Quad 204
Deepsea Aberdeen: New 6th Gen' semi – dual derrick

Quad 204
New FPSO, Glen Lyon: biggest in N hemi-sphere

Quad 204 – Schiehallion Field – Restarting a brownfield subsea development

Thomas Harpley, Reservoir Engineer
9th May 2018

SICCAR POINT ENERGY

CHRYSAOR

Outline

- Quad 204 Introduction
- Field suspension
- What happened during shut-in period?
- What happened on start-up?
- What's next?

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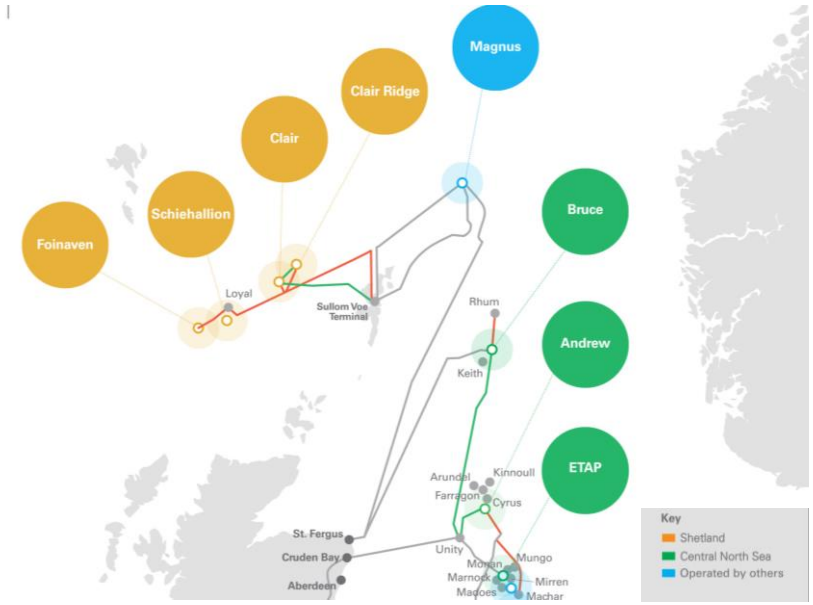
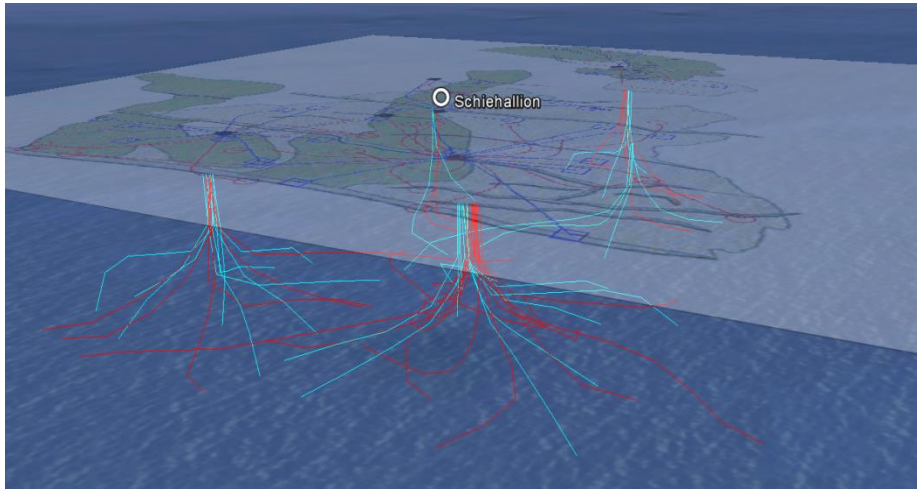
Schiehallion and Loyal: Introduction

- The Schiehallion and Loyal fields
  - Located 175km to the West of the Shetland Isles in >350m water depth
- BP operate both fields
  - Schiehallion: BP 33.35%, Shell 44.896%, Siccar Point Energy 11.754% and Chrysaor 10%. Loyal: BP 50% and Shell 50%
- Discovered 1993, production start-up 1998
  - >2 bbn bbls in place
  - Oil is ~26API; GOR 350 scf/stb; 4cp
  - Stacked Palaeocene turbidites at ~2000m TVDSS
- Sub-sea tie-back to FPSO
  - Developed under waterflood
  - 50+ wells drilled to date tied back through 5 production/injection manifolds
  - ~400 mmboe produced via the original Schiehallion FPSO with watercuts of ~50% in 2013 at field suspension
  - Field was suspended due to inadequate capacity, operating life and operating efficiency

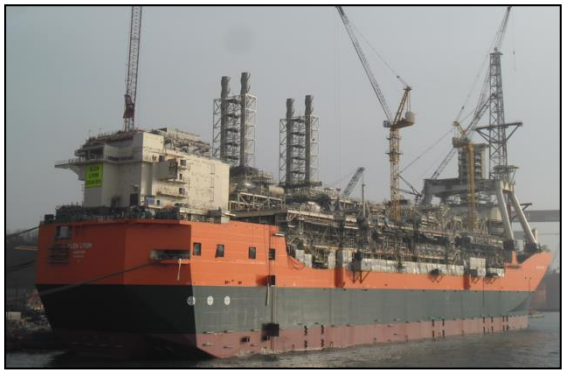




The QUAD 204 project: Addressing cut-offs & Improving sweep

Our Investment

Vessel



- A further 20 years of vessel life
- Enhanced operational efficiency
- 320mbd total liquids capacity (130mbd oil)
- 220mmscf/d gas capacity
- 380mbd water injection capacity

Wells

- Replace aging trees
- Commitment to long term safety and well integrity through interventions

Subsea




Re-use existing hardware. Install new flowlines, umbilicals, risers ,manifolds.

Cut - offs

Physical & commercial constraints affecting end of field life

Opportunity:
- Invest in topsides, wells and subsea to extend facilities life
- Invest in increased plant capacity to process large water volumes

Sweep

Movement of mobile oil and gas to wells

Opportunity:
- Invest in infills and wellwork
- Invest in surveillance
- Invest in technologies to improve waterflood conformance

The QUAD 204 project: Addressing cut-offs & Improving sweep

Our Investment

Infills

- A further 20 infill wells drilled from the new Deep Sea Aberdeen rig
- 6th Gen semi-sub
- Long term rig commitment

Wellwork

- Rate/reserves adding wellwork jobs such as water shut-offs

Surveillance

Seismic | PLTs | Appraisal

Continue to commit to surveillance in support of production optimisation, long term waterflood optimisation, and optimised well planning

