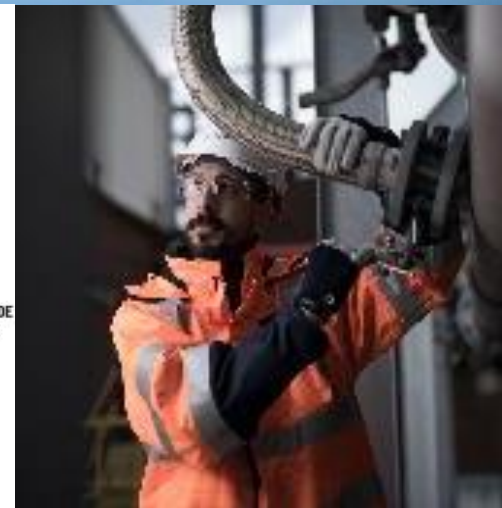
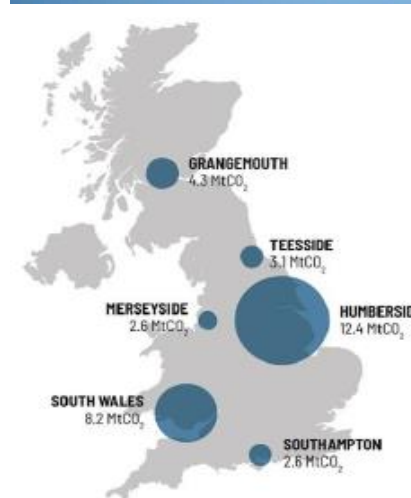




Shallow aquifer fluid sampling for carbon capture and storage (CCS) - *Development of a novel fluid sampling trace chemical*

