

# **MACRO – an innovative method to characterise Main Area Claymore remaining oil**

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# What is MACRO?



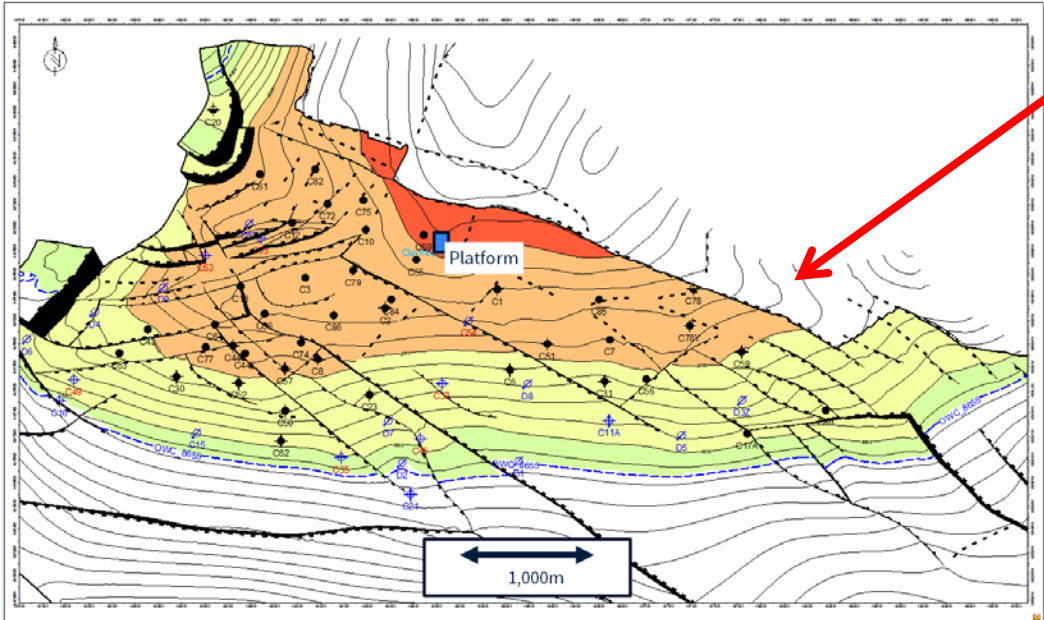
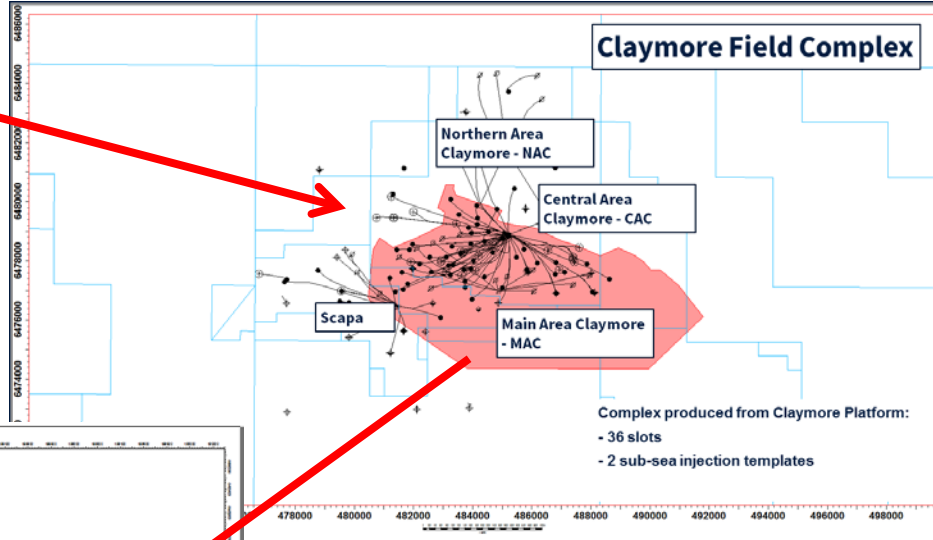
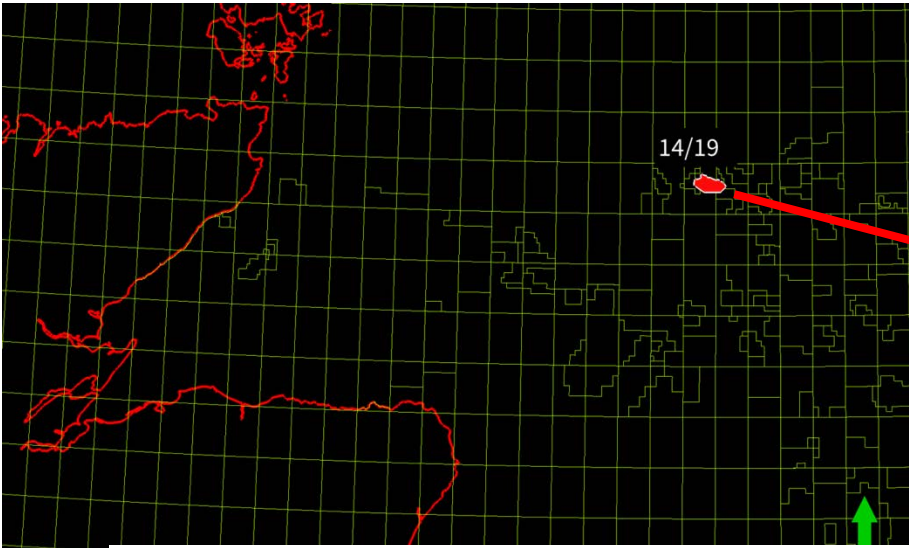
**MACRO** (Main Area Claymore Remaining Oil) : a study to identify and characterize the remaining MAC infill drilling opportunities.