Cut - offs

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Timeline

Shut-in prep

Field shut-in

Start-up

1998 2012 2013 2014 2015 2016 2017

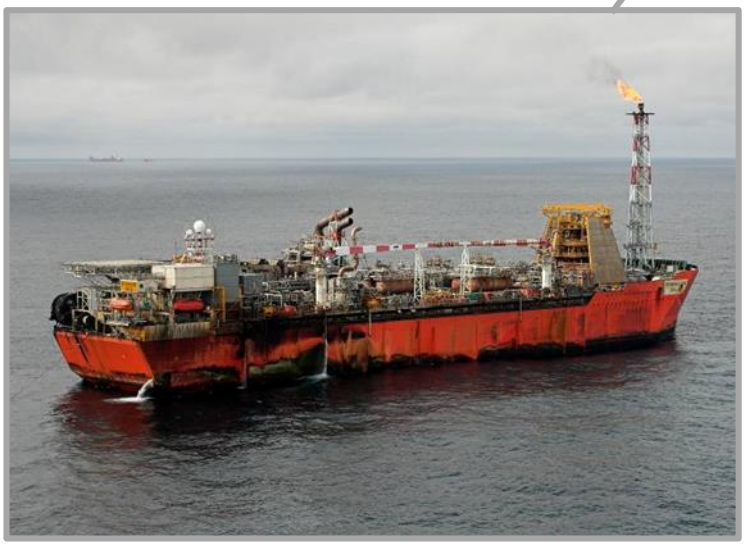
First Oil

Field suspended

Deep Sea Aberdeen arrives

Glen Lyon FPSO on station

Field restart



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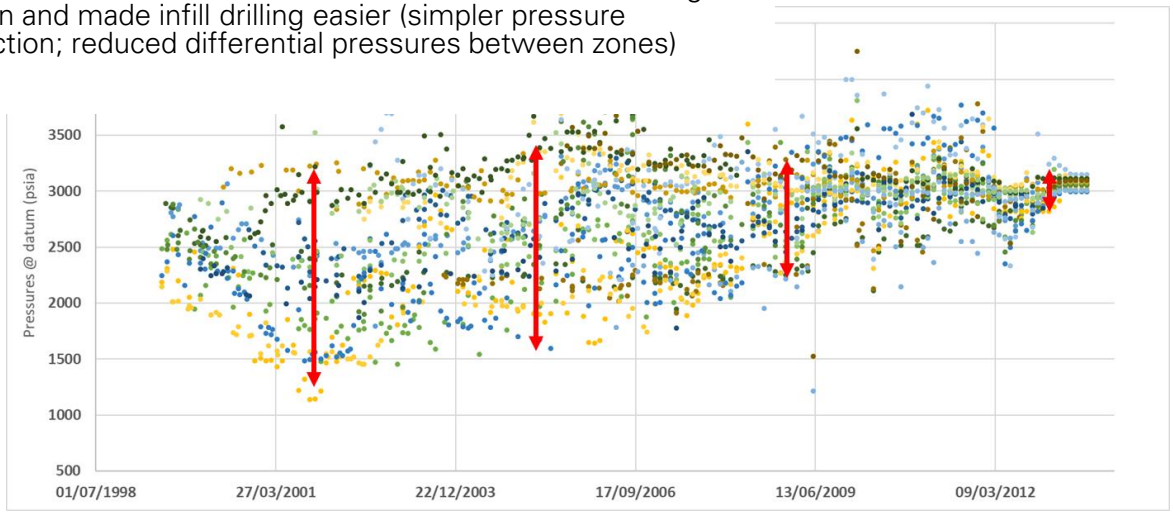
Preparing for field suspension

1 Over-voidage to stabilise pressures

- Large pressure ranges observed in wells across field in the past
- Prior to shutdown, voidage was actively managed to reduce this range and return pressures close to initial levels
- This minimised the risk of cross-flow between zones during shut-in and made infill drilling easier (simpler pressure prediction; reduced differential pressures between zones)



2 Surveillance

- All wells tested over 12-months leading up to field suspension
- Provided baseline for well performance prior to being shut-in and helped inform shut-in (and start-up) sequence
- DHPGs left connected for several weeks following well shut-in to allow collection of PBU/PFO data
- 4D survey acquired in 2013 post field shut-in to aid infill planning and reservoir management

3 Making wells and subsea infrastructure safe for suspension

- Wells shut-in following a phased sequence, with injection last
- Hydrocarbons left across producing intervals
- Methanol injection prior to shut-in to minimise risk of hydrate build-up
- Calcium Nitrate overdose in injectors prior to shutting in for H_2S inhibition
- Flowlines flushed and left containing appropriate inhibitor chemicals to prevent internal corrosion whilst left on seafloor

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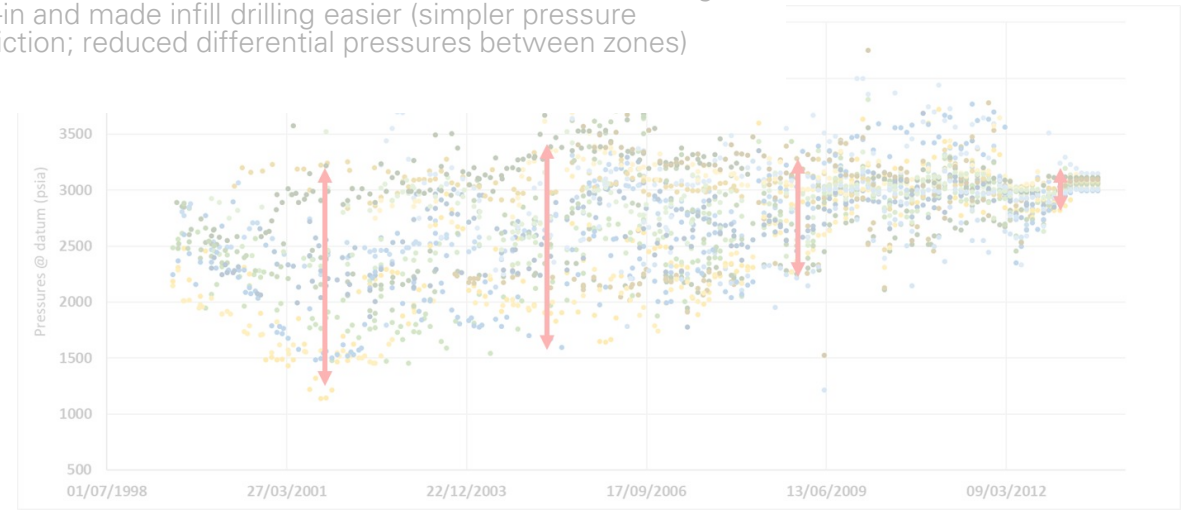

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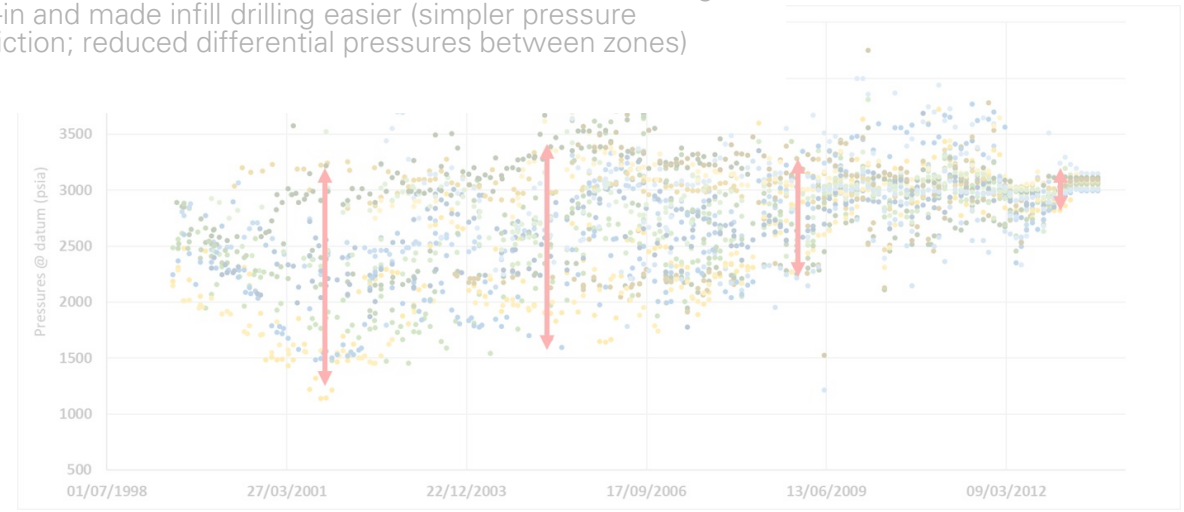

