These lecture materials are for the Marine Coastal and Delta Sustainability for Southeast Asia (MARE) (Project No. 610327-EPP-1-2019-1-DE-EPPKA2-CBHE-JP).

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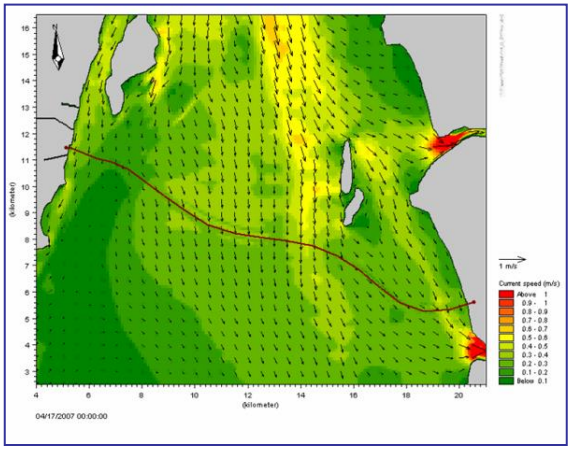
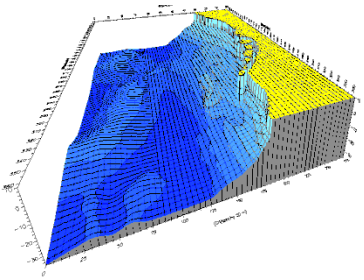
Co-funded by the Erasmus+ Programme of the European Union

Hydraulic Study for Shoreline Management



Overall Learning Outcomes



CLO1 Assess the influencing environmental factors and related coastal processes, and analyze causes of coastal erosion/sedimentation

CLO2 Develop skills and knowledge for the planning and management of coastal zone in respecting the principles of sustainability

CLO3 Evaluate application of different coastal stabilization schemes and the governing factors for their selection and impacts

PO1 Acquire and apply engineering fundamentals to complex civil engineering problems

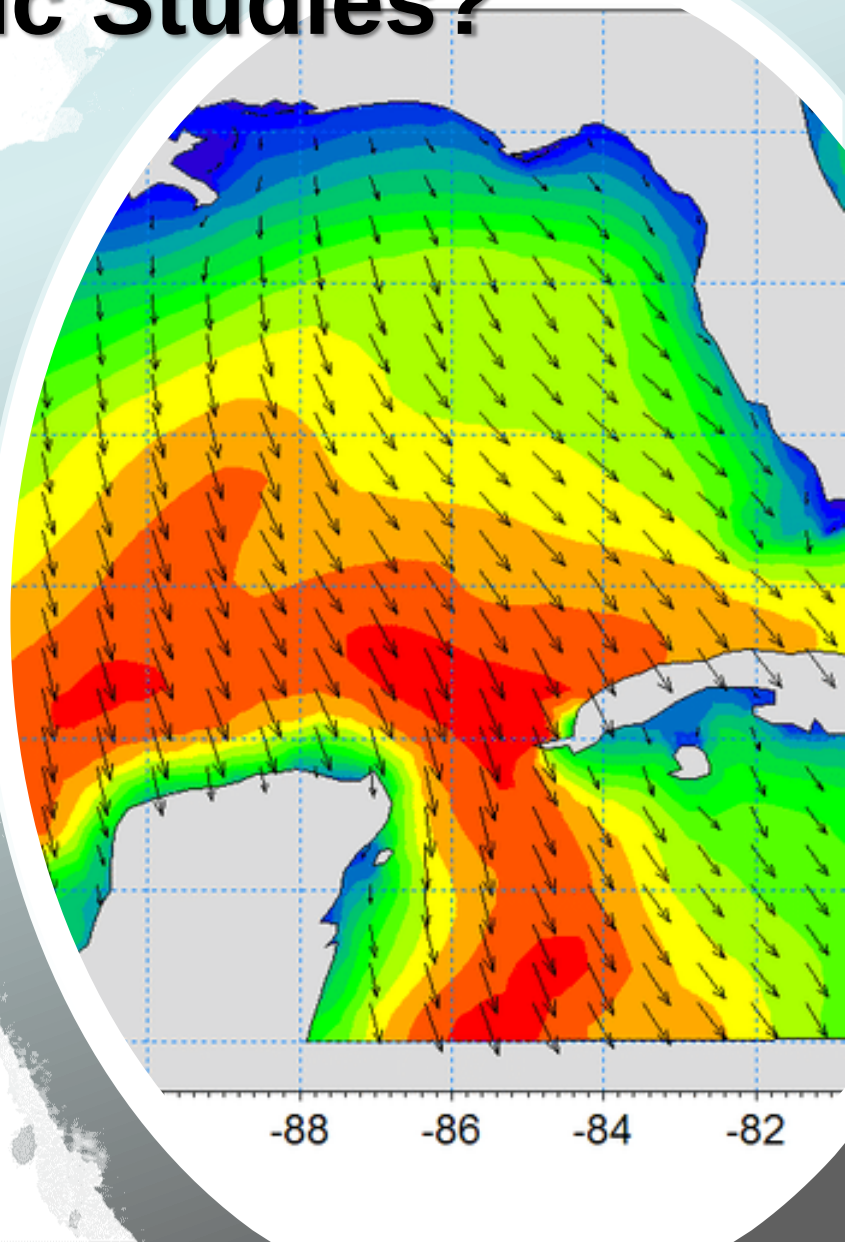
PO2 Identify, formulate and solve complex civil engineering problems using creativity and innovativeness

Coastal Modelling & Case Studies

- Purpose of coastal and marine studies
- Overview of hydraulic and coastal modelling
- Example applications and case studies

Why Coastal Hydraulic Studies?

- Understanding hydraulic phenomena/ problems
- Design parameters for planning/design of mitigation/improvement works
- Impact assessment of coastal development
- Monitoring feedback

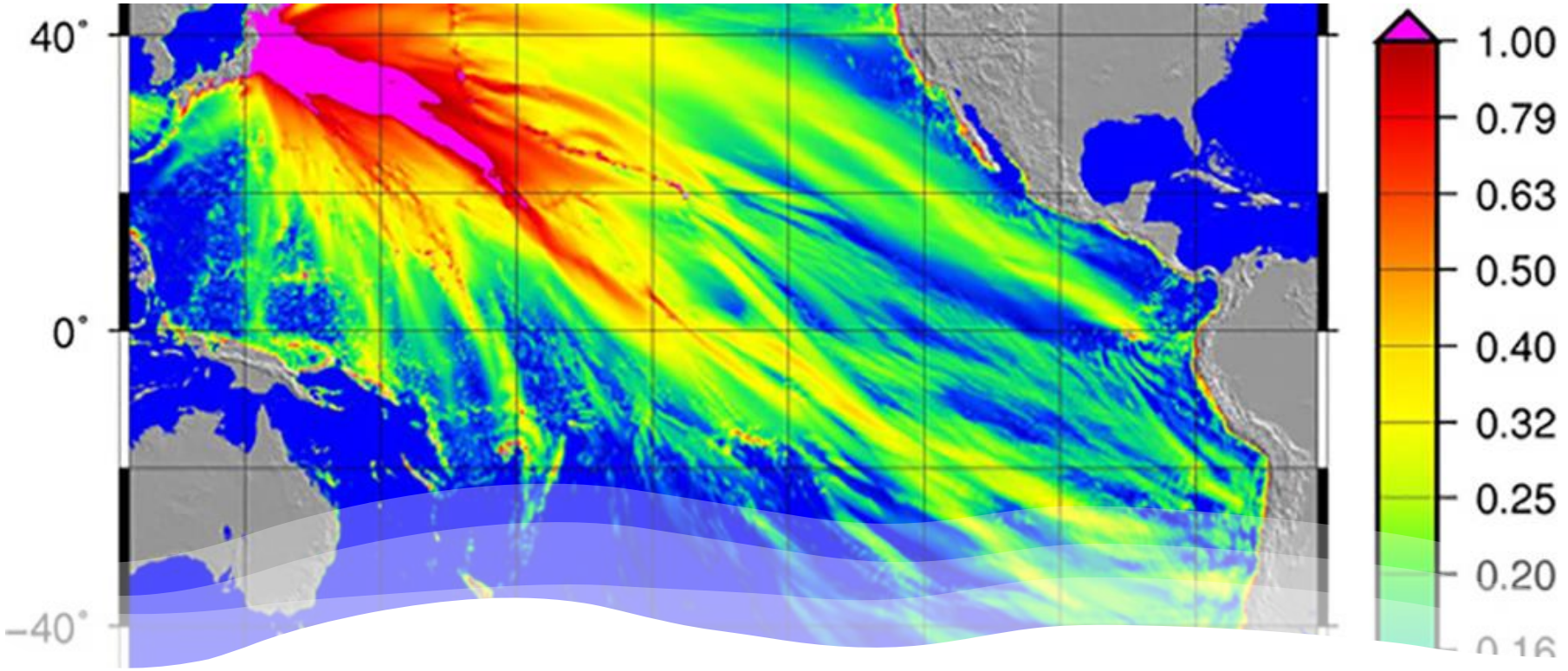


Scientific Investigation

- Scientific investigations of sediment transport in tidal areas can provide the crucial information needed to understand and predict the morphological changes.
- In most of the existing sediment transport and morphological models, analysis are made based on several assumptions, probably due to lack of available data or as part of the simplifications approach in making realistic modelling assessment.
- Often these assumptions are made with respect to most engineering applications, thus require careful judgment.

Complexity in Coastal Environment

- Coastal processes is generally very complex.
- Various factors influencing the behavior and the corresponding responses.
- Responses cannot be simply generalized and it is very site specific.
- Knowledge about the coastal processes is progressively developing especially in fine sediment dynamics.



Why Modelling?

- **Resources constraint**

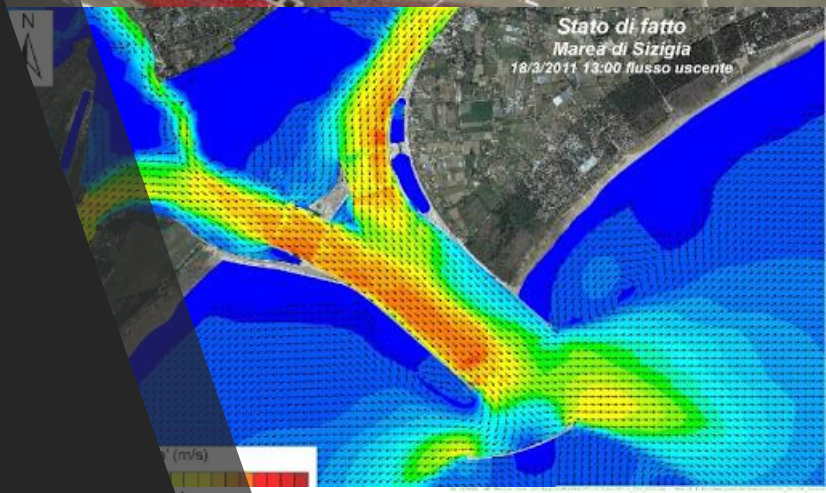
  Time, money, spatial coverage

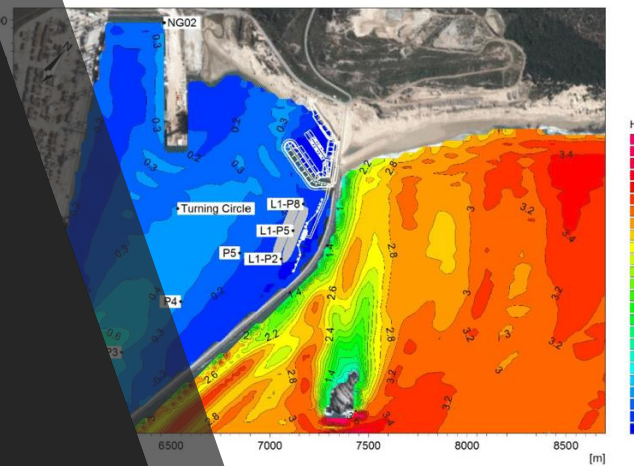
- **Knowledge deficiency/gap**

  Regression using field data; analytical solutions

Type of Modelling

- **Physical modeling**
- **Numerical modelling**
- **Hybrid modeling** (regional numerical modeling feeding into local physical modeling)