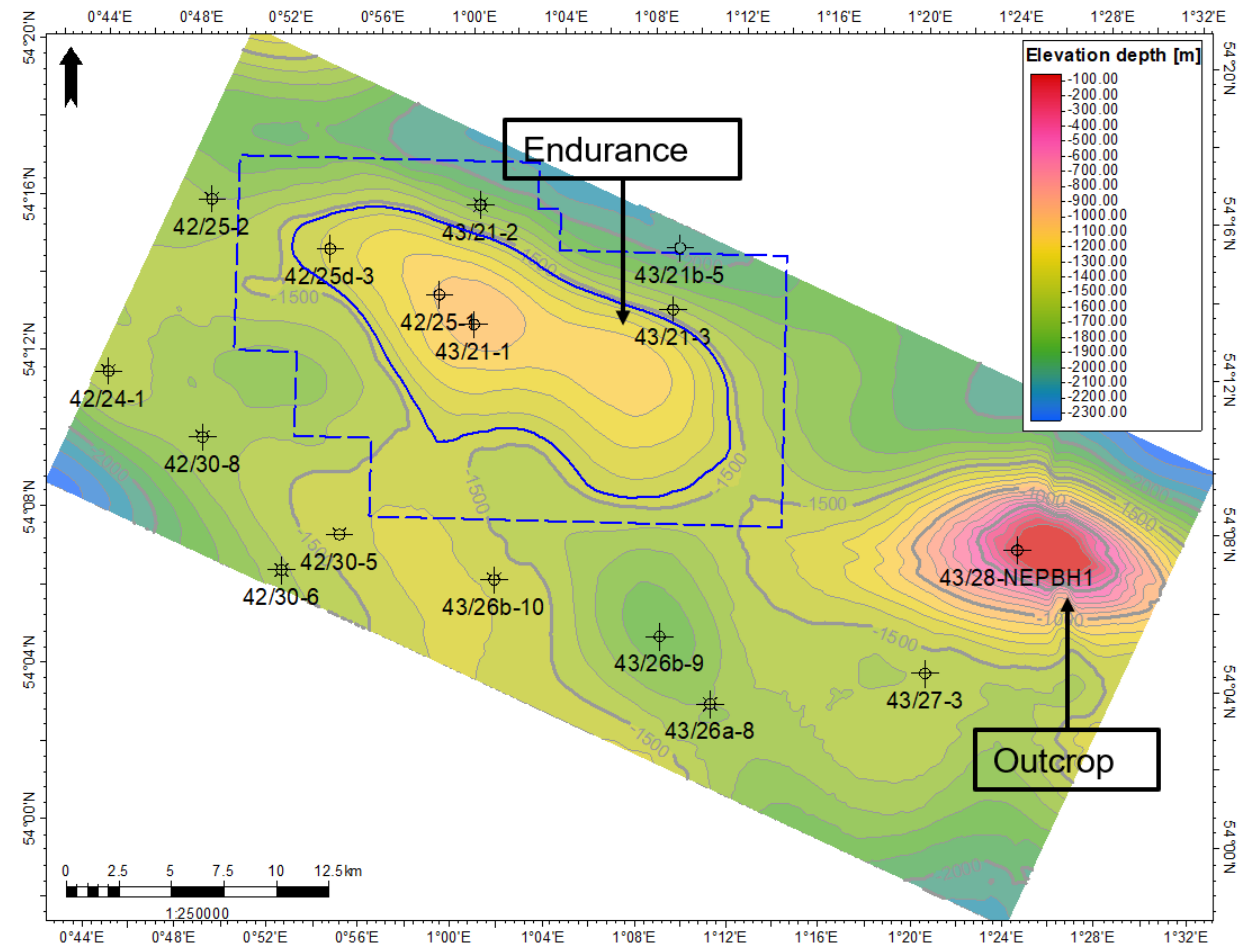
Kirsty Hitchen, bp

DEVEX 2024 Conference
P&J Live, Aberdeen
29th May 2024



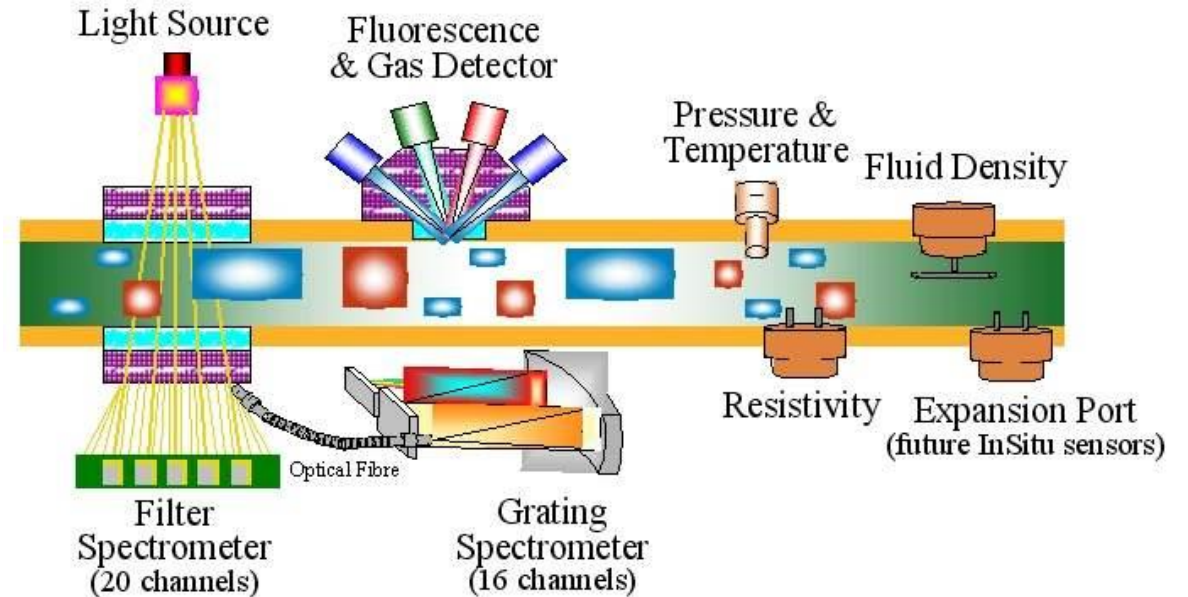
Introduction

- Plan to store CO₂ in the Bunter Sandstone aquifer at Endurance.
- Formation water at Endurance is hyper-saline.
- Outcrop likely in communication with the sea
- Formation water expected to be displaced at the outcrop by pressure increase due to CO₂ injection at Endurance
- **Well drilled with main objective of collecting representative water sample at outcrop**



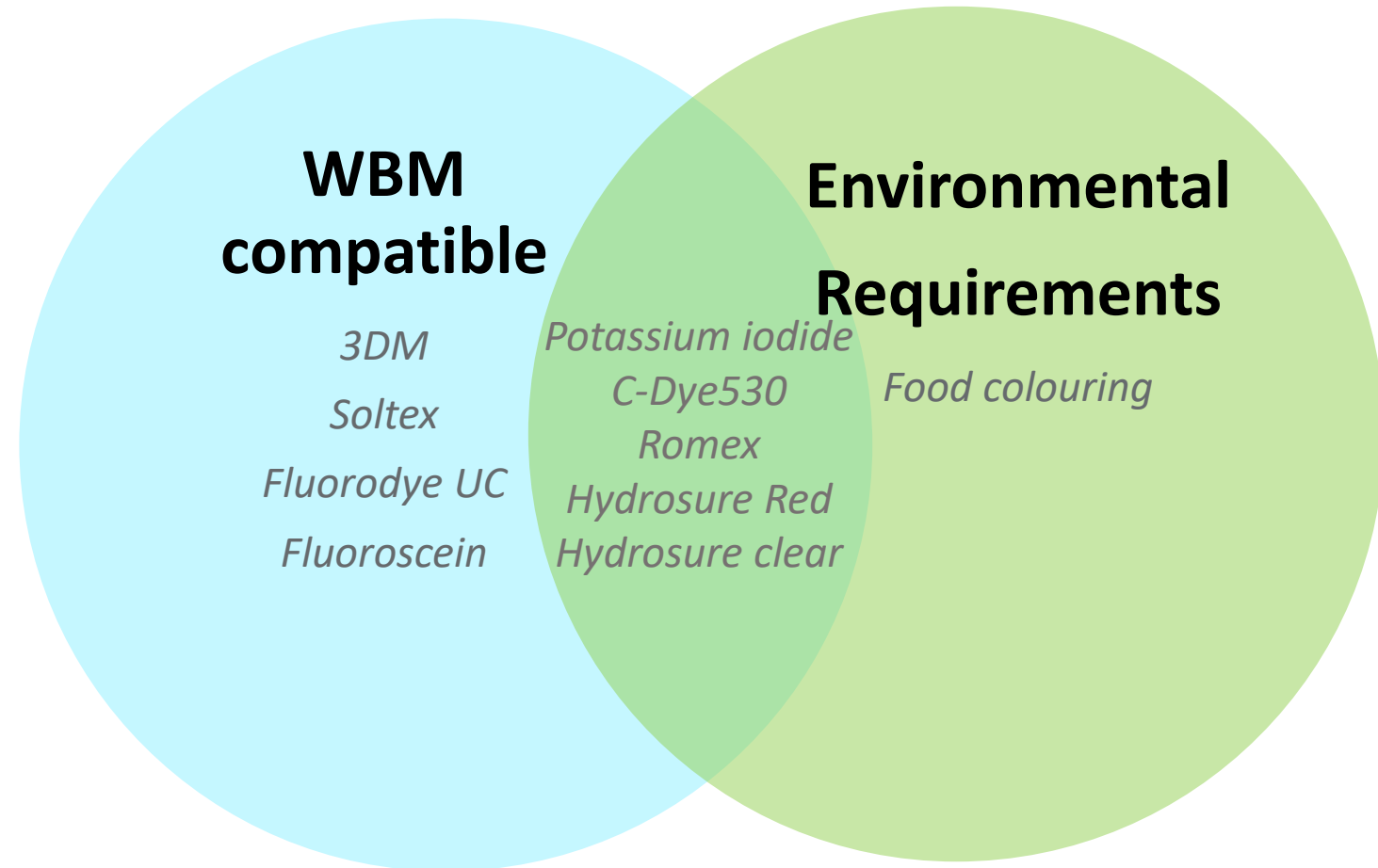
Why do we need a tracer?

- Formation likely in hydraulic communication with the sea
 - No OBM permitted
 - Strict chemical requirements – environmental permit
- Water chemistry highly uncertain
 - resistivity sensor may not help
- Need to change mud colour and/or fluorescence
- D_2O to measure contamination in lab after the job.