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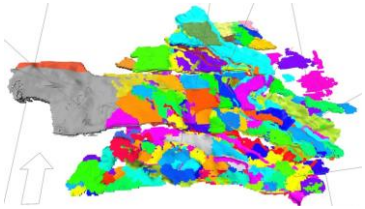
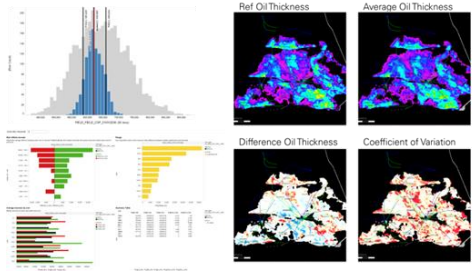
Reservoir management activities during field suspension

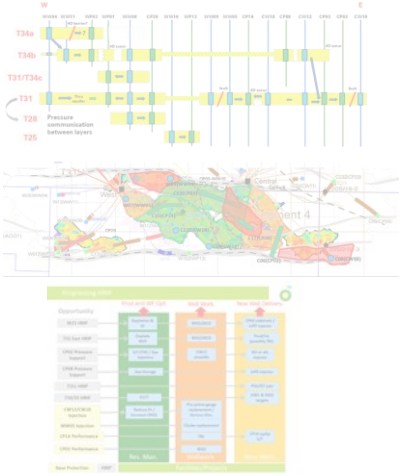
1 History matching of dynamic FFM

- Period of field stability offered a great opportunity to update our FFM dynamic model and complete a history match and reservoir uncertainty study
- Outputs from this work assisted in identifying and ranking infill opportunities





2 Panel Reviews



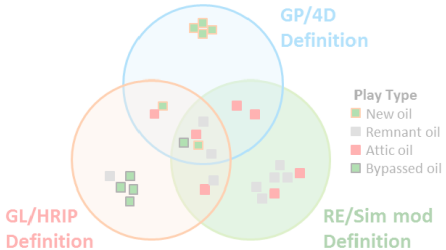
- Multi-disciplinary panel reviews held in order to:
  - Assess panel performance
  - Identify remaining HRIP
  - Capture risks and surveillance required
  - Identify optimisation, wellwork and infill opportunities

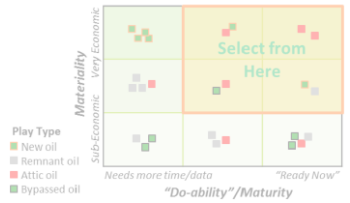
3 LWI campaigns

- Tree change-outs completed on 4 wells with integrity concerns (2 producers & 2 injectors)
- Mechanical blockage milled in well with performance issues
- Interventions also used to obtain surveillance: pressure data, saturation log and PLT

4 Infill opportunity identification

- Outputs from simulation studies and panel reviews used to identify infill opportunities
- Assessed and prioritised by multi-disciplinary team incorporating geological, geophysical and engineering understanding





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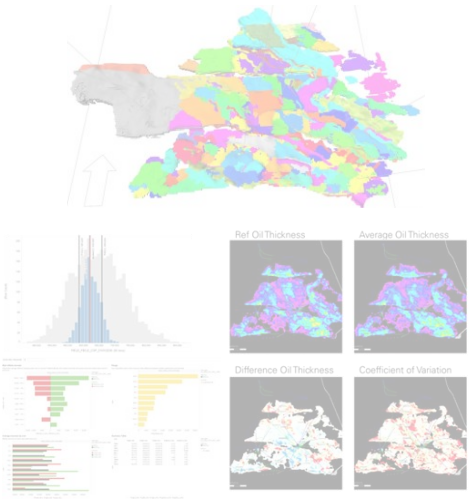

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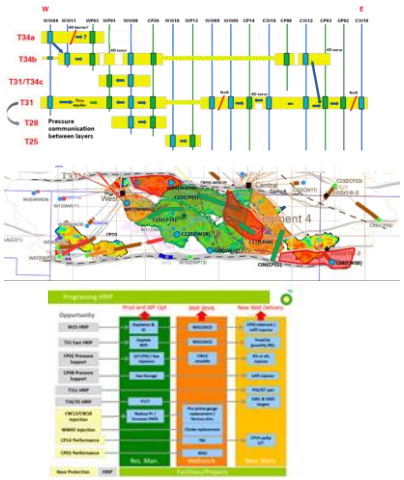

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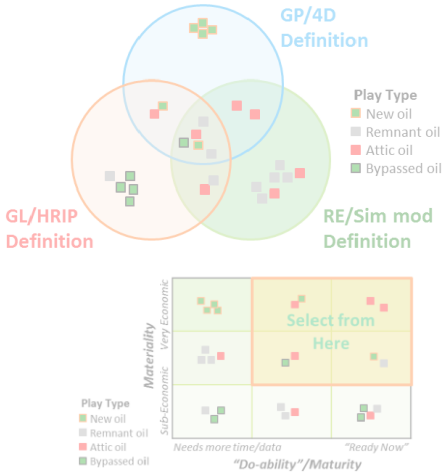

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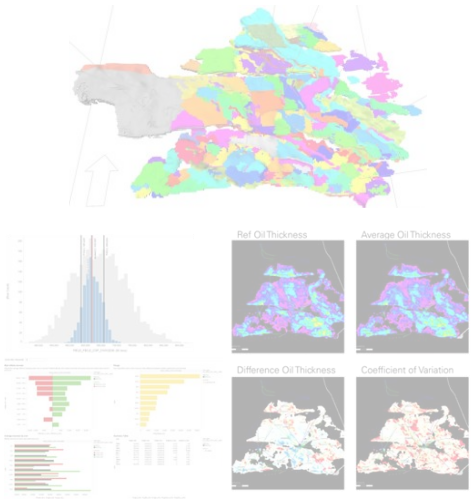

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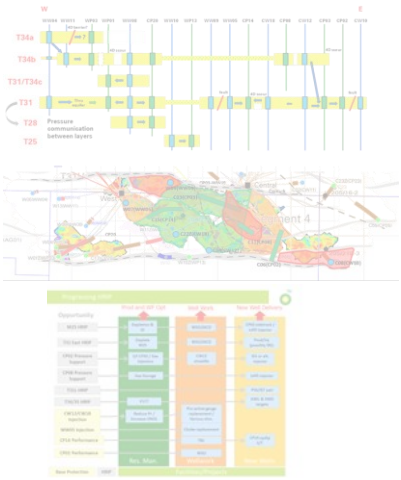

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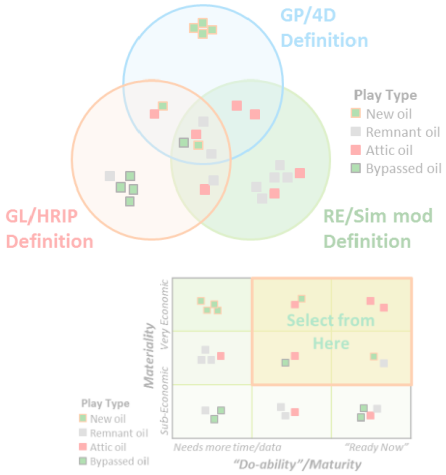

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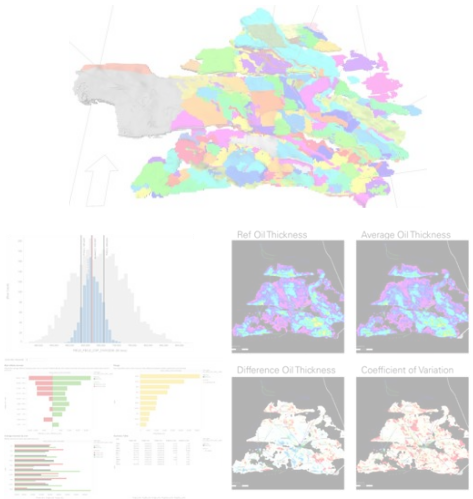

