionally prone to crashes and instabilities*

# Types of coastal modelling

## Wave models

- Phase (wave) resolving – Xbeach, Mike Boussinesq wave, CFD

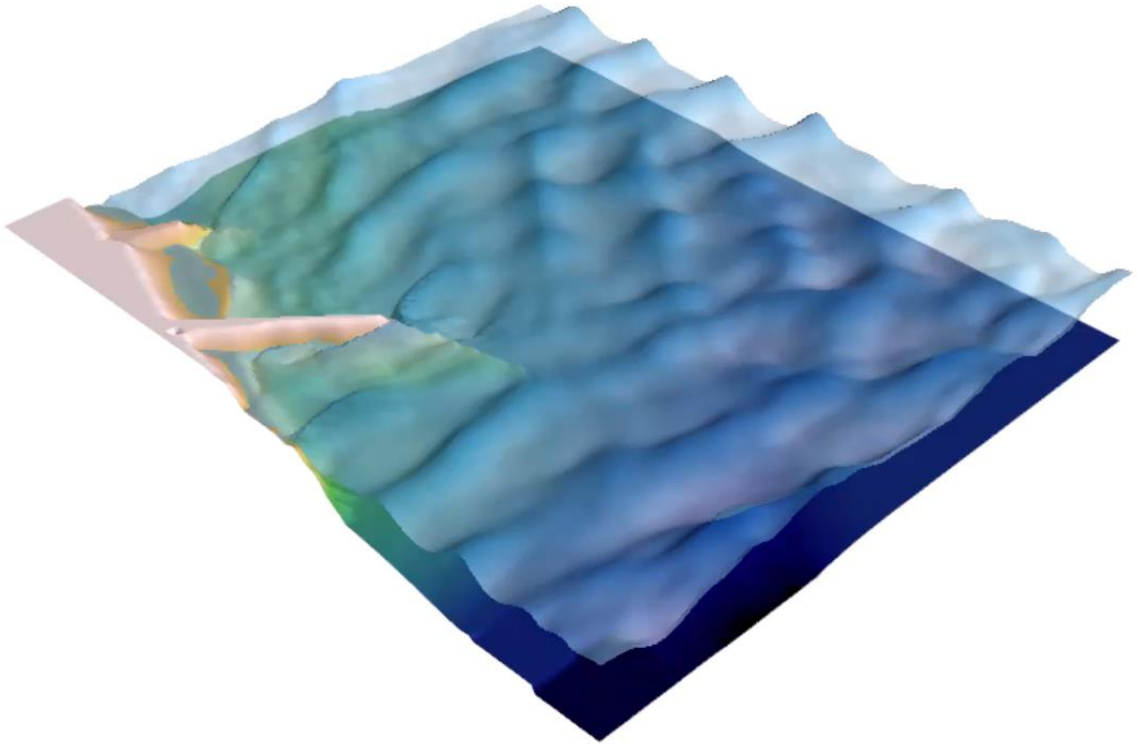
*Project: River Carron Wave Propagation Study*

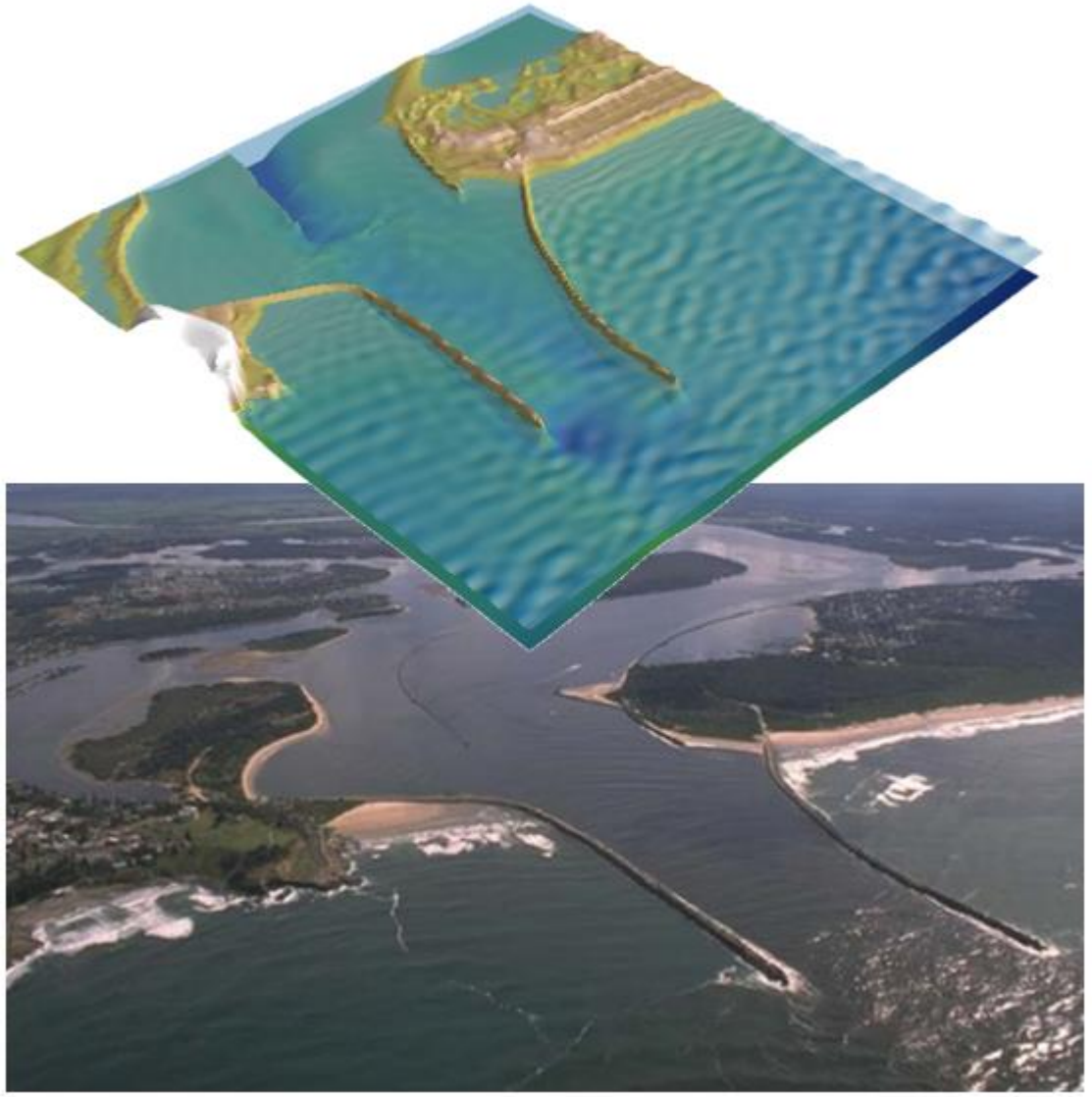


# Types of coastal modelling

## Wave models

- Phase (wave) resolving – Xbeach, Mike Boussinesq





# Types of coastal modelling

## Wave models

- Overtopping – Neural Network, Xbeach, CFD

*Typically calculates the average volume of overtopping during a storm*

*Neural Network uses the results of laboratory results*

*Empirically based, inherently stable*

*Detailed modelling can estimate individual waves, however they are not commonly validated*

# Types of coastal modelling

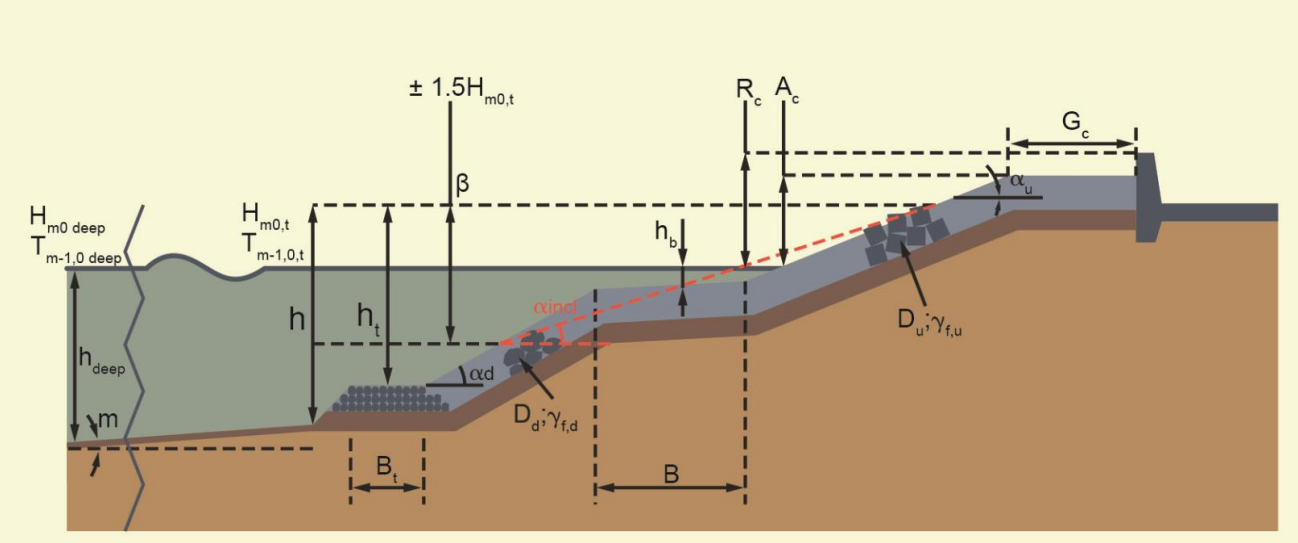
*Project: Rhyl Coastal Defence Upgrade (north Wales)*