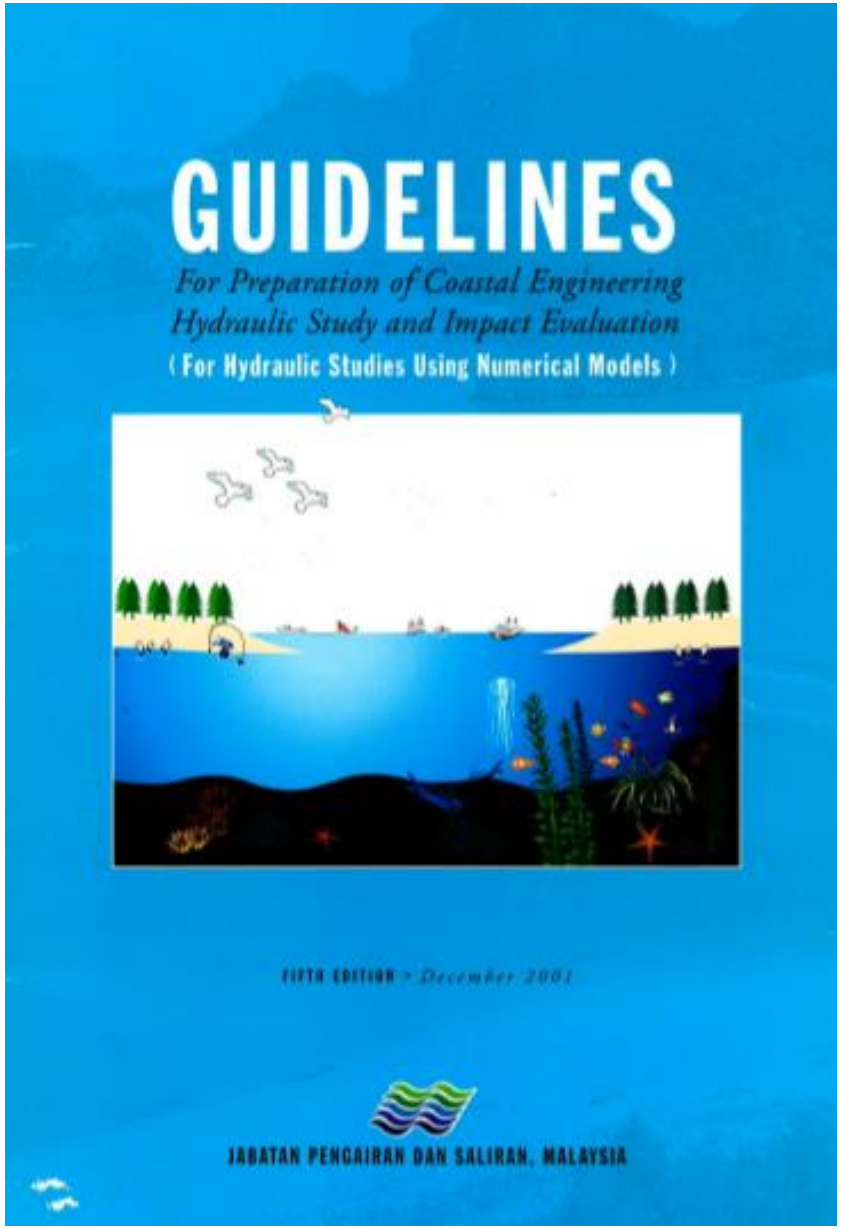


Guidelines

Guidelines on Erosion Control For Development Projects In The Coastal Zone (Garispanduan JPS 1/97) aims at ensuring proper planning & implementation of coastal development projects in Malaysia.

https://www.water.gov.my/jps/resources/PDF/GUIDELINES_ON_EROSION_CONTROL.pdf

Guidelines

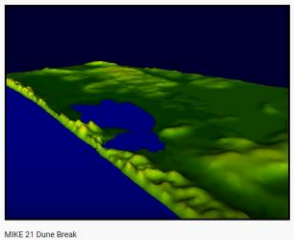


Guidelines For Preparation of Coastal Engineering Hydraulic Study and Impact Evaluation (For Hydraulic Studies using Numerical Models)
Fifth edition
(December 2001)

https://www.water.gov.my/jps/resources/Guidelines_for_Hydraulics_Studies.pdf

Present Technology

- New tools in predicting and accessing coastal engineering projects / problems
- State-of-the-art modelling software available



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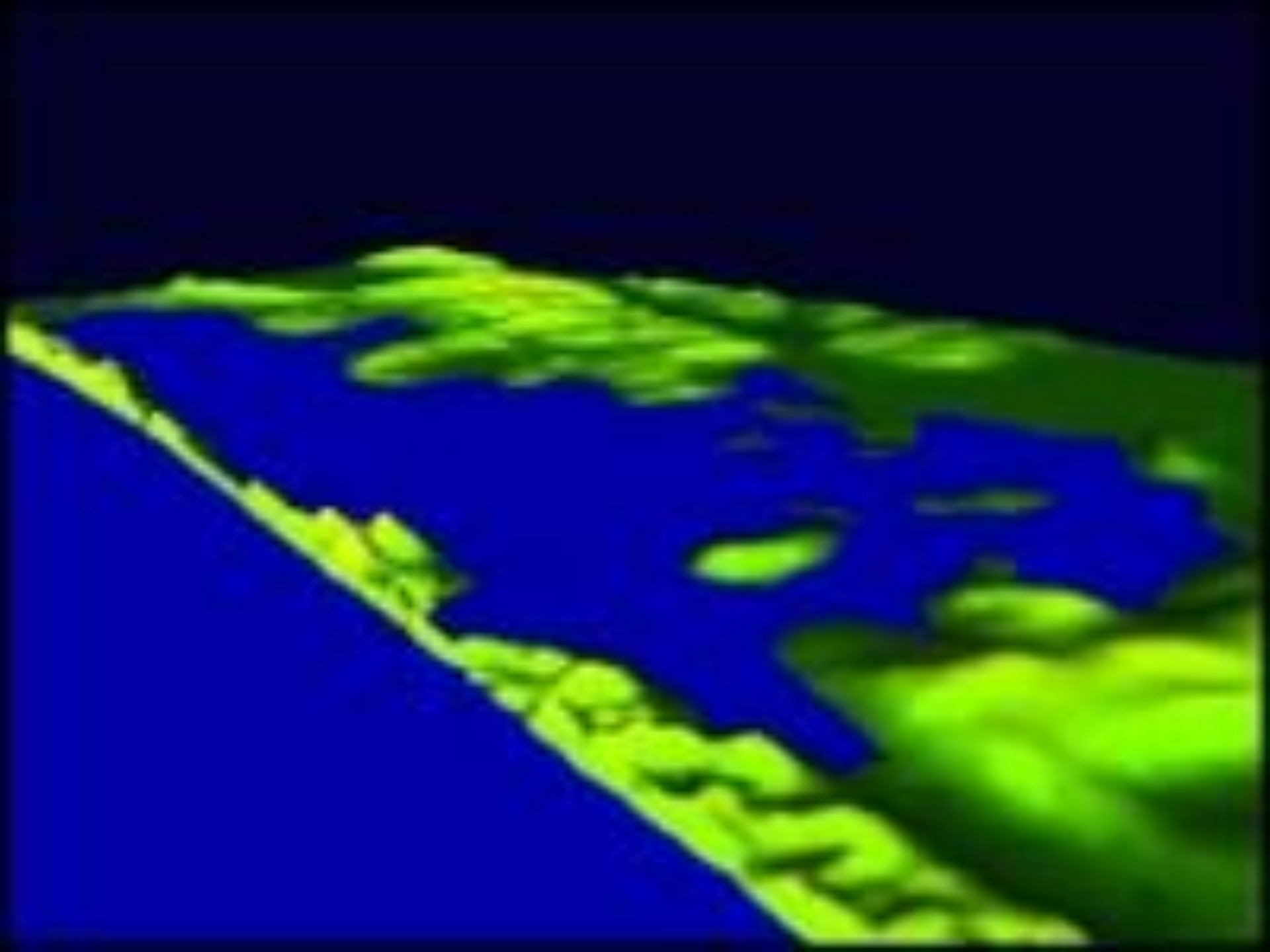
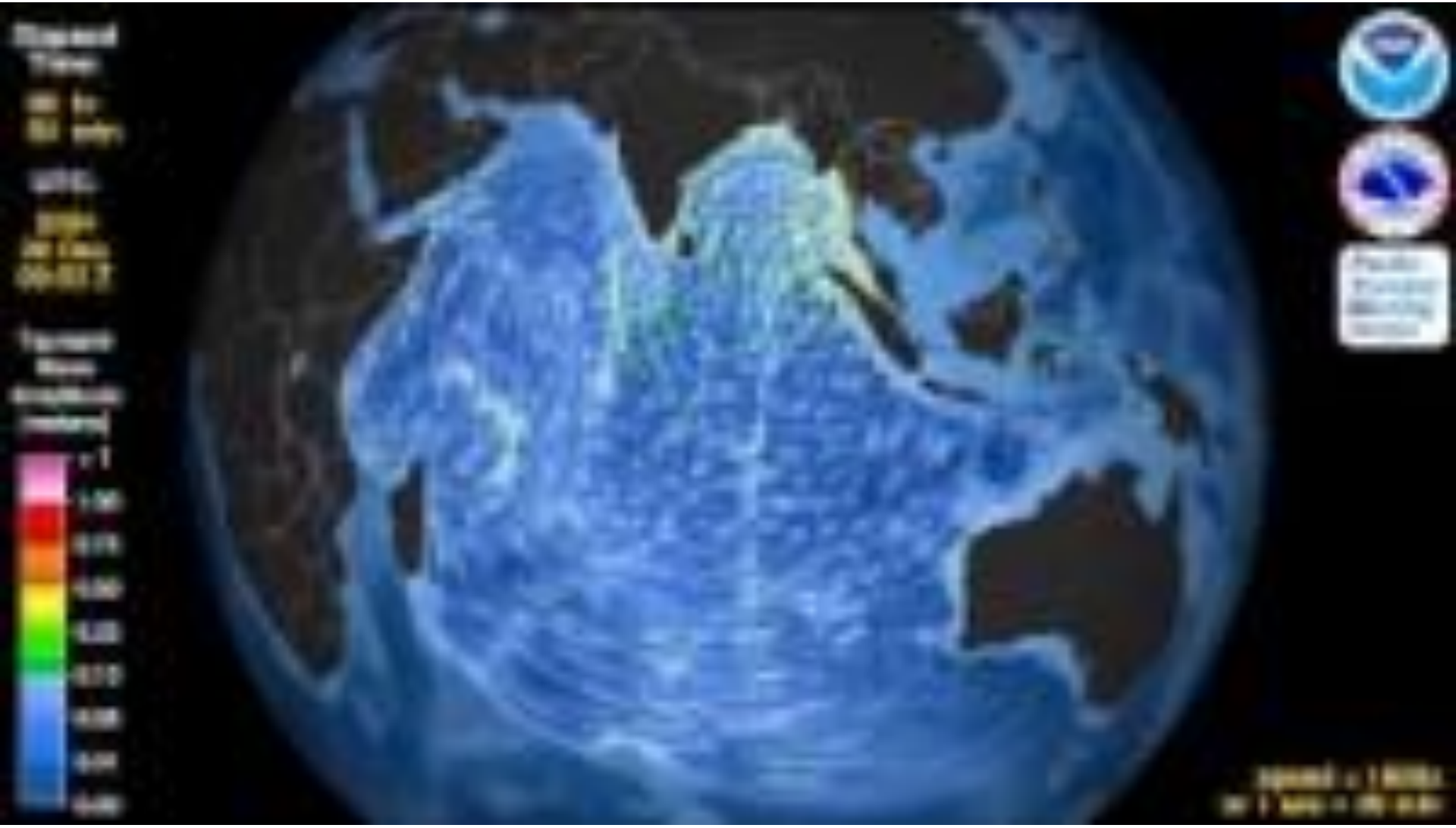


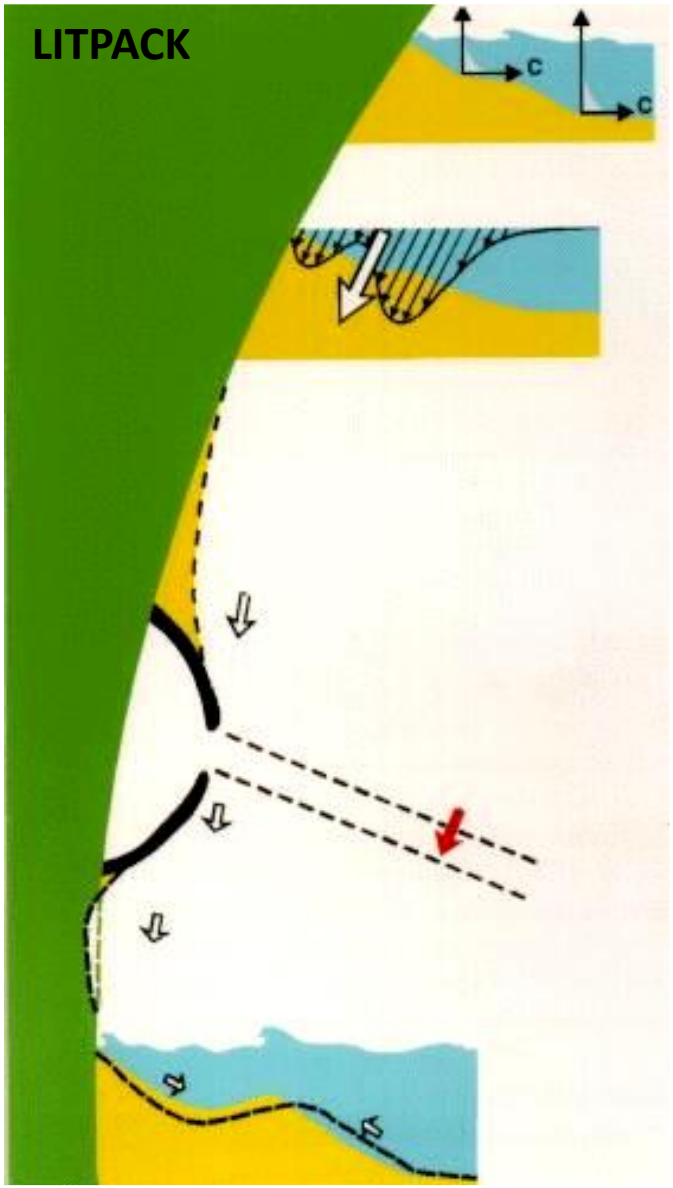


Coastal Hydraulic Software Packages

Name of Software	Type	Developer/ Vendor	Knowledge Domain	Physical Domain
SMS	proprietary	USA	Estuarine / Coastal hydr	Estuaries/ coastal seas
AQUASEA	proprietary	USA	Coastal hydraulics	Estuaries/ coastal seas
QUAL2E	Non-proprietary	US EPA	Water quality	River/coastal seas/ocean
MIKE21/ MIKE3	proprietary	DHI	Coastal hydraulics	Estuaries/ coastal seas
DELFT3D	proprietary	DHL	River/coastal/ ocean hydraulics	River/coastal seas/ocean
TELEMAC	proprietary	LNH of EDF	Coastal hydraulics	Coastal seas
SEAWORKS	proprietary	HR Wallingford	Coastal hydraulics	Coastal seas
EFDC/ HEM2D	Non-proprietary	John M.Hamrick, Tetratech, USEPA	Estuarine / Coastal hydr	Estuaries/ coastal seas
GEMSS	proprietary	J. E. Edinger Associates, Inc., 37 Wayne, PA 19087, USA	River/lake/ estuarial/coastal hydraulics	Rivers/lakes/ estuaries/ coastal seas
GCOM3D	proprietary	GEMS Australia	Coastal/Ocean hydraulics	Coastal seas/ocean
SBEACH/ GENESIS	Non-proprietary	US Army Corps of Engineers	Coastal profile change/evolution	Coastal seas