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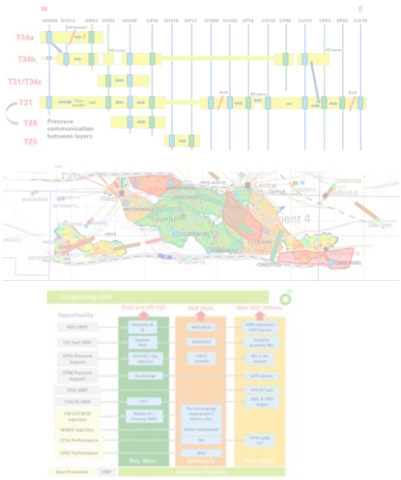

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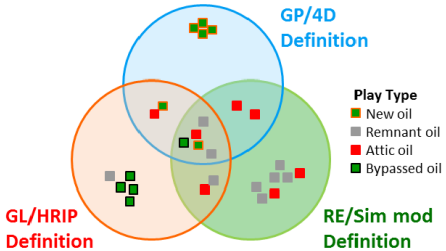
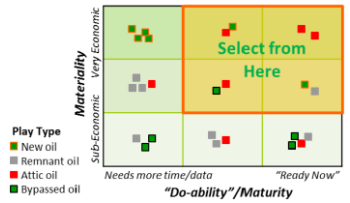
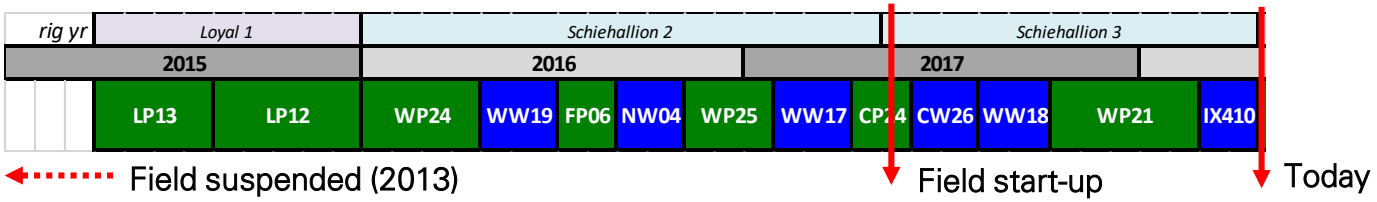
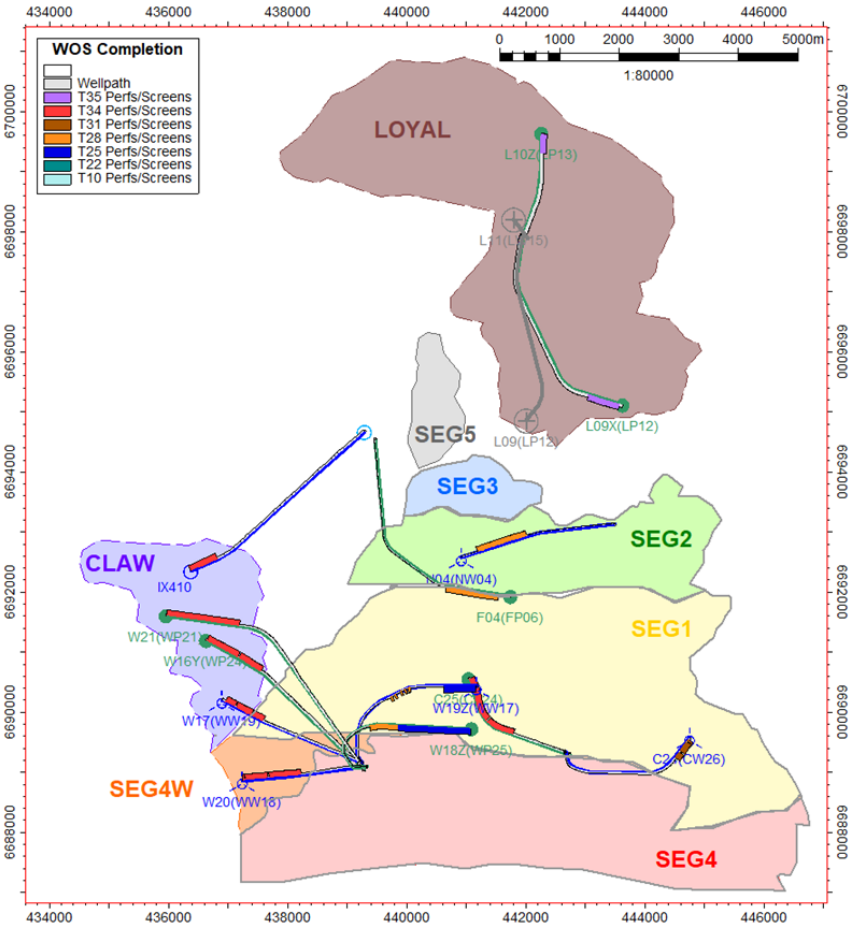




Infill drilling



- **13 wells/3 yrs into campaign** (*7 producers, 6 Injectors)*
- **11 wells exceeded prognosis** (*All key metrics at or above prediction)*
- **Stratigraphic split:**
  - T25/T28 - 4 wells (FP06/NW04 & WP25/WW17 pairs)
  - T31 – 1 well (CW26)
  - T34 – 5 wells (WP24/WW19, WP21/IX410 & CP24)
  - T25 – 2 wells (LP12 & LP13)
- **Surveillance:**
  - Pressures obtained in all wells to inform on connectivity between sands and identify fluid contacts
  - Opportunistic appraisal of unpenetrated or bypassed oil targets



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Start-up context

Subsea facilities…

15 flow lines

2 dynamic and 5 static umbilicals

Largest ever riser bend stiffeners

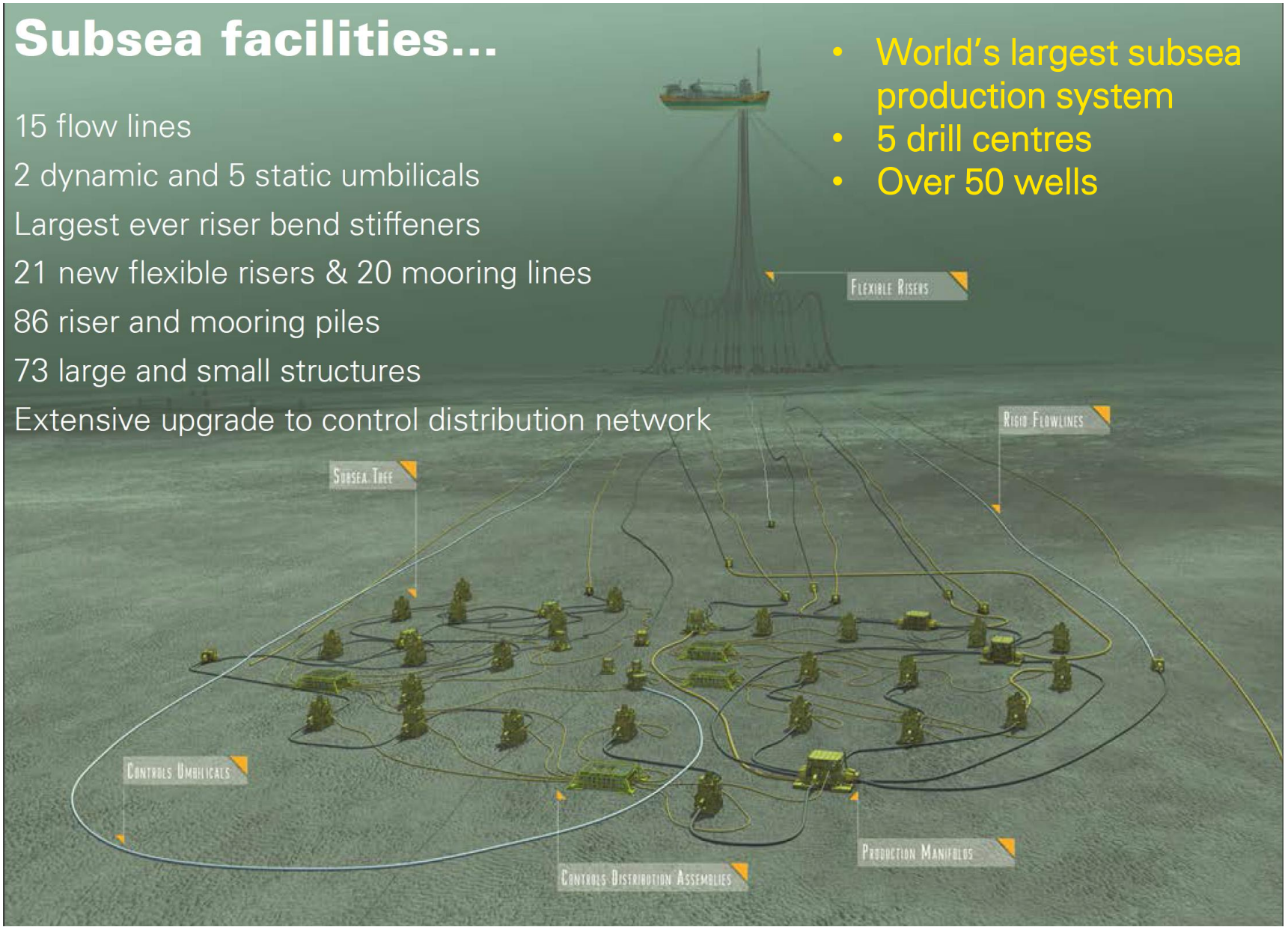
21 new flexible risers & 20 mooring lines

