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THE 4Gs IN PRACTICE: INVESTIGATING HOW THE 4Gs ARE APPLIED IN THE OIL & GAS INDUSTRY

Society for Underwater Technology, Evening Technical Meeting

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GEOPHYSICS & PORT DEVELOPMENTS – EXPLORING MARINE & TRANSITION ZONES

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SUMMARY

- WHY USE GEOPHYSICS?
- MARINE GEOPHYSICAL TECHNOLOGIES
- THE PROS & CONS
- EXAMPLE RESULTS & CASE STUDIES

WHY USE GEOPHYSICS?

Geophysics is a useful tool for pre-development investigations in the marine environment and within the onshore/offshore transition zone

- **What?** Dredging, Piling, Causeways, Reclamation, Pipelines
- **When?** Pre-planning, Pre- or post-drilling activities
- **Where?** Near shore (shallow) marine, Land, Transition zones

WHY USE GEOPHYSICS?

- **Why?** Geophysics can assist with:
  - Determination of suitable locations for berths, turning pockets and approach channels
  - Identifying dredgeable areas
  - Providing geotechnical or geohazard information – e.g. impediments to dredging such as hard ridges
  - Providing layer information & depth to bedrock

WHY USE GEOPHYSICS?

- **Products:**
  - Layer mapping of geophysical boundaries along transects, and 3D surface modelling
  - Correlation with lithology data (borehole/vibrocore)
  - Geophysical unit characterisation – geophysical properties, thickness/depth, dominant lithologies
  - Volume estimation

MARINE GEOPHYSICAL TECHNOLOGIES

- Marine Surveying in Shallow (<30 m) Water:
  - Bathymetry & Side Scan Sonar
  - Magnetics
  - Seismic Reflection
  - Seismic Refraction
  - Electrical Methods
- Transition Zone & Land-based surveying:
  - Seismic Methods – Refraction, MASW, Reflection
  - Electrical Methods – Electrical Resistivity Imaging (ERI)
  - Electromagnetic (EM) Methods – Shallow EM
  - And more…
- Airborne Electromagentics

THE PROS & CONS

TECHNOLOGY	TYPE OF METHOD	POSITIVES	NEGATIVES
Seismic Reflection (CSP – Continuous Seismic Profiling)	Seismic	Provides structural information (layers, depths) Fast acquisition	Does not produce hardness information
Seismic Refraction	Seismic	Established correlation between P-wave velocity and dredgeability	Cannot detect velocity inversions (low velocity layers between higher velocity layers)
MASW (Multi-channel Analysis of Surface Waves)	Seismic	Can detect velocity inversions .	Horizontal resolution reduced Frequency-dependant
Resistivity	Electrical	Maps porosity and clay variations	Does not produce hardness information Low resolution

THE PROS & CONS

TECHNOLOGY	TYPE OF METHOD	POSITIVES	NEGATIVES
Magnetics	Potential Fields	Detects iron (metallic objects) Can map magnetic geologic units	Does not provide depth discrimination
Side Scan Sonar	Sonar	Detects seafloor features e.g. sand structures, coral, obstructions	Seafloor surface only
MBES (Multi-Beam Echo-Sounder)	Bathymetry	Provides detailed bathymetry .	Seafloor surface only
SkyTEM	Airborne Electromagnetics	Fast coverage	No hardness information Low resolution

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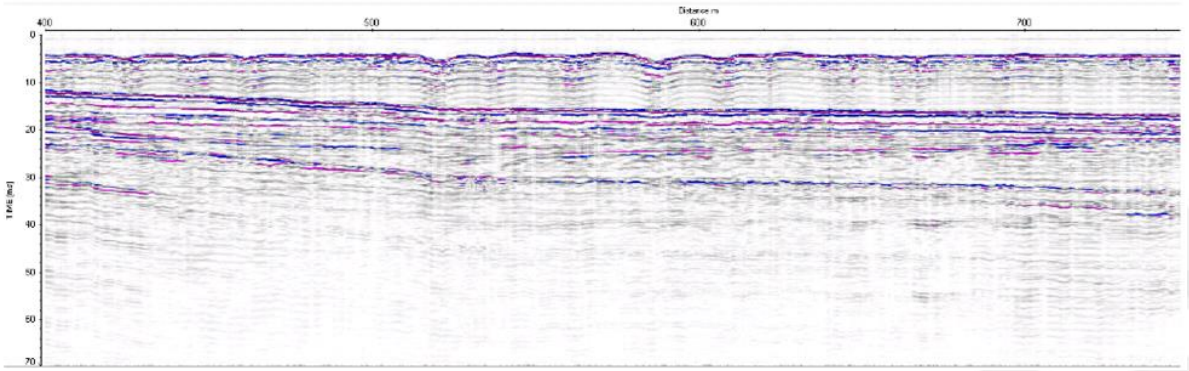
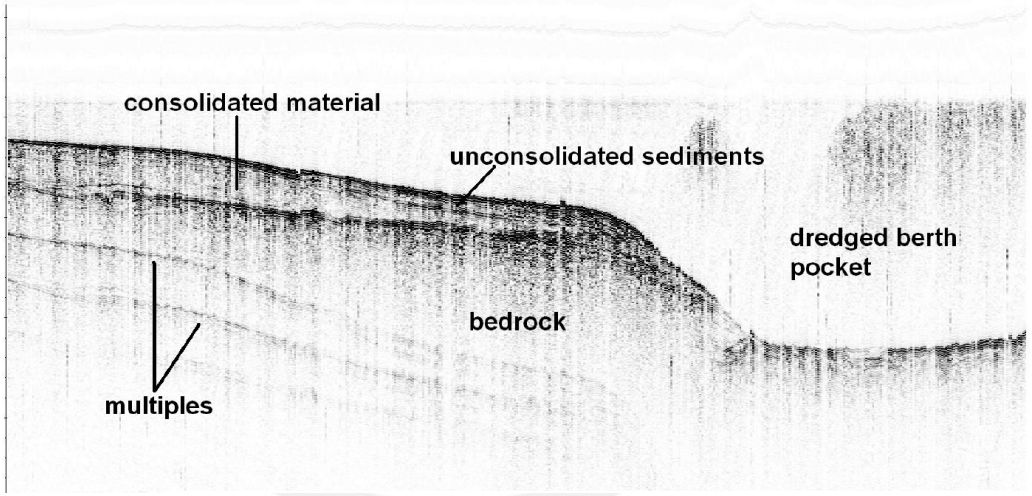
MARINE SEISMIC