Software

MIKE
Powered by DHI



FEFLOW

Advanced groundwater modelling

MIKE 3

3D modelling of coast and sea

MIKE SHE

Integrated hydrology

MIKE 21

2D modelling of coast and sea

MIKE HYDRO

Integrated basin management

MIKE by DHI

LITPACK

Littoral processes and coastline kinetics

MIKE 11

Unlimited river modelling

WEST

Modelling and simulation of WWTPs

MIKE URBAN

Urban water modelling

MIKE FLOOD

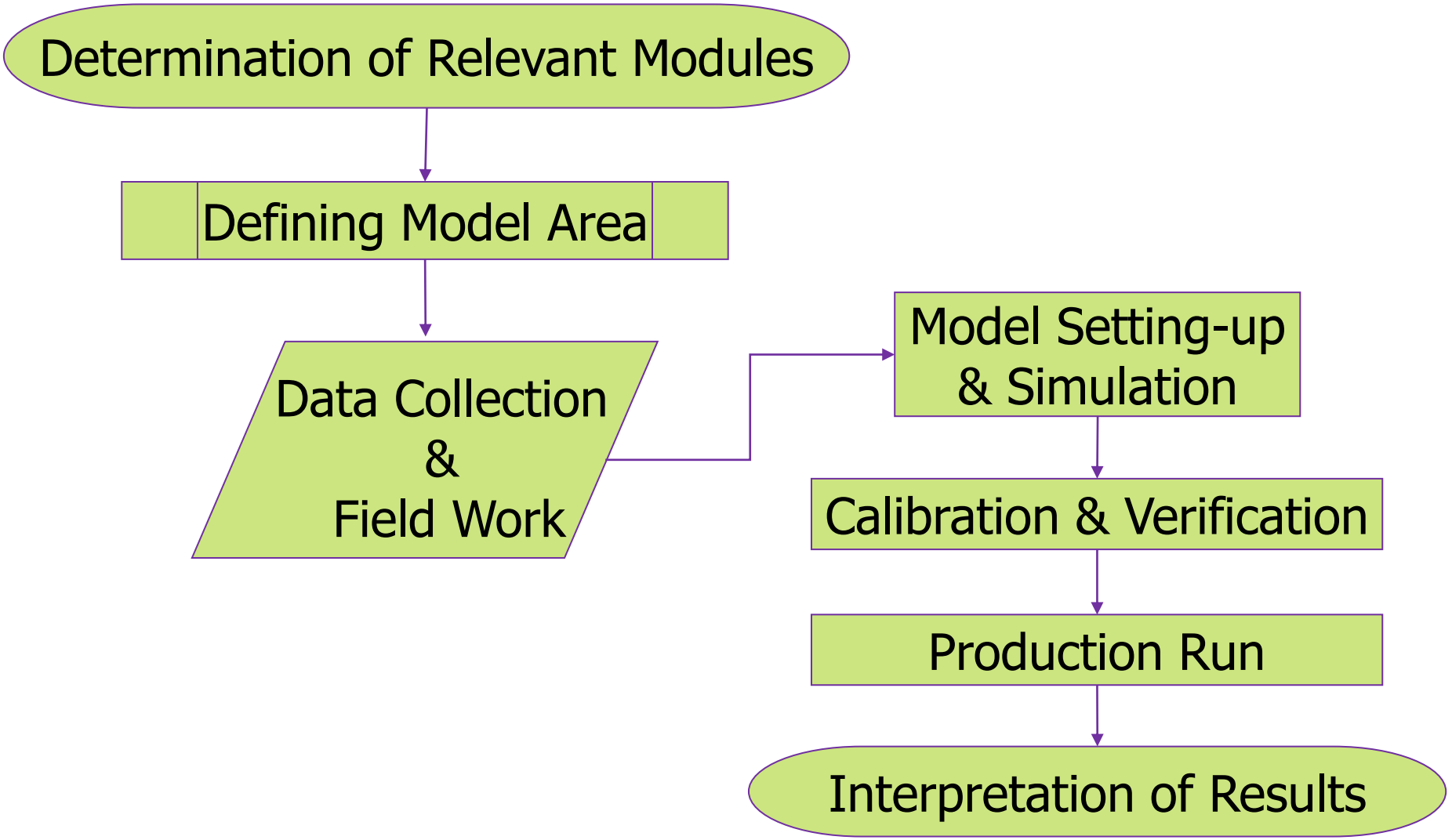
Urban, coastal and riverine flood modelling

MIKE21

- ***HD*** – Hydrodynamic model (simulates currents and water level variations)
- ***NSW*** – Near Shore Wave model (simulates propagation of waves taking into account wave breaking, shoaling, refraction, etc.)
- ***MT*** – Mud Transport model (simulates movement of cohesive material on the bed)
- ***ST*** – Sand Transport model (simulates movement of non-cohesive material)
- ***AD*** – Advection Dispersion model (simulates spreading of heat, salt, coliform & xenobiotic compounds)
- ***WQ*** – Water Quality model (simulates spreading of DO, BOD, ammonia, nitrate & phosphorus)

