Increasing Recovery at Captain Field

Devex 2024 – Day 2 – 1045-1110Hrs

Duncan Farthing | 29th May 2024

Agenda

1. Captain asset overview
2. Pilot and Stage 1 results
3. Mechanism and benefits of polymer flooding
4. EOR Stage 2 update

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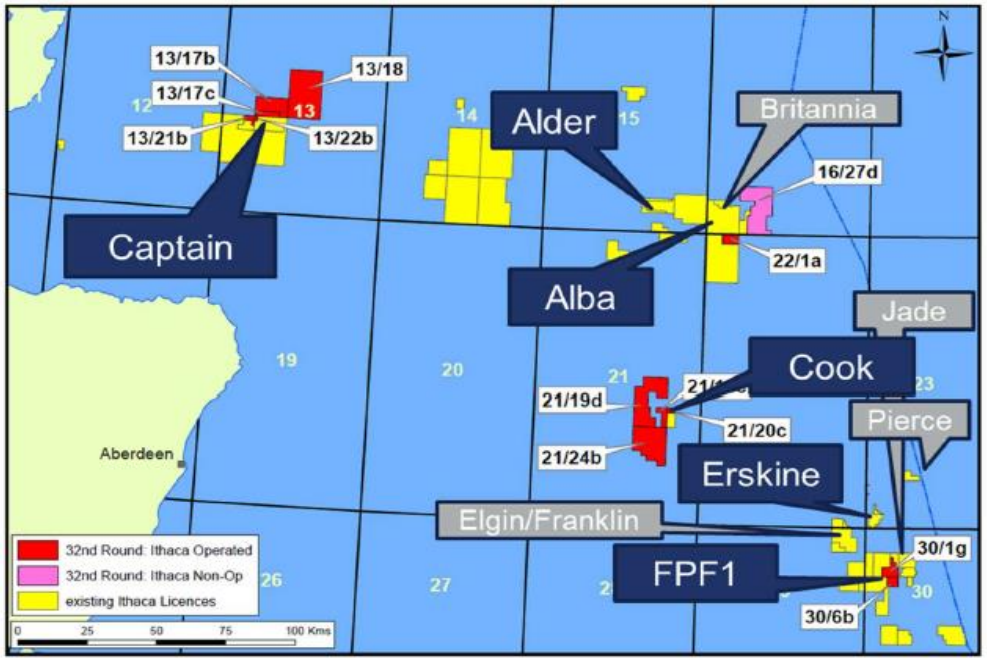
Captain asset overview

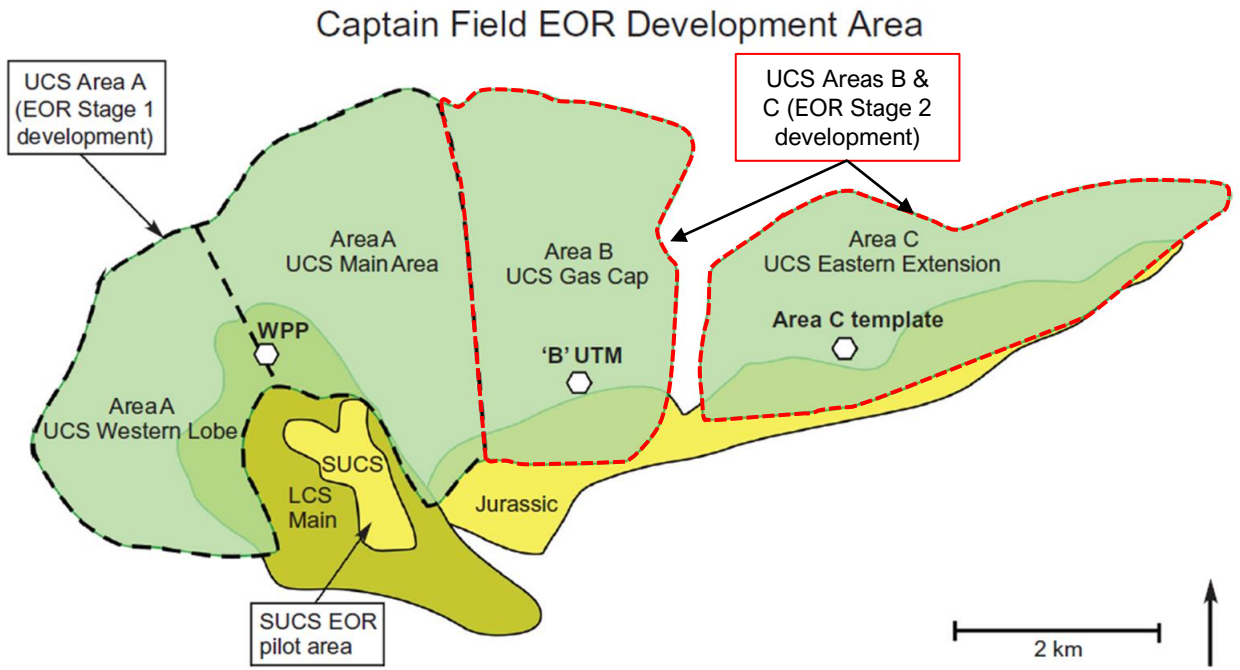
Captain asset overview



- Operated by Ithaca Energy
- Offshore UK North Sea – Outer Moray Firth
- Discovered in 1977, first oil in 1997
- ~1 billion barrels STOIIP

- Oil viscosity 40-140 cP
- 3-11 Darcy sandstones
- T = 31°C, P_{res} = 1,270psi
- PWRI