- **Seismic Reflection**





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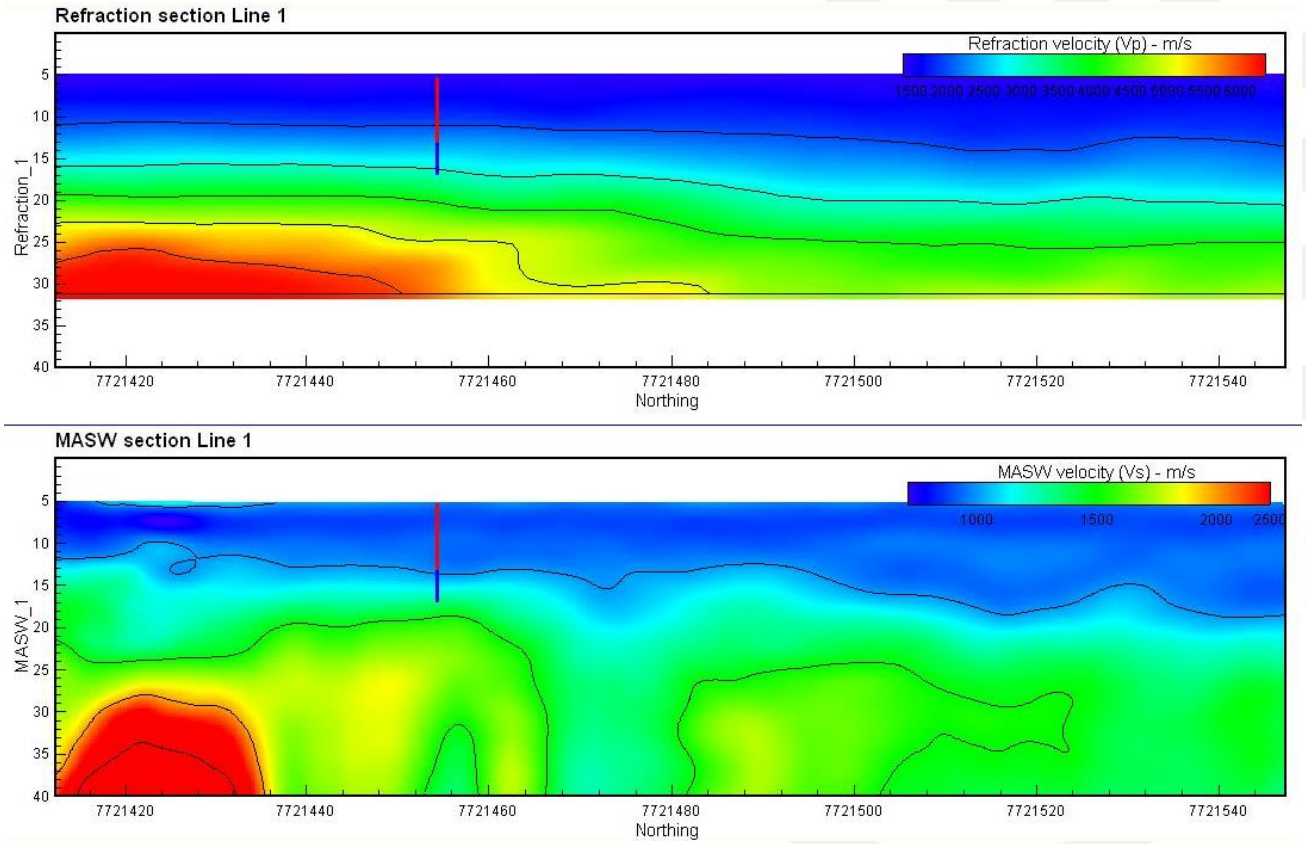
MARINE SEISMIC