86 riser and mooring piles

73 large and small structures

Extensive upgrade to control distribution network

- World's largest subsea production system
- 5 drill centres
- Over 50 wells



Start-up sequencing

- Start-up sequence determined by:
  - topsides constraints
  - drill centre availability
  - historical well performance
  - surveillance requirements
- All producers had DHPGs available for monitoring
- Throughout ramp-up, well start-ups staggered to allow interference testing between wells
- Preference for bringing injectors online first, to test for response in DHPG of shut-in producer

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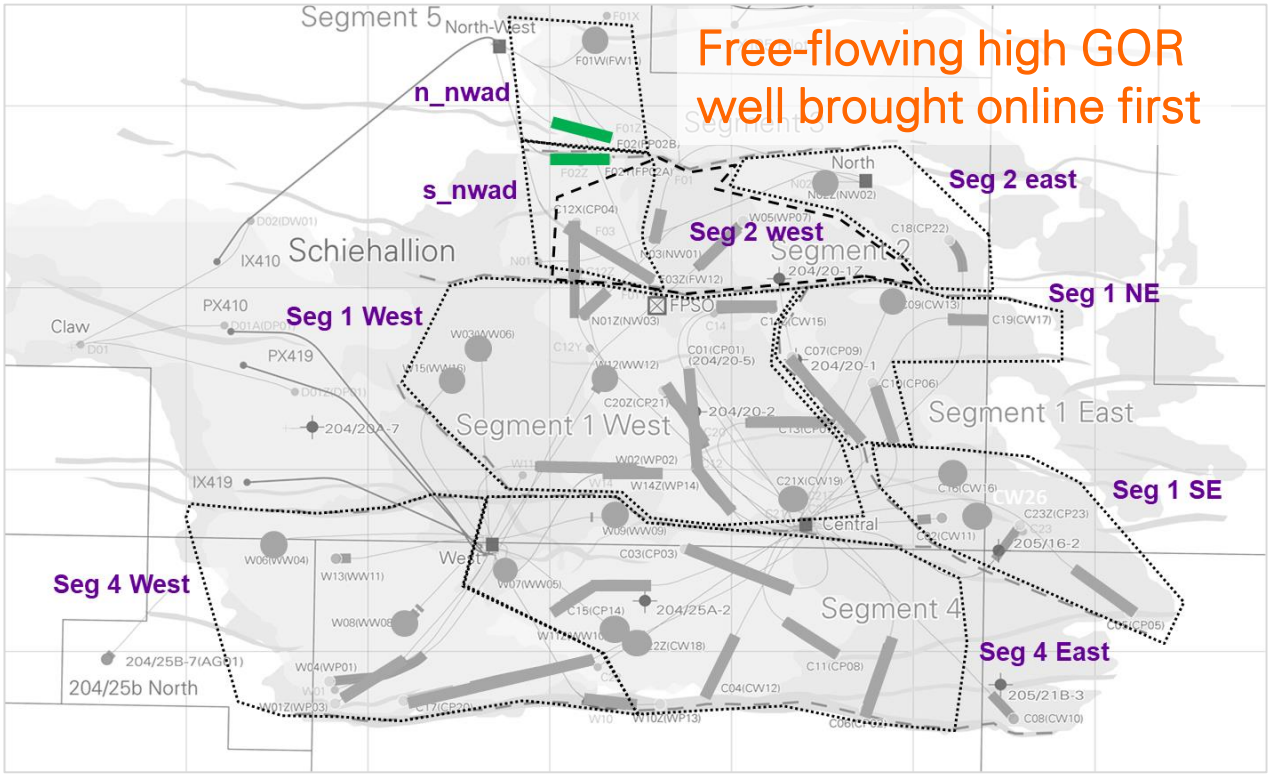
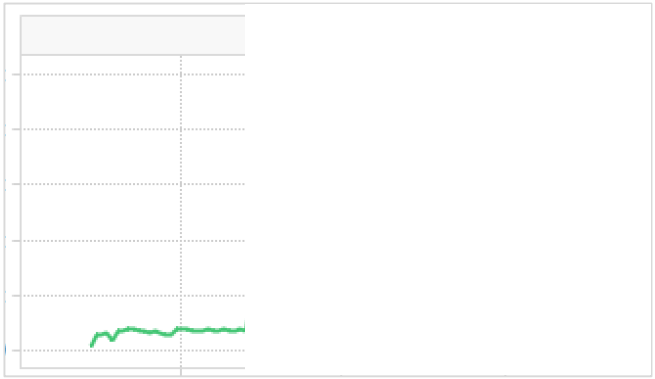


Oil Production



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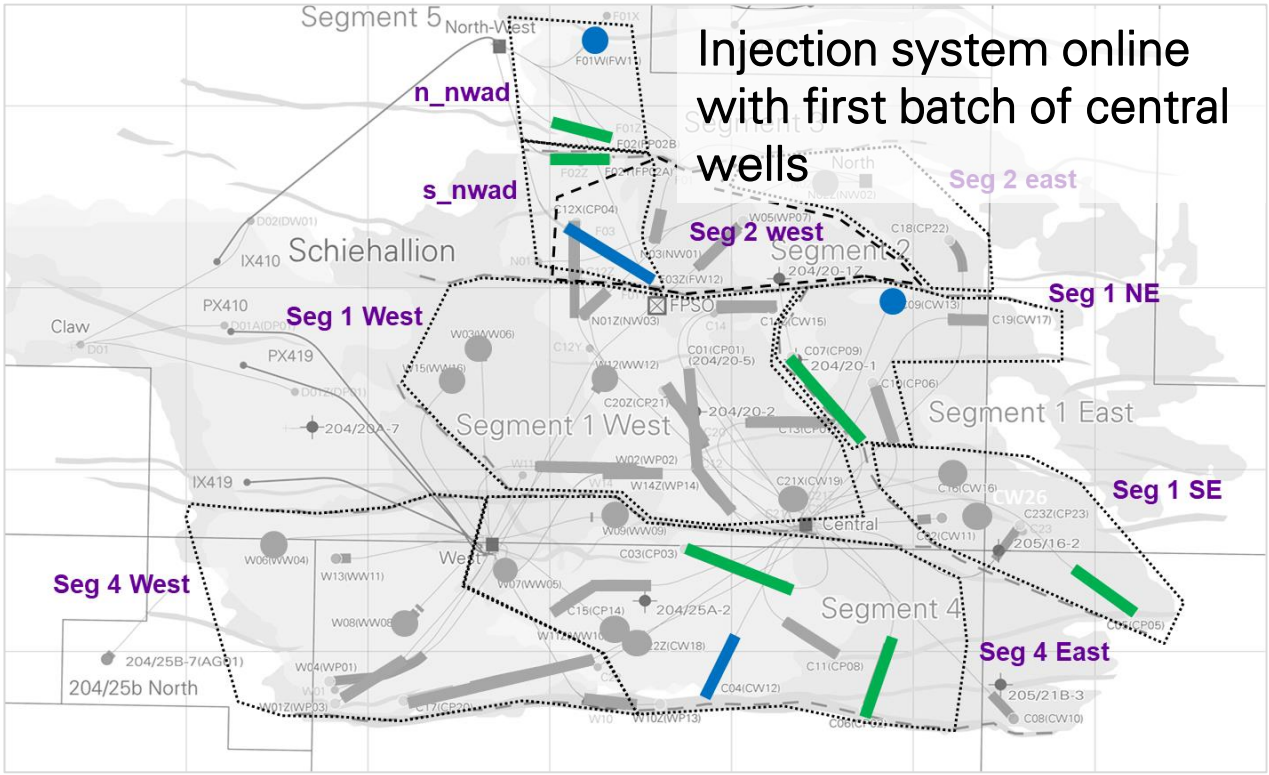