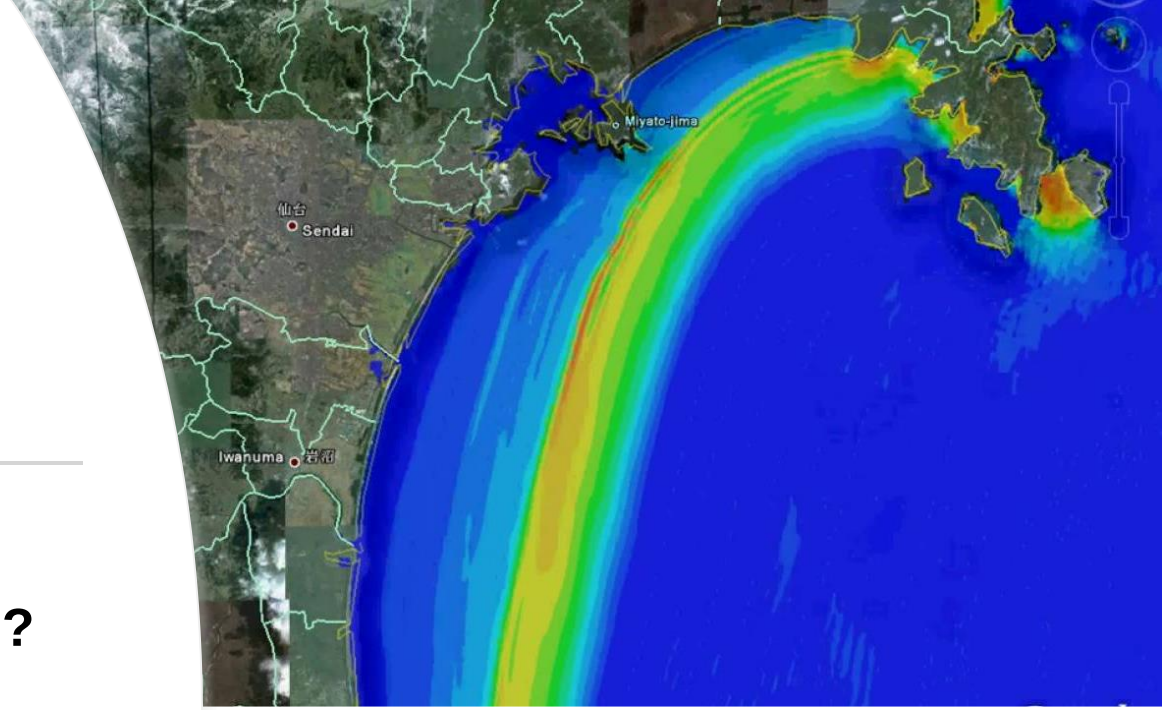
Hydraulic Modelling

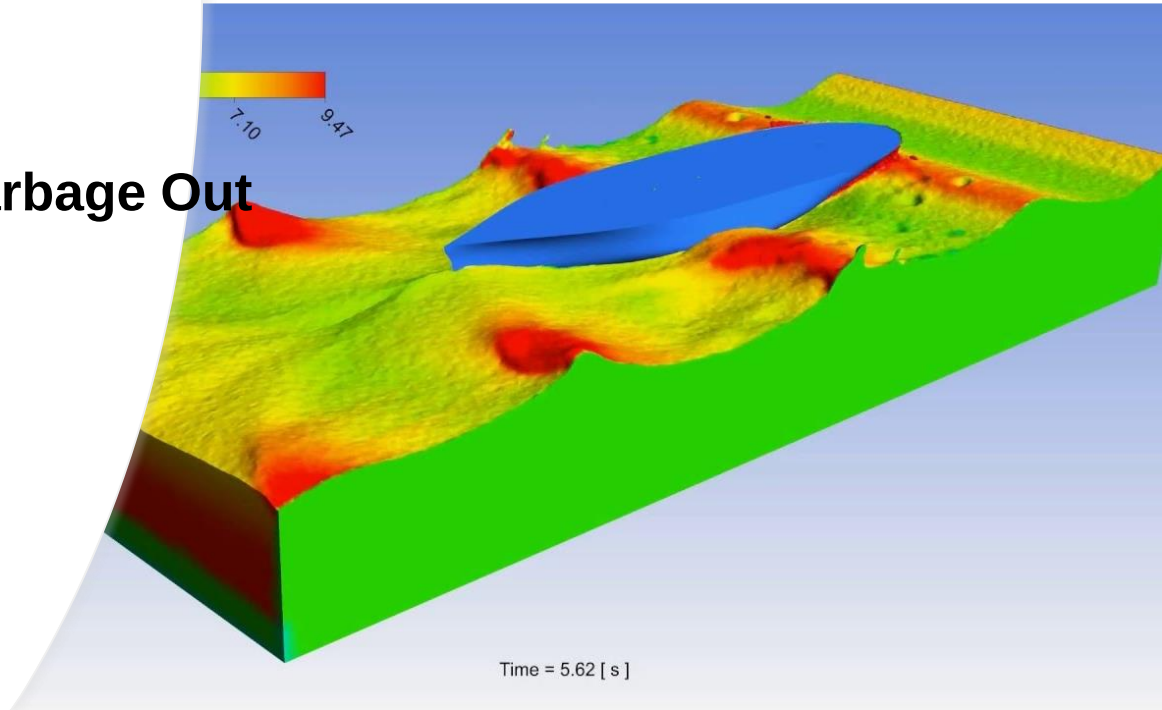
General Modelling Concept

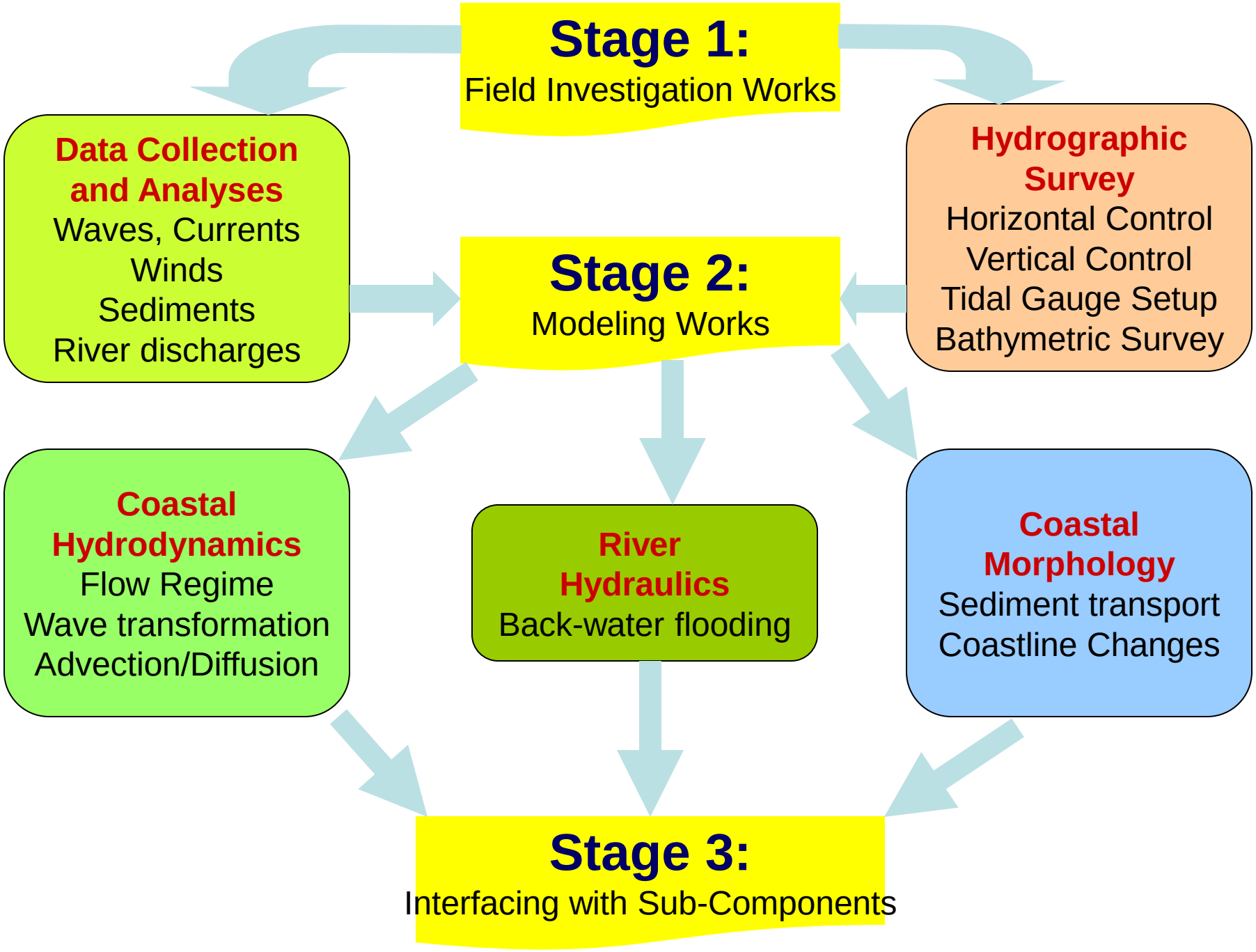


Modelling Technology

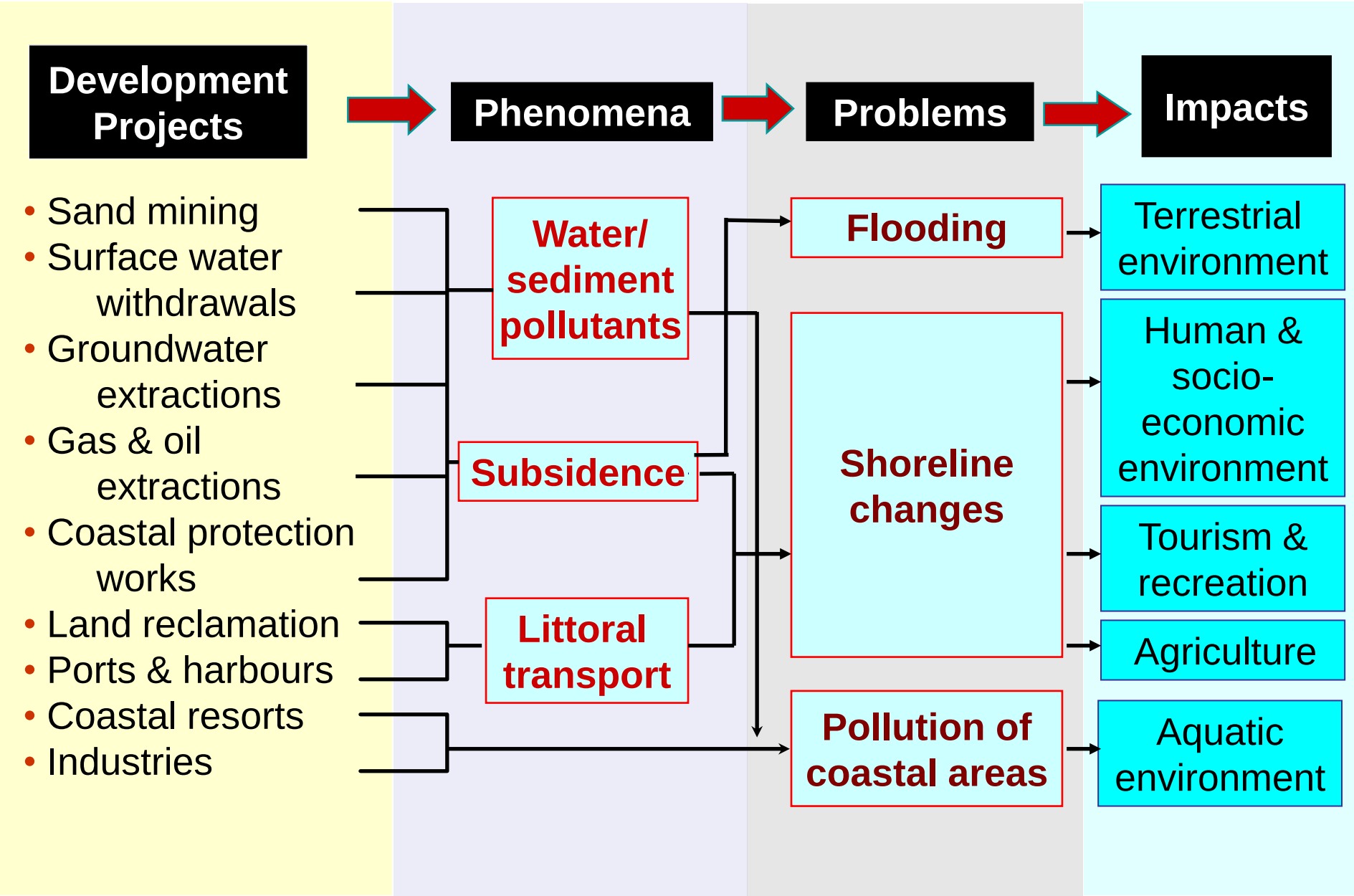
- How many dimensions?
- Which model?
- GIGO – Garbage In, Garbage Out






Stage 1:
Field Investigation Works
Data Collection and Analyses
Waves, Currents
Winds
Sediments
River discharges
Hydrographic Survey
Horizontal Control
Vertical Control
Tidal Gauge Setup
Bathymetric Survey
Stage 2:
Modeling Works
Coastal Hydrodynamics
Flow Regime
Wave transformation
Advection/Diffusion
River Hydraulics
Back-water flooding
Coastal Morphology
Sediment transport
Coastline Changes
Stage 3:
Interfacing with Sub-Components

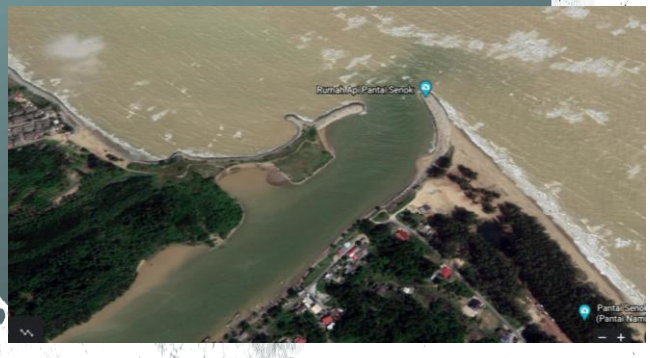
Impacts of Development



Typical Coastal / Marine Study & Example Applications

CASE STUDY 1: Coastal Erosion Studies

- **Typical causes:** Interruption of longshore sand transport, reduction in river sediment supply, dredging in the nearshore, etc.
- **Implications:** Lives and coastal properties are threatened.
- **Main Goal of Study:** Identify cause of erosion and propose options for shore protection.
- **Model used:** LITPACK, MIKE21
- **Project Examples:** Pantai Sabak Coastal Erosion Study, Kelantan



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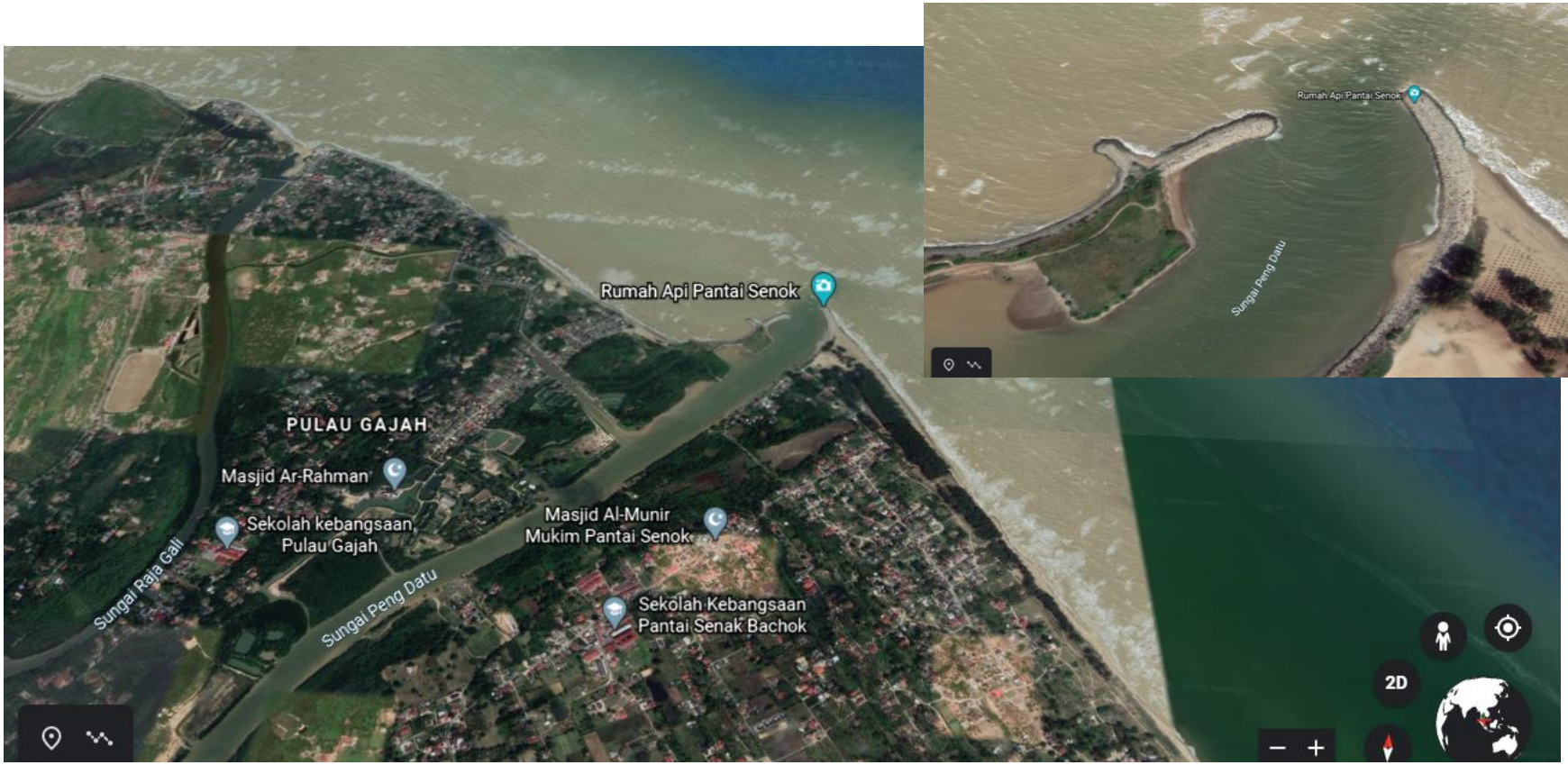
Activity 1

Perform a desktop study of the coastal erosion problem at Pantai Sabak, Kelantan.