- **Seismic Refraction vs MASW**



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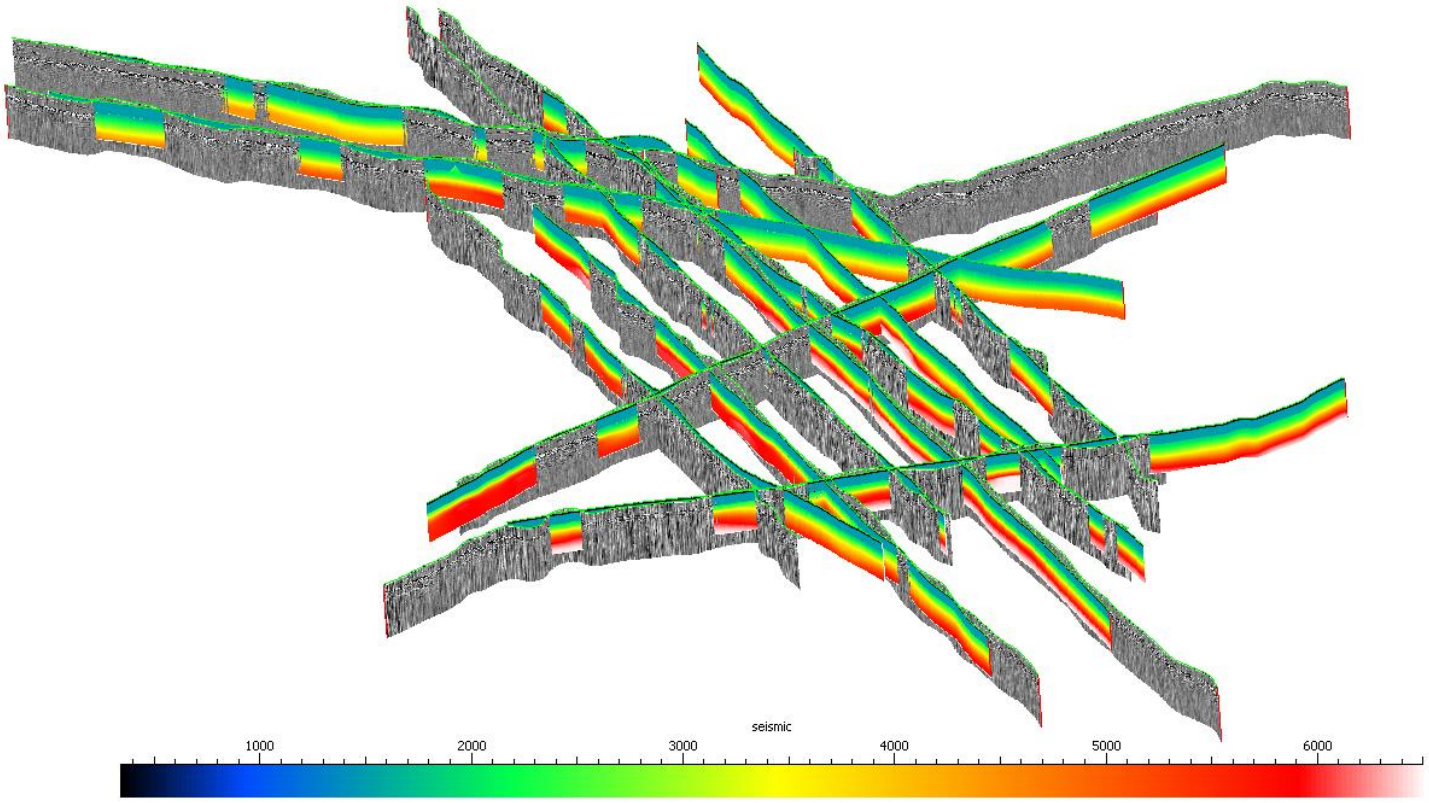
MARINE SEISMIC – PORT DEVELOPMENT CASE STUDY 1