Captain asset overview



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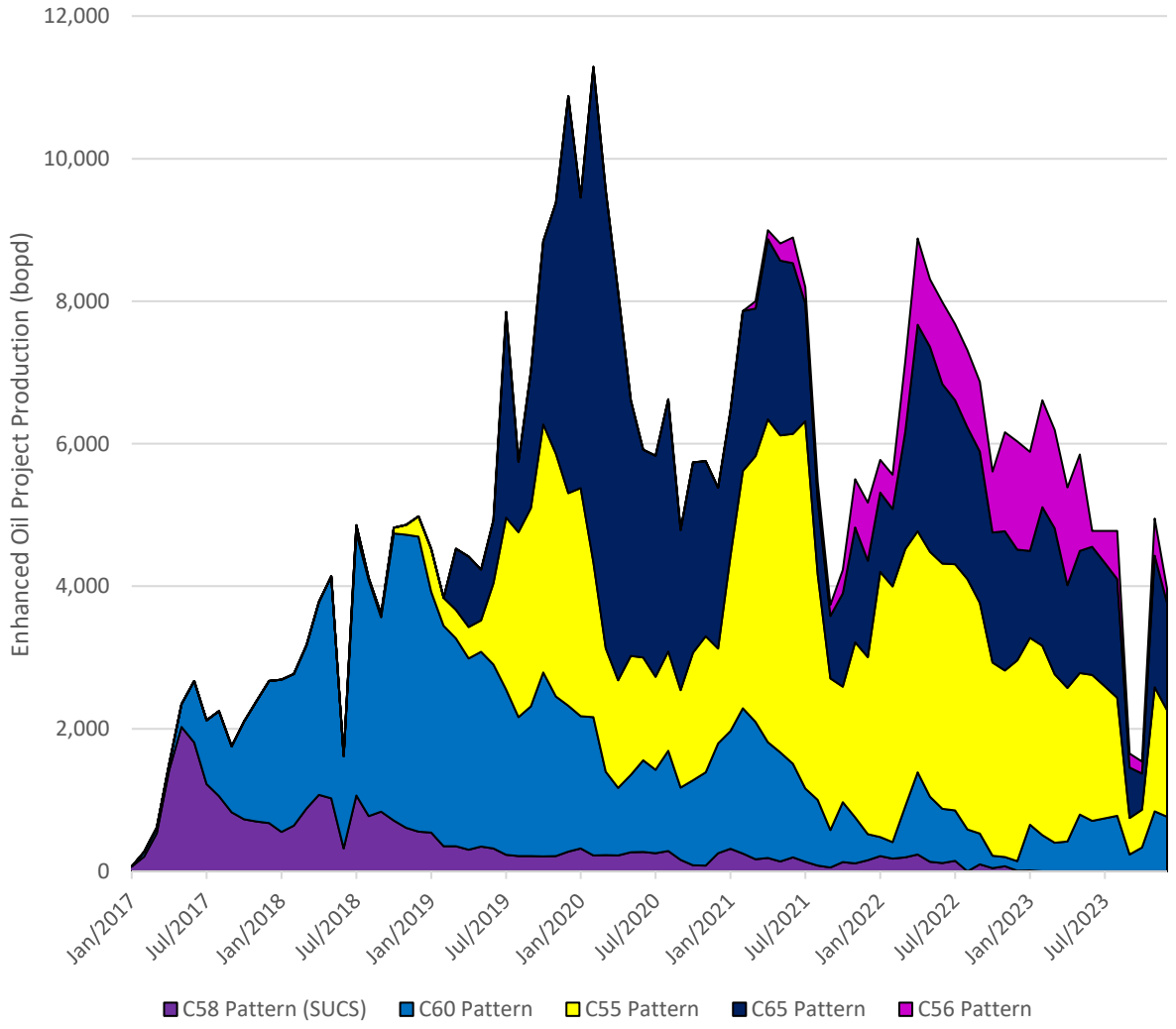
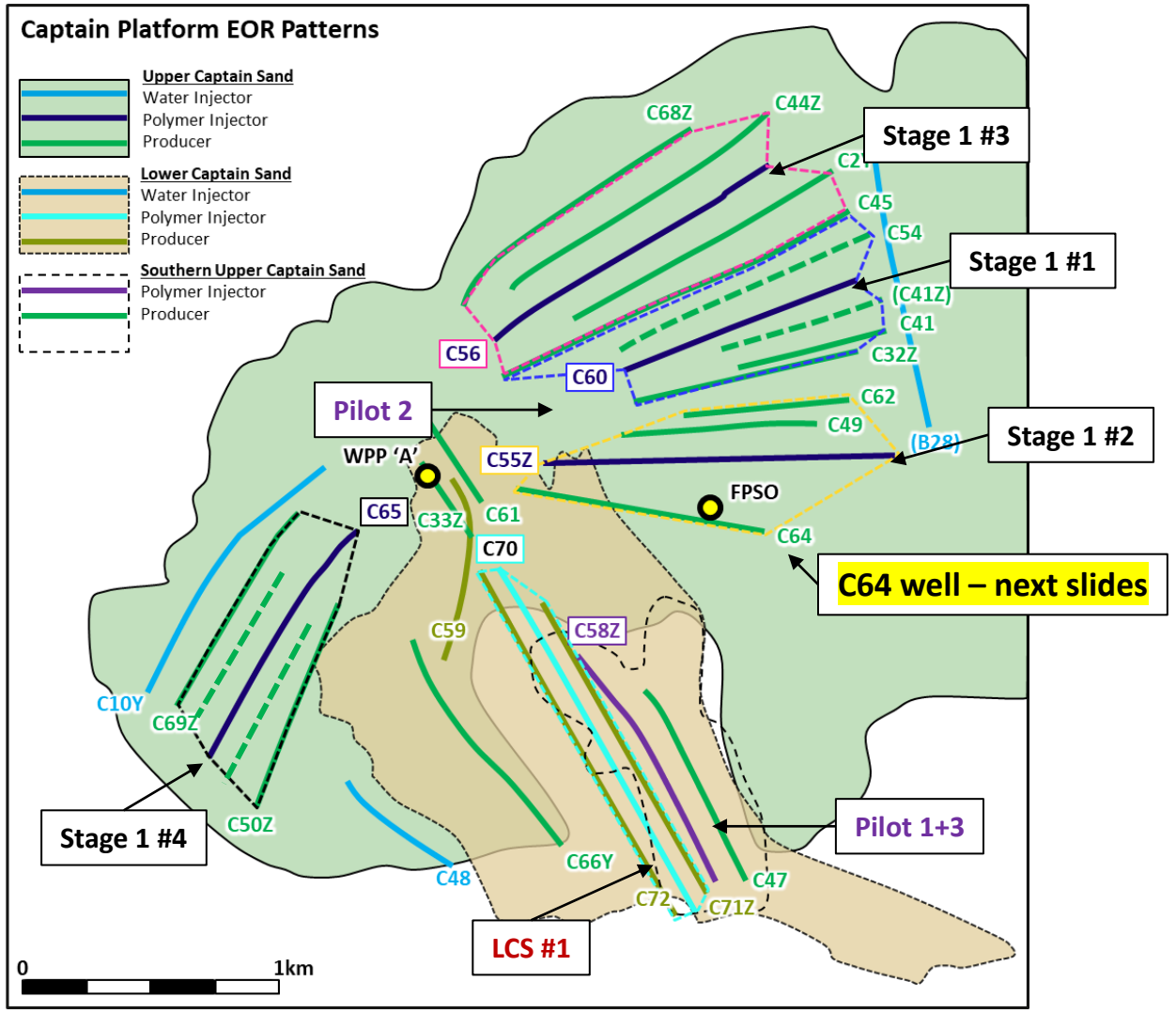
Pilot and Stage 1 results

Enhanced oil production across Captain

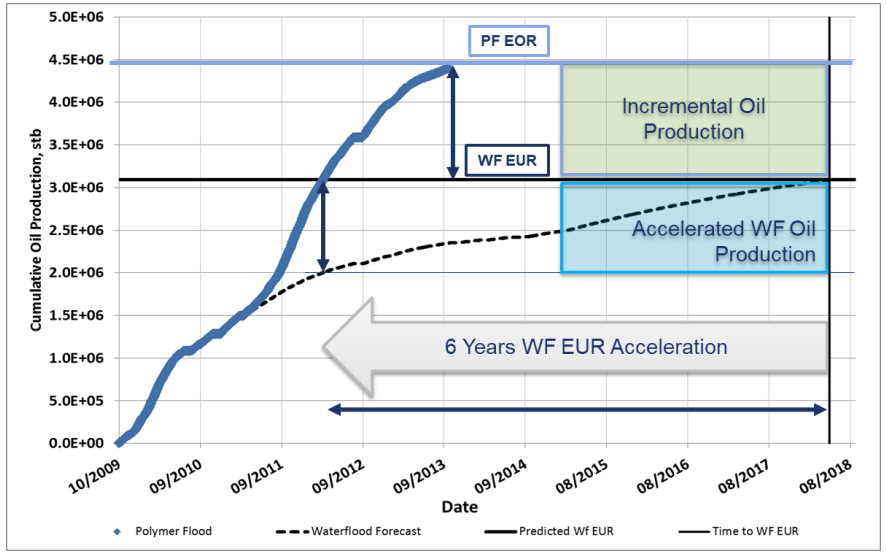
- Consistent enhanced oil success across the Captain reservoir development
- Achieved >15 MMbbls enhanced oil to date from the pilots and Stage 1 wells