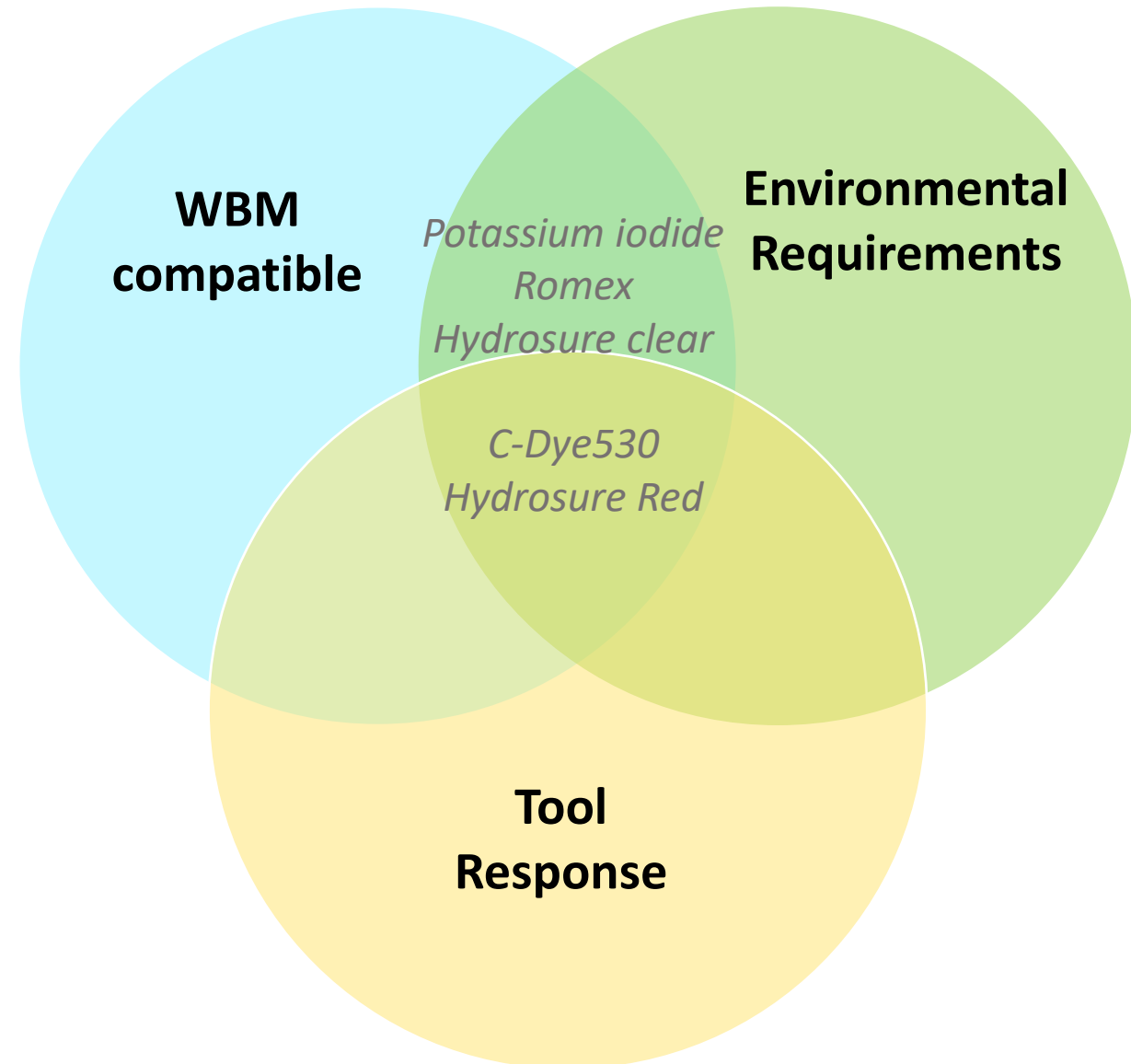
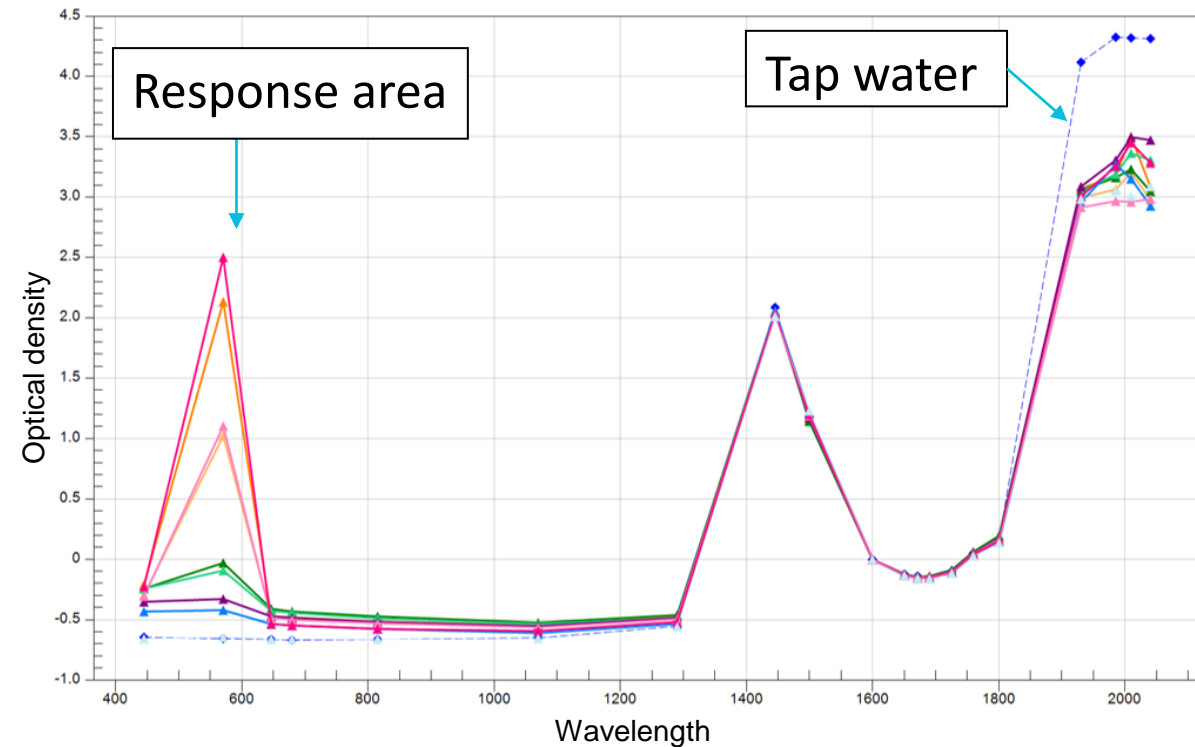
Tracer development

- Reviewed previous similar jobs – none suitable
- Search for a new chemical
 - Started with the UK regulator “approved” chemical list
 - Checked shortlist did not degrade over the period before lab analysis (4 weeks)
- Tested chemicals in the mud lab to ensure compatibility