# Types of coastal modelling

## Wave models

- Overtopping – Neural Network, Xbeach, CFD

*Estimates are given based on a dataset of actual physical model tests which are linked to 22 input parameters to "fit" the design case to data from over 13,000 wave overtopping tests*




| References | EurOtop - Neural Network for overtopping volume | | |
|---|---|---|---|
| | The following 22 parameters are updated into The neural network | | |
| | to find the overtopping volume, q (litre/sec/linear m). | | |
| | The definitions of each parameter explained as below. | | |
| | | Numbering | |
| | Name | 1 | 1.0 |
| | Foreshore slope, cot m | 2 | 50.0 |
| | Water depth at toe, h (m) | 3 | 1.7 |
| | Significant wave height at toe, Hmo (m) | 4 | 2.2 |
| | Spectral wave period, Tmm10 (s) | 5 | 10.9 |
| | Wave obliquity, B (degs) | 6 | 0.0 |
| | Toe submergence, ht (m) | 7 | 0.5 |
| | Width of toe berm, Bt (m) | 8 | 3.5 |
| | Berm submergence, Hb (m) | 9 | 1.7 |
| | Width of central berm, B (m) | 10 | 0.0 |
| | cot(alpha) below the central berm | 11 | 1.5 |
| | cot(alpha) above the central berm | 12 | 1.5 |
| | Roughness downslope | 13 | 0.55 |
| | Roughness upslope | 14 | 0.55 |
| | structure elements size along cot(alpha,d), D_down (m) | 15 | 1.2 |
| | structure elements size along cot(alpha,u), D_up (m) | 16 | 1.2 |
| EurOtop, (2016). Neural Network for the design of coastal and harbour structures. http://overtopping.ing.unibo.it/o | Armour crest level above water, Ac (m) | 17 | 1.0 |
| | Wave return wall crest level about water, Rc (m) | 18 | 1.0 |
| | Armour crest width, Gc (m) | 19 | 3.5 |
| | Logical flag to get the prediction of Kr | 20 | 0.0 |
| | Logical flag to get the prediction of Kt | 21 | 0.0 |
| | Logical flag to get the prediction of q | 22 | 1.0 |

# Types of coastal modelling

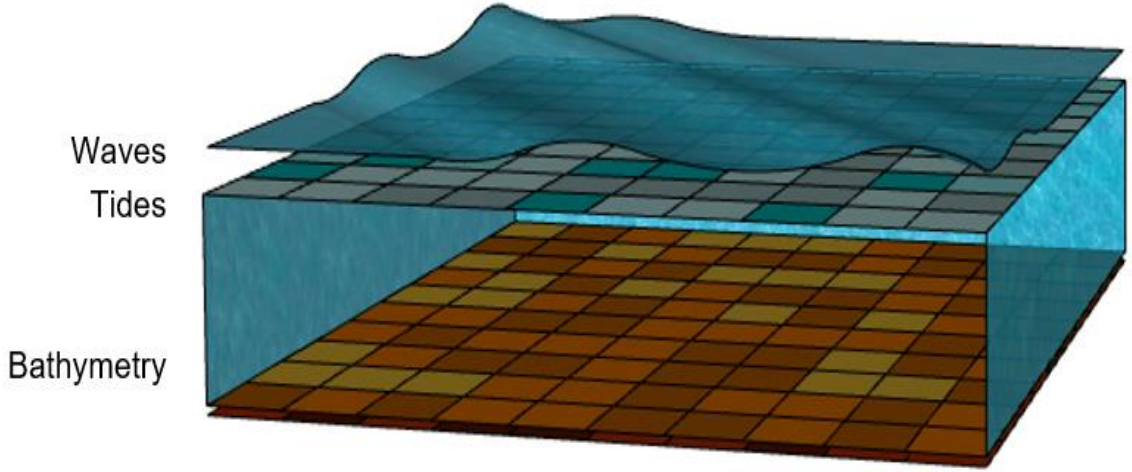
## Coastal processes and hydrodynamics

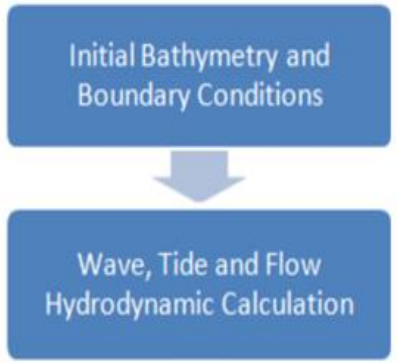
- Tuflow FV, Delft3D, Telemac, Mike 21

Can estimate tides, water levels, currents, cyclones and wave conditions.

Couples hydrodynamic simulations (tides, currents) and spectral wave modelling

…(also morphology models for sediment transport and bed morphology)