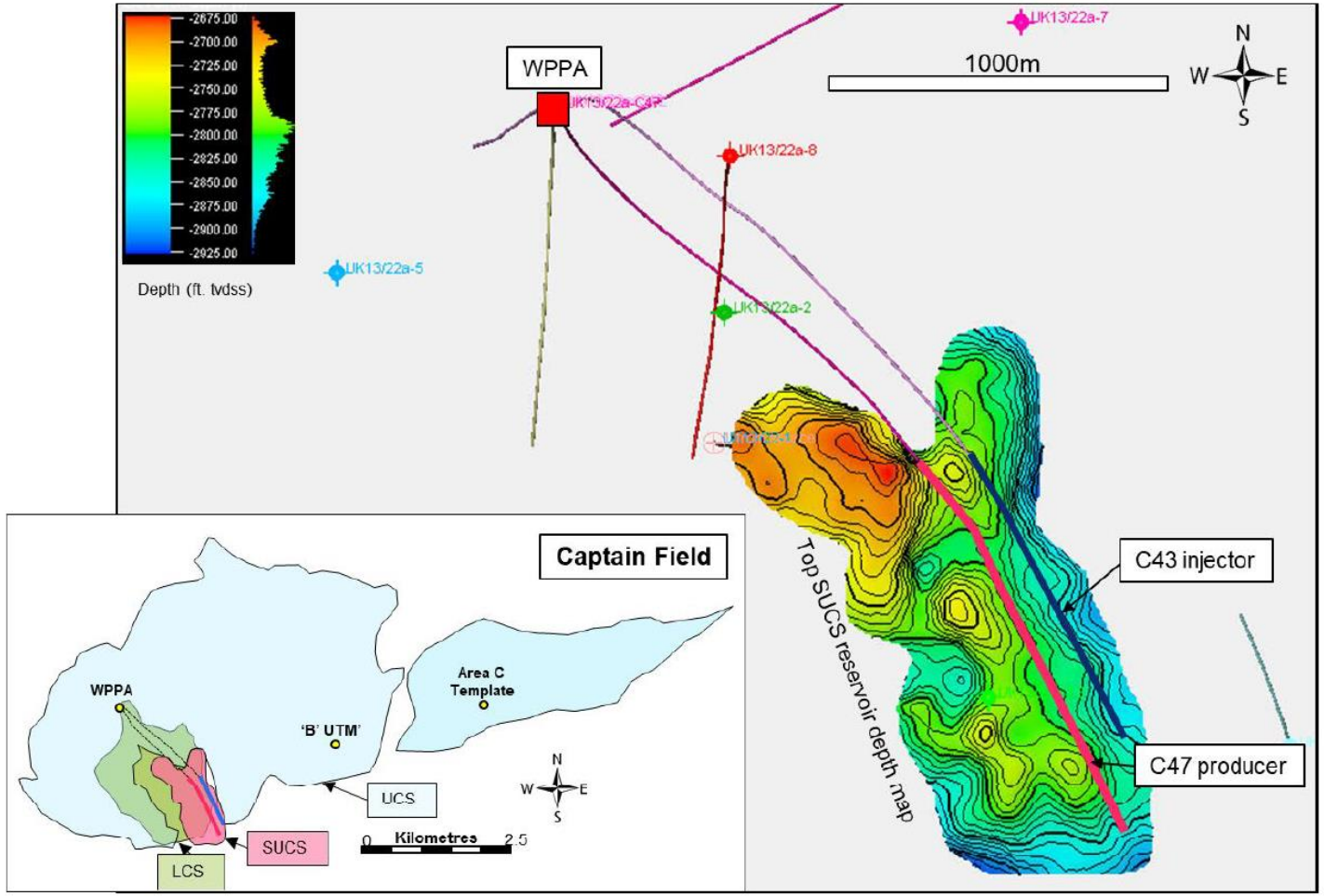




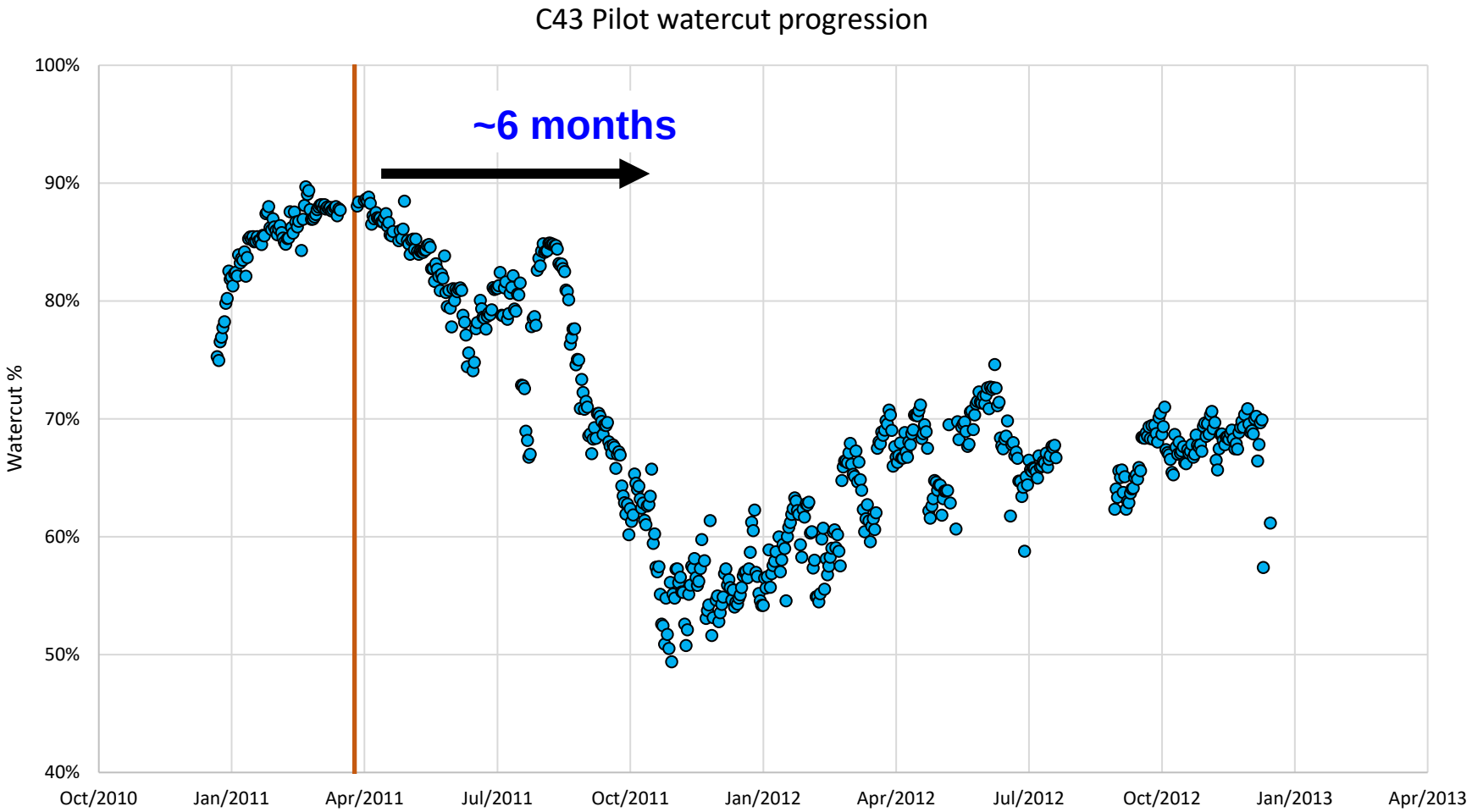
Pilot 1 – SUCS (Southern Upper Captain Sand) 2011

- Producer – injector pair
- Polymer injected from C43 to C47
- Isolated location – little interference
- 6 years acceleration of WF reserves
- Incremental oil production over WF





Pilot 1 results – Timing of response to polymer flooding



- Quick and clear response aids decision making for future developments
- No ambiguity in the results

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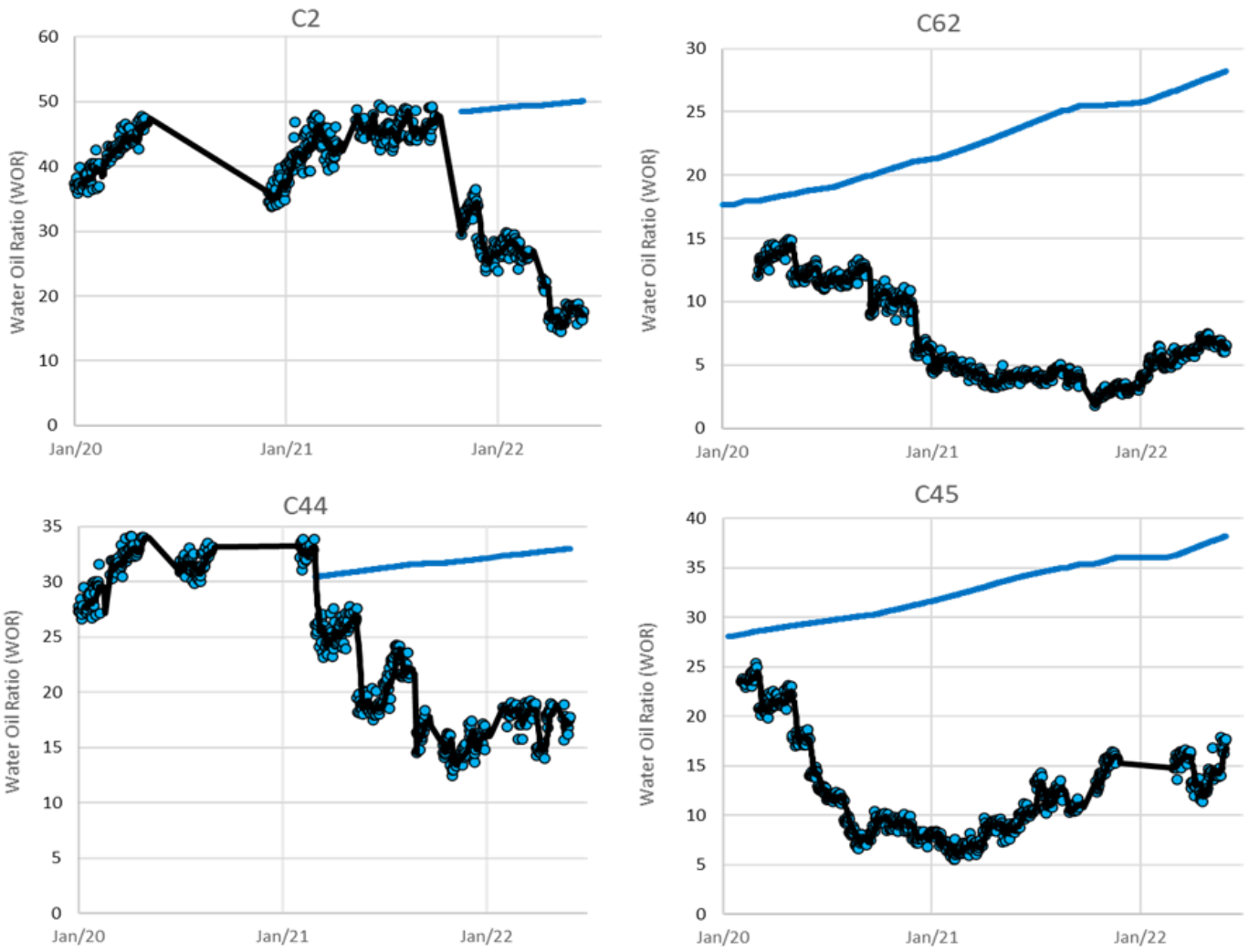
Stage 1 results – Typical WOR responses due to polymer flooding