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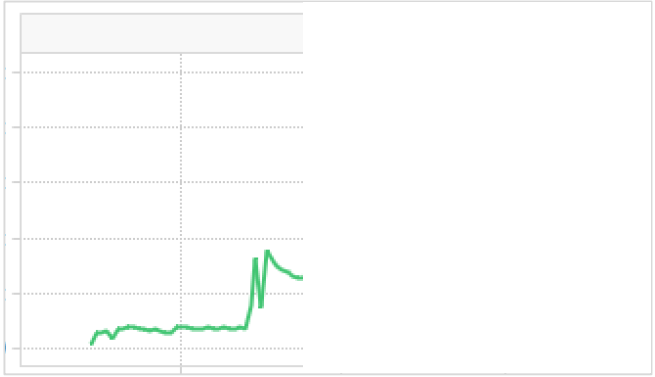

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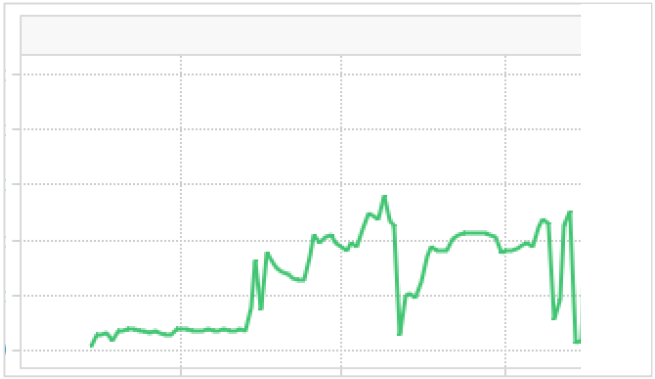