- This talk will:
  - Describe the challenge.
  - Introduce the field and the modelling approach.
  - Present the 7 step target identification and development optimization process.

# Why MACRO?

- MAC provides significant opportunities for increased recovery.
  - MAC is a complex field with a base case projected EUR of circa 40%. Fluid displacement efficiency varies between the eight reservoir zones and is dependent on structure, reservoir and fluid properties and production and injection history.
  
- The challenge was to:
  - identify and describe all remaining economic infill opportunities as a component of an integrated strategy to increase the EUR.
  - incorporate sub-surface risk and uncertainty in the range of outcomes for each target well.
  - incorporate target interference and water injection in any development drilling strategy.
  
- What we hope to convey:
  - **An innovative method utilizing static and dynamic modelling and forecasting techniques to i) rigorously interrogate a field's remaining hydrocarbon potential, and ii) derive the building blocks to optimize a development drilling programme.**

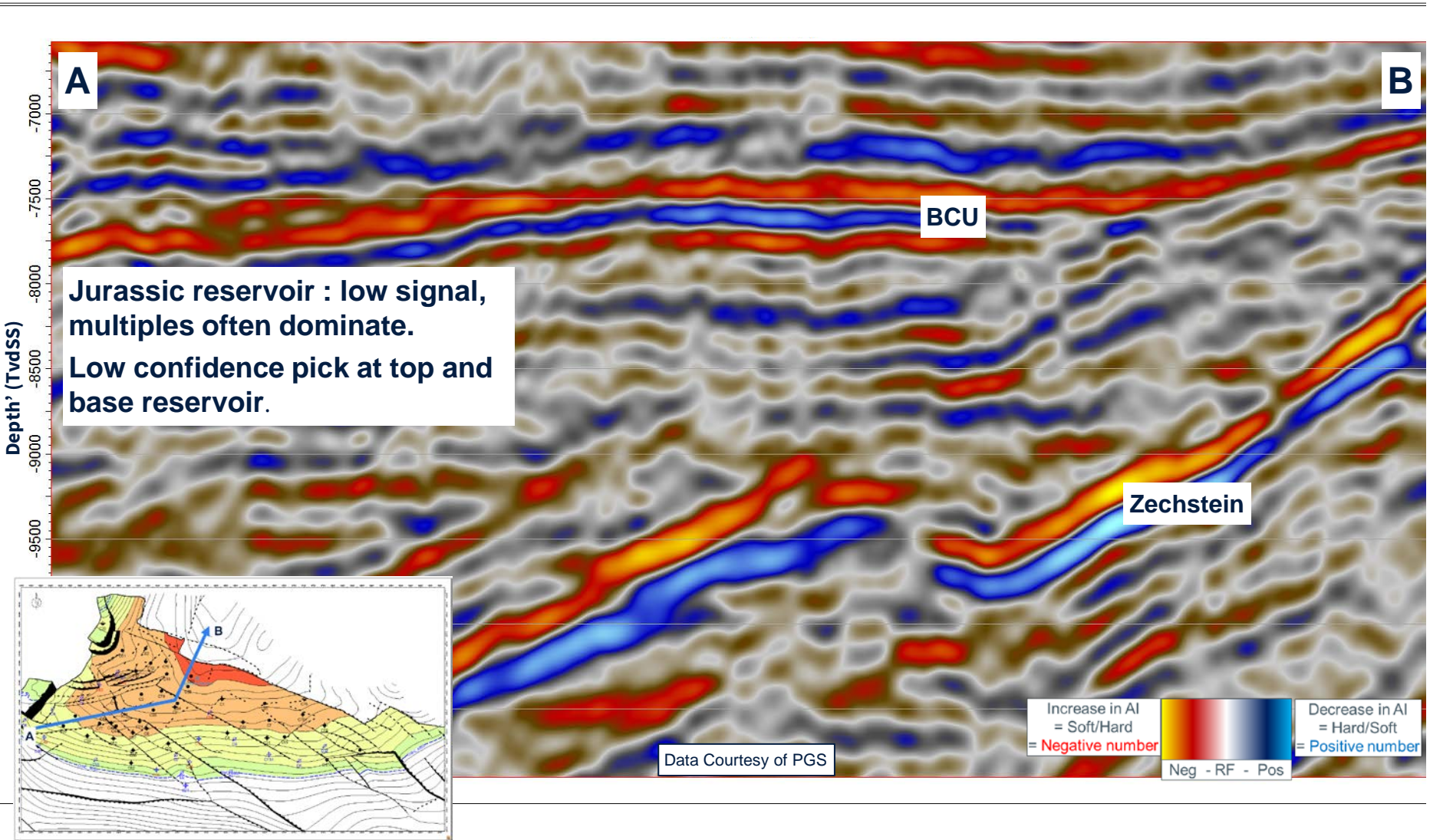
# Setting: Main Area Claymore (14/19 and 14/20)