# Types of coastal modelling

## Coastal processes and hydrodynamics

*TUFLOW*
*Project: Midge Point Coastal Protection*

# Types of coastal modelling

## Coastal processes and hydrodynamics

- Delft3D, Tuflow, Telemac, Mike 21

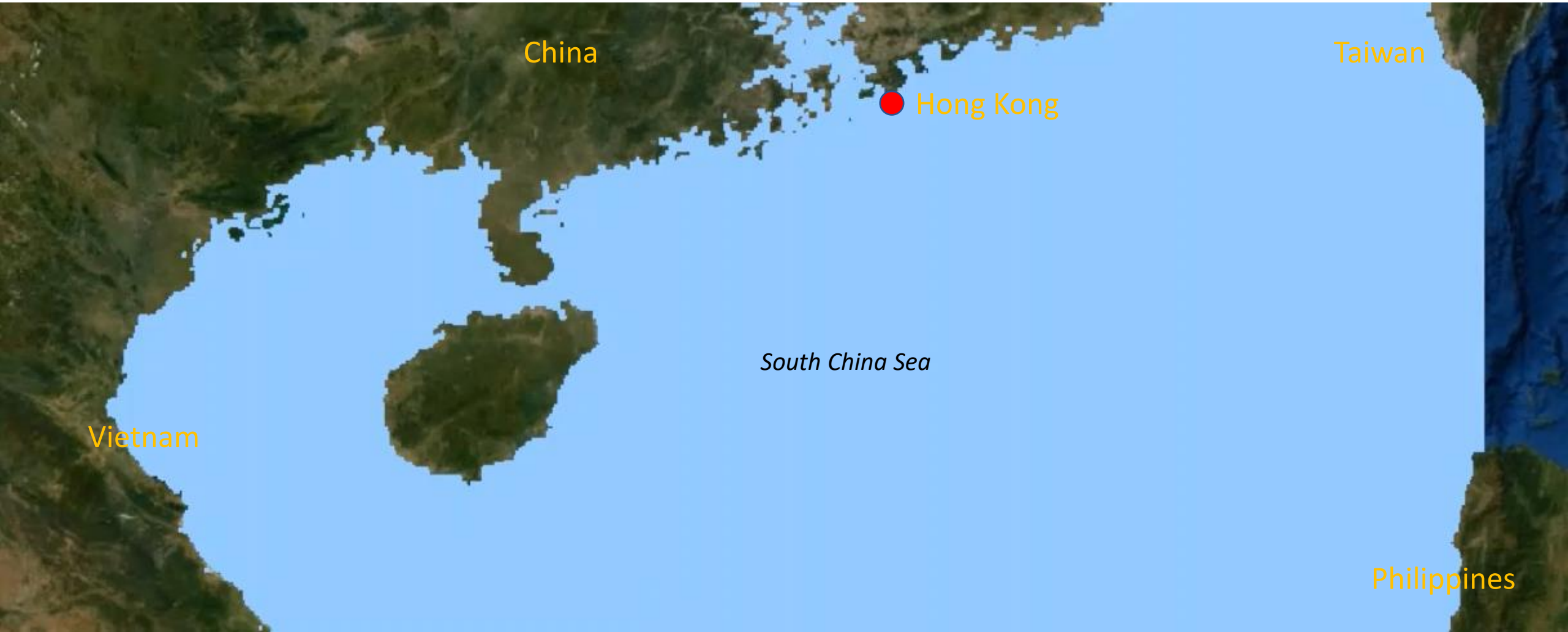
*TUFLOW*

*Project Douglas Shire-Wide coastal storm surge mapping*

# Types of coastal modelling

## Coastal processes and hydrodynamics

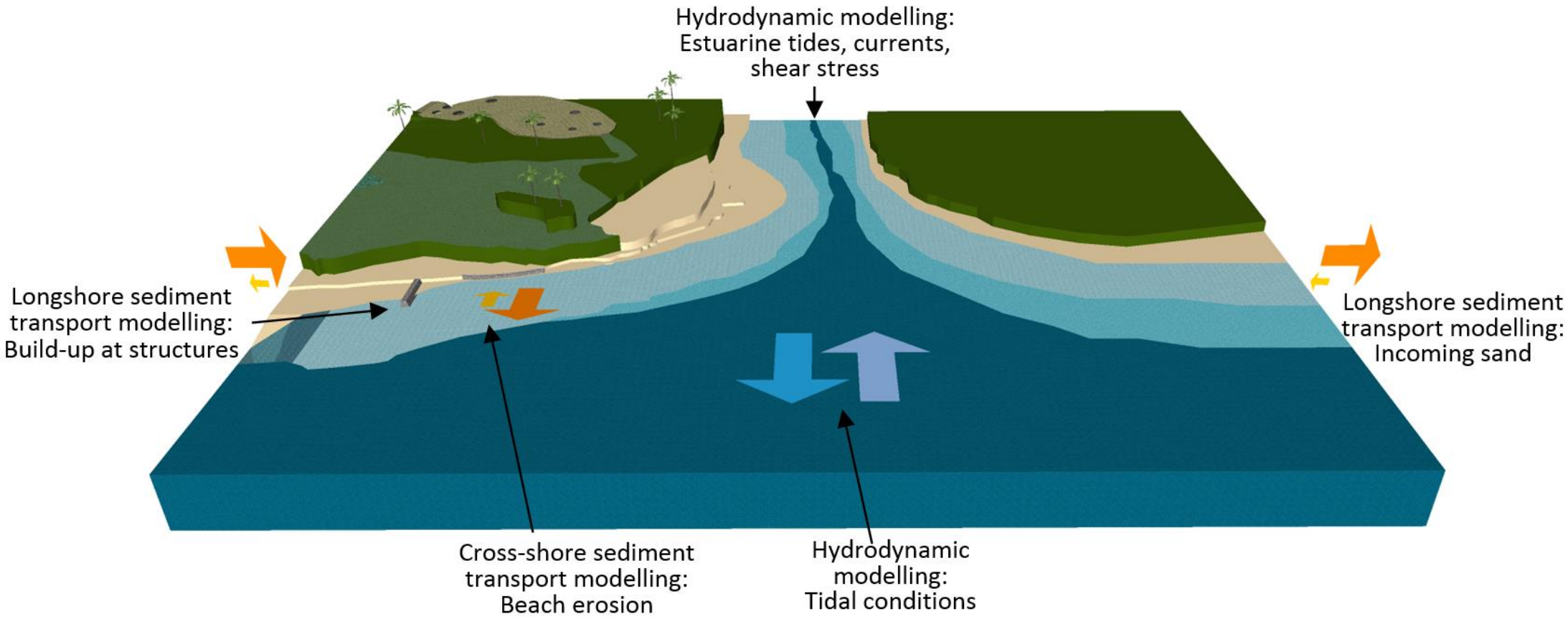
*DELFT3D*
*Project: Hong Kong*
*Storm Surge Analysis*



# Types of coastal modelling

## Sediment transport

- Tuflow FV, Delft3D, Xbeach, Mike 21, Telemac



# Types of coastal modelling

## Sediment transport

- Tuflow FV, Delft3D, Xbeach, Mike 21, Telemac

In addition to your hydrodynamic model you need to have:

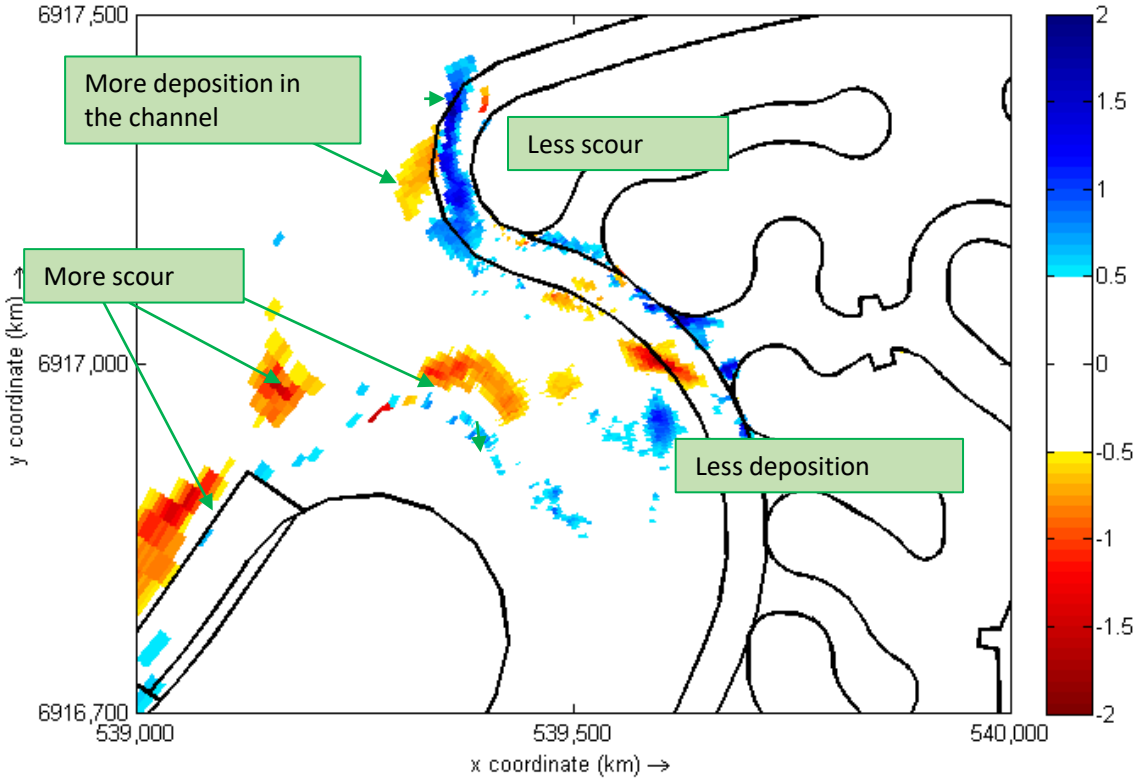
- Sediment information (sand or cohesive sediment can be modelled)
- Turbidity information helps define suspended solids and bedloads

# Types of coastal modelling

## Sediment transport

- Tuflow FV, Delft3D, Xbeach, Mike 21, Telemac


*Project: Sovereign Island Dredge Management – Options testing*



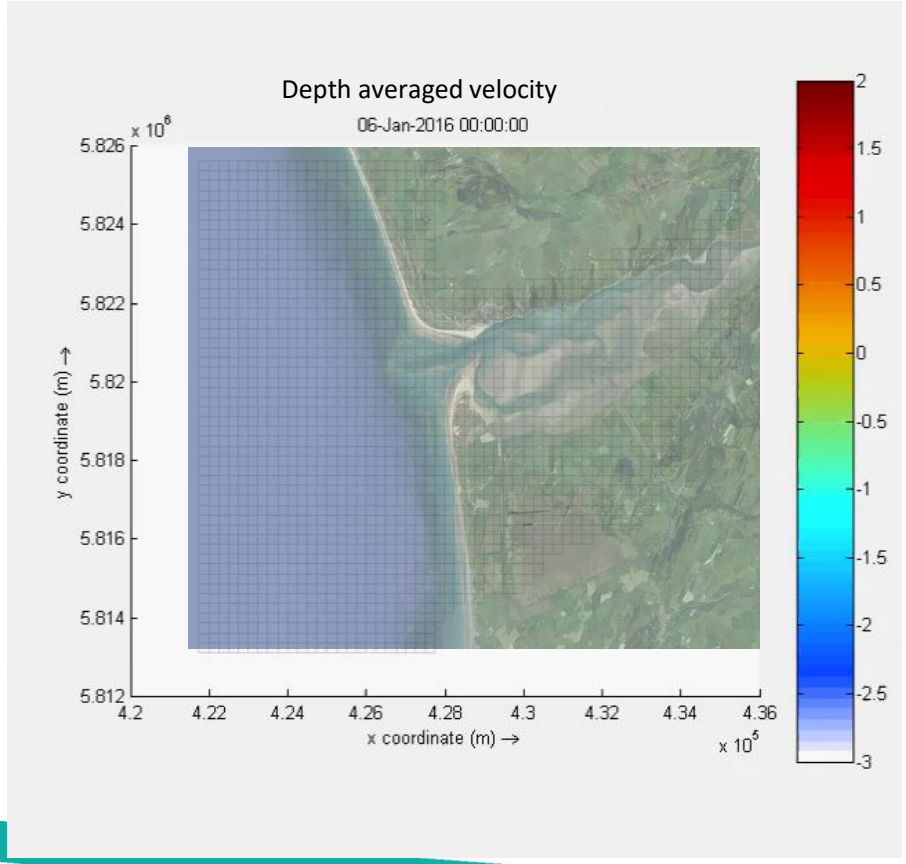
# Types of coastal modelling

## Sediment transport

- Tuflow FV, Delft3D, Xbeach, Mike 21, Telemac

*Simple models can also be setup using the Delft Dashboard – including fast model builder, global tidal database, global bathymetric information*