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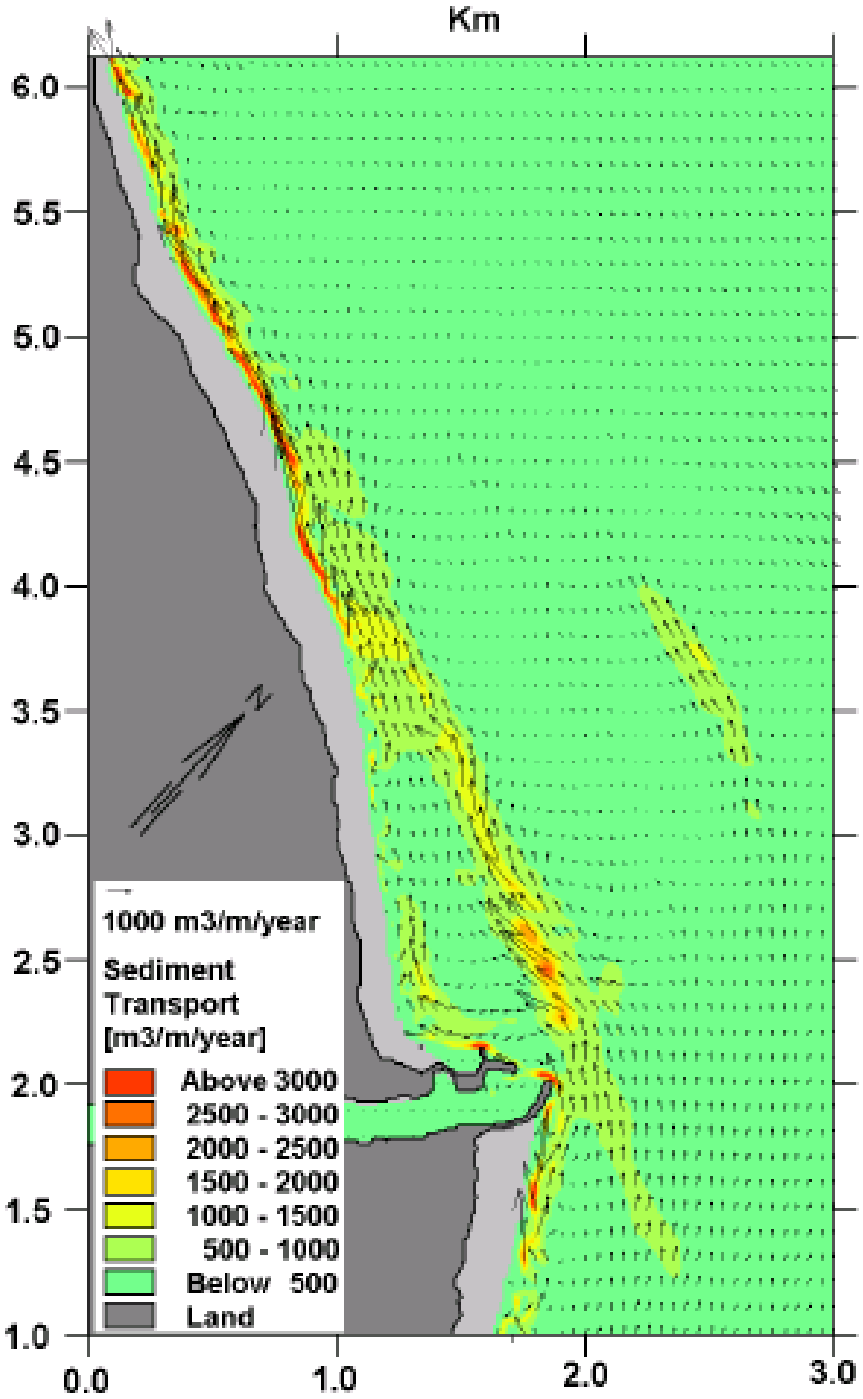
Coastal Protection Works at Pantai Sabak, Kelantan

Classified as a Category I (critical erosion) area (NCES, 1985).

Scope of work:

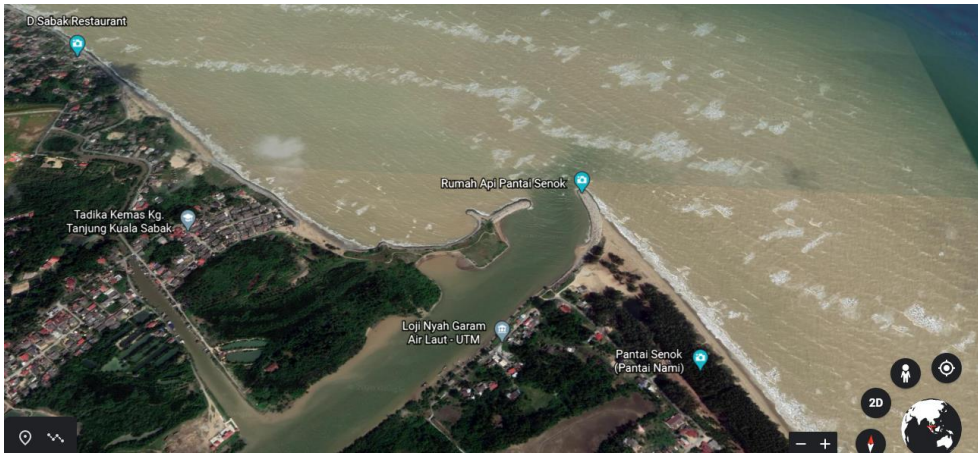
- primary & secondary data collection
- comprehensive hydraulic study of the coastal area using numerical models
- propose feasible defence options & carry out technical and financial evaluations of the proposed alternatives
- detailed design of the selected option

2D Sediment Transport



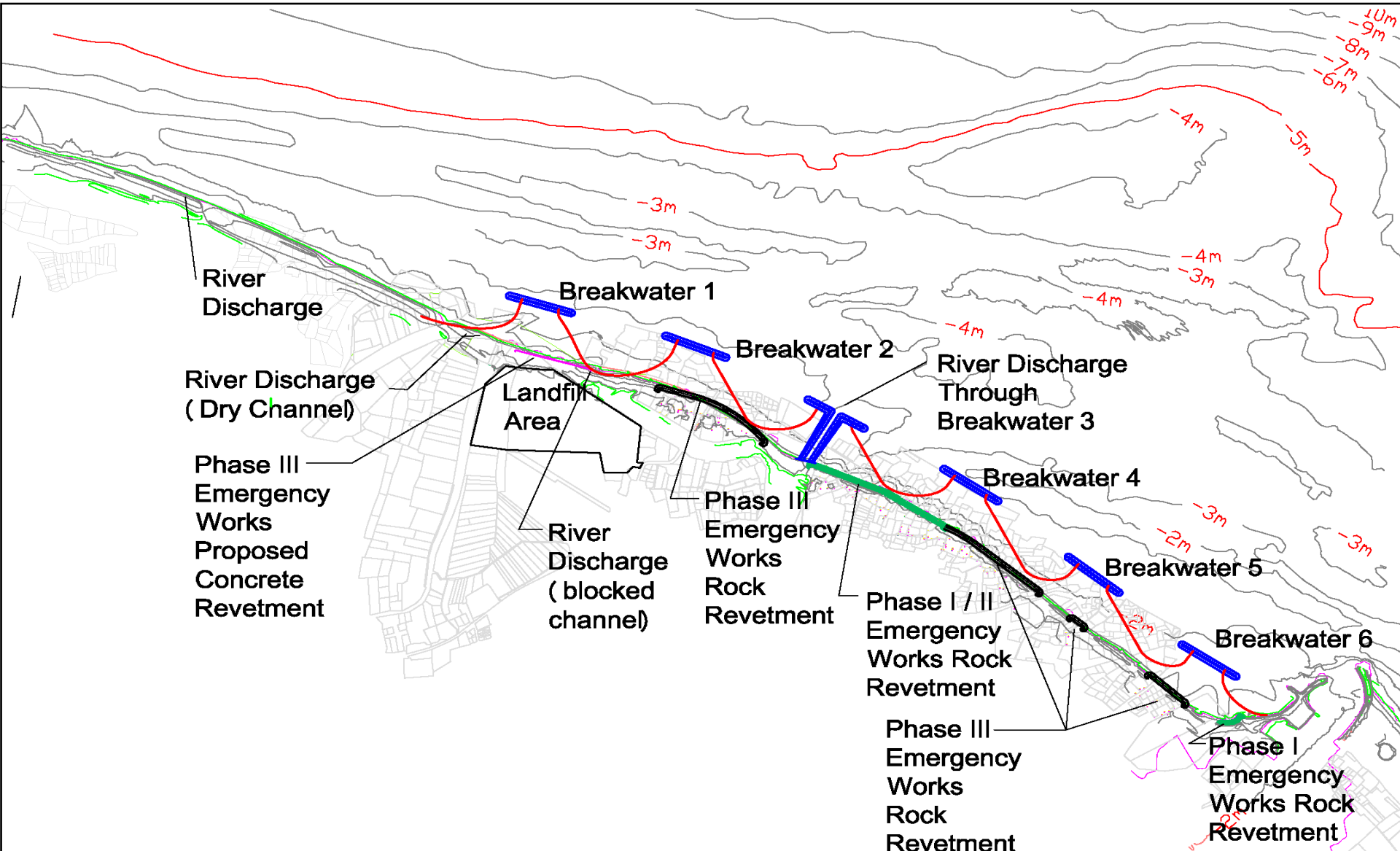
- Existing Condition

- Most of the transport bypassing Pengkalan Datu breakwater travels on a bar parallel to the coast prior to re-attaching to the surf zone 1.5 to 2 km further along the coast

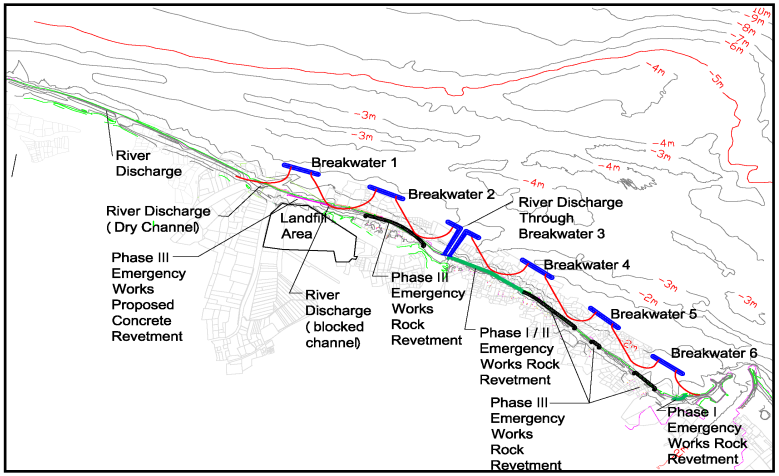


The Proposed Beach Protection Scheme

- Series of Offshore Breakwater



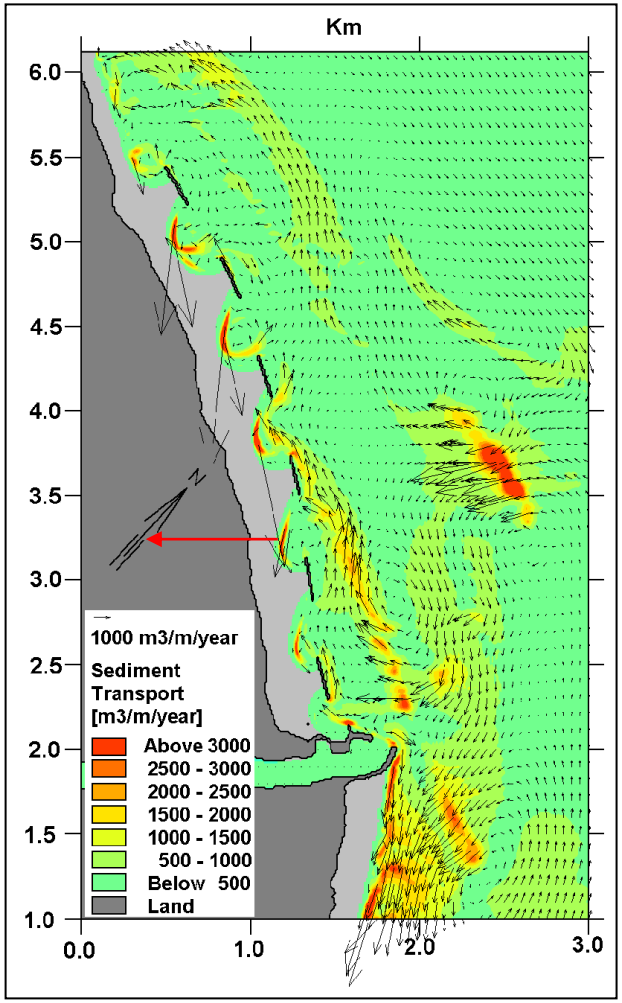
Main Components of The Proposed Scheme



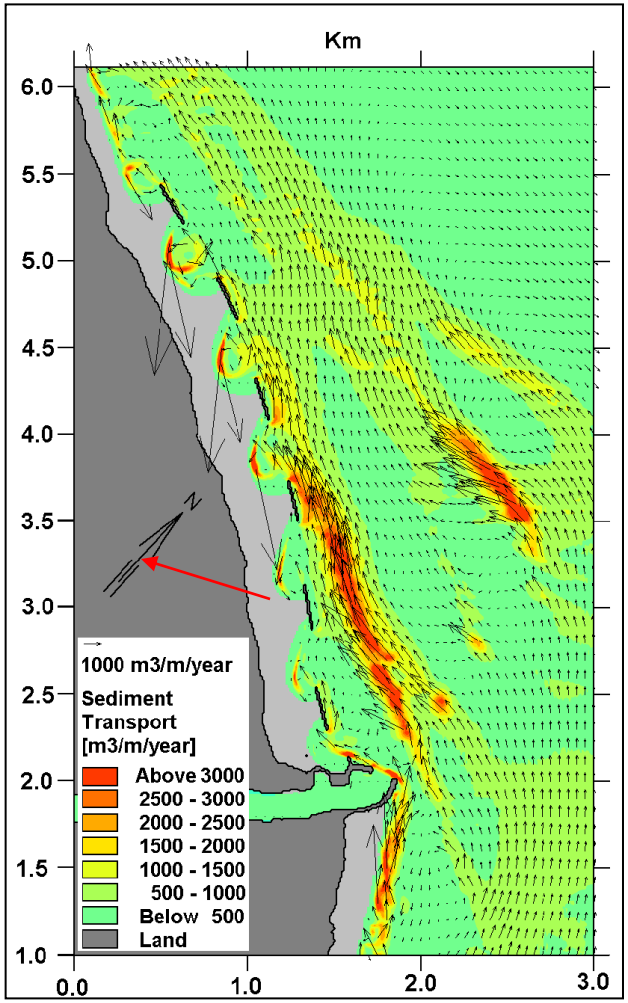
- **Six (6) offshore breakwaters** along Pantai Sabak covering from the northern of Sg. Pengkalan Datu breakwater to just north of the landfill site (including river training allowing a new outlet of Sg. Raja Gali).