**MAC:**  
**STOIIP – 1.08 Bstb**  
**Production commenced - 1977**  
**Produced to date – 410 MMstb**  
**Current RF – 38%**  
**Current water cut – 80%**

# Model Inputs: Seismic Data

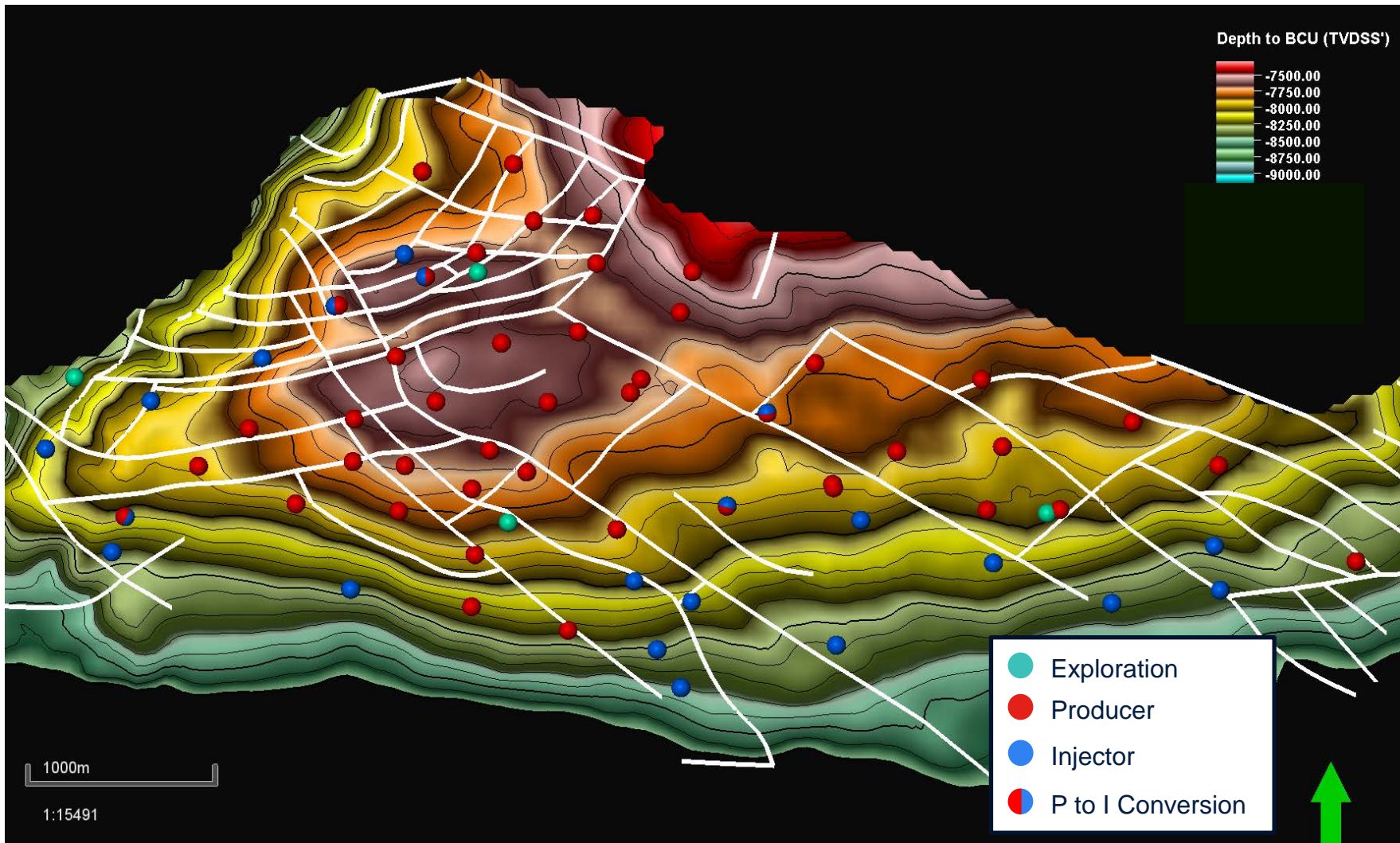
Can interpret BCU and Zechstein surfaces with confidence. Fault interpretation challenging. Independent interpretations utilised in the more complex areas of the field.