Aberdyfi, West Wales



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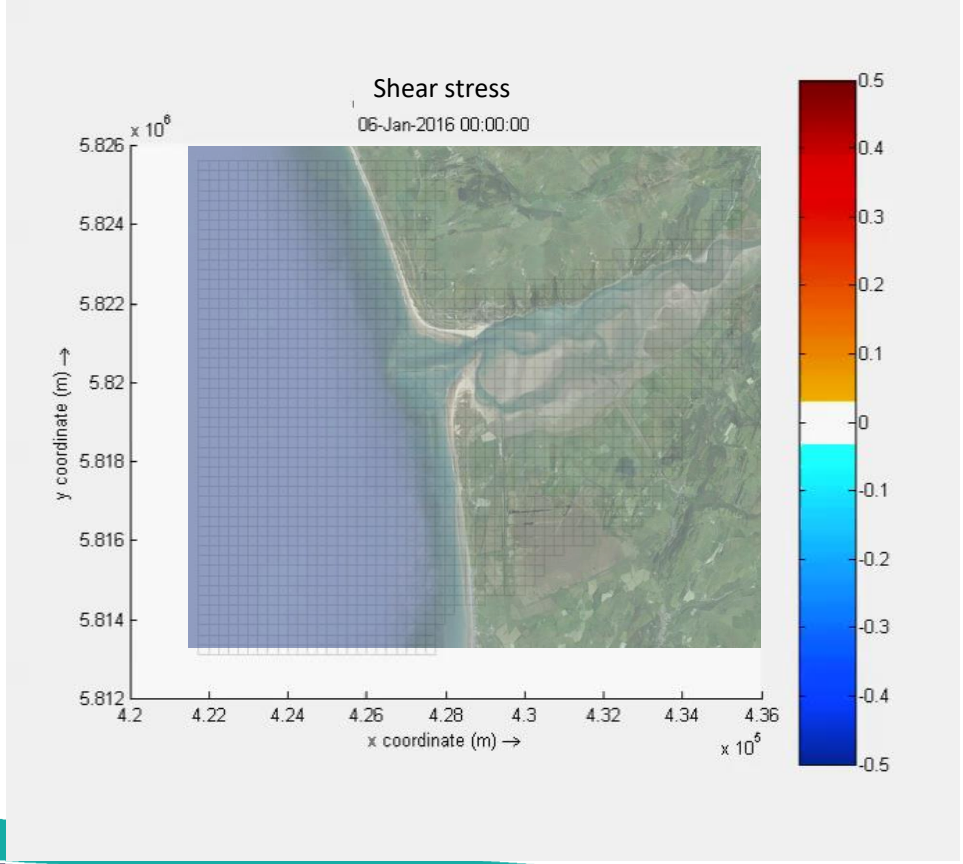


# Types of coastal modelling

## Beach erosion

- Vellinga equations, XBeach

- Estimated based on empirical datasets
- We have developed the JBP Erosion Prone Area (JBPA) tool
- This predicts the beach erosion under extreme wave, period and storm tide conditions.

$$\left(\frac{7.6}{H_{0s}}\right) y = 0.47 \left[ \left(\frac{7.6}{H_{0s}}\right)^{1.28} \left(\frac{w}{0.0268}\right)^{0.56} x + 18 \right]^{0.5} - 2.00$$

Where, $H_{0s}$ = significant 'deep water' wave height and w = fall velocity of sand

*P. Vellinga (1982). "Beach and dune erosion during storm surges" Delft Hydraulics Laboratory*

# Types of coastal modelling

Beach erosion

- Vellinga equations, XBeach

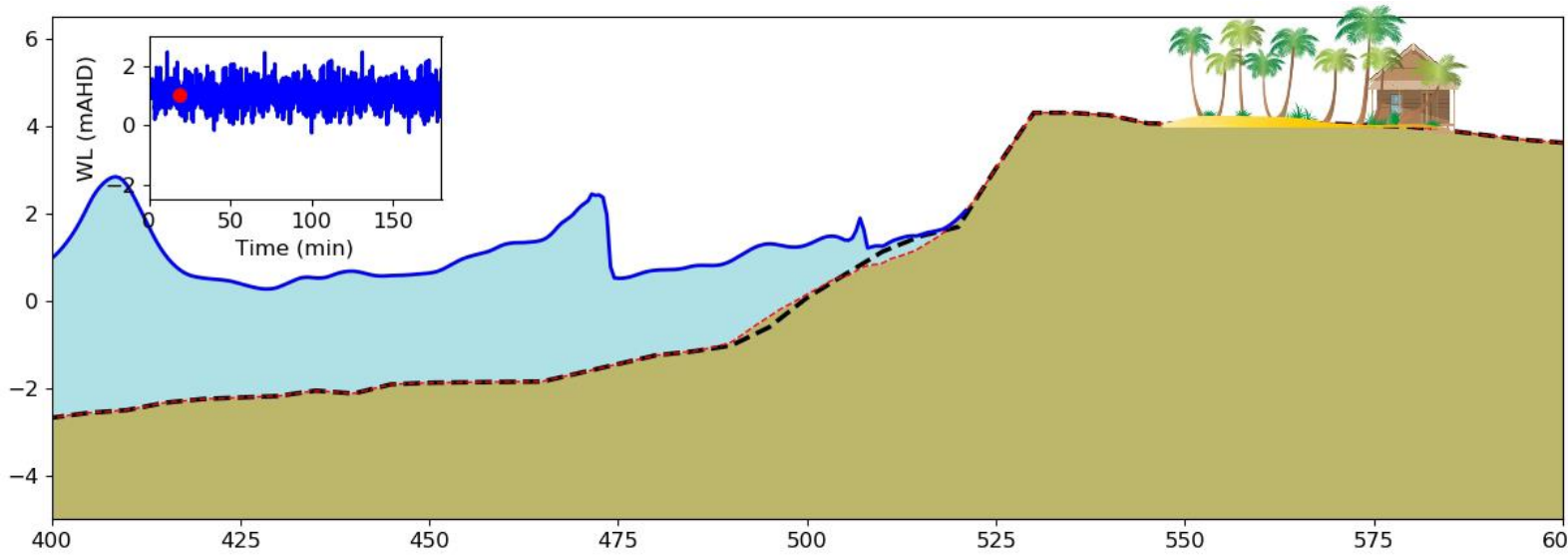

Probabilistic erosion modelling

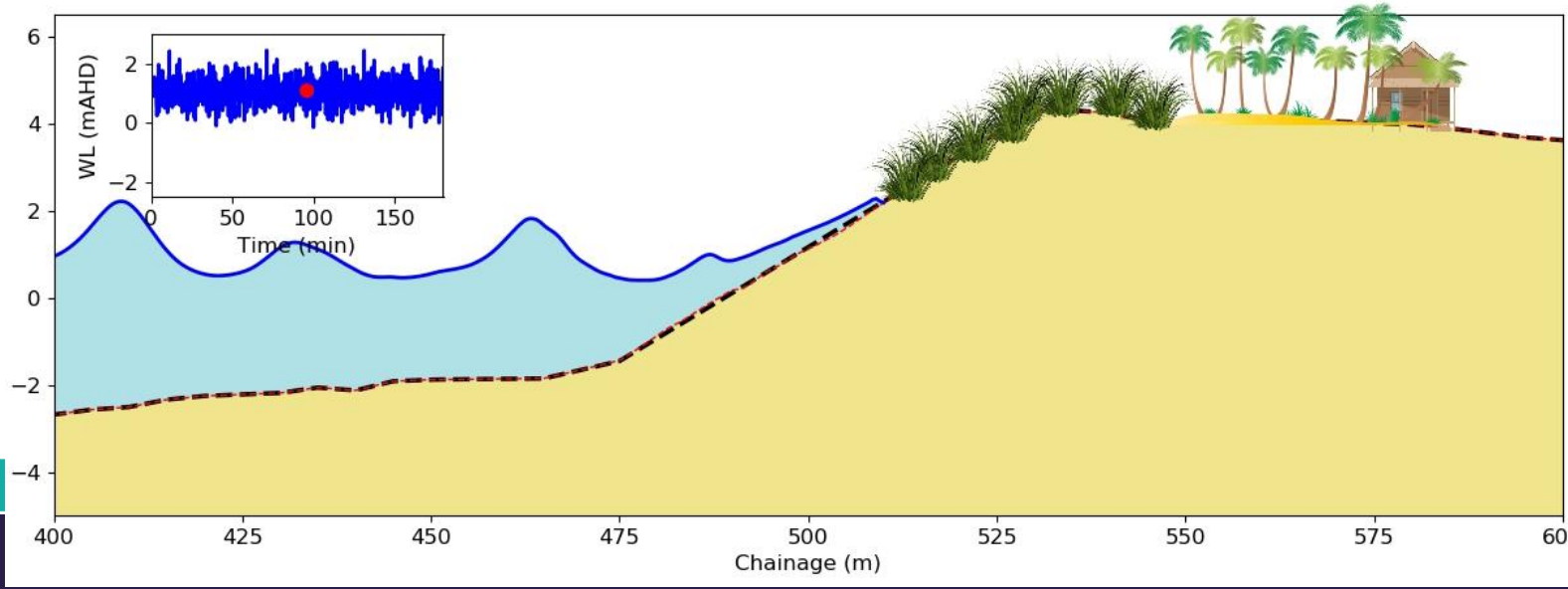
# Types of coastal modelling

Beach erosion

- Vellinga equations, XBeach

*Alternatively a process-based Xbeach model can be used to consider different beaches and vegetation types*