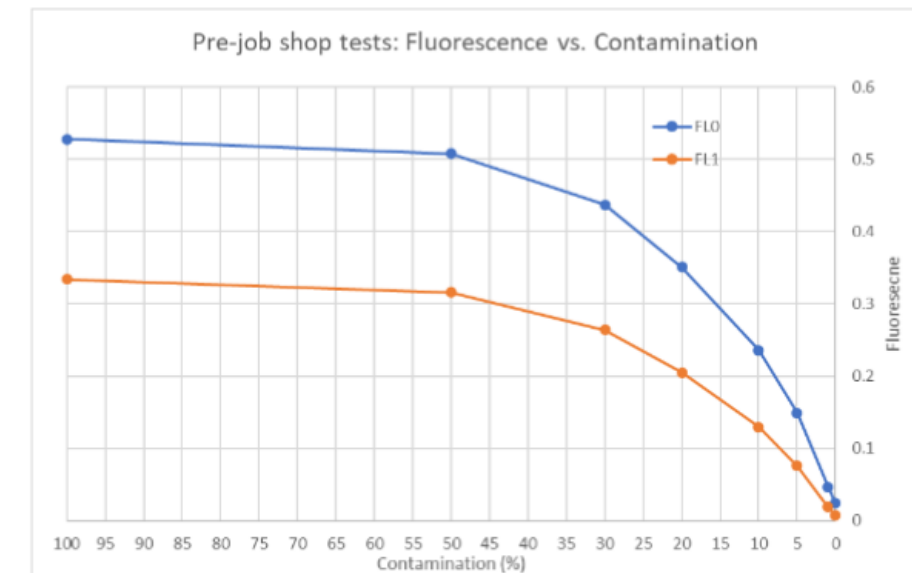
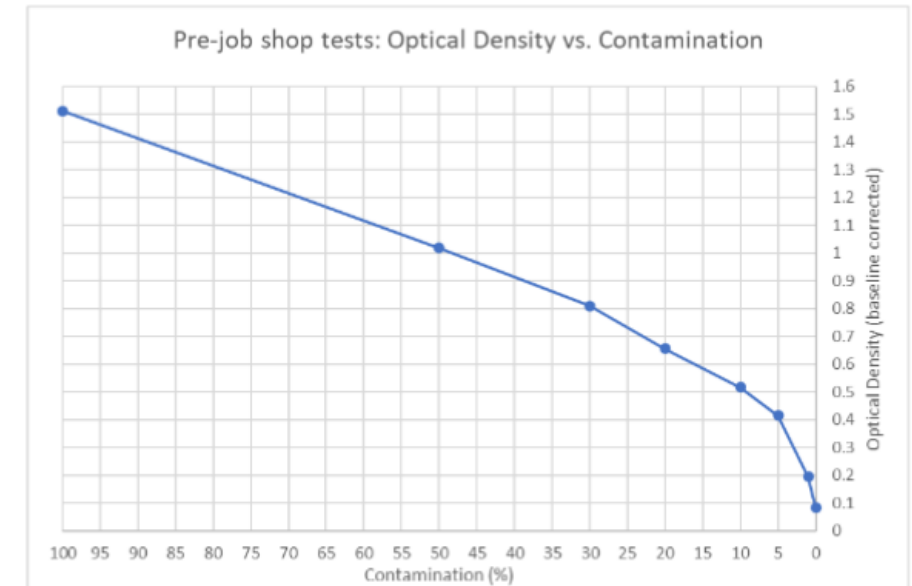
Tracer development – tool test

- Do the tool sensors respond to the dye?
- 2 chemicals showed a response at 1% and 0.25% concentration



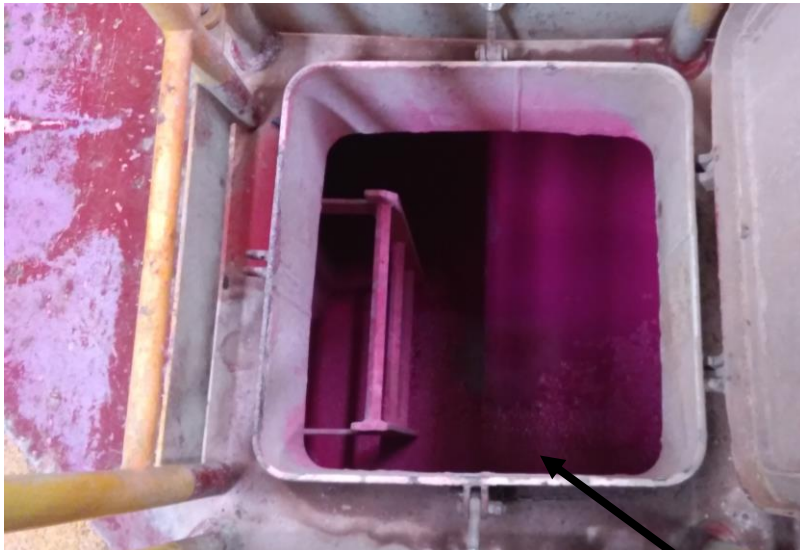
Tracer development – tool testing

- Selected dye tested at multiple dilutions
- Clear detectability at 5% contamination (<10% to be considered success)

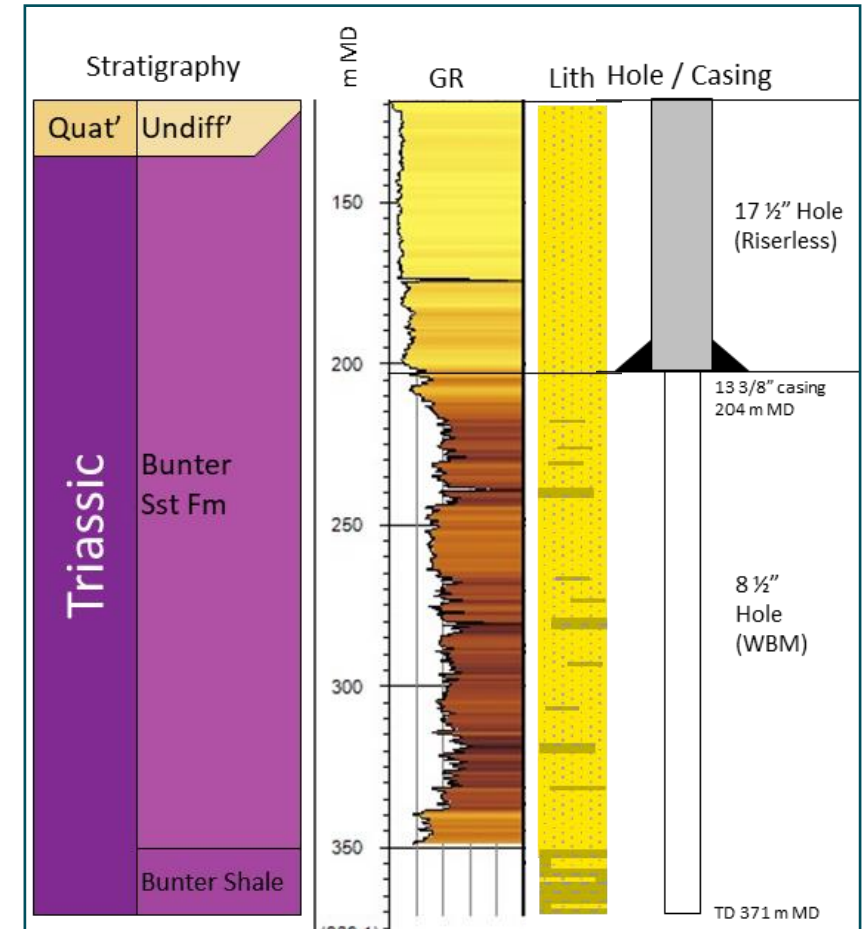


Implementation – operations summary (1)

- Discussed drilling with Geotech survey vessel
 - lots of invasion, challenging tool deployment.
- Drilled from a jack up with a closed circulation system
- Added dye and D_2O to the mud system prior to 8.5" section