- **Defining layers & stiffness/velocity variations**



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MARINE SEISMIC – PORT DEVELOPMENT CASE STUDY 1

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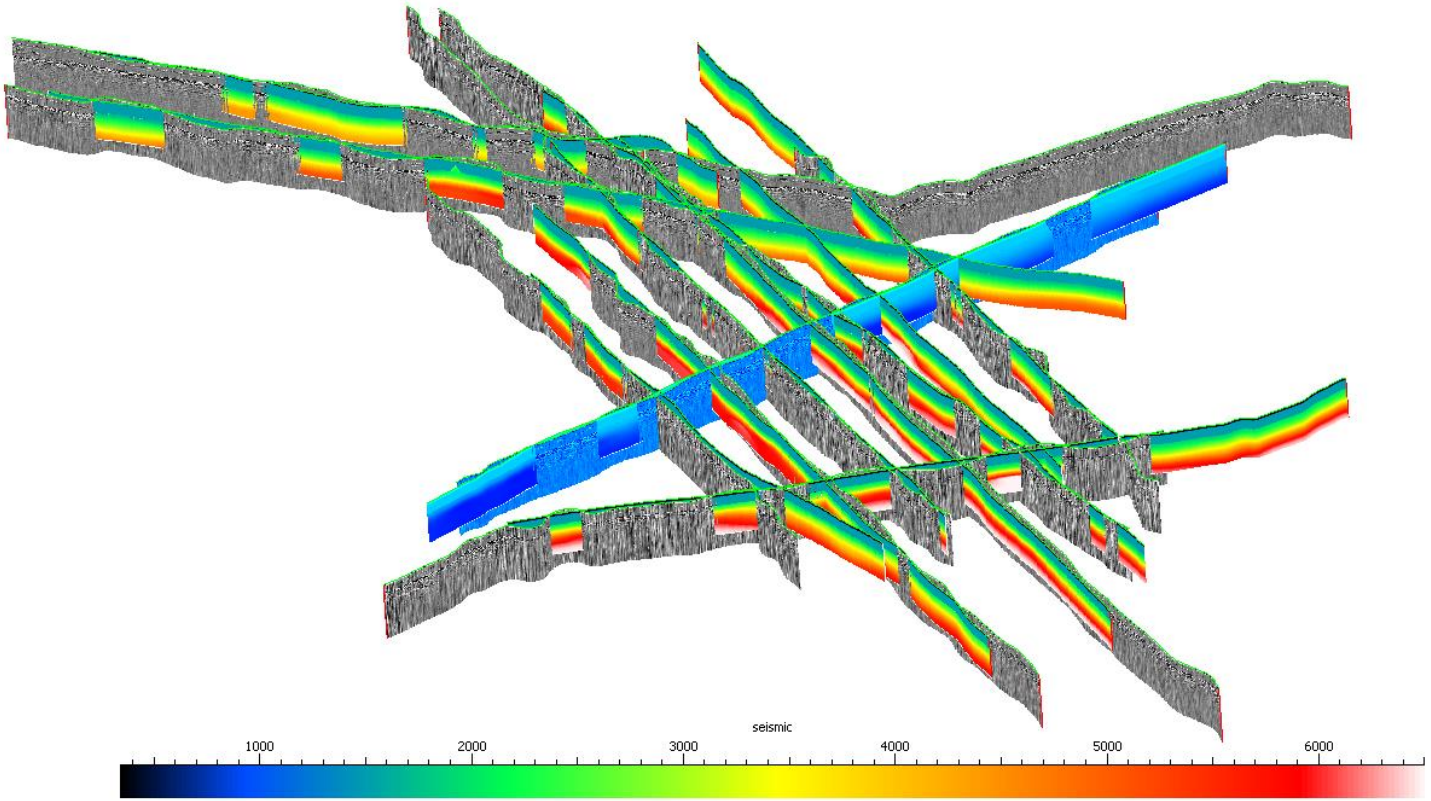

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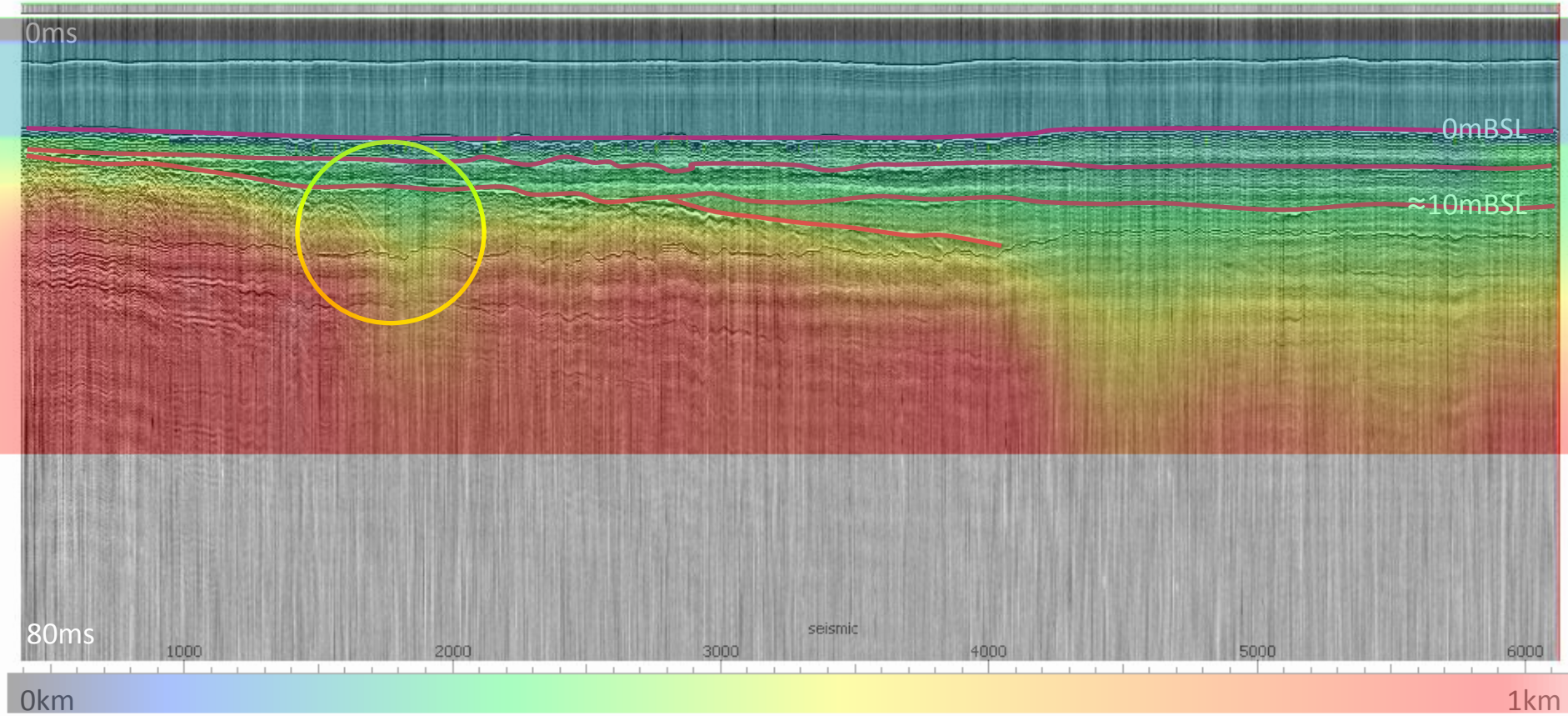
MARINE SEISMIC – PORT DEVELOPMENT CASE STUDY 1