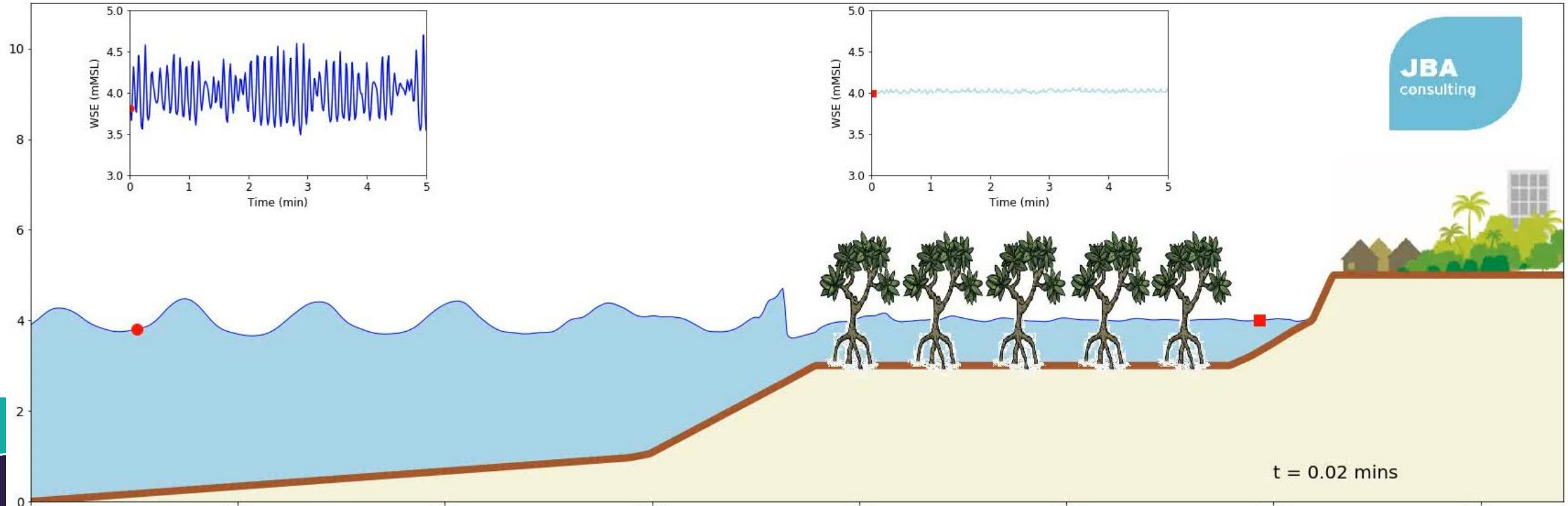


# Types of coastal modelling

## Nature Based Solutions

- Assessment of mangrove efficiency and ideal forest widths
- Placement of pile fields,
- Design of rock fillets

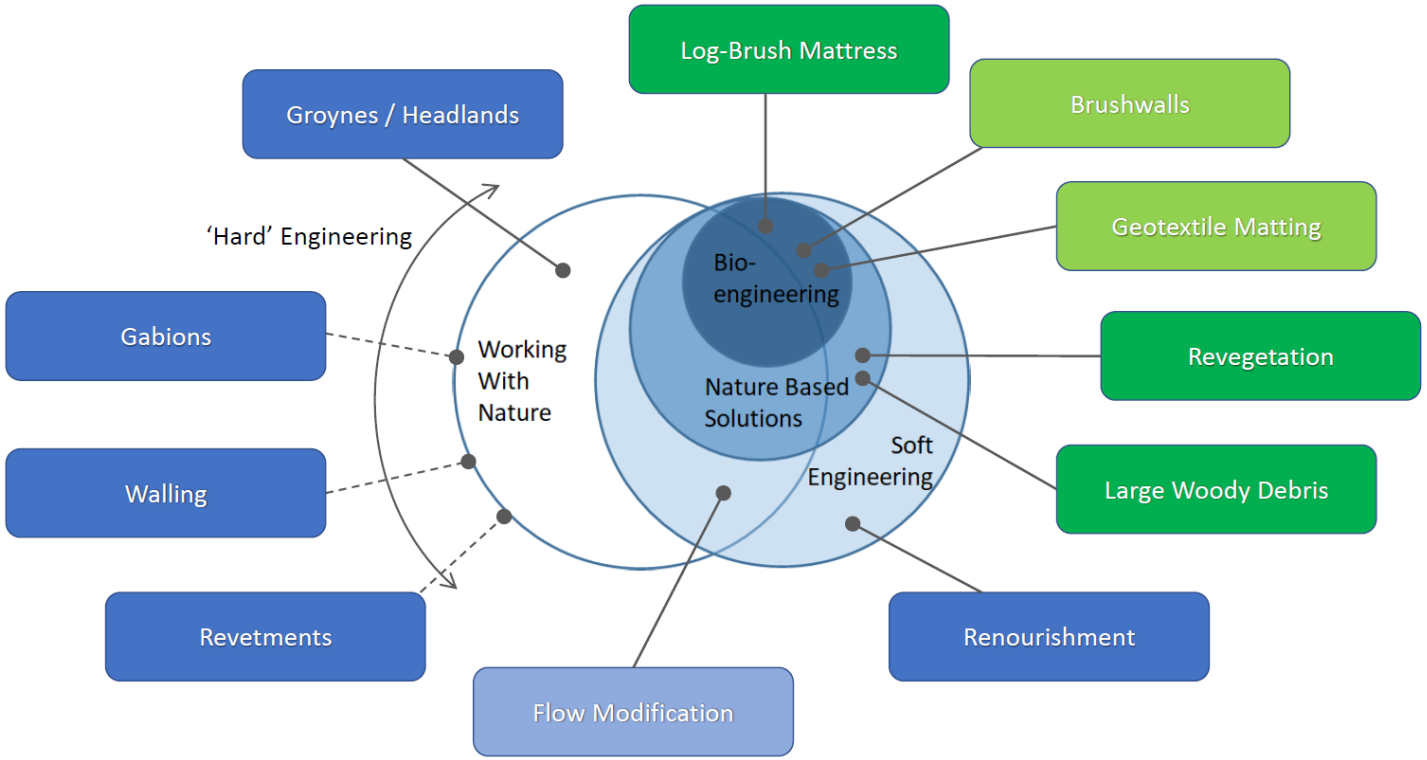


# Nature based resilience

Nature-based coastal resilience measures are being increasingly recommended to protect against coastal and estuarine erosion.

They are gaining interest as a substitute for – or in conjunction with – standard engineering designs