# Model Inputs: Legacy Well Data

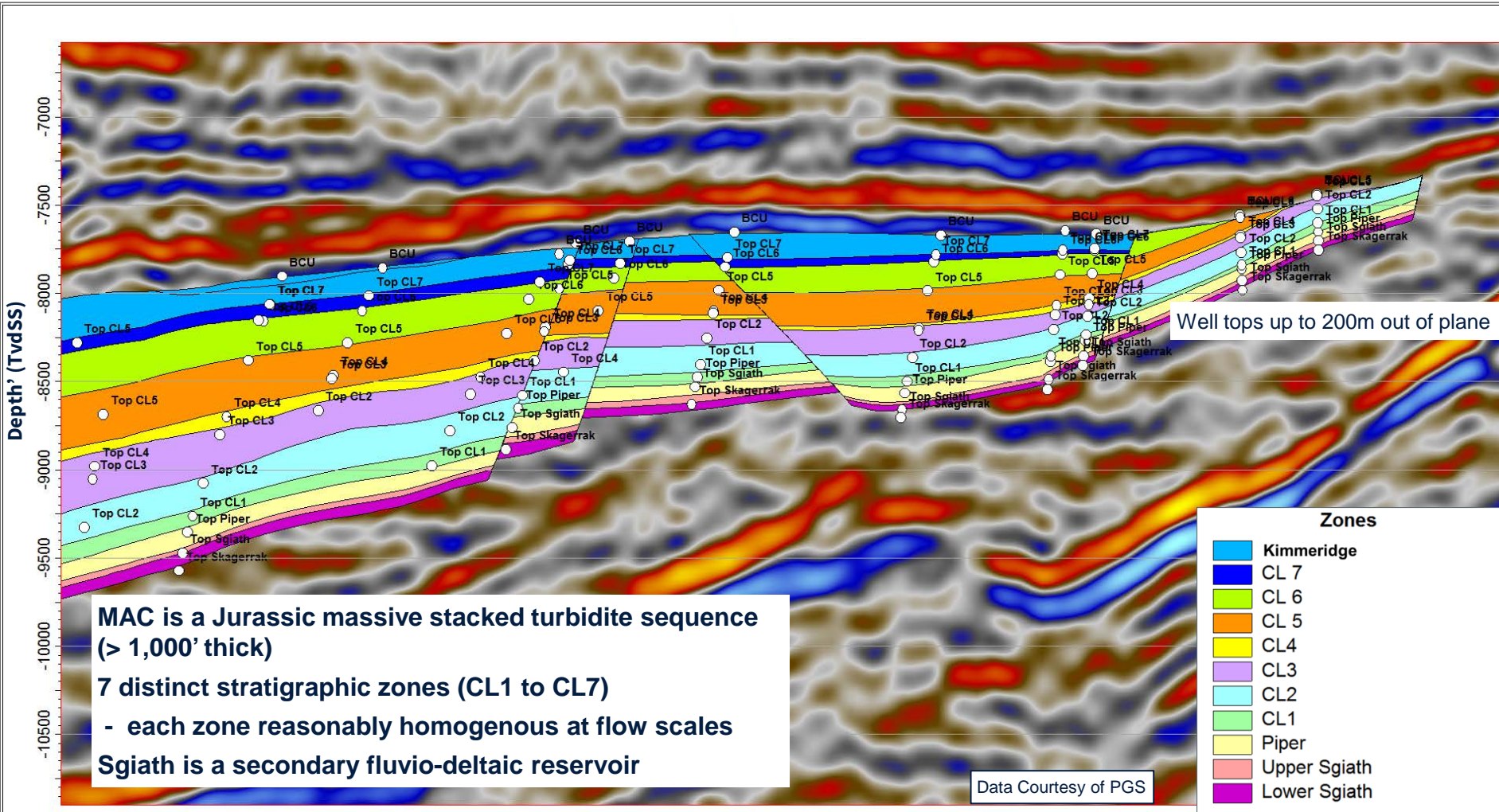
70 wells have been drilled on MAC

Wealth of structural, stratigraphic, petro-physical, and dynamic data covering 40 years of production history.