- An **initial beach fill** is required together with construction of offshore breakwaters. This is because formation of a tombolo behind the breakwater would likely lead to significant erosion between the breakwater if no nourishment was performed as part of the overall construction.

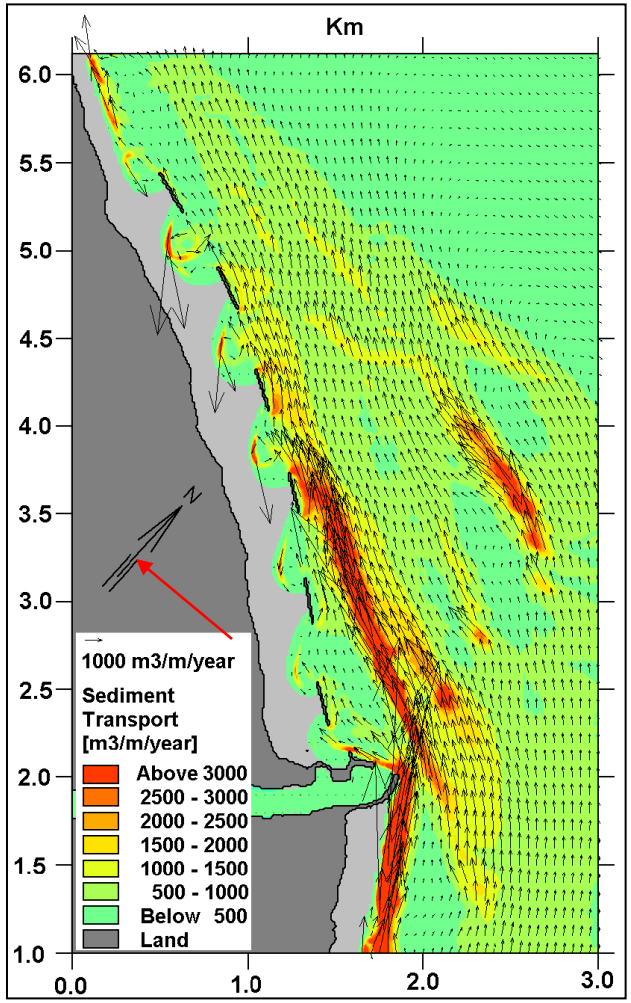
Optimized Breakwaters' Option: Sediment Transport Averaged Over 5 Yrs



H_s = 1.5m, θ = 45°N



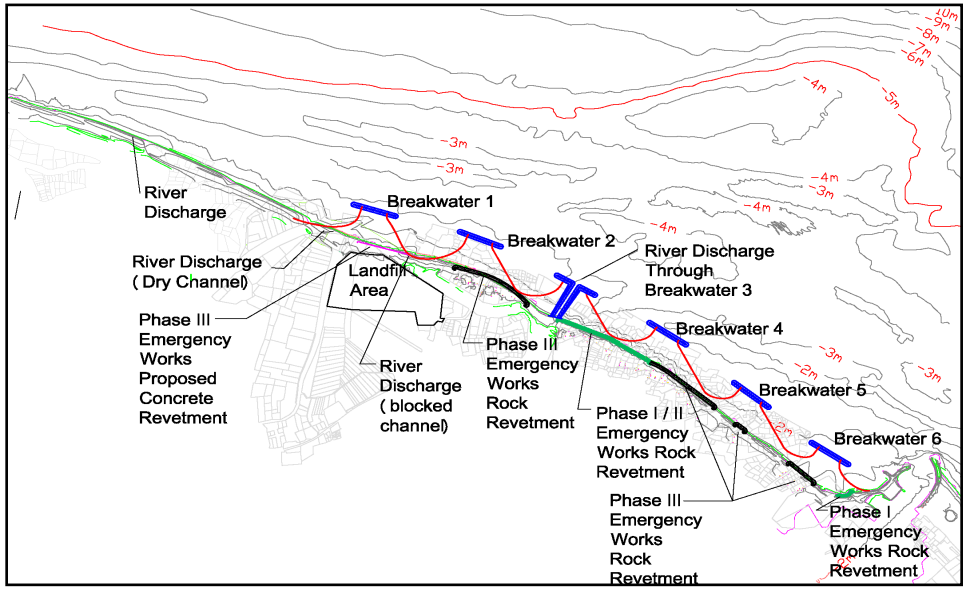
H_s = 1.5 m, θ = 67.5°N



H_s = 1.5 m, θ = 90°N

What do you observed from these numerical outputs?

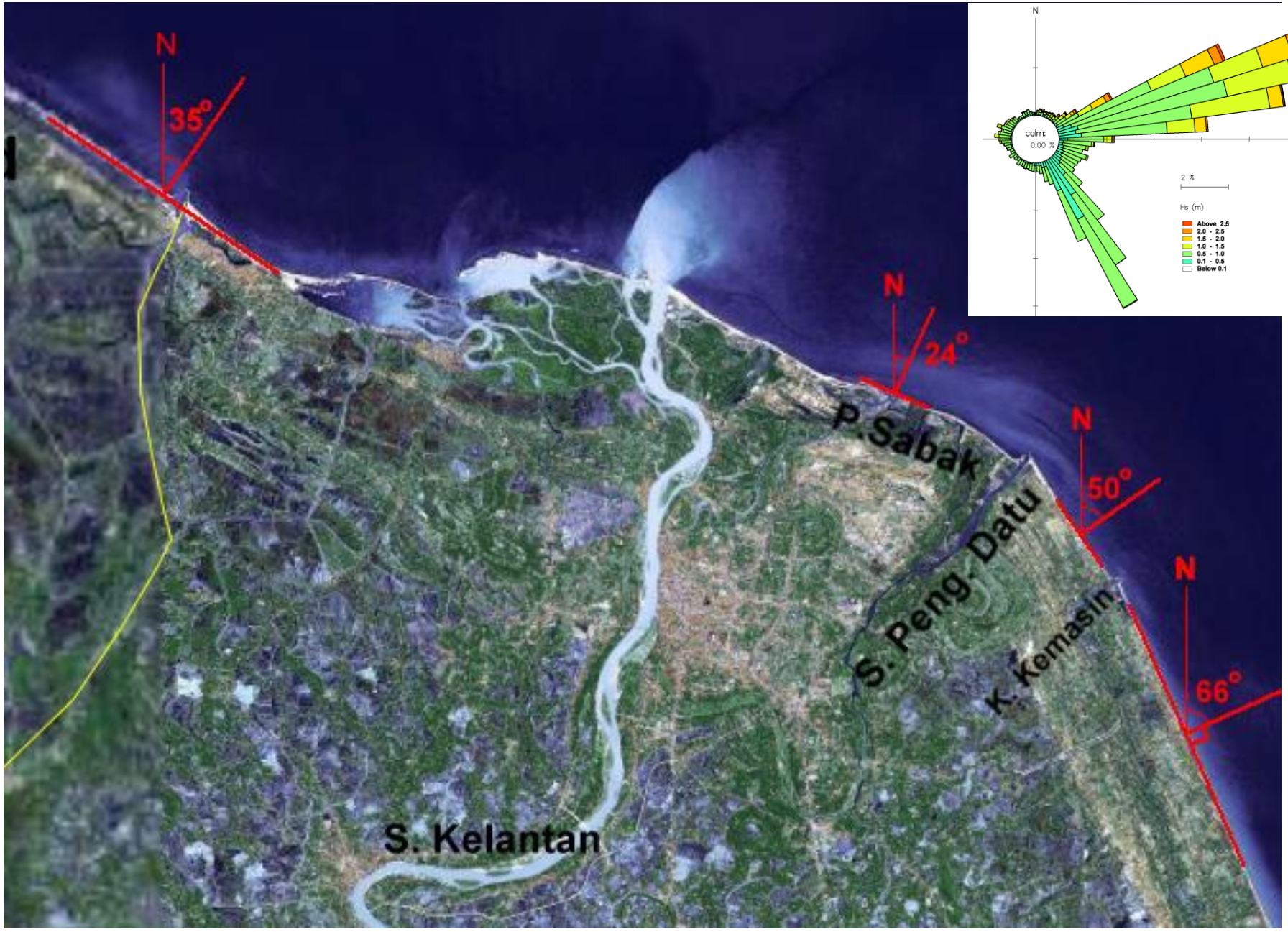
Morphological Impact



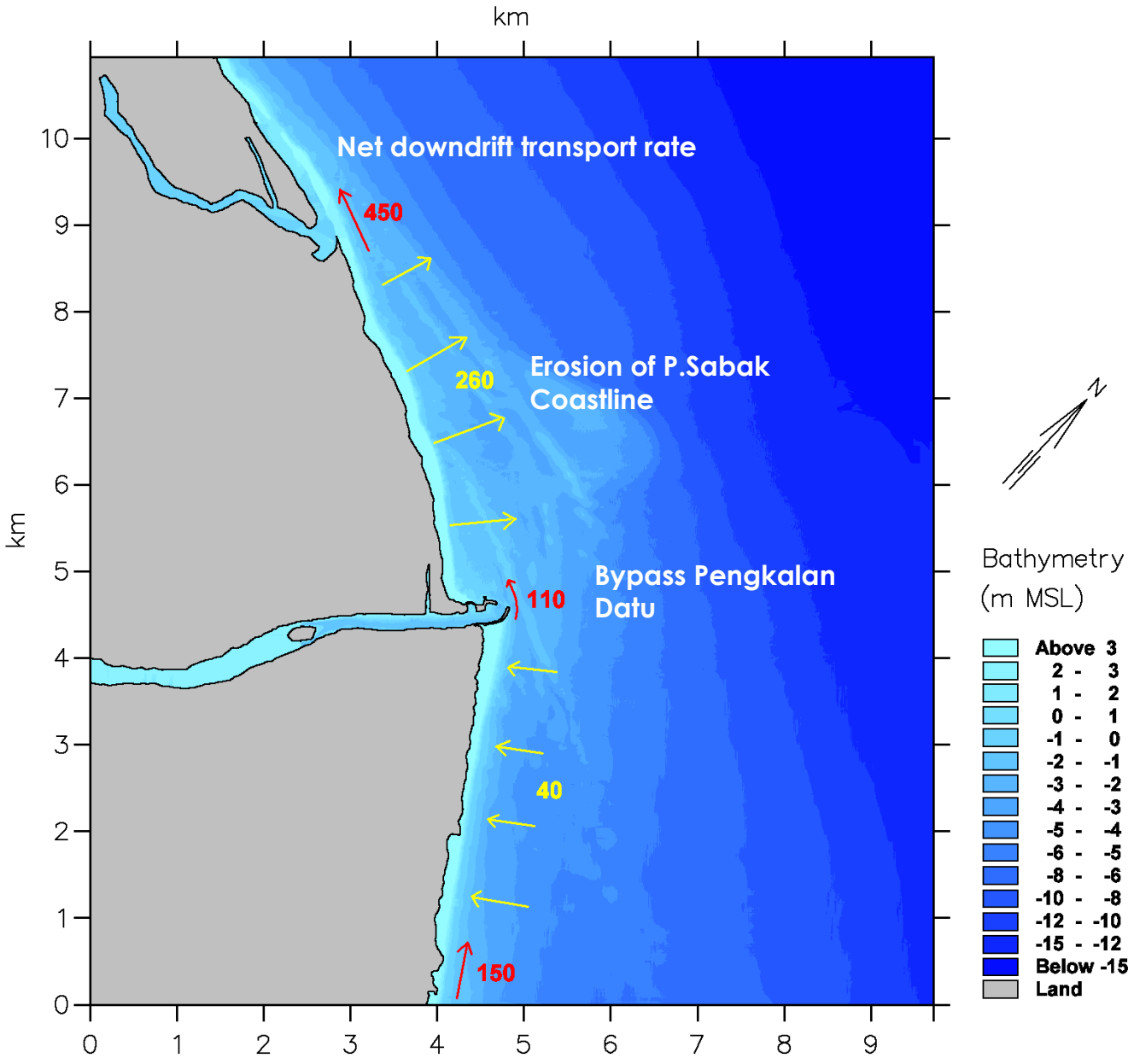
- The protection of the Pantai Sabak coastline will lead to accelerated erosion rates along the coast to the northwest, downdrift of the proposed Breakwater 1.

- The area is much less densely populated than the area presently suffering the brunt of the erosion. It therefore makes sense to protect the Pantai Sabak area knowing that it will not solve but only transfer the overall erosion problem.