However, implementation has been limited in many areas

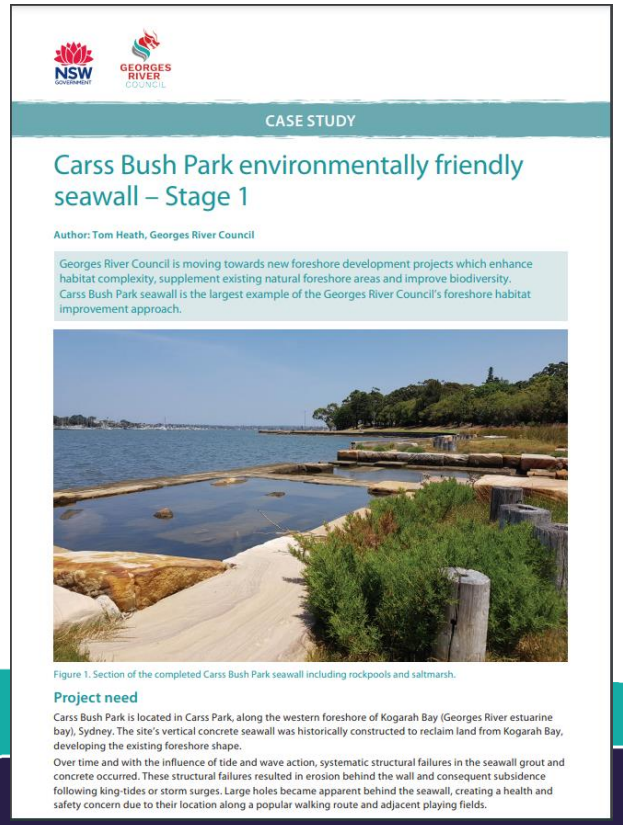



*Courtesy Matt Eliot, Damara*

# Nature based resilience

## Challenges in implementing nature-based designs

1. Lack of local case studies
2. Planning requirements
3. Certainty in designs (modelling can help)



NSW GOVERNMENT

GEORGES RIVER COUNCIL

CASE STUDY

### Carss Bush Park environmentally friendly seawall – Stage 1

Author: Tom Heath, Georges River Council

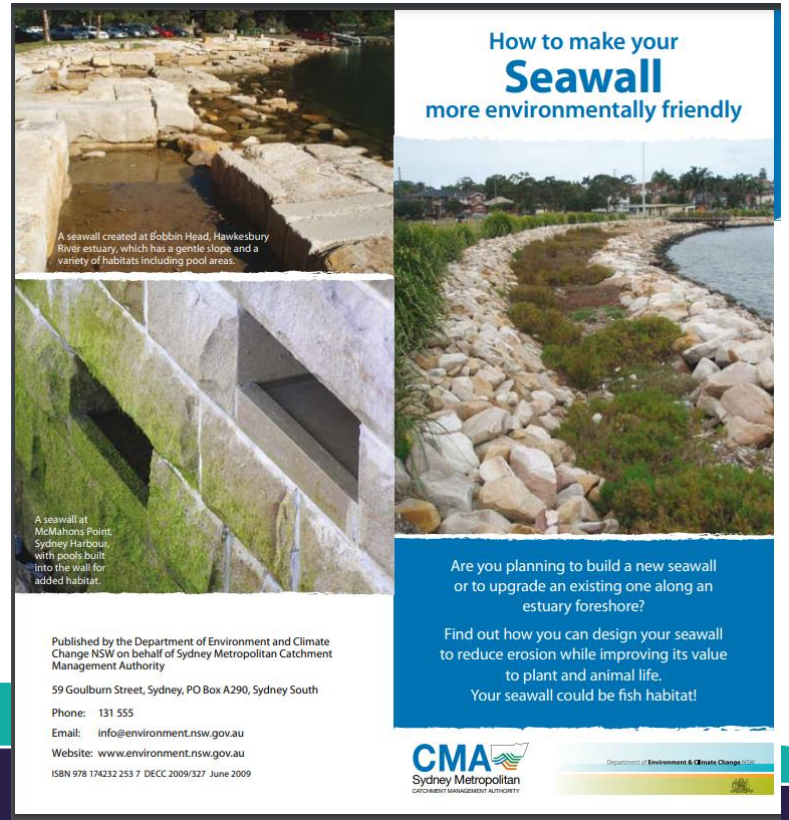
Georges River Council is moving towards new foreshore development projects which enhance habitat complexity, supplement existing natural foreshore areas and improve biodiversity. Carss Bush Park seawall is the largest example of the Georges River Council's foreshore habitat improvement approach.

Figure 1. Section of the completed Carss Bush Park seawall including rockpools and saltmarsh.

**Project need**

Carss Bush Park is located in Carss Park, along the western foreshore of Kogarah Bay (Georges River estuarine bay), Sydney. The site's vertical concrete seawall was historically constructed to reclaim land from Kogarah Bay, developing the existing foreshore shape.

Over time and with the influence of tide and wave action, systematic structural failures in the seawall grout and concrete occurred. These structural failures resulted in erosion behind the wall and consequent subsidence following king-tides or storm surges. Large holes became apparent behind the seawall, creating a health and safety concern due to their location along a popular walking route and adjacent playing fields.



A seawall created at Bobbin Head, Hawkesbury River estuary, which has a gentle slope and a variety of habitats including pool areas.

A seawall at McMahons Point, Sydney Harbour, with pools built into the wall for added habitat.

How to make your **Seawall** more environmentally friendly

Are you planning to build a new seawall or to upgrade an existing one along an estuary foreshore?

Find out how you can design your seawall to reduce erosion while improving its value to plant and animal life.
Your seawall could be fish habitat!

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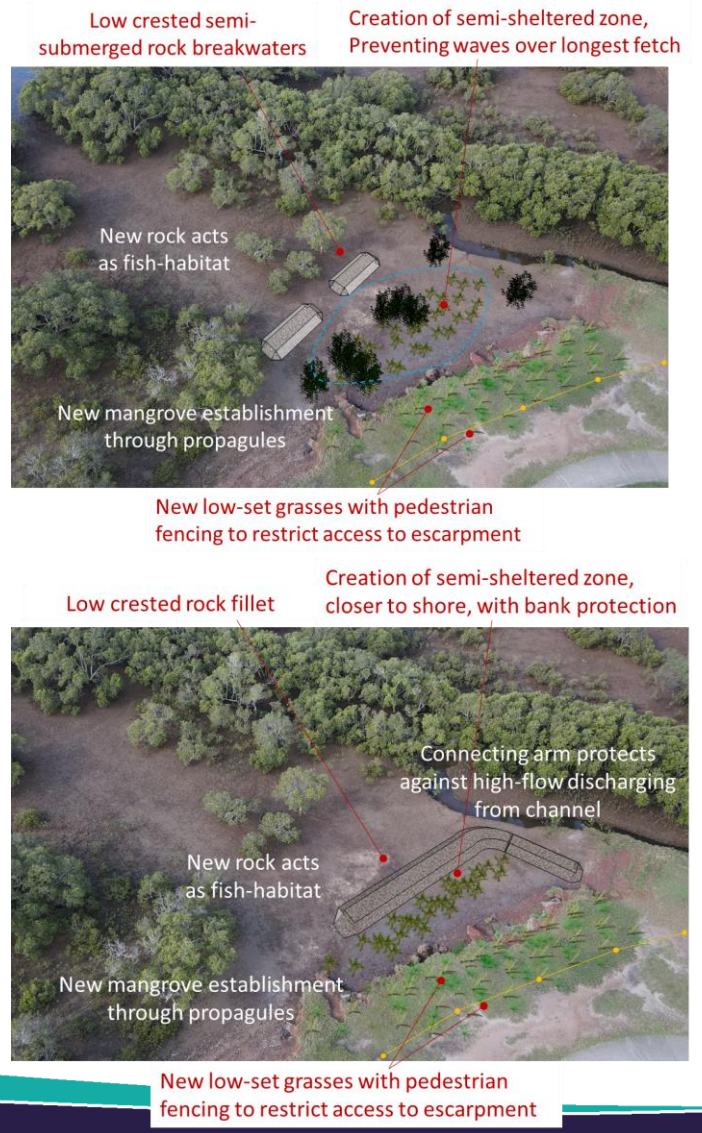
CMA Sydney Metropolitan Catchment Management Authority

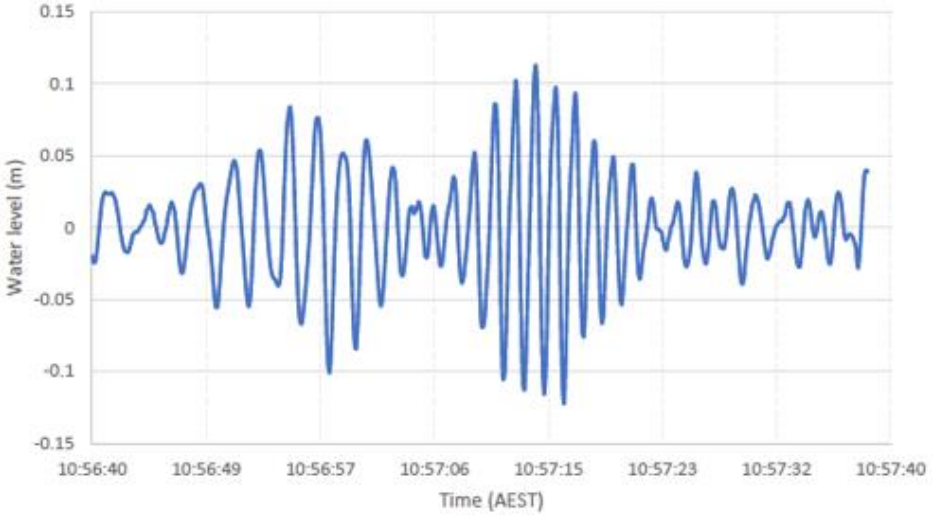


# Nature based resilience

- John Oxley Reserve, SE QLD
  - 120m of eroded estuarine banks.
  - Near-vertical banks 0.5m to 2.0m
  - Undercut scarps
  - ~ 5m lateral erosion over ten years (approx. 0.5m/yr)

# Nature based resilience

- High boat wake wave environment

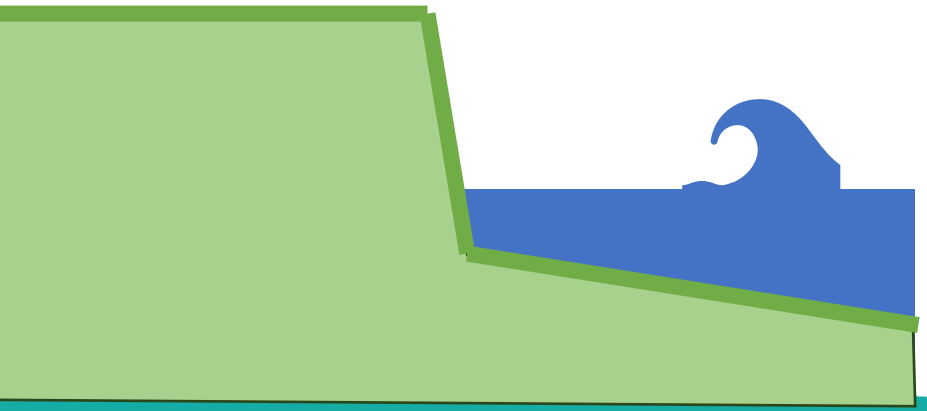
# Nature based resilience

## Design

- Inspiration from NSW, but limited published design guidance

*Newly installed rock fillet, rock fillet protecting saltmarsh, mangrove trees behind rock fillet*