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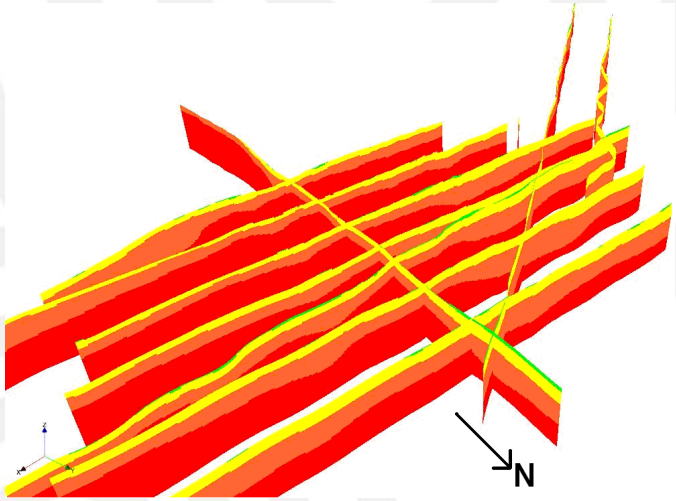
MARINE SEISMIC – PORT DEVELOPMENT CASE STUDY 1

- **Dredgeability**

P-WAVE VELOCITY	DREDGING CHARACTERISTICS	COLOUR (IN IMAGE)
1530 – 1900	Easily dredged with a TSHD[1]	GREEN
1900 – 2500	Easily dredged with a CSD[2]	YELLOW
2500 – 4000	Dredge with difficulty with a CSD[2]	ORANGE .
> 4000	Blasting required	RED



[1]TSHD - Trailing Suction Hopper Dredger

[2]CSD - Cutting Suction Dredger

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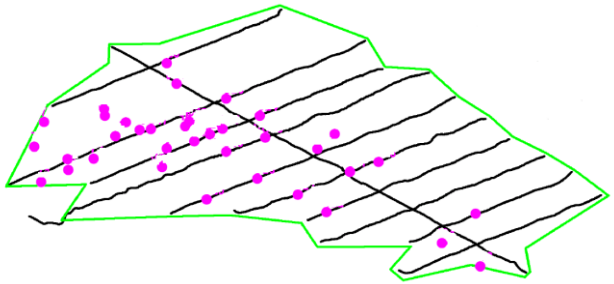
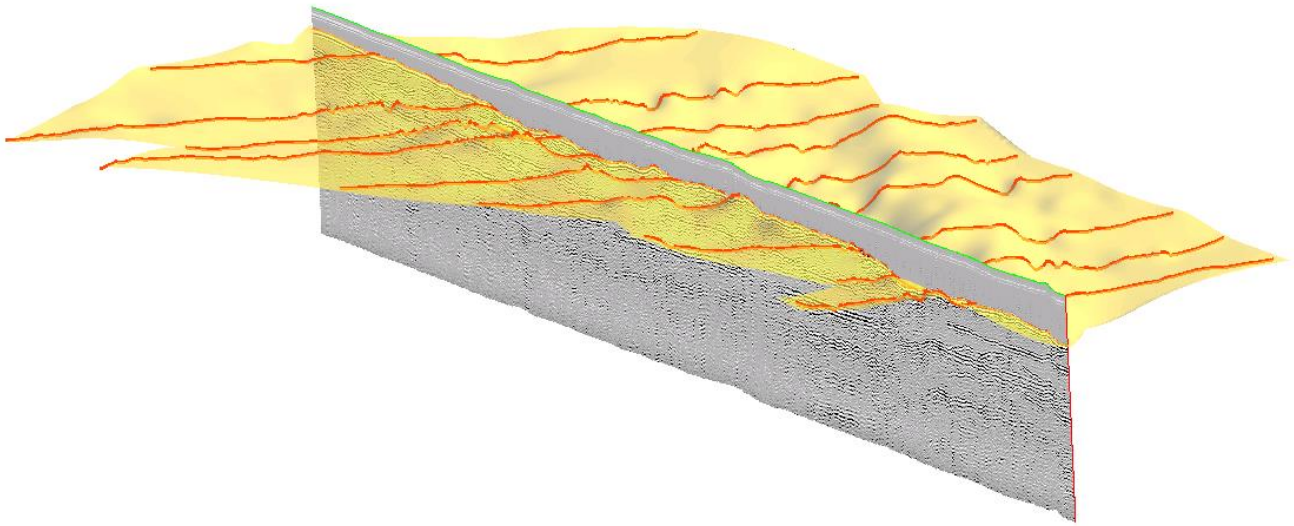
MARINE SEISMIC – PORT DEVELOPMENT CASE STUDY 2