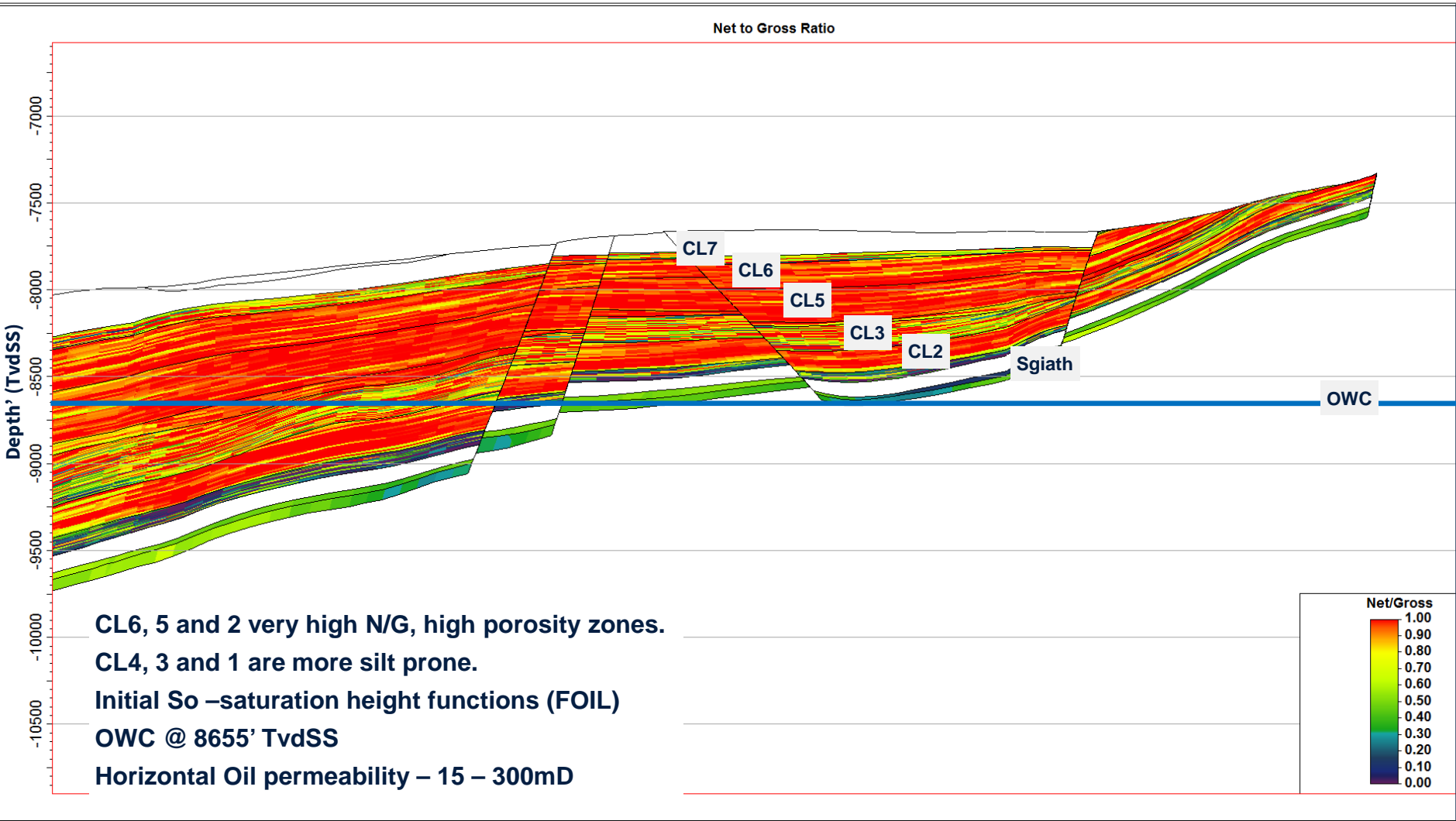
# Structural Model

Faults interpreted from seismic data + well tops, well fault cuts and dynamic constraints.  
Horizons based on well tops and isopachs.  
Iterative approach – start simple, integrated detail addition.