Coastal Processes Study



Alongshore Sediment Transport

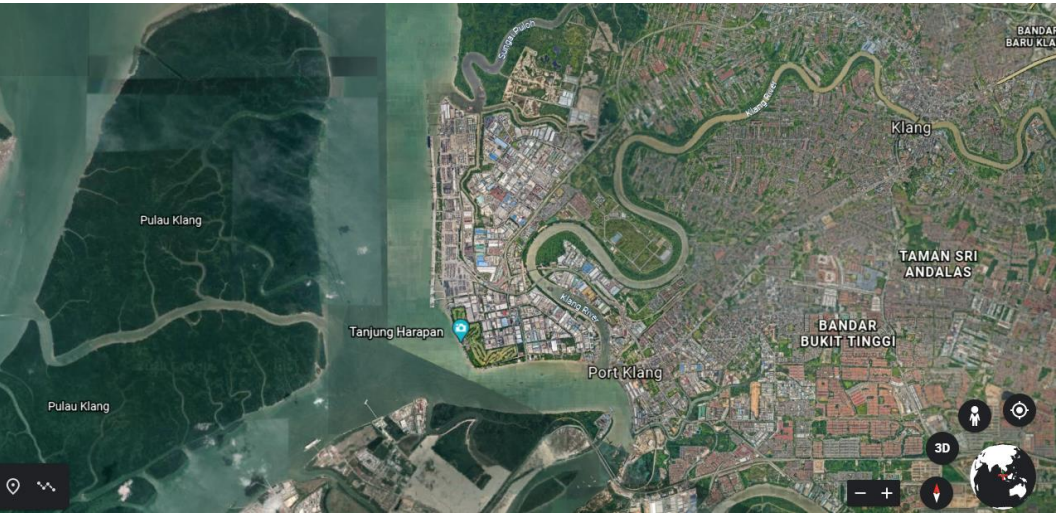


Mud Siltation Studies

- **When:** Navigation channels on muddy coast (predominant on West Coast of Peninsular Malaysia)
- **Typical causes:**

  High sedimentation from surrounding area especially from Sg. Klang
- **Main Goal of Study:**

  Identify cause of siltation and estimate rates of siltation. Propose dredging requirement.
- **Model/s used:** MIKE21
- **Project Examples:** North Port Hydraulic Study, Port Klang



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Activity 2

Perform a desktop study of the siltation problem at the river mouth of Sungai Klang.

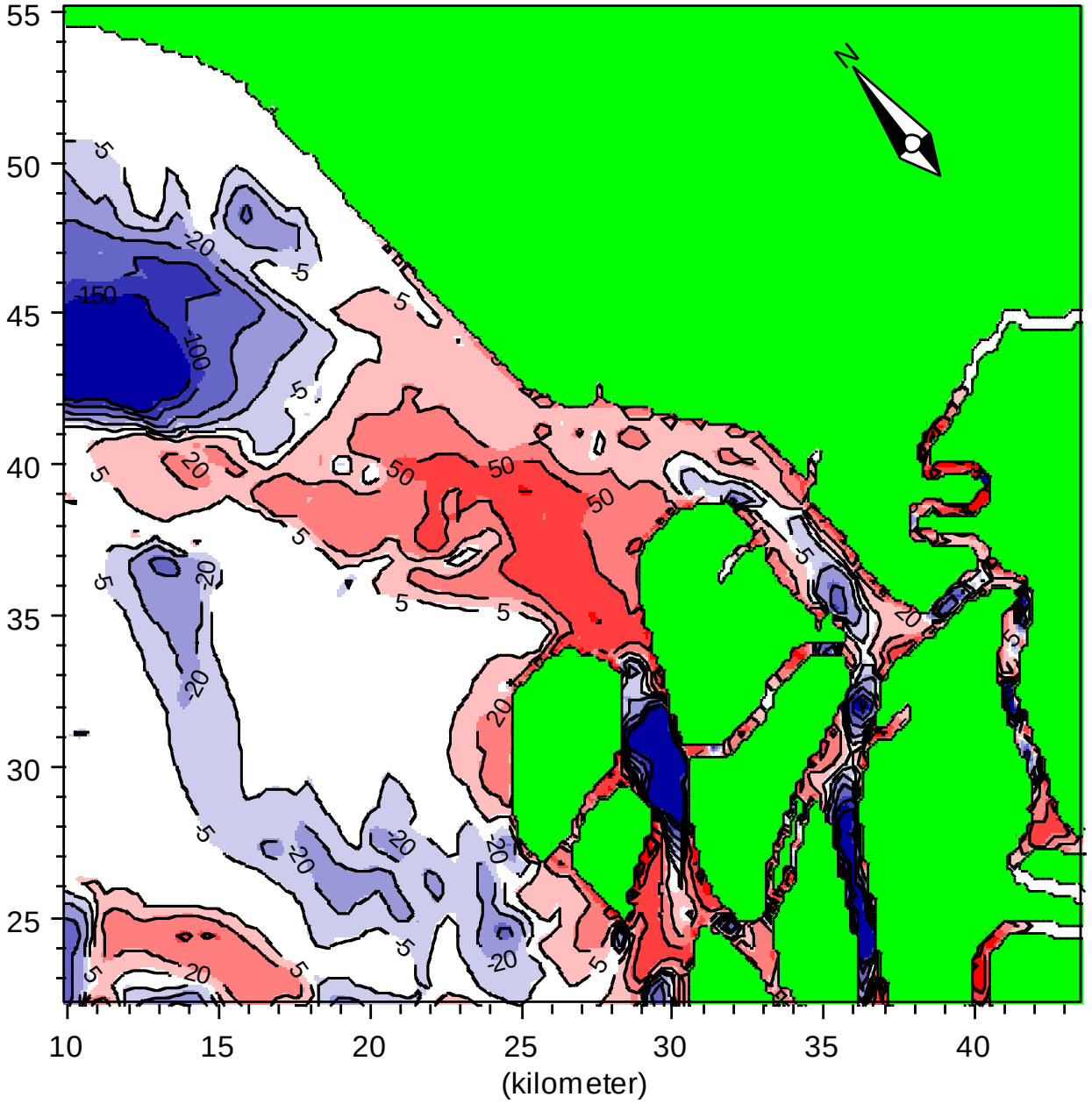
https://earth.google.com/web/@3.0184392,101.36768857,6.91732558a,17669.90160297d,35y,-0h,0t,0r

North Port Hydraulic Study, Port Klang

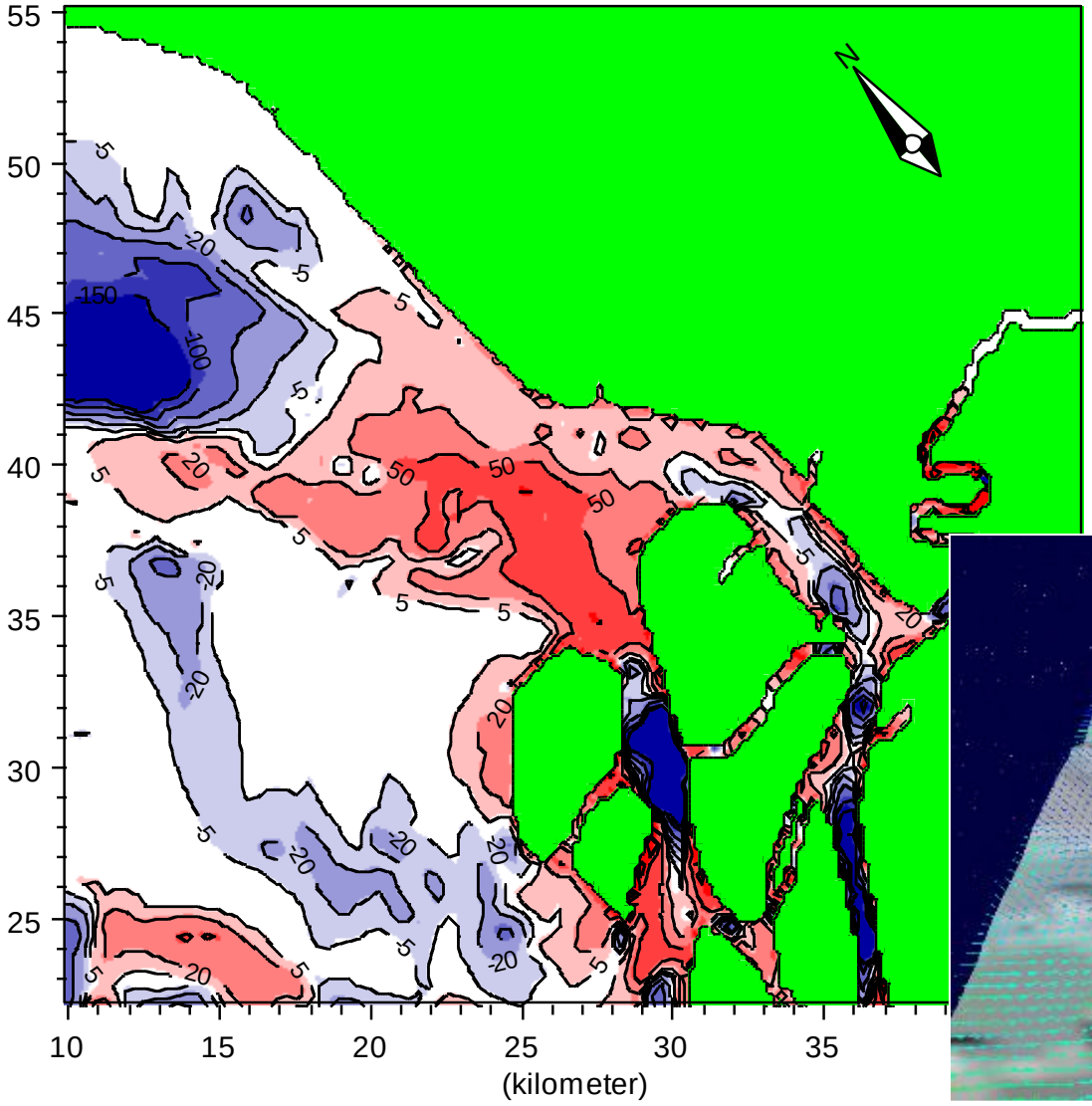
Scope of work:

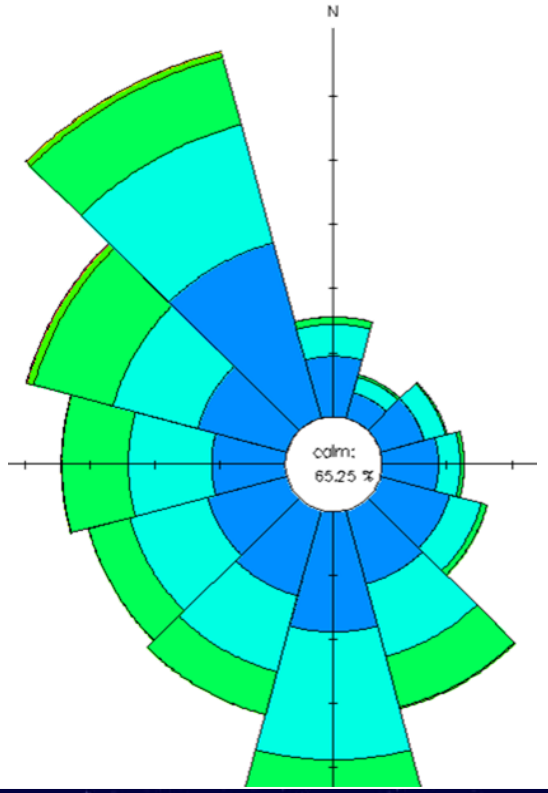
- collect, collate and calibrate data for hydraulic study
- hydraulic modelling for analysis of currents, waves & sediment transport
- identify sources of siltation material, predict volume & rate of siltation within, around the channel - analyse, propose requirements for capital & maintenance dredging and devise optimum dredging strategy for the future
- hydrodynamic impact study on to the port's future development plans
- financial analysis

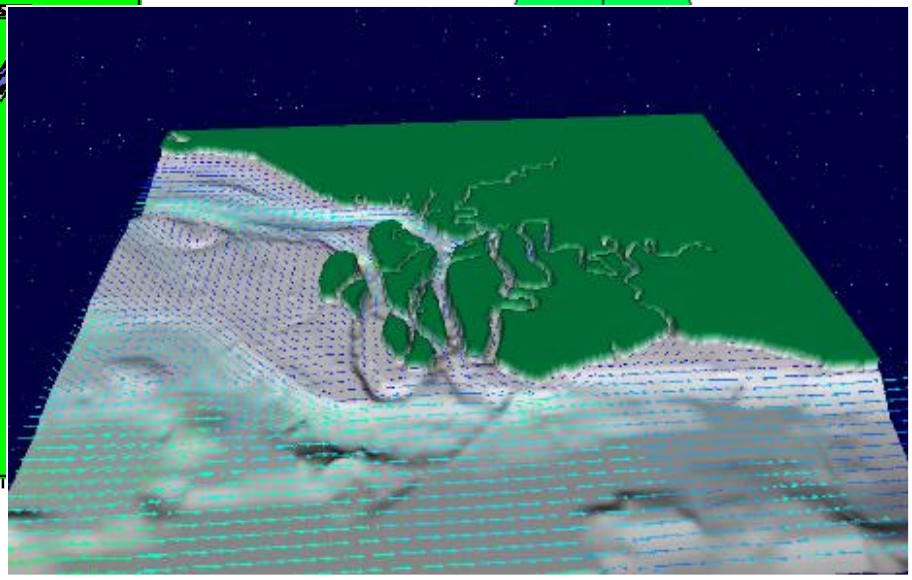
North Port Hydraulic Study, Port Klang



North Port Hydraulic Study, Port Klang







River Mouth Siltation Studies

- **When:** Navigation through river mouths is made difficult because of frequent siltation.
- **Typical causes:**

  Imbalance between river sediment supply and ability of waves to move sediments away from the river mouth.
- **Main Goal of Study:**

  Identify cause/s of problem and propose mitigating options.
- **Model/s that can be used:** MIKE21
- **Project Examples:**

  National River Mouth study by JICA

  Setiu River Mouth Improvement Works, Terengganu.