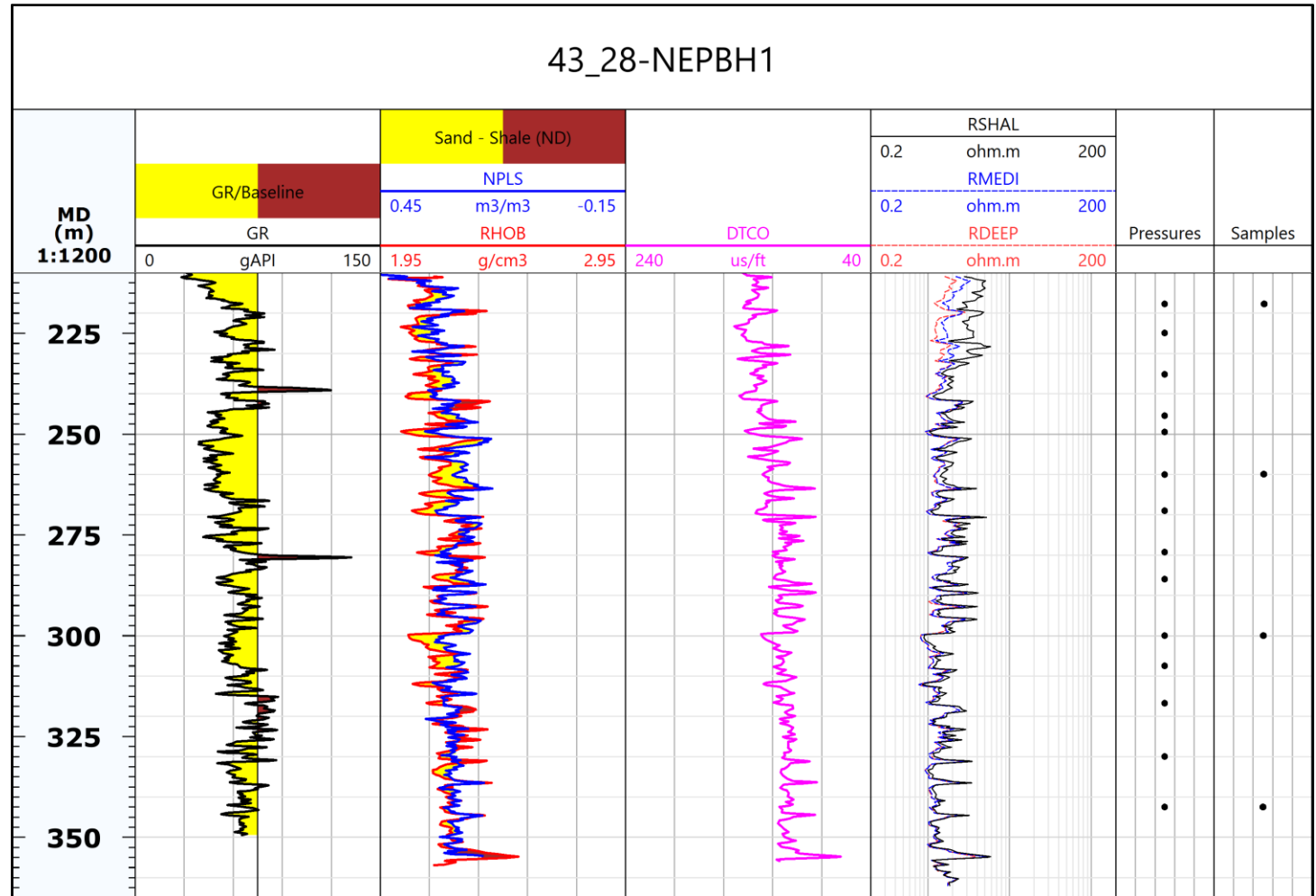
Mud system



Well schematic

Implementation – operations summary (2)

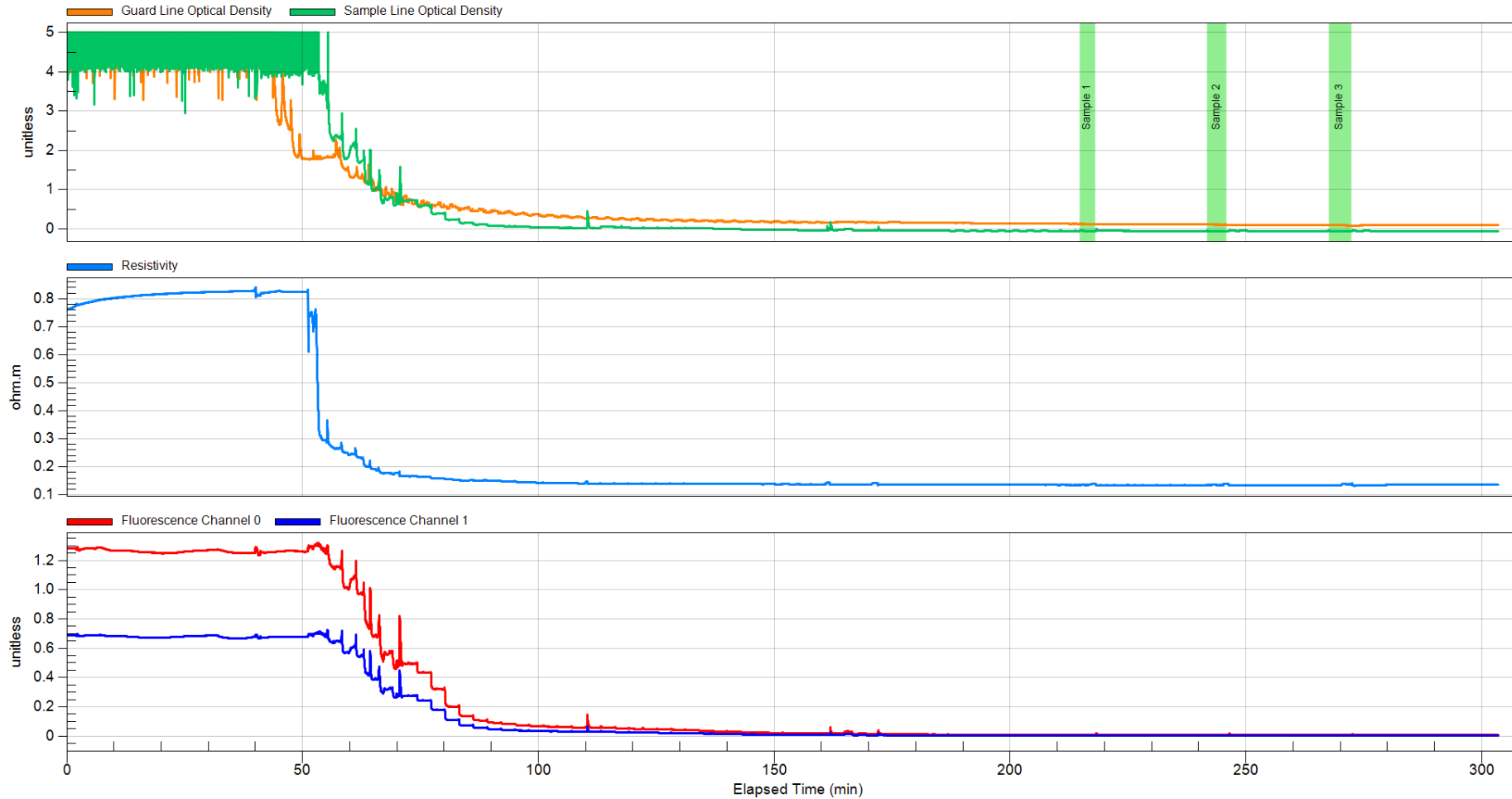
- 130m of whole core collected, sections preserved on deck
- Pre-job, highly uncertain rock properties
- Core showed good consolidation and high permeability
- Deployed focused sampling probe