- Sharp WOR reduction observed across the well stock for EOR Stage 1
- These reproduced the behaviours and success observed in the EOR pilots
- All areas have shown repeatable success – expanding the flood size and increasing the pore volume
- Response is characterised by a sharp WOR reduction, followed by a gradual increase over time
- For detailed mechanism please see:

Beteta, A., Sorbie, K.S., McIver, K., Johnson, G., Gasimov, R., & Zeil, W. van. [2022] The Role of Immiscible Fingering on the Mechanism of Secondary and Tertiary Polymer Flooding of Viscous Oil. Transport in Porous Media.

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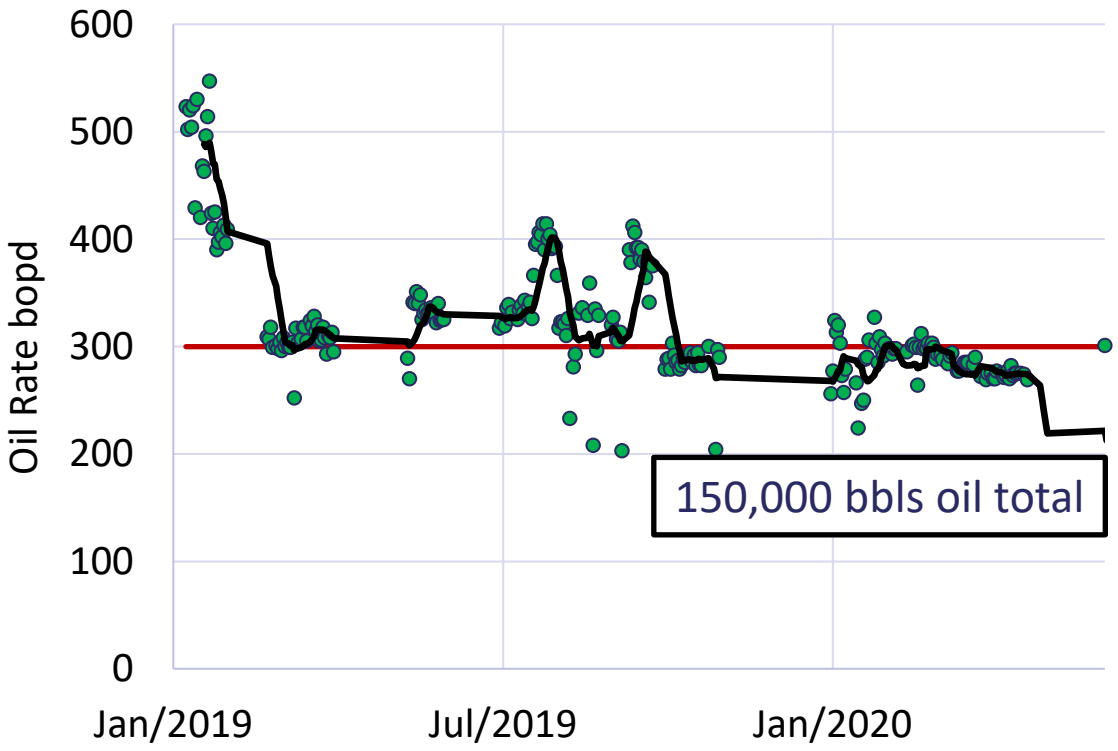
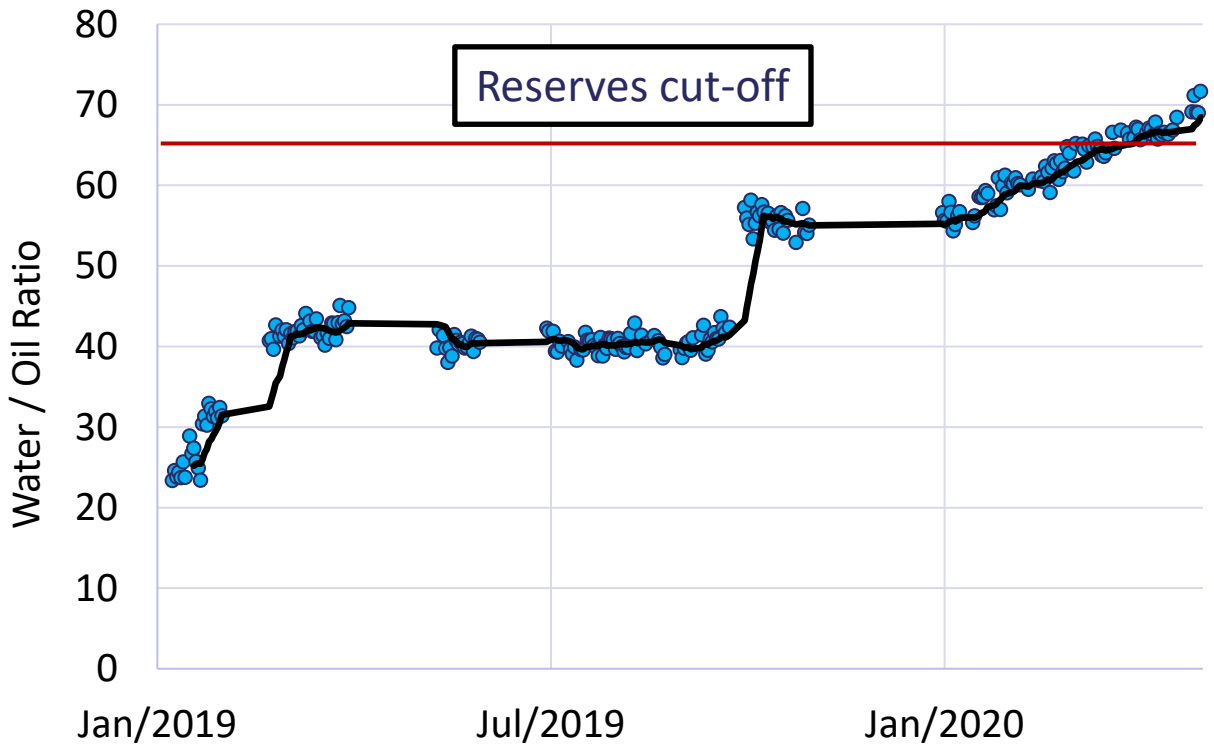
Enhanced oil recovery example – Stage 1 well C64

- The C64 well was drilled in very swept, high water saturations of the UCS reservoir
- The well was not considered as a waterflood target: Too low recoverable volumes and negative NPV
- After drilling as a Stage 1 well, 18months in the well had only produced 150k bbls oil and was producing almost completely water
- This would be the total recoverable volume under a waterflood, and it would have been an economic failure