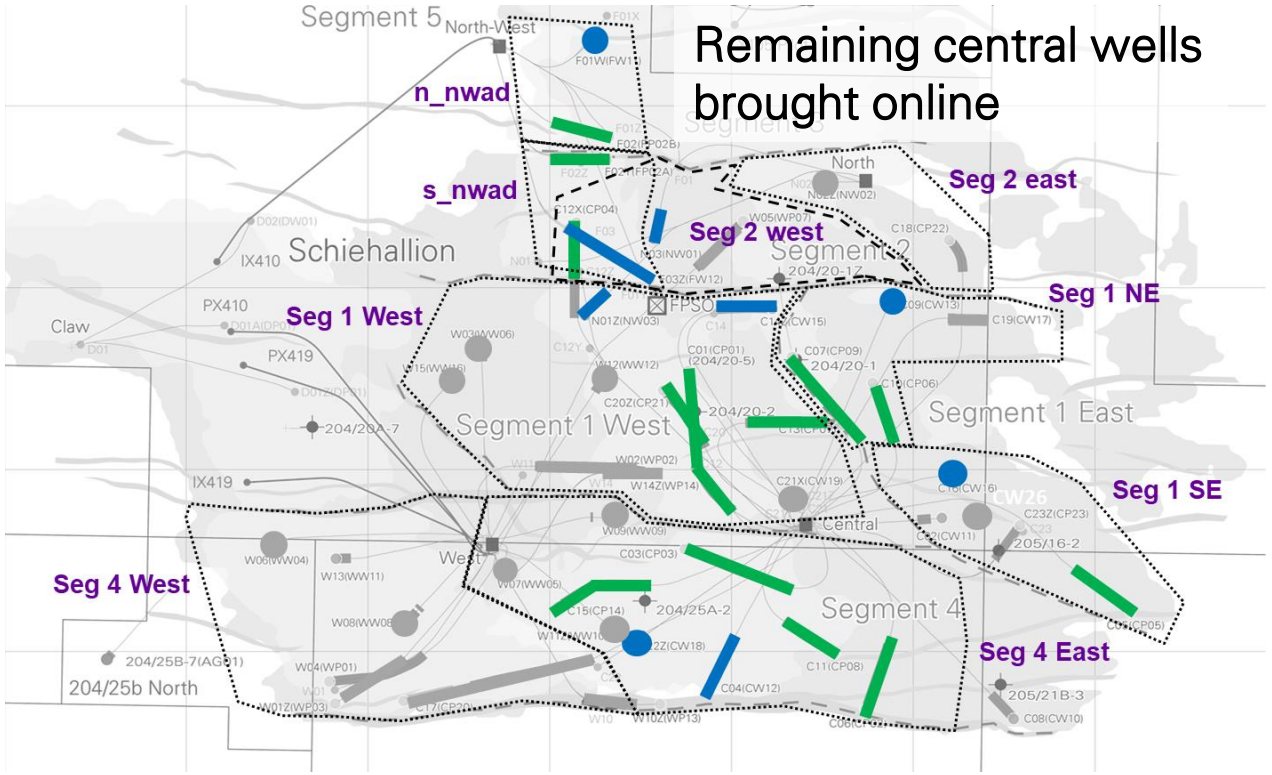

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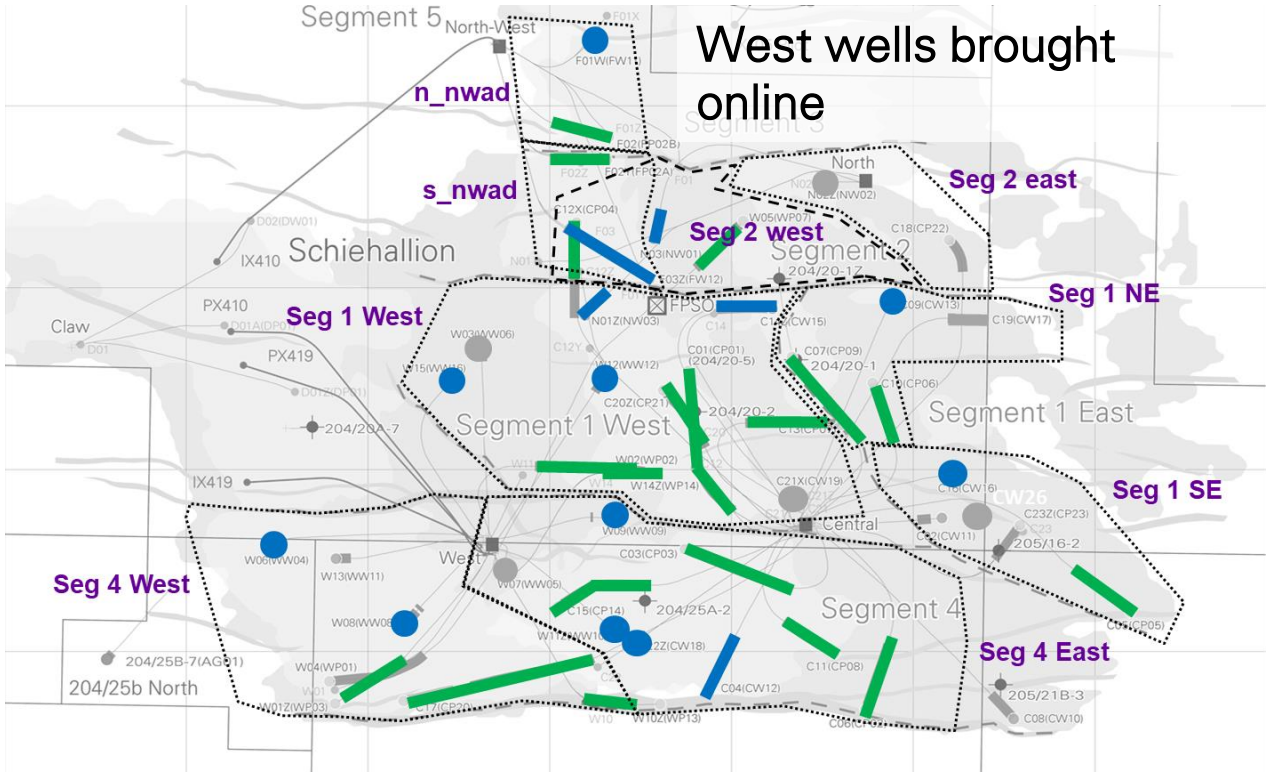

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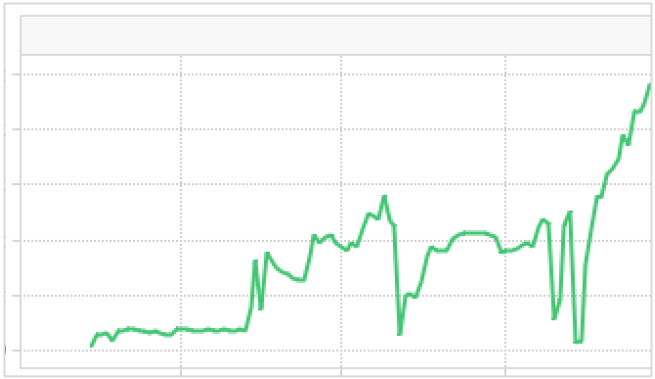
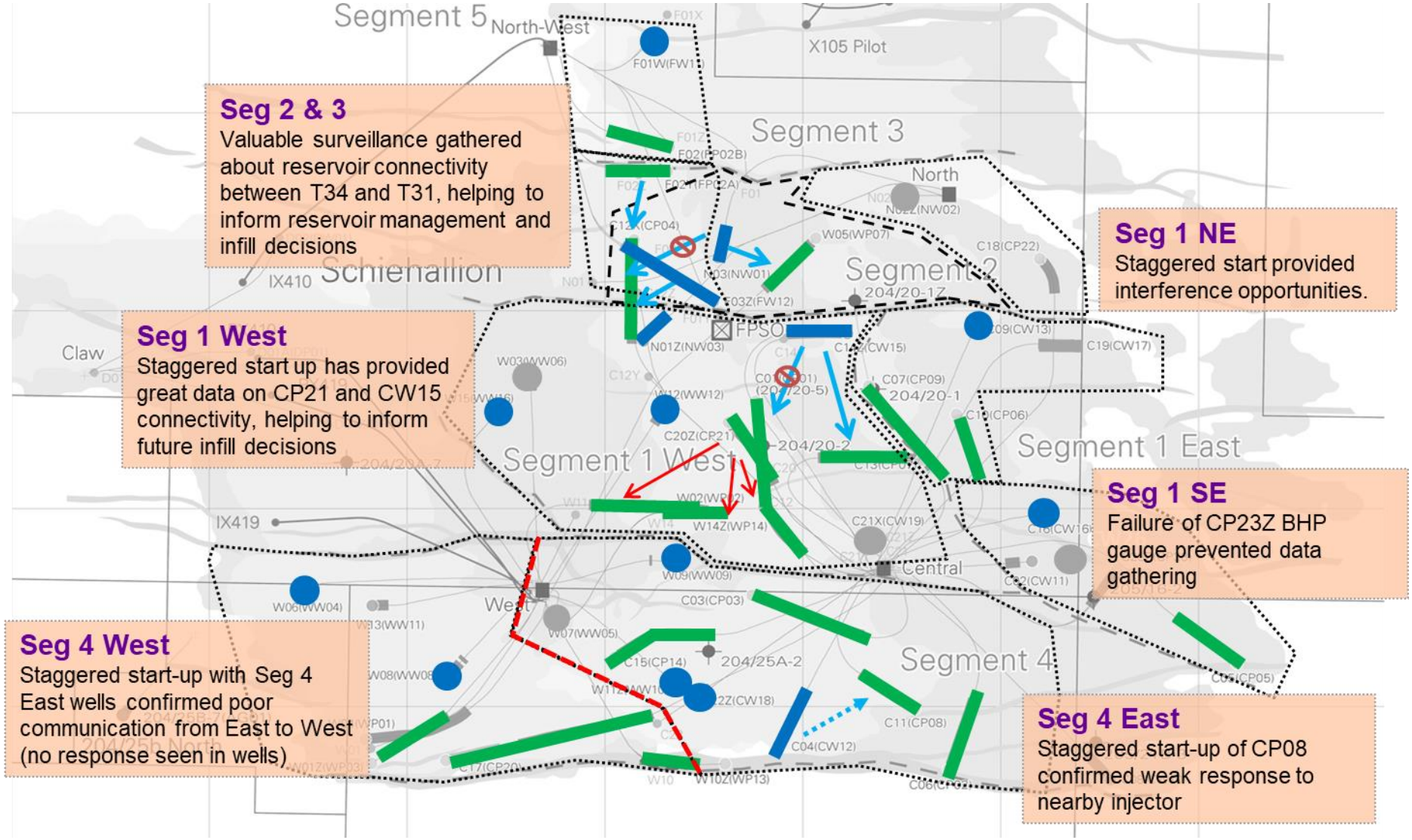


- No significant issues encountered with producers during start-up
  - 2 wells experienced comms issues which have since been resolved
- Majority of injectors brought online without issue
  - a small number of wells had washed out chokes, requiring choke change-outs
- Start-up presented a unique opportunity for interference testing

Start-up surveillance: Interference testing overview



Seg 2 & 3
Valuable surveillance gathered about reservoir connectivity between T34 and T31, helping to inform reservoir management and infill decisions

Seg 1 NE
Staggered start provided interference opportunities.