Implementation – station 2

- Clear tracer response on sensors as expected from shop tests, samples 5,6,7

Fluid Analyzer Display



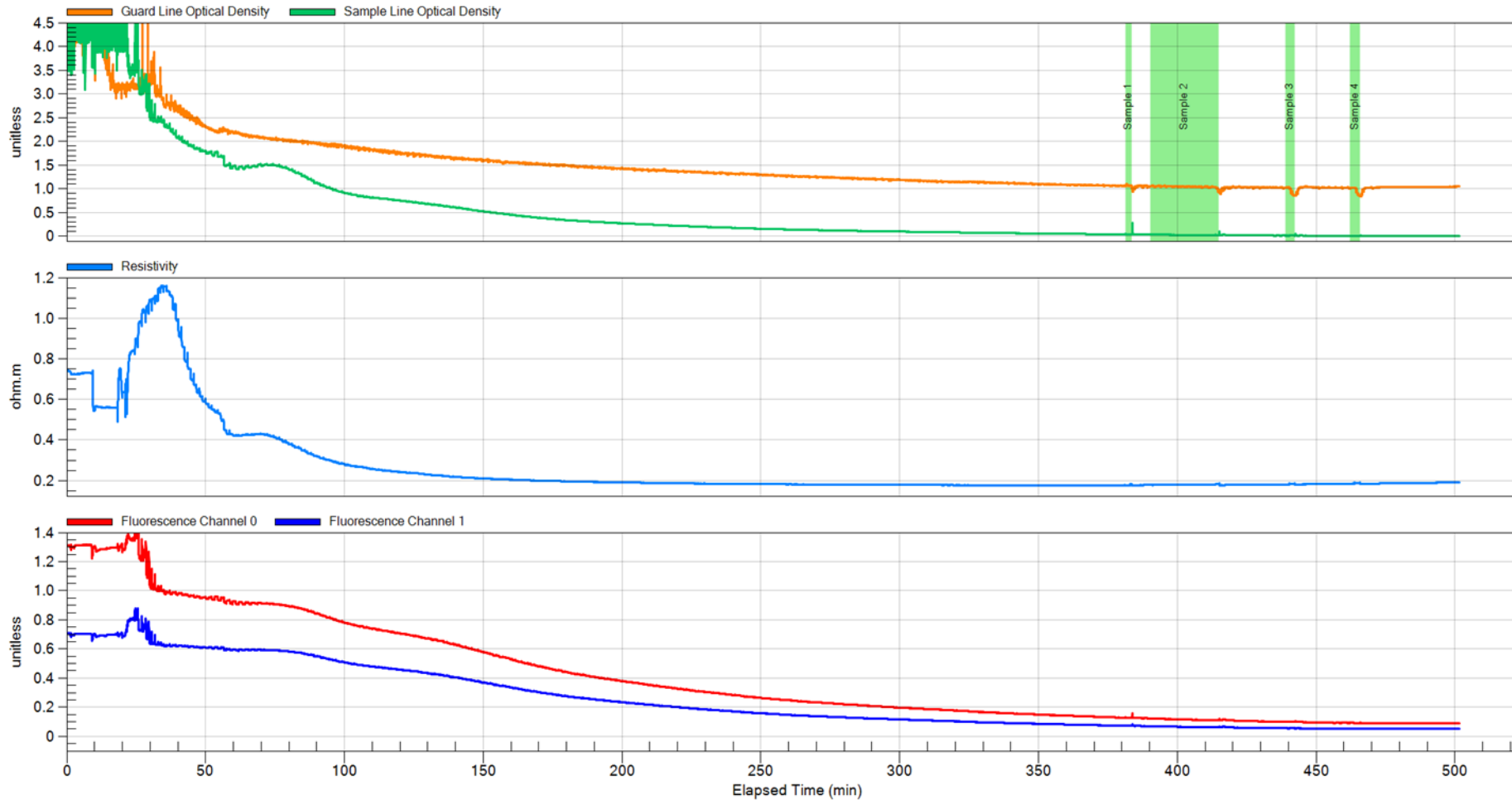
Contamination

- Real-time: 1-3%
- Lab: 1.2/1.1%

Implementation – station 4

- Highest contamination station (significant invasion), samples 11,12,13 and 14

Fluid Analyser Display



Contamination

- Real-time: 1-5%
- Lab: 2.4%

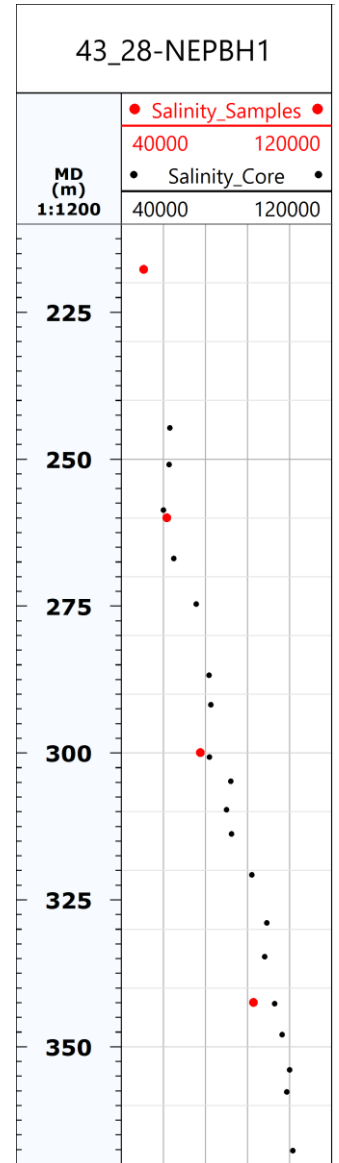
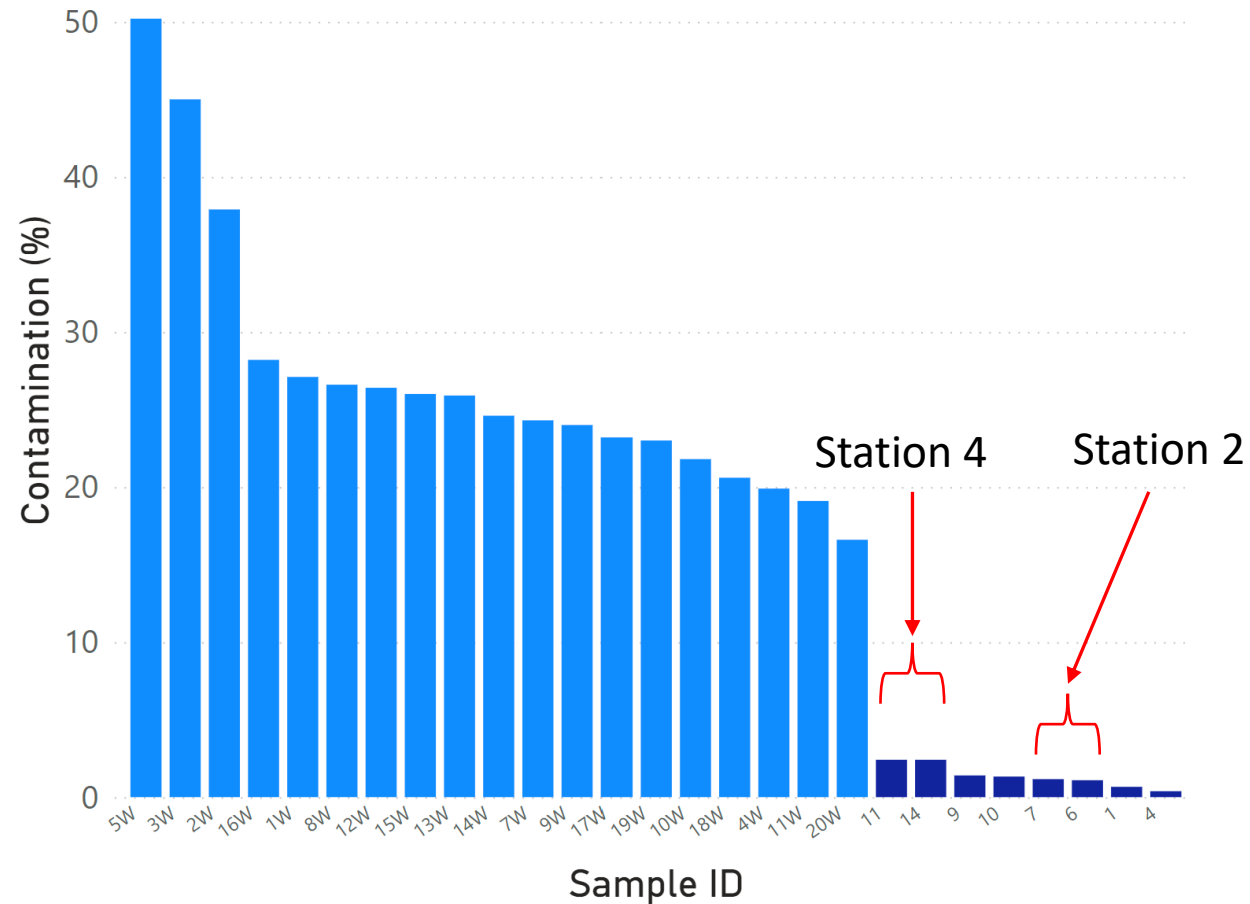
Results – fluid and core sample analysis