- **3D Surfaces, Volumes, Layer Characterisation**





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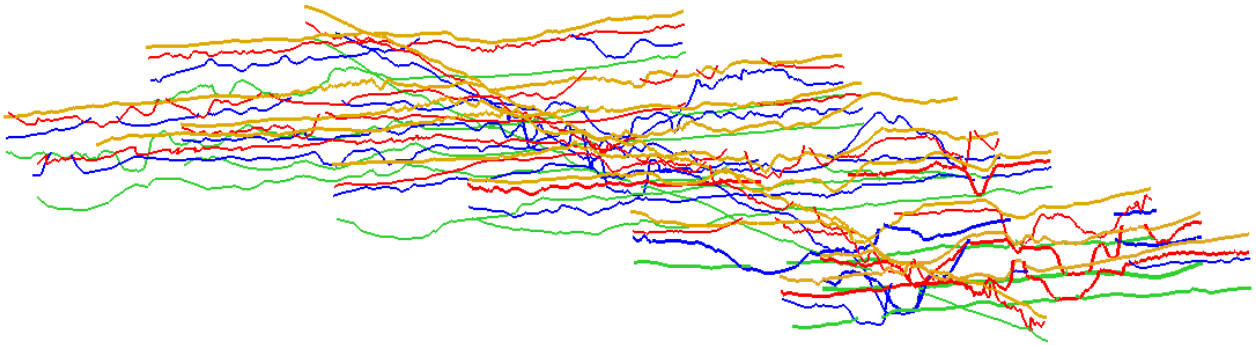

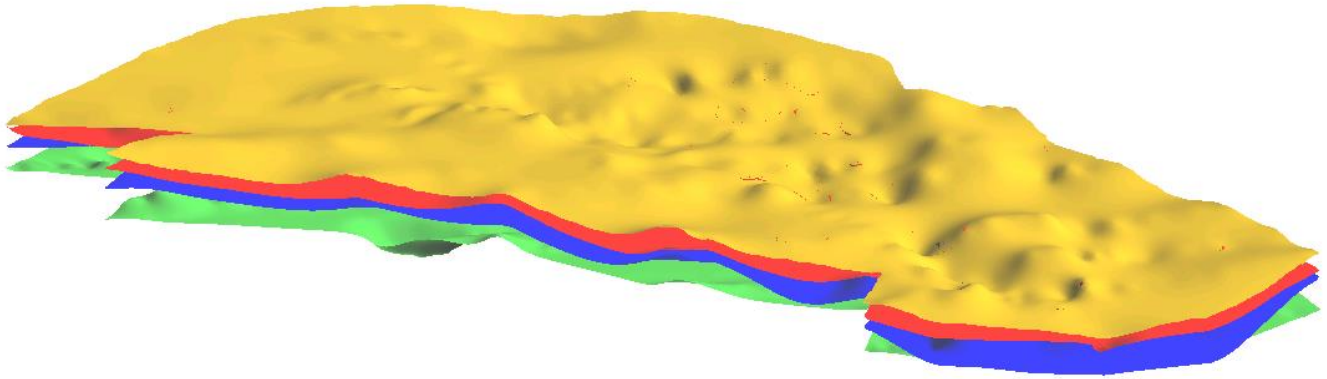

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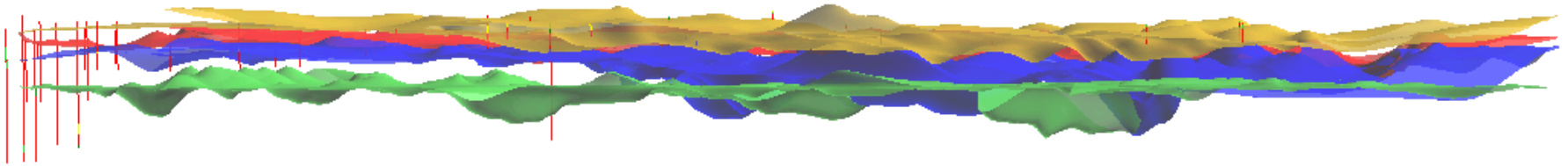
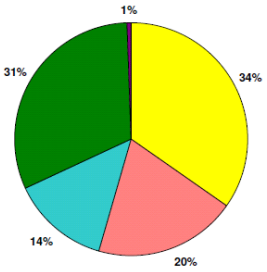


SEISMIC UNIT A

Volume Unit A:	30782200	m^3
Map Area Unit A:	6417940	m^2

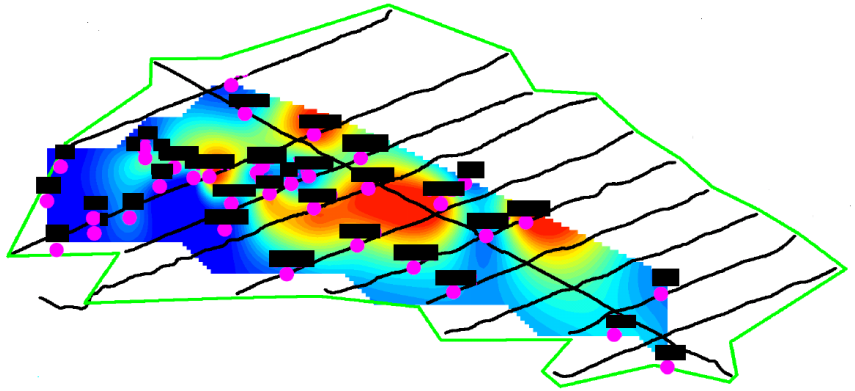
SEISMIC UNIT A - GROUP LITHOLOGY % CONTENT