C64 oil production rate start-up to June 2020



C64 Water / Oil Ratio start-up to June 2020



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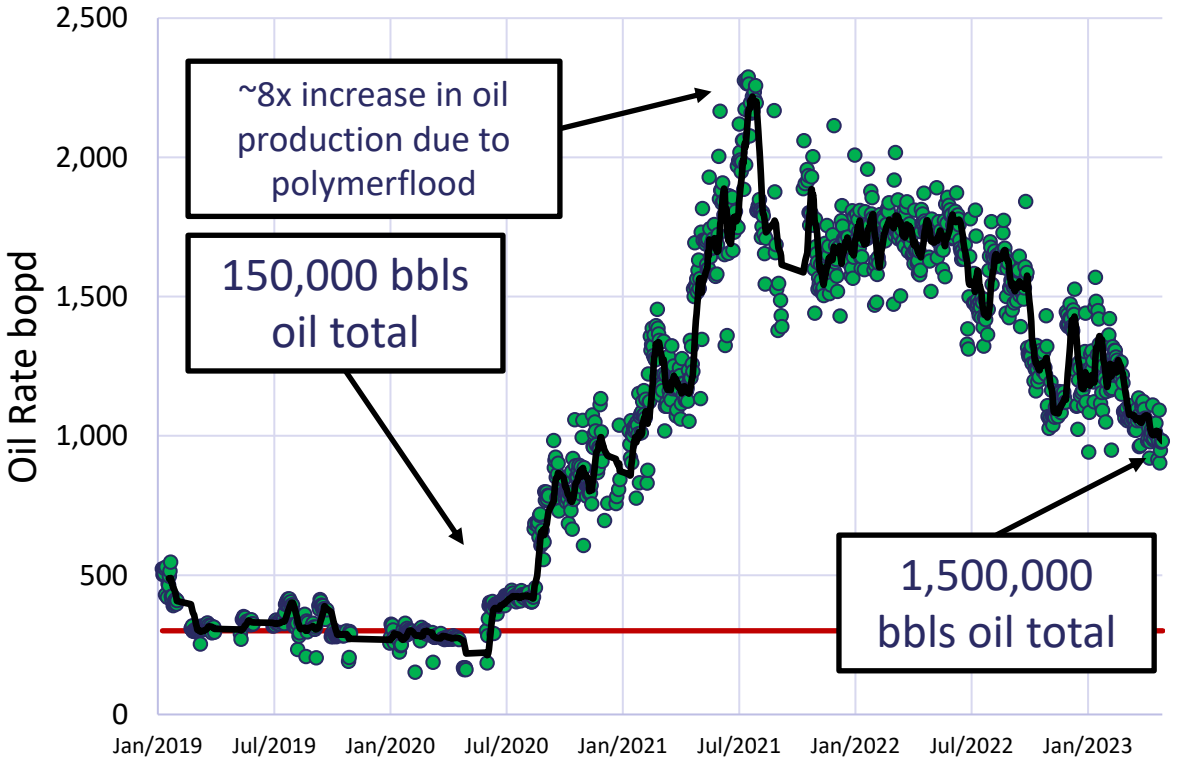
Enhanced oil production example – Stage 1 well C64

- Once the enhanced oil began to arrive, the well experienced an ~8x increase in oil rate
- Oil recovery is ~10x the waterflood recovery to date
- For a period of time this well was the second highest producing oil well in the field
- The enhanced oil continues today and is exceeding expectations

C64 oil production rate since start-up



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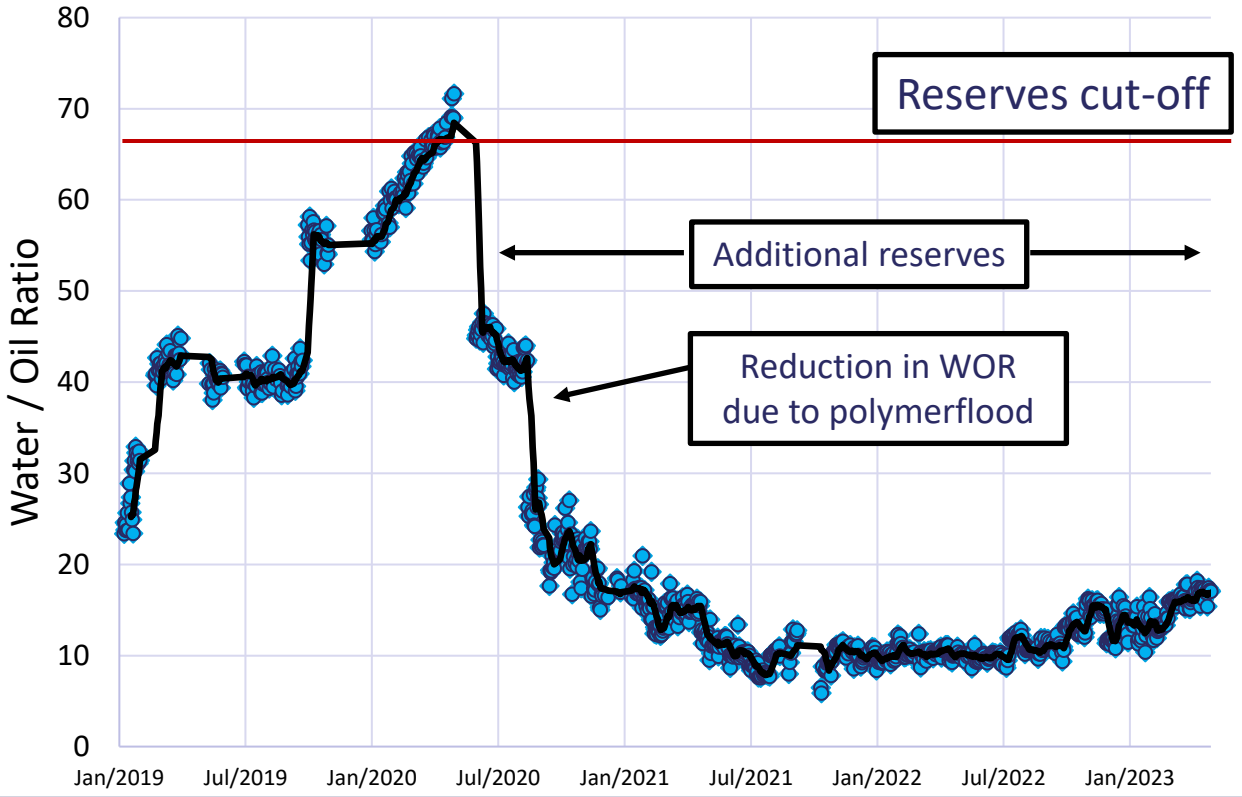

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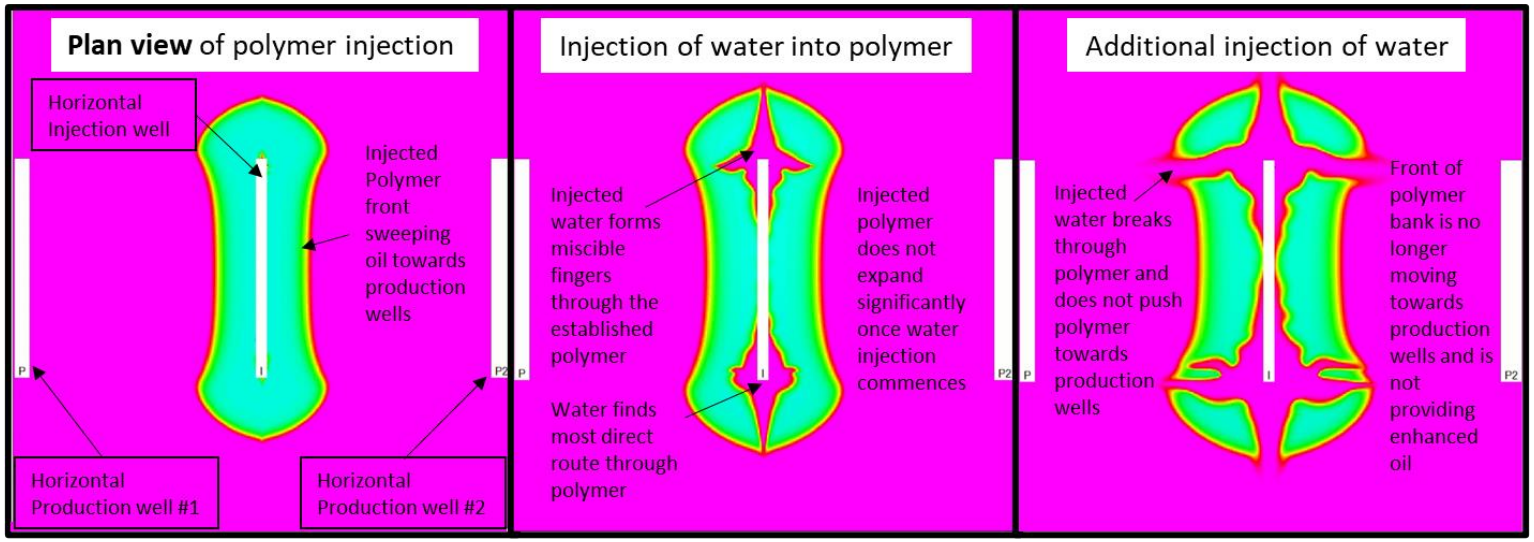
Mechanism and benefits of polymer flooding