Seg 1 West
Staggered start up has provided great data on CP21 and CW15 connectivity, helping to inform future infill decisions

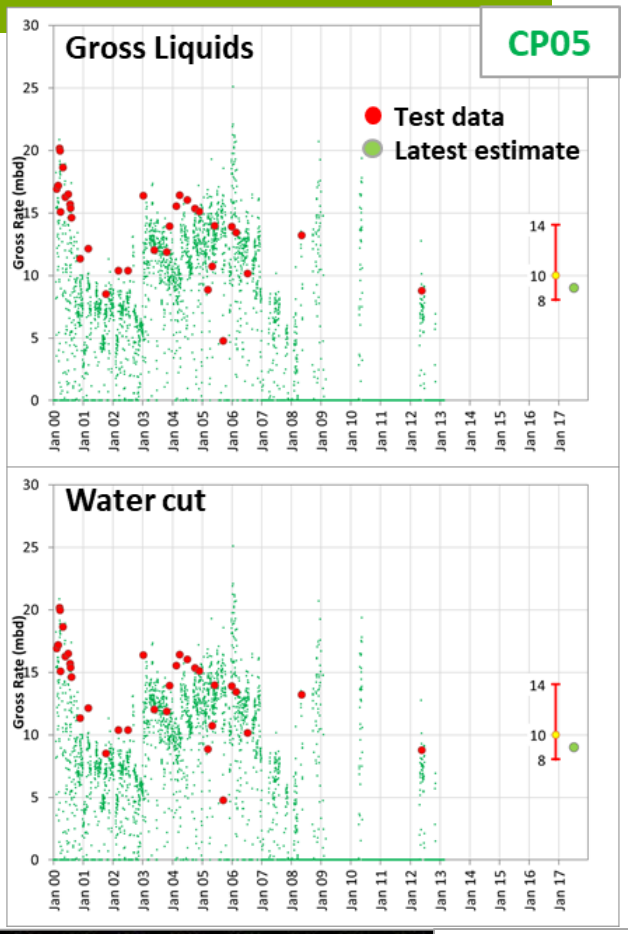
Seg 1 SE
Failure of CP23Z BHP gauge prevented data gathering

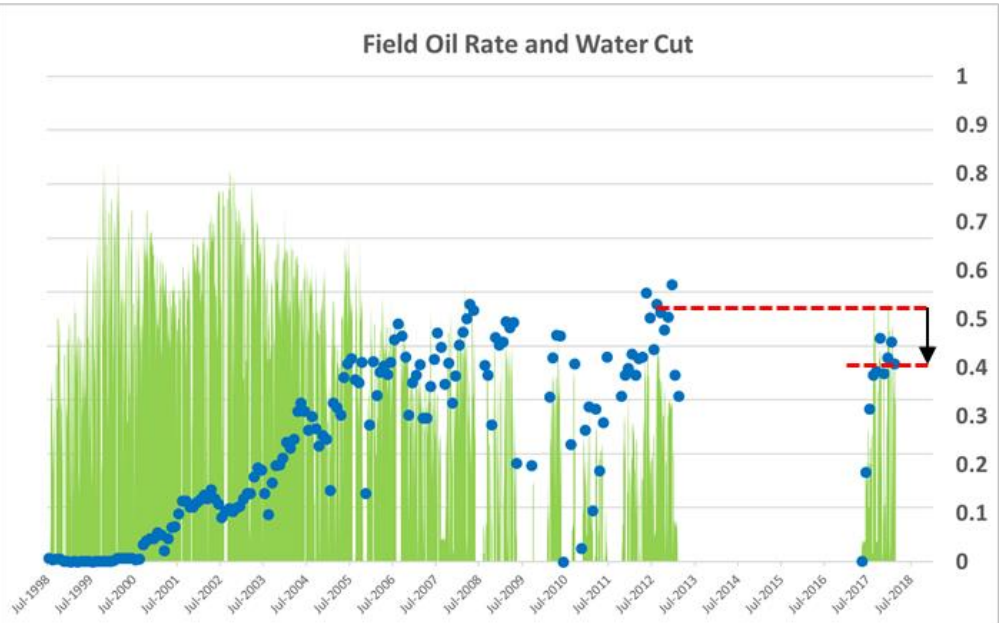
Seg 4 West
Staggered start-up with Seg 4 East wells confirmed poor communication from East to West (no response seen in wells)

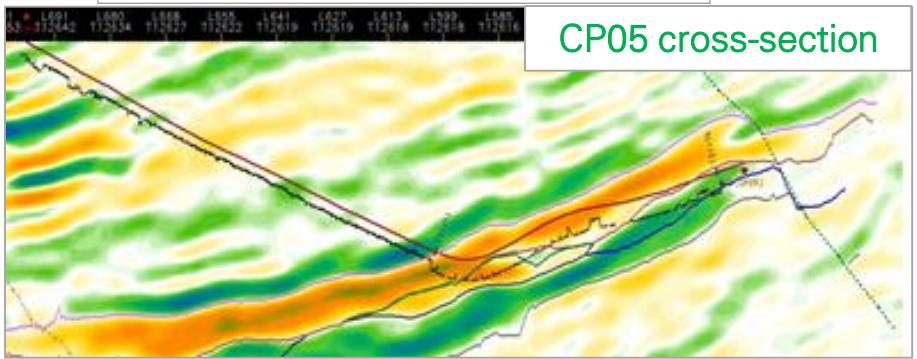
Seg 4 East
Staggered start-up of CP08 confirmed weak response to nearby injector

Start-up surveillance: Well performance

- Field level water cut indicated wells had come back online drier than before shut-in (~10% reduction)
- With the test separator initially unavailable, estimates were made on individual well performance using:
  - riser samples
  - wellbore fluid gradients
  - previous test data
- Reduction in water cut observed in several wells a result of gravity segregation; with water slumping away from the producers
- PBU/PFO data is also being analysed and compared to data collected on shut-in to identify any changes in well KH or skin







Outline

- Quad 204 Introduction
- Field Suspension
- What happened during shut-in period?
- What happened on start-up?
- What's next?

What's next?

1 Base optimisation

- Gathering well tests and PBU/PFO post start-up to assist in optimisation within plant constraints
- System optimisation using integrated asset models
- Replacing control modules to ensure long term sensor operability and well health
- Continuing to utilise interference testing and 4D surveys for waterflood optimisation

2 Wellwork

- 2018 pumping campaign under assessment to stimulate wells
- Screening for summer 2019 LWI campaign in progress (likely to consist of water shut-off and PLTs)

3 Further infills

- 7 wells left to drill as part of Quad 204 re-development
- Unlocking smaller targets by:
  - Best in class drilling performance
  - Delivering BPs longest open-hole gravel pack
  - Utilising technology
  - Advanced hopper characterisation workflows

4 Future expansion

- Recently sanctioned development of Alligin (50% BP & 50% Shell)
- Satellite field which will be a two well development (P&I pair) tied back to the Glen Lyon FPSO
- First oil is scheduled for 2020
- Installation of new subsea architecture to facilitate future expansion

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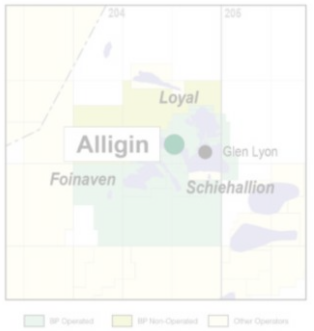

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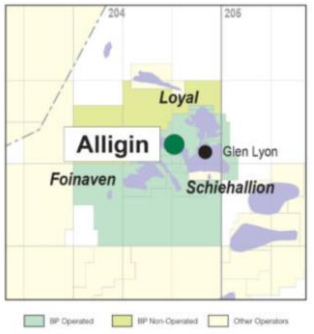

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Summary

Field suspension

- Good field management prior to shutdown reduced risk of damage to wells and made infill drilling easier and more predictable
- Collection of baseline well performance (well tests, PBU/PFO data) was crucial for optimisation of start-up sequence and identification of any issues

What happened during shut-in period?

- Invested time in tools and process to develop our opportunity hopper
- 13 wells drilled to date, 11 better than prognosis

What happened during start-up?

- Sequencing of well start-up offered a unique opportunity for interference testing; tailored to answer key questions and help inform infill decisions
- Well performance since start-up has been good, with no issues as a result of an extended shut-in and lower initial water cuts than previously

What's next?

- Ongoing optimisation of field
- Continuing to invest beyond Quad 204 via wellwork, new wells and near-field tie-backs

Acknowledgments

- BP
  - Deepwater Area Reservoir Management and New Well Delivery teams

- JV Partners
  - Shell
  - Siccar Point Energy
  - Chrysaor