- Wireline samples (pressurized and non-pressurized)
- Core plugs from preserved sections
- Contamination (C) measured via D_2O concentrations

$$C = \frac{D_{sample} - D_{formation}}{D_{mud} - D_{formation}}$$

Contamination levels (%)

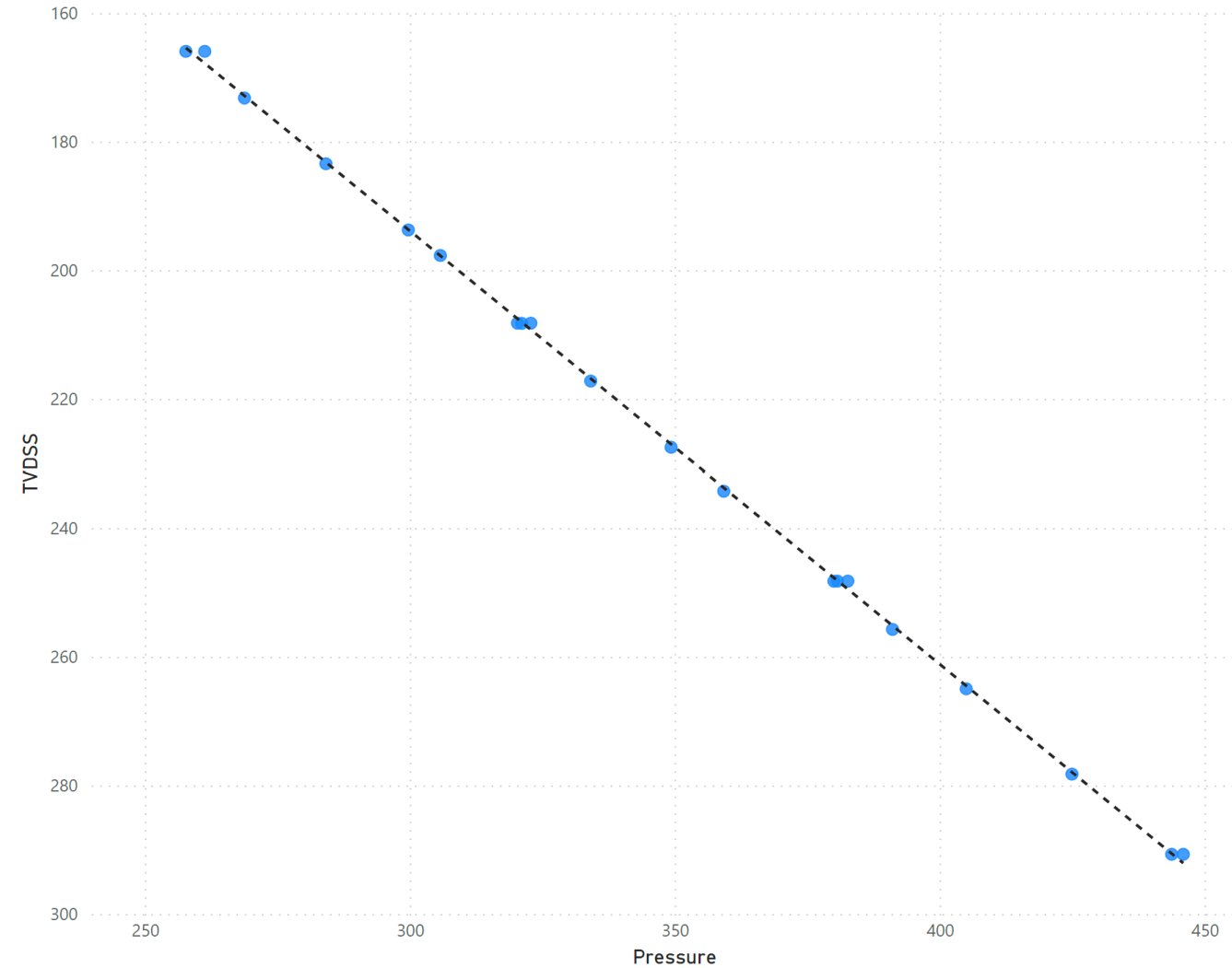
Collection Method ● Core ● Wireline



Results – pressure analysis

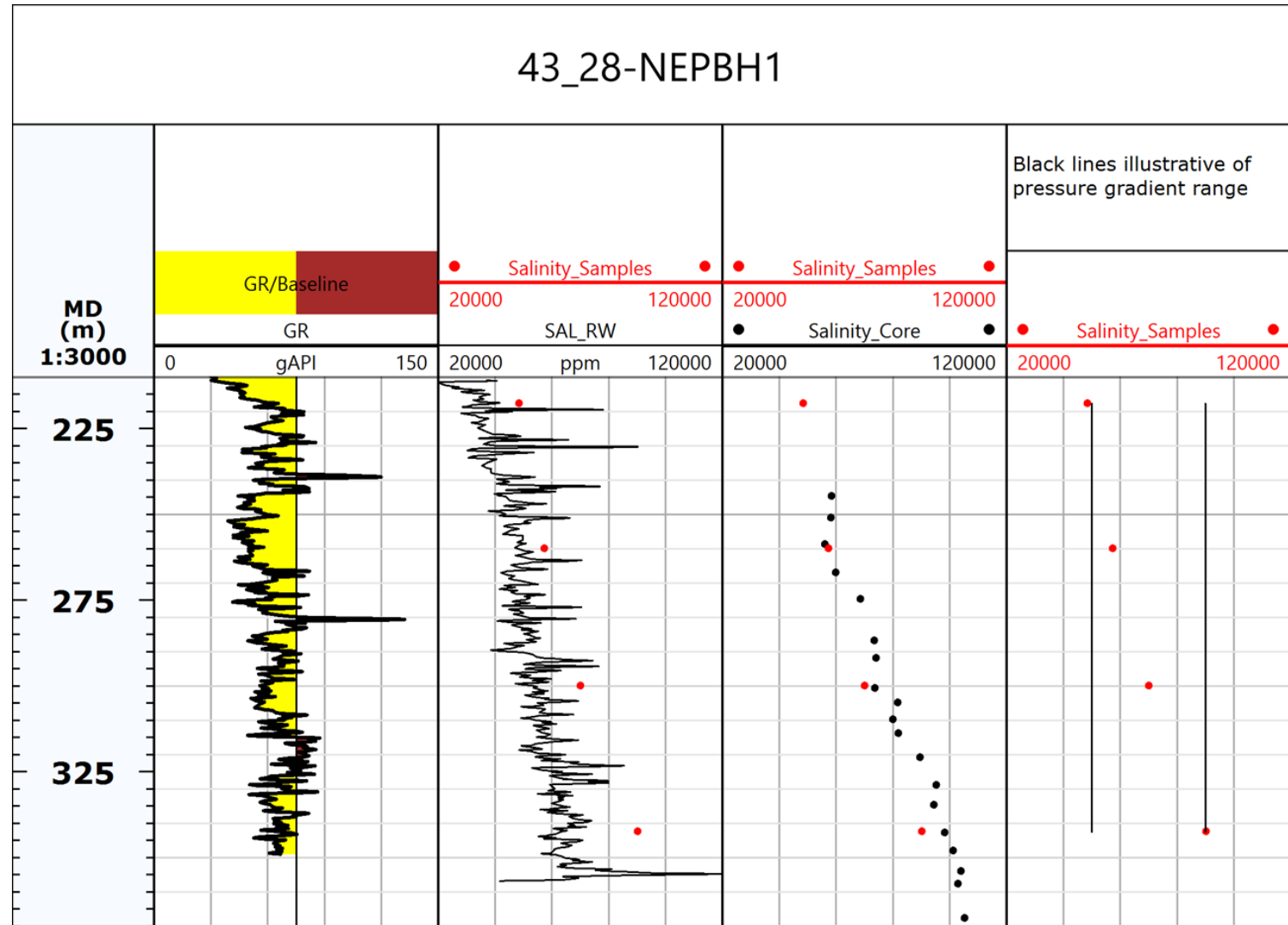
- Salinity was estimated using pressure gradients and assuming a NaCl solution
- Salinity range of 50-90kppm
- N.b. Strong tidal effects at these shallow depths

Pressure and TVDSS



Results – comparison of methods

- Wireline fluid sample data agrees with formation pressures and core fluids
- Salinity was also derived from the resistivity log
 - Highly uncertain as no Archie “m” data available in this well.



Conclusions