Immiscible displacement of oil by water and polymer

- Waterflooding in Captain suffers from significant slumping of water, with high water saturations at the base of the reservoir
- Attic oil is completely unswept by water flooding and left stranded towards the top of the reservoir
- Polymer injection results in crossflow of oil into water channels before sweeping the attic oil

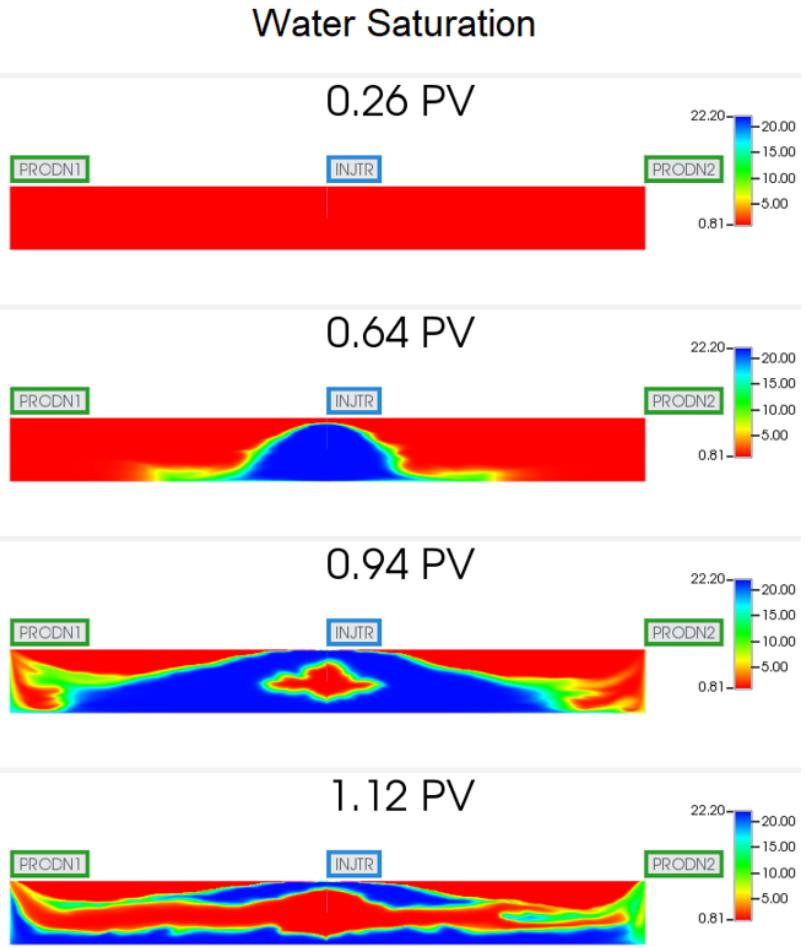
Miscible displacement of water through polymer



- A hard switch to water results in near complete loss of the enhanced oil production
- Tapering offers a more effective way to maximise remaining oil recovery from unswept areas of the reservoir than the switch to water.
- Tapering maximises the economic oil recovery by ensuring the front of the polymer bank keeps moving through the reservoir, and continues to push oil to the production wells, but the cost of doing so decreases with time

Immiscible Viscous Fingering at the Field Scale: Numerical Simulation of the Captain Polymer Flood

A. Beteta[*1], K.S. Sorbie[1], G. Johnson[2] 2023



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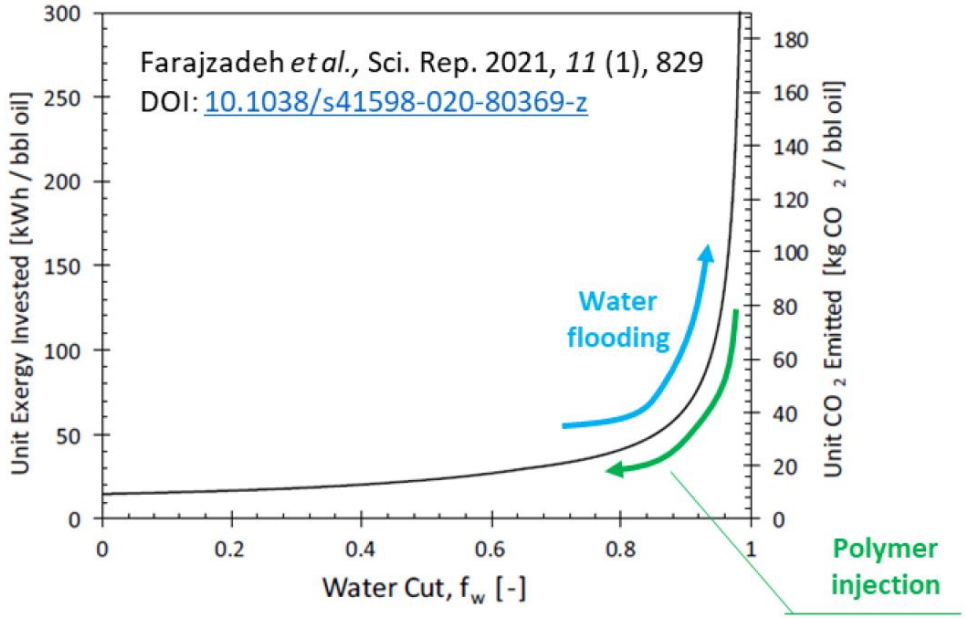
Benefits of polymerflood over waterflood

- Reduction of producing watercuts and increased instantaneous oil rate
- Acceleration of waterflood reserves and incremental reserves over waterflood
- Reduced production time requirement
- More energy and CO2 efficient recovery of oil
- Improved cash flow and NPV of infill development projects

Offset by:

- Requirement to manufacture, ship and store polymer
- Increased complexity of operations
- Back-produced polymer management