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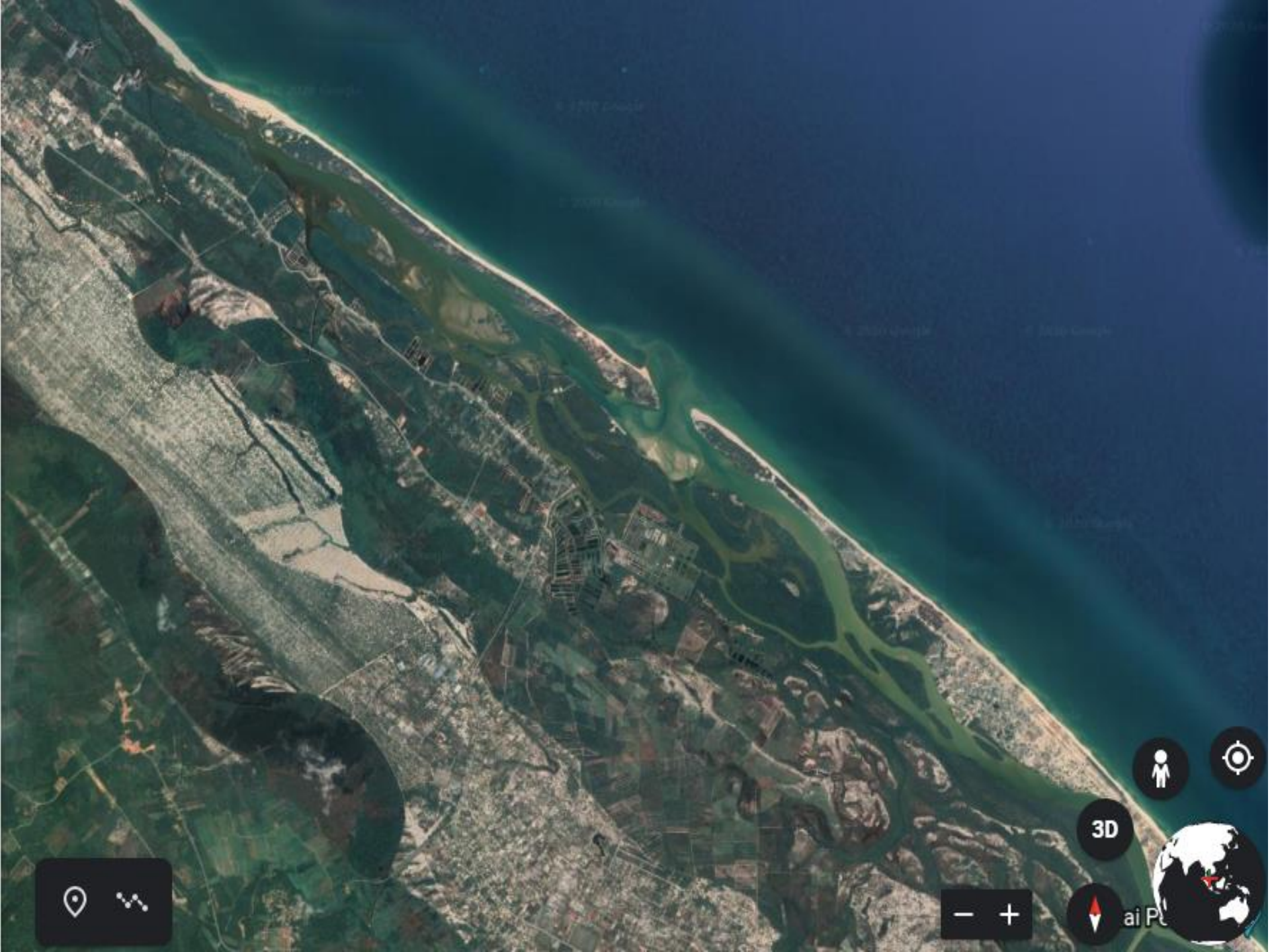
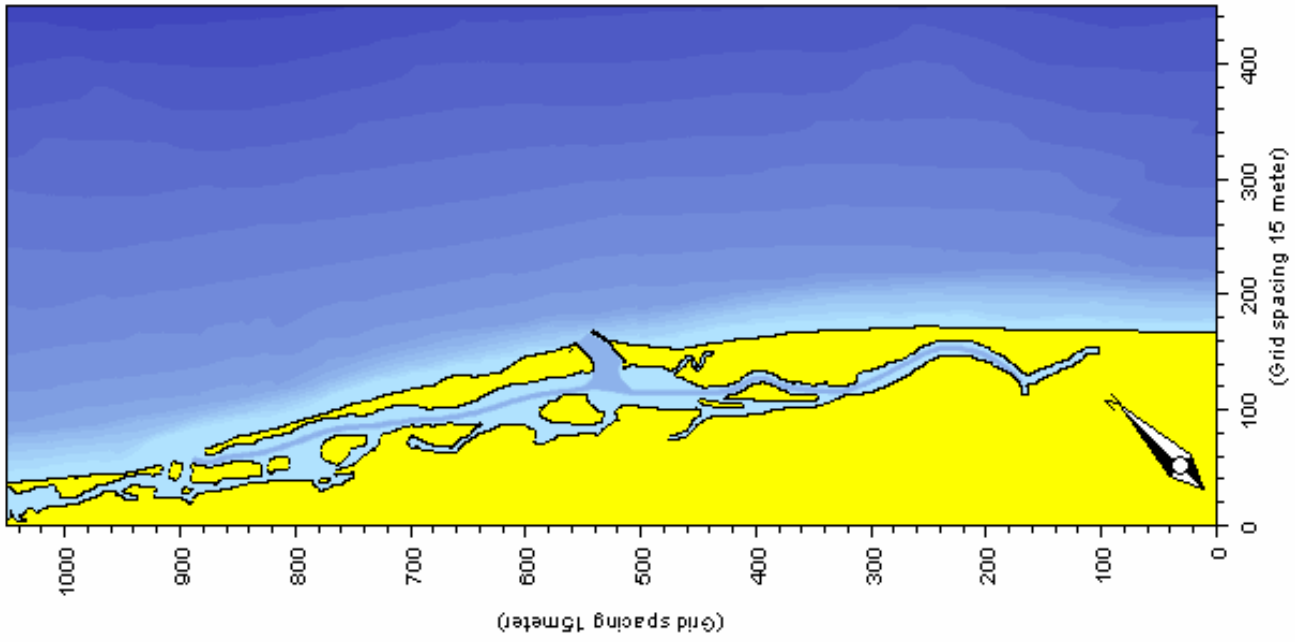

3D

Setiu River Mouth Improvement Works

- Improvement works in the form of dredging and provision of structures to stabilize the Setiu river mouth is to be carried out.
- A fish landing complex is also to be constructed to cater for the growing fishermen population.



Setiu River Mouth Improvement Works

Studies include:

- collect, collate and review relevant data necessary for the design and modelling works;
- identify various river mouth improvement alternatives;
- conduct a hydraulic study using numerical models to assess effectiveness and impacts of the improvement works on the hydraulic regime and select the most suitable option;
- determine environmental parameters for the detailed design;
- perform detailed design for the river mouth improvement works.

Sediment Dispersion Studies

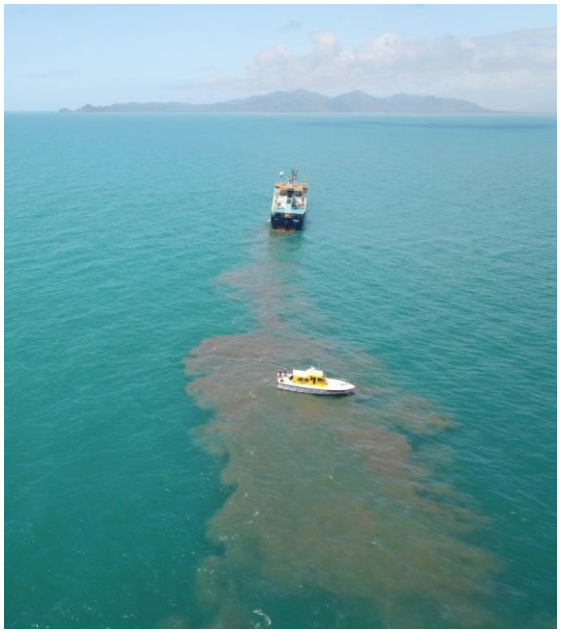
- **When:** Reclamation and Dredging projects
- **Typical causes:**

  Sediment re-suspension during dredging operations and sediment losses during dumping.
- **Main Goal of Study:**

  Identify extent of sediment plume and propose mitigating options if necessary.
- **Model/s used:** MIKE21
- **Project Examples:**

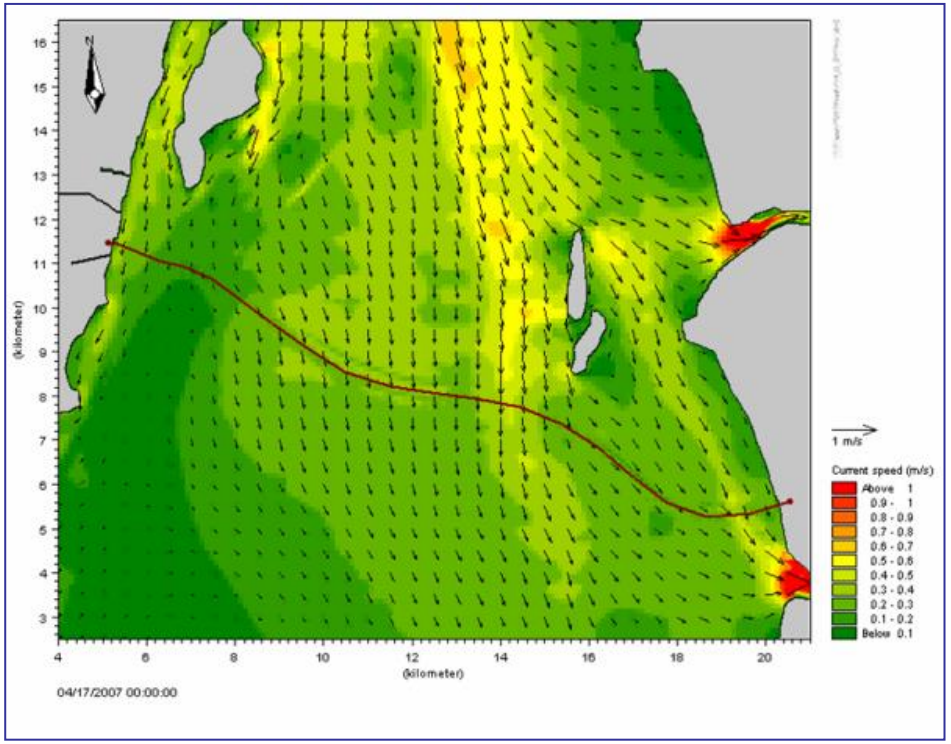
  Proposed Penang 2nd Bridge.

  Proposed Tg. Langsat Port Expansion.



The Proposed Penang Second Bridge

Penang Second Bridge - the longest bridge in Southeast Asia.



The Proposed Penang Second Bridge

Scope of work includes:

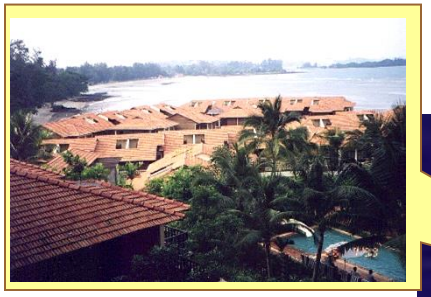
- Extensive hydraulic and coastal modeling of the impact of the bridge construction on coastal regime within the Penang channel and adjacent waters using MIKE 21 modeling system.
- Investigation includes assessment on waves, tidal flows, sediment transport and dispersion of suspended sediment;
- Investigation on the impact during construction based on various components and implementation stages;
- To provide assessment input for the concurrent EIA study

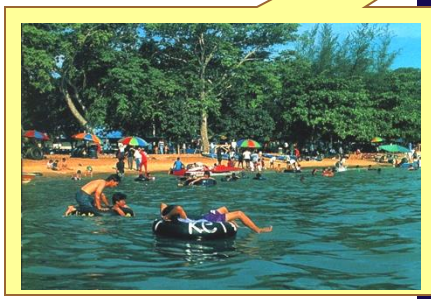
Integrated Approach

- Planning requires holistic approach accompanied by regulatory and legislative mechanisms (eg. ICZM / ISMP to avoid independent developments leading to adverse consequences elsewhere.

- Discourage development and construction of structures on highly dynamic coasts
  - Prior comprehensive study
  - Remedial measures

Need for ISMP





Negeri Sembilan

Monitoring

- Monitoring should be implemented during & after any coastal development in the vicinity of the development.
- Monitoring assists in quicker detection of any discrepancy between expected & effective coastline response.
- Some monitoring works may serve as good ground for continuing research in fostering better understanding and developing new scientific knowledge. This is where universities and local institution can play active role in instituting significant research, which will benefit the nation as a whole.

Conclusions

- Coastal processes are influenced by many physical processess and mechanisms.
- Human interference can further add to the complexity of the present natural processes
- The behavior of coastal processes, especially sediment transport, in coastal areas can be more complex with the interactions between these physical processes and mechanisms
- Development for better understanding and predictive tools greatly assist in the overall assessment for better planning