# Static Model

## Properties from up-scaled well logs





# History Matching (HM)

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**History matching: Modelled well and field production and pressures were closely matched to field data, providing a degree of confidence for predicting future reservoir behaviour.**

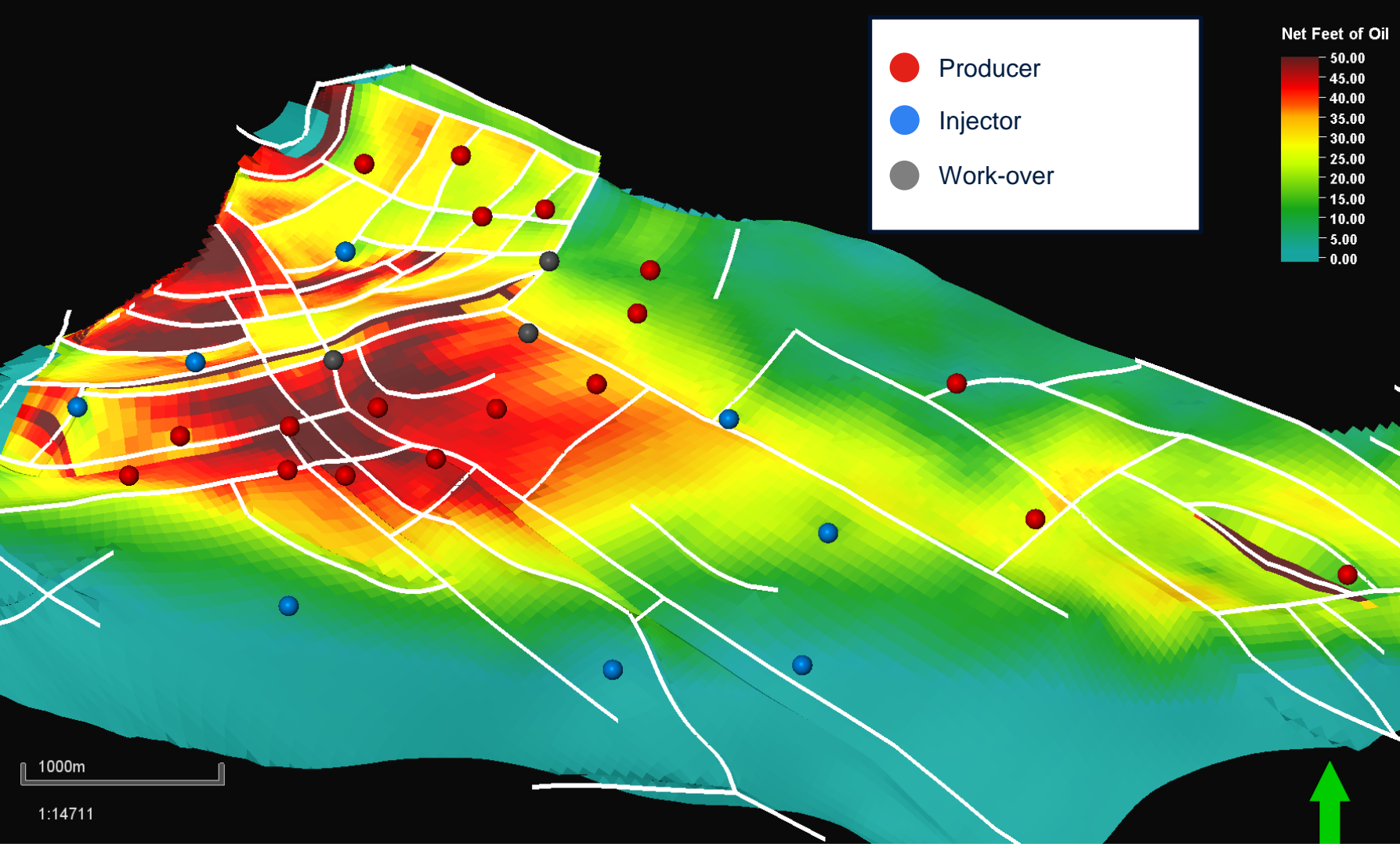
**MACRO is an integrated study:**

- **History matching commenced when the first structural model was available - pillar grid of boundary + major faults, simple horizons.**
  - **The HM guides – and is guided by – the evolution of the structural model and ensures the property elements of the static model are matured at an early stage.**
  
- **Opportunity forecasting commenced as soon as the static model was finalized.**
  - **Target robustness can be assessed as the HM is fine tuned to match detailed production information at every well.**