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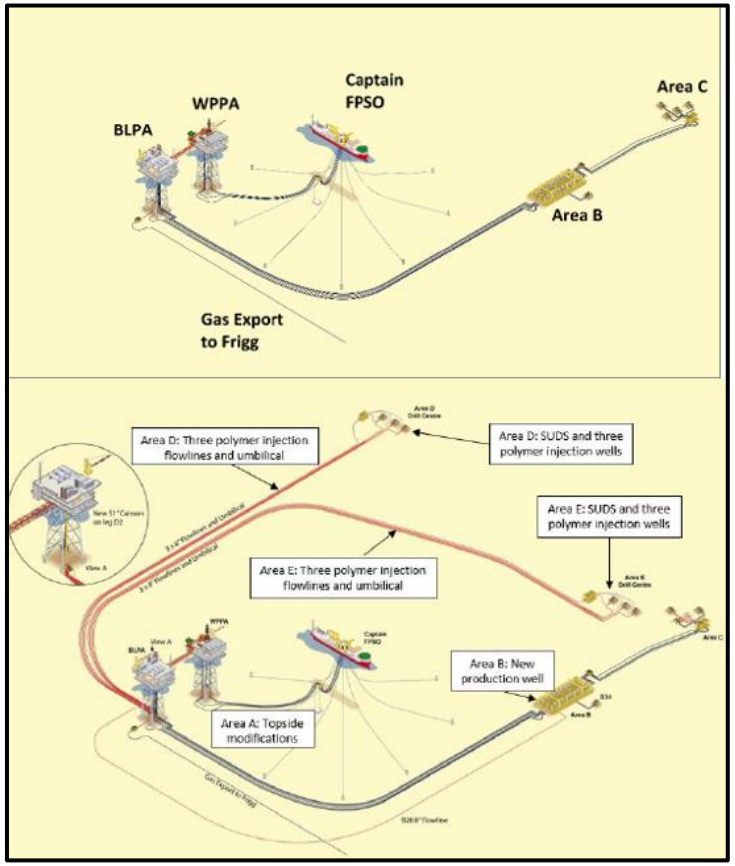
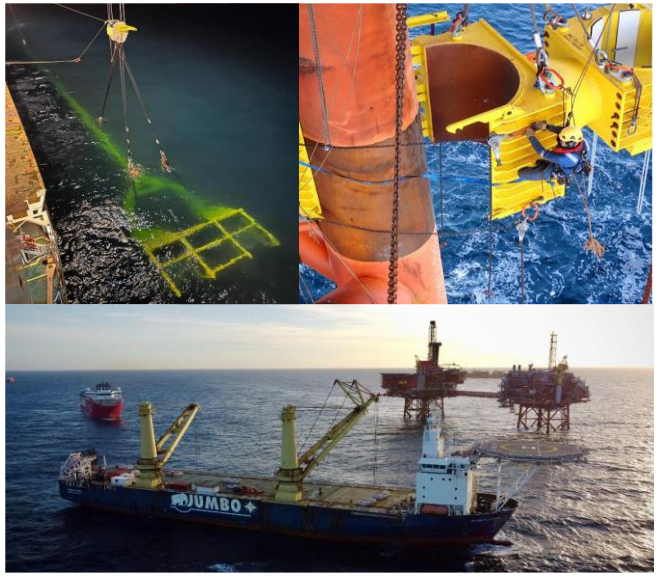
EOR Stage 2 update

Full field development – Captain EOR Stage 2 overview

- Six new subsea polymer injection wells drilled across two new drill centres.
- Two additional production wells drilled.
- Polymer injection flowlines and control umbilicals installed between the existing Captain Bridge Linked Platform (BLP) and the new wells
- Construction nearing completion with first polymer injection in 2024 and peak production in 2025-2026



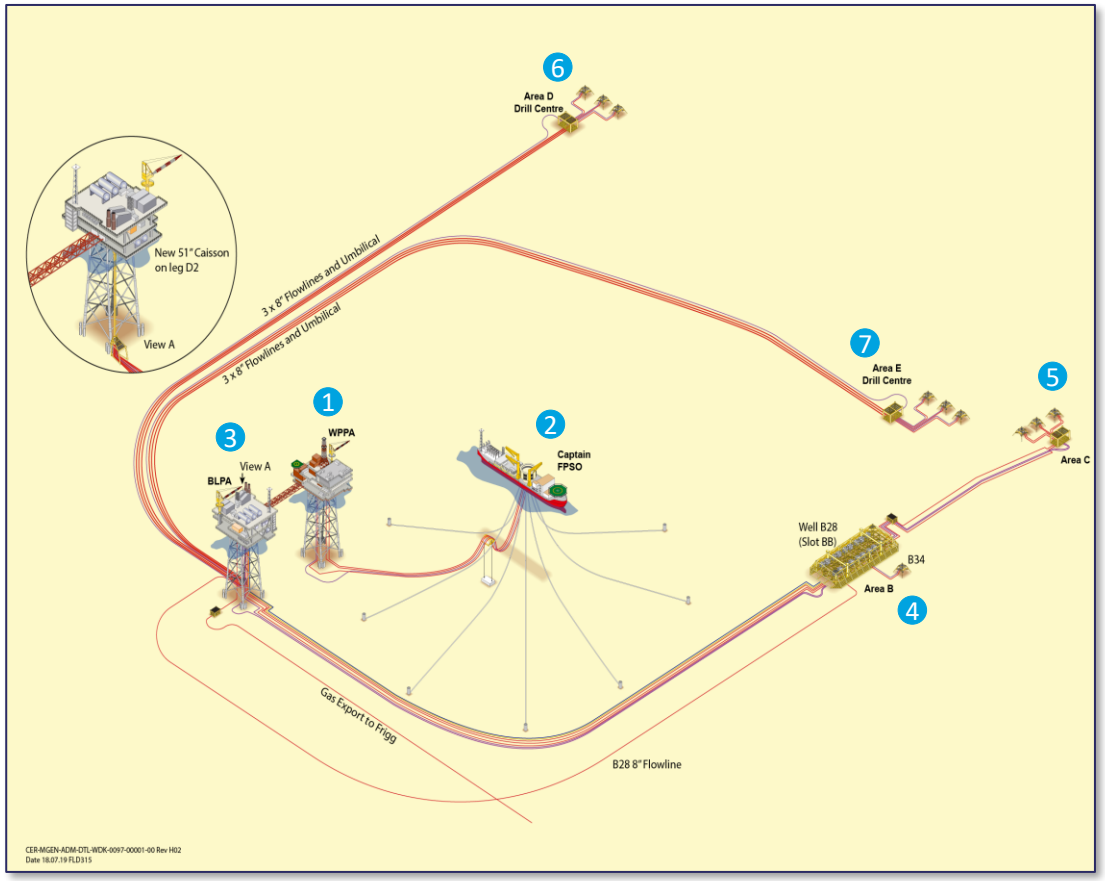


EOR Stage 2 facilities overview

Overview of Major Facilities

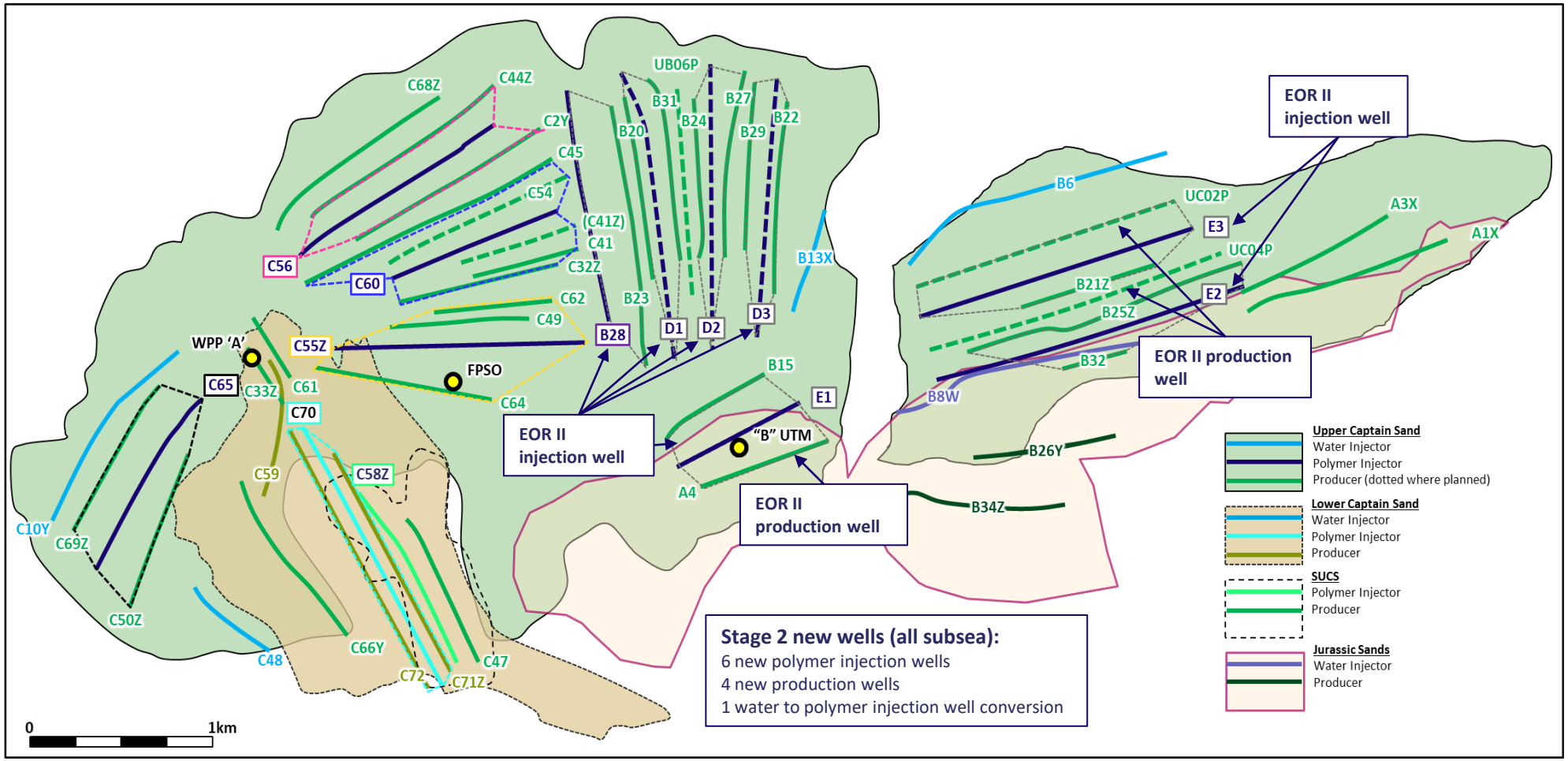
1. **Wellhead protector platform (WPP-A)**
   - The WPPA is the Area A drilling center, with wellhead facilities, EOR polymer injection facilities, a drilling/workover rig and accommodation for up to 121 people
   - Connected via pipelines running along the seabed to FPSO (16” production fluids line, 10” well test fluids line, 14” water injection line, 3” polymer line)
2. **FPSO**
   - Permanently stationed 1.5 km east of the WPP-A
   - Storage capacity ~550,000 bbl, with accommodation for up to 98 people
   - Processes water for reinjection and crude for offloading to a dynamically positioned shuttle tanker which is then transported to onward sales point
   - Bulk storage of polymer for EOR operations
3. **Bridge Linked Platform (BLP)**
   - Connected to WPPA, incorporating process and utilities equipment for Area B development
   - Captain gas is imported / exported via the BLP to a subsea pipeline to the Frigg UK gas transportation system and on to St Fergus gas terminal
   - New riser caisson installed on leg D2 of the BLPA to enable connection to the Captain topsides facilities
4. **Area ‘B’ UTM**
   - Subsea drilling center in Area B; Unitized Template Manifold (UTM)
   - Connected via pipelines running along the seabed to the BLP
5. **Area ‘C’ Template**
   - Three-slot subsea mini-manifold connected to Area B UTM
6. **Area ‘D’ Drill Centre**
   - Three polymer injection wells
7. **Area ‘E’ Drill Centre**
   - Three polymer injection wells