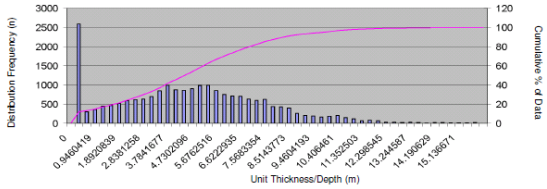
GROUP LITHOLOGY KEY:

- "CLEAN" SANDS AND GRAVELS
- MIXED SEDIMENT CLAY/SILT/SAND/GRAVEL
- SILTS AND CLAYS
- SILTY CLAY
- ROCKS

% "Clean" Sands and Gravels Unit A:	35%



SEISMIC UNIT A - THICKNESS/DEPTH HISTOGRAM



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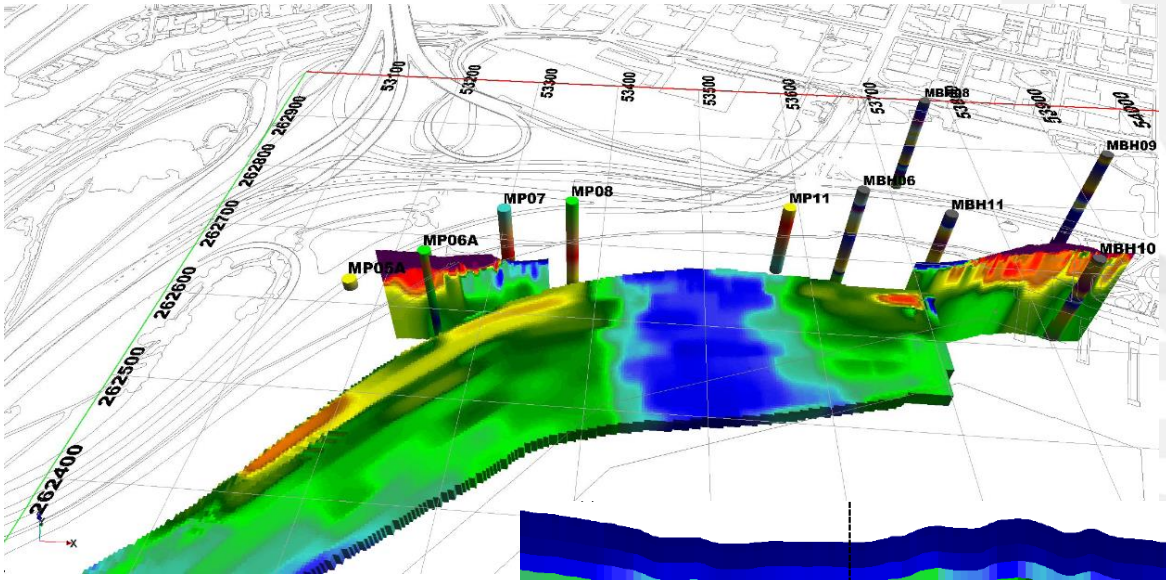
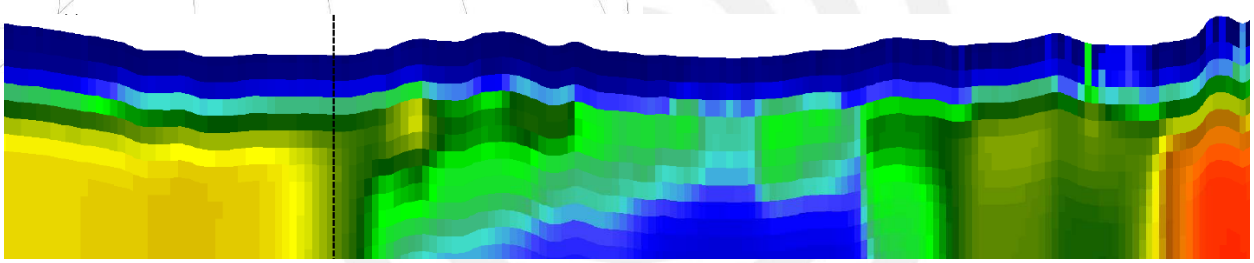
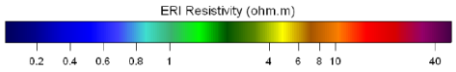
SHALLOW MARINE AND NEAR SHORE RESISTIVITY