*Ash Island (Hunter River NSW) eroding bank before, during and 3 years after installation of rock fillet, showing mangrove seedling colonisation of still water between rock fillet and previously eroding bank*



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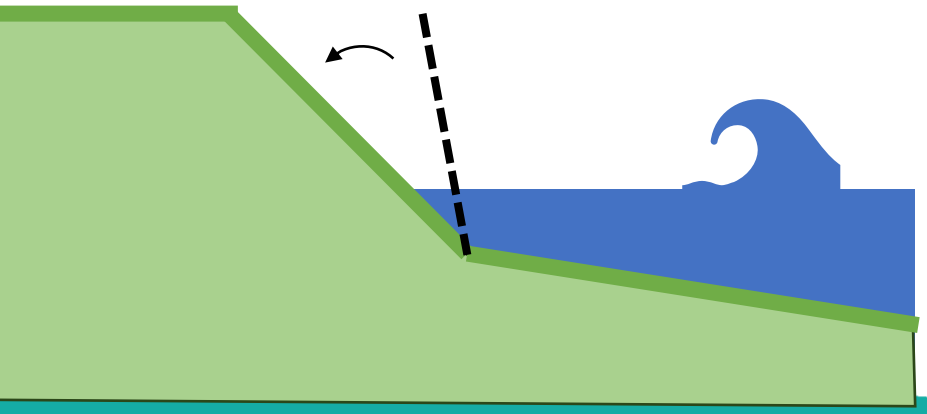

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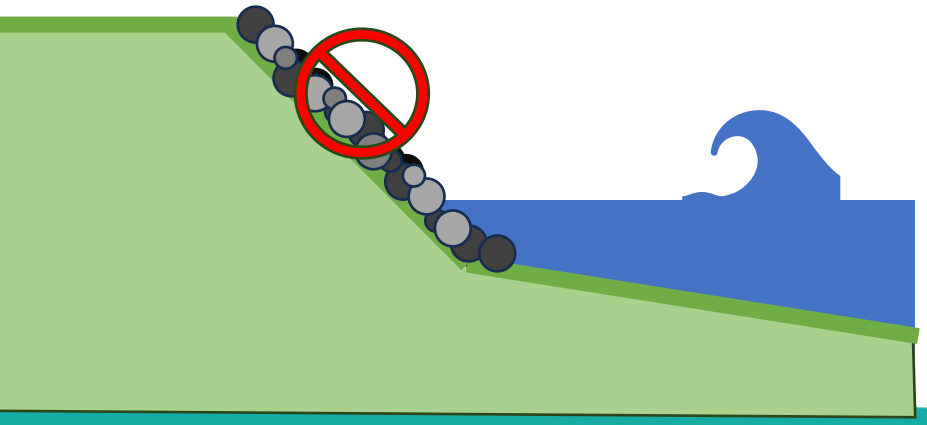

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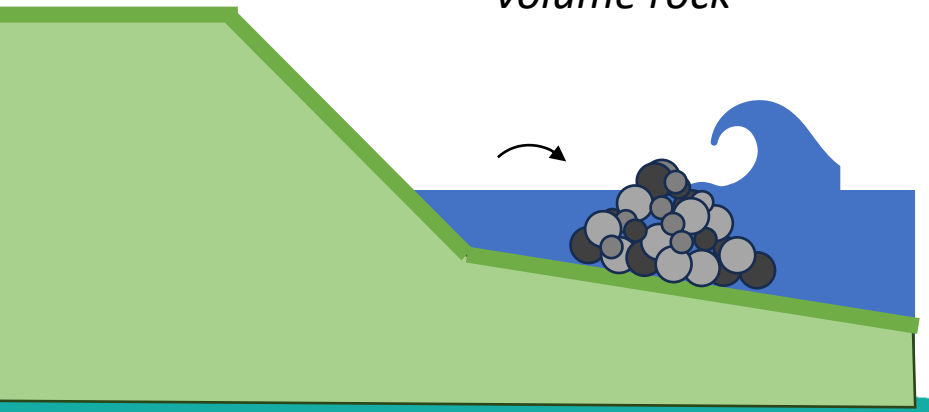
*Ideally using ½ volume rock*



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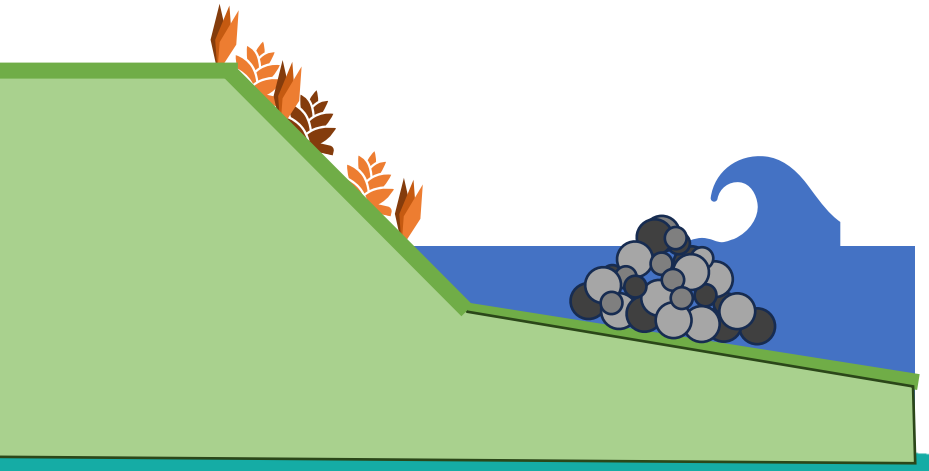
*New bank planting*



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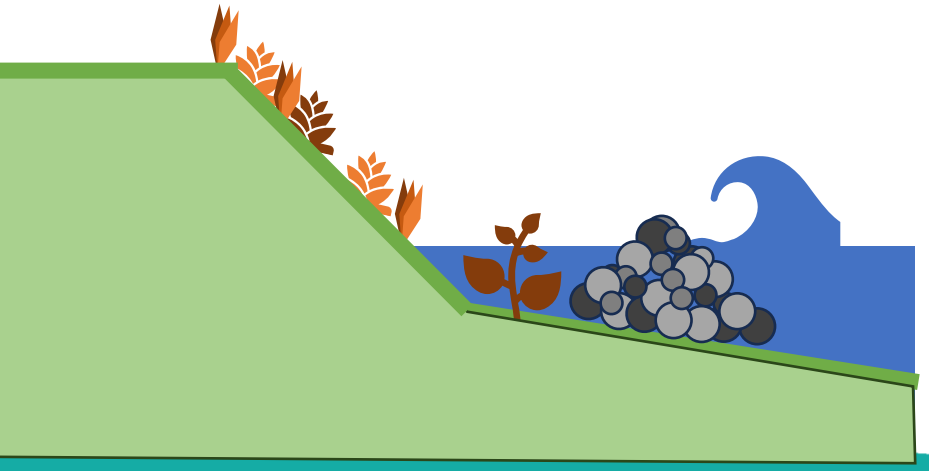
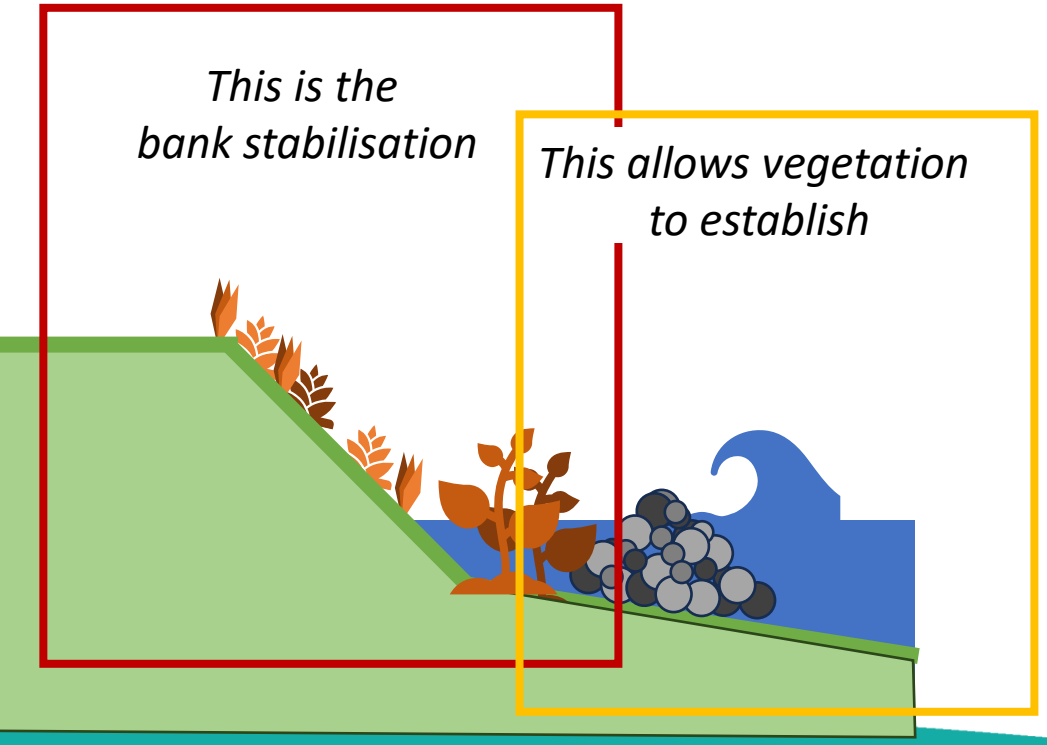
*Encouraging new mangrove growth*