Facility Diagram



EOR Stage 2 development areas

Captain EOR Patterns



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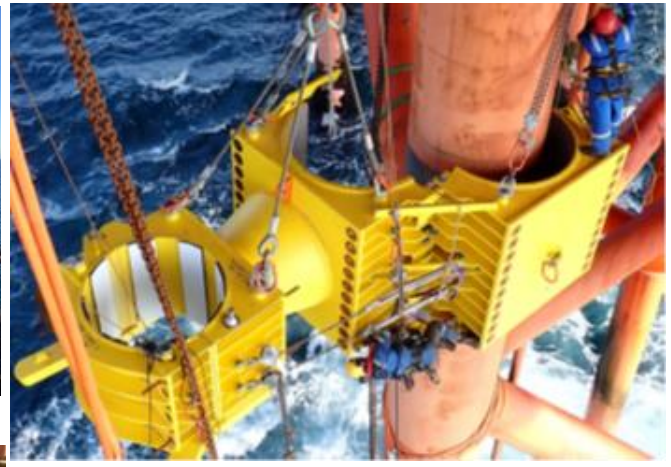
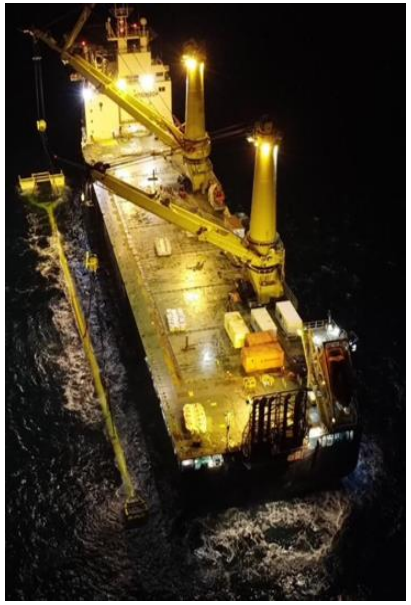
EOR Stage 2 offshore installation





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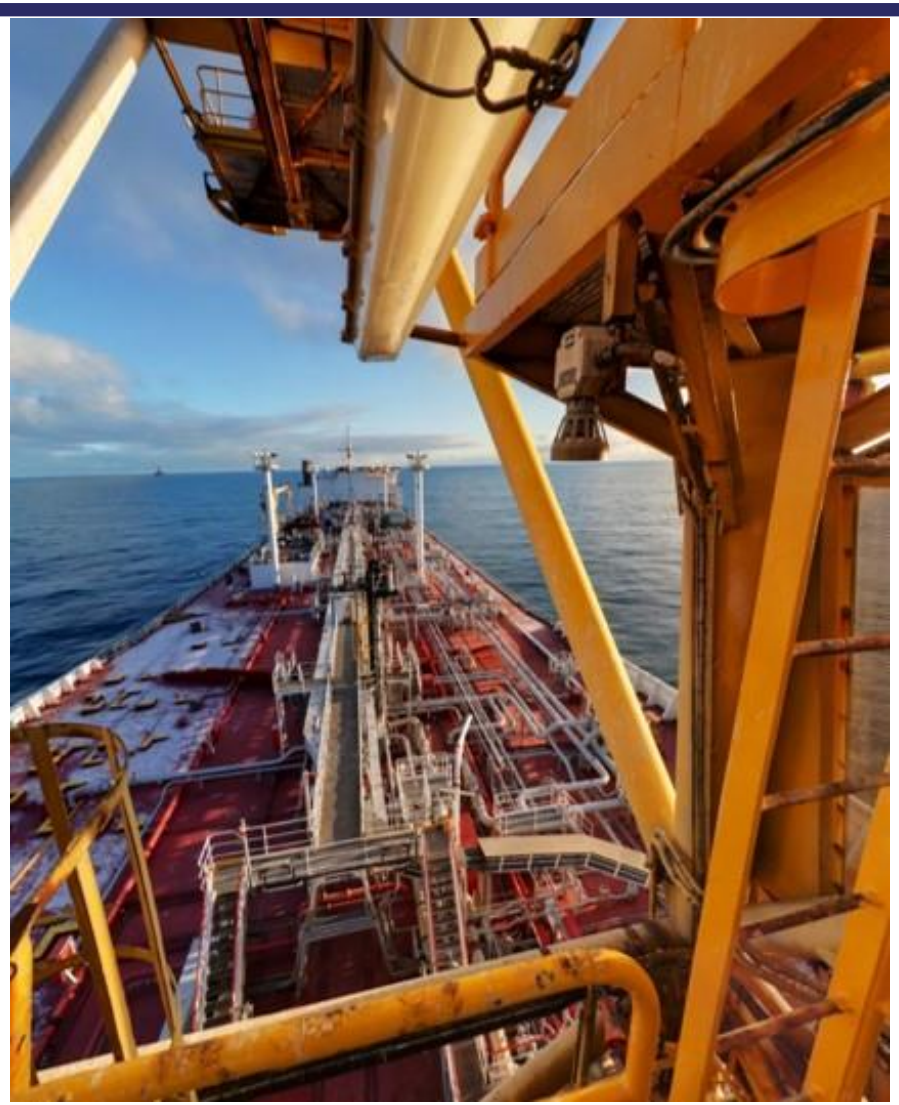
Summary and conclusions

- The Captain Field has a very successful polymerflood EOR scheme, which is currently being expanded across the field in an offshore environment
- Strong water coning due to gravity observed from waterflood development results in remaining attic oil, which can then be swept using polymerflood
- Polymerflooding has been shown to accelerate waterflood reserves, enable additional incremental reserves and reduce water handling requirements for the field
- Field oil rate decline has been offset by enhanced oil production from the Captain polymerflood
- Production responses from the individual wells has been very positive to date for each polymer injection pattern
- Further investment in polymer flood EOR is continuing with the development of the LCS reservoir from the platform area and EOR Stage 2 in the subsea area



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Thank you.

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The authors acknowledge the contributions of many people who made the project possible, not least including:

- Captain Asset team personnel
- Ithaca's Captain co-ventur partner Dana Petroleum (E&P) Limited for reviewing and granting their permission to present these slides