- **Onshore & Offshore Electrical Resistivity Imaging**







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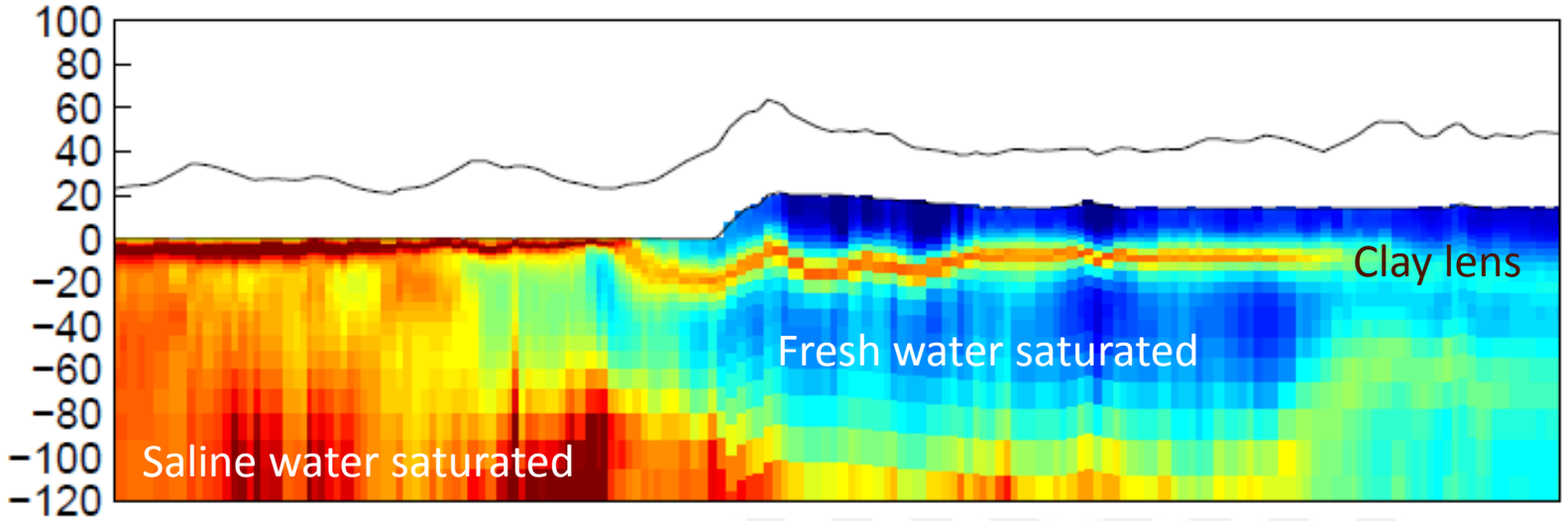
AIRBORNE ELECTROMAGNETICS OVER MARINE-LAND TRANSITION

- **Mapping clays & fresh vs saline groundwater**



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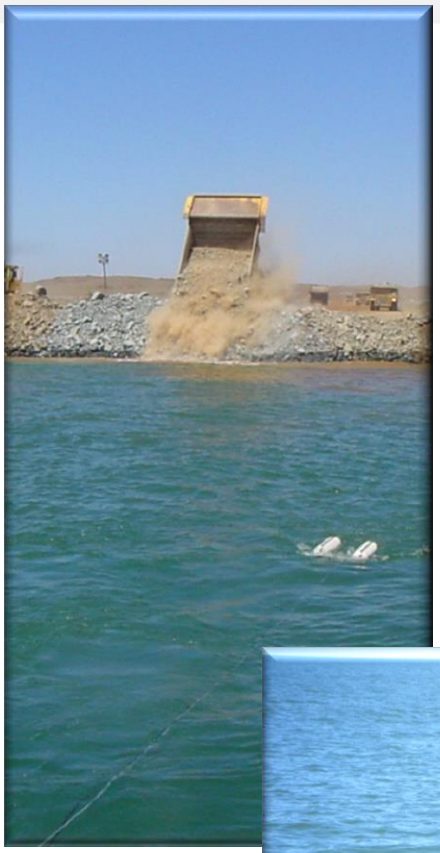
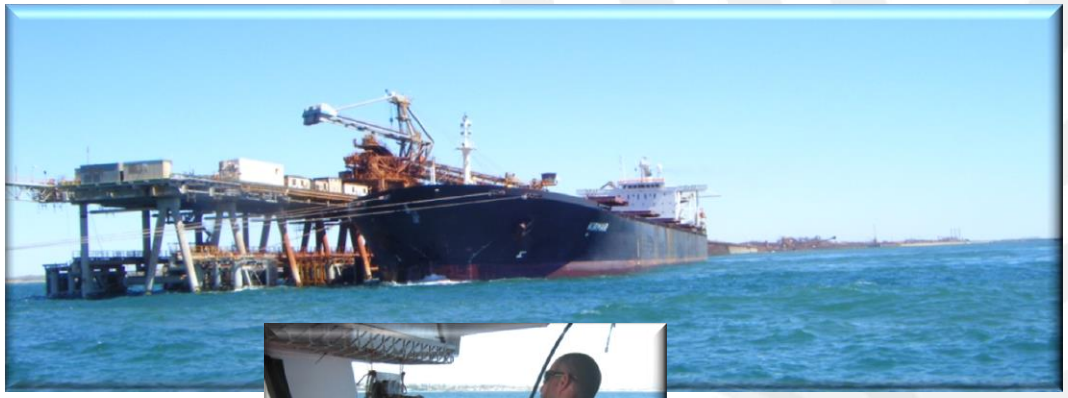
THANK YOU





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