# Nature based resilience

## Design

- Inspiration from NSW, but limited published design guidance

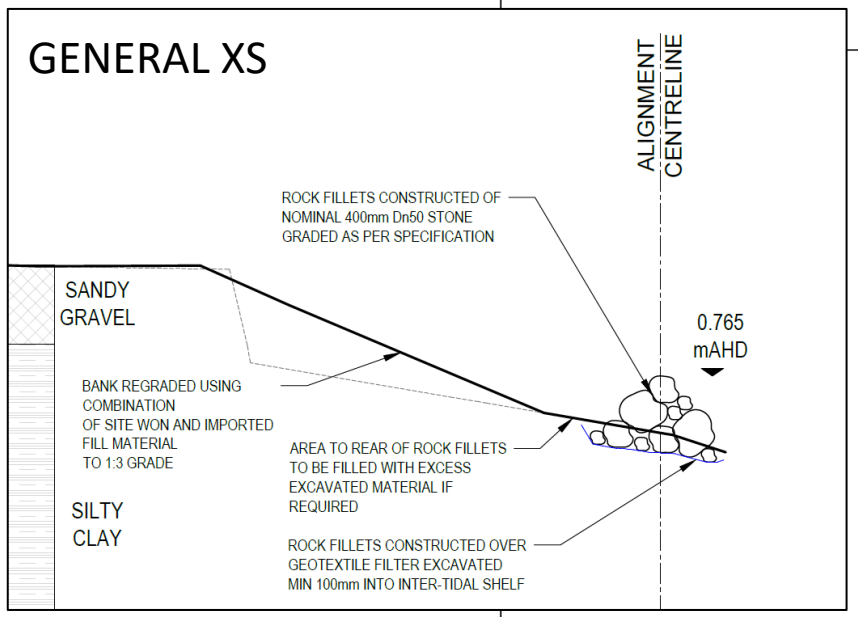


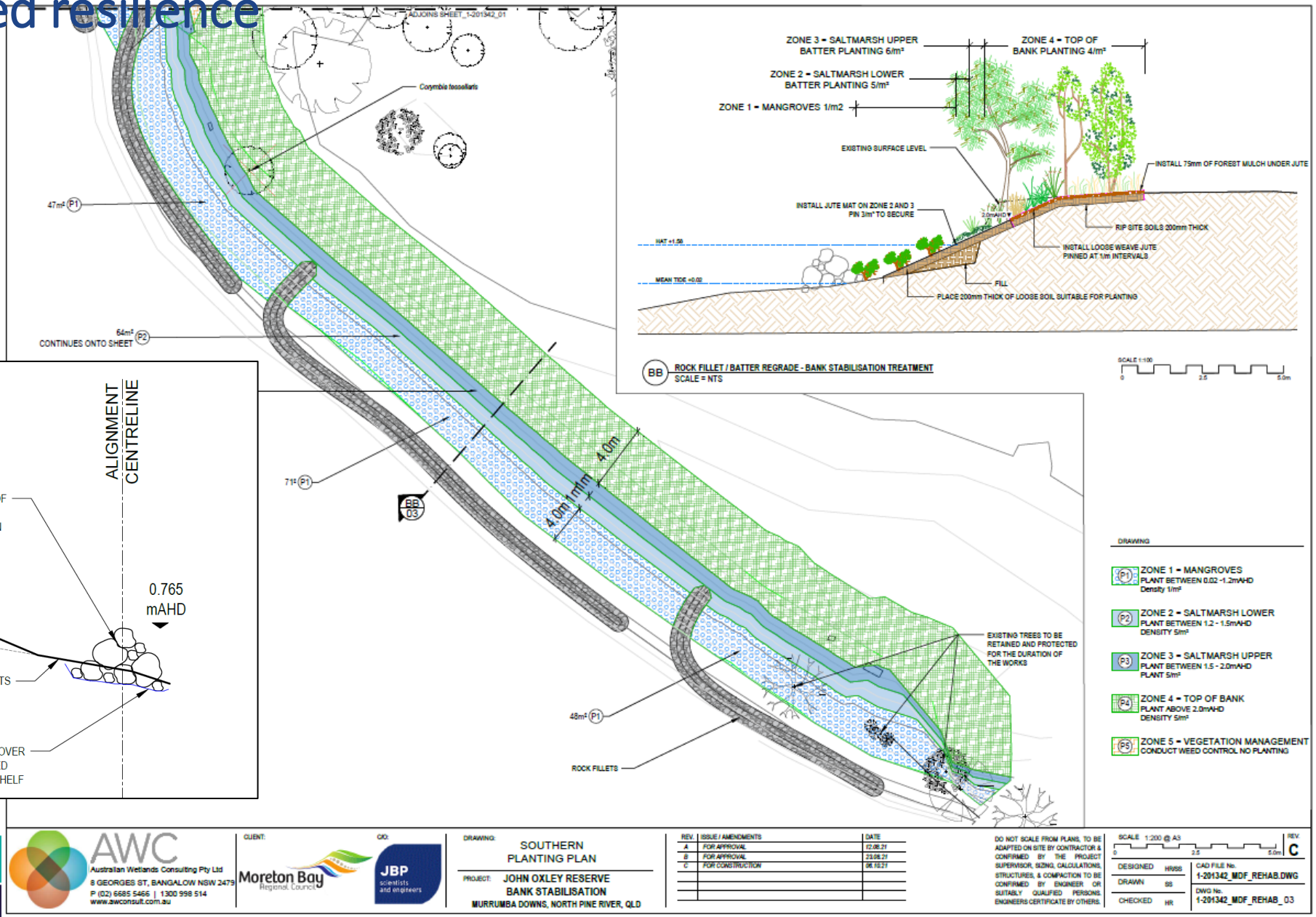

*Newly installed rock fillet, rock fillet protecting saltmarsh, mangrove trees behind rock fillet*

*Ash Island (Hunter River NSW) eroding bank before, during and 3 years after installation of rock fillet, showing mangrove seedling colonisation of still water between rock fillet and previously eroding bank*

# Nature based resilience

- Design



# Nature based resilience

- Construction

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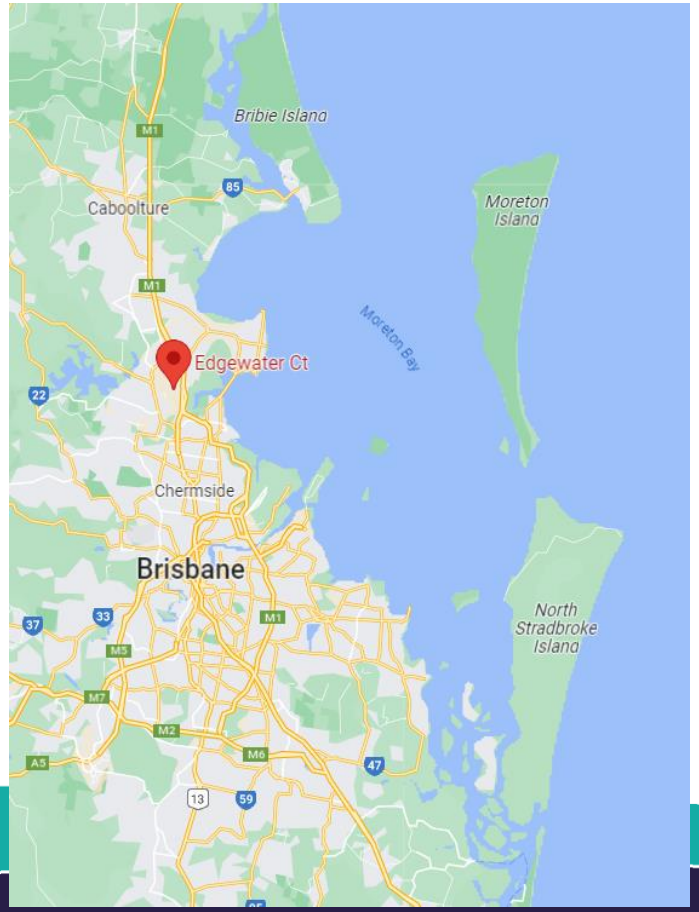
- Construction
  - Why the bank work and planting?
  - We need successful, good looking case studies in QLD to act as demonstration projects

*Ash Island (Hunter River NSW) eroding bank before, during and 3 years after installation of rock fillet, showing mangrove seedling colonisation of still water between rock fillet and previously eroding bank*

# Nature based resilience

Go check out the site yourself!

Head to Edgewater Ct,
Murrumba Downs QLD 4503

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