# Production Forecasts: Current Well Stock

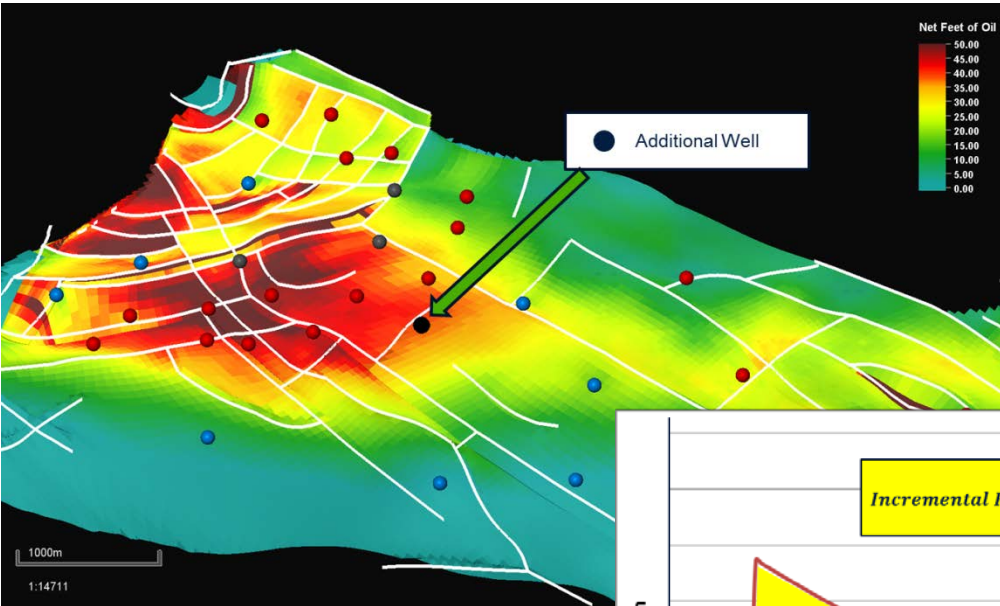
21 producers (+ 3 planned work-overs) and 7 injectors.

Run production forecast with these wells (tubing head pressure control) until end of field life to determine reference production ( NFI - No Further Investment case ).



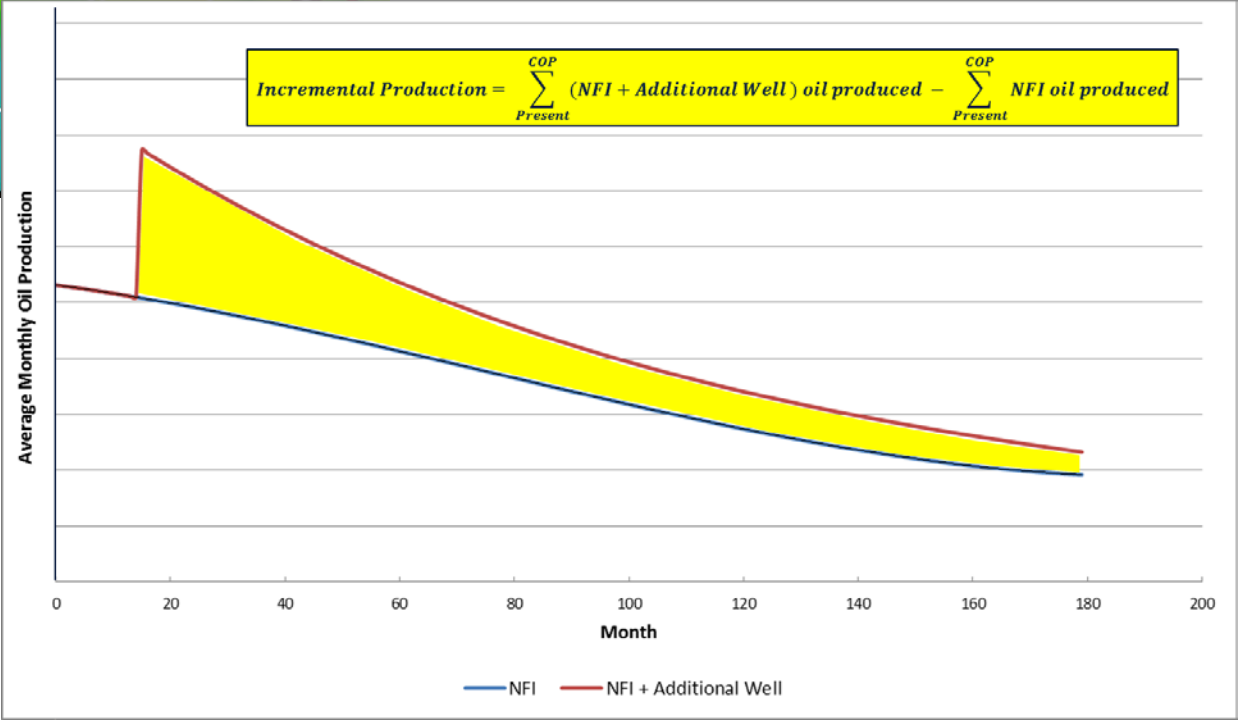
# Production Forecasts: Additional Well

Many Claymore wells compete for the same oil volume.