- Tracer chemical C-dye 530 was successfully built into a WBM formulation, tested at surface in a wireline tool and deployed offshore on a jack-up rig.
- This tracer was successfully used for real-time contamination monitoring of a wireline fluid sampling pump-out
- Low contamination fluid samples were acquired and the results successfully validated against independent calculation methods.
- High quality water sampling and analyses are key to the characterisation of saline aquifer carbon storage sites.

Acknowledgements

- My co-authors: Michael Taplin (bp), Emilie Peyret (slb), Phillip Jackson (bp)
- Northern Endurance Partnership:



- Operational service providers (slb wireline, Halliburton coring)
- Laboratory service providers (Expro fluid analysis, Stratum core analysis)
- **Further information to be published in SPWLA-2024-0013**

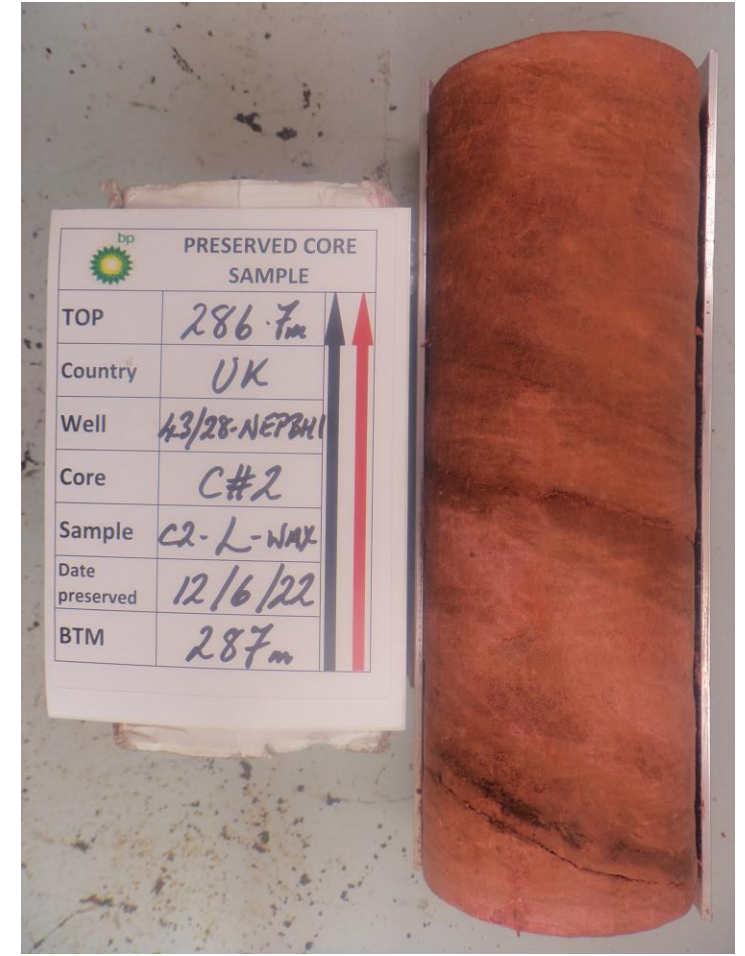
Questions?



Core head



Wireline tool



Whole core