Determine the total amount of oil produced by the NFI wells + the additional well.

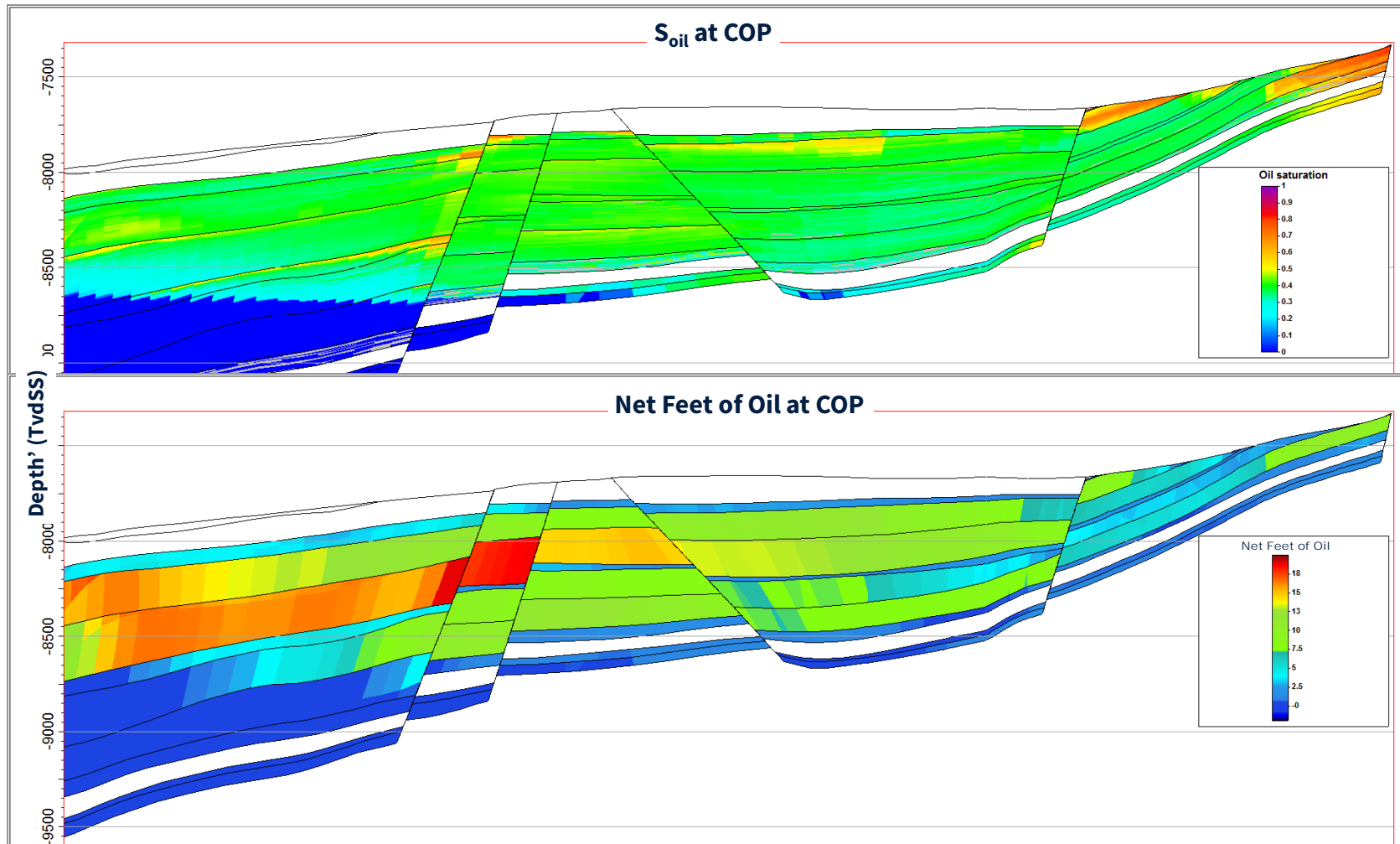
Subtract the total amount of oil produced by the NFI wells only.



# Target Identification – Step 1

Different property representations can be utilised to identify potential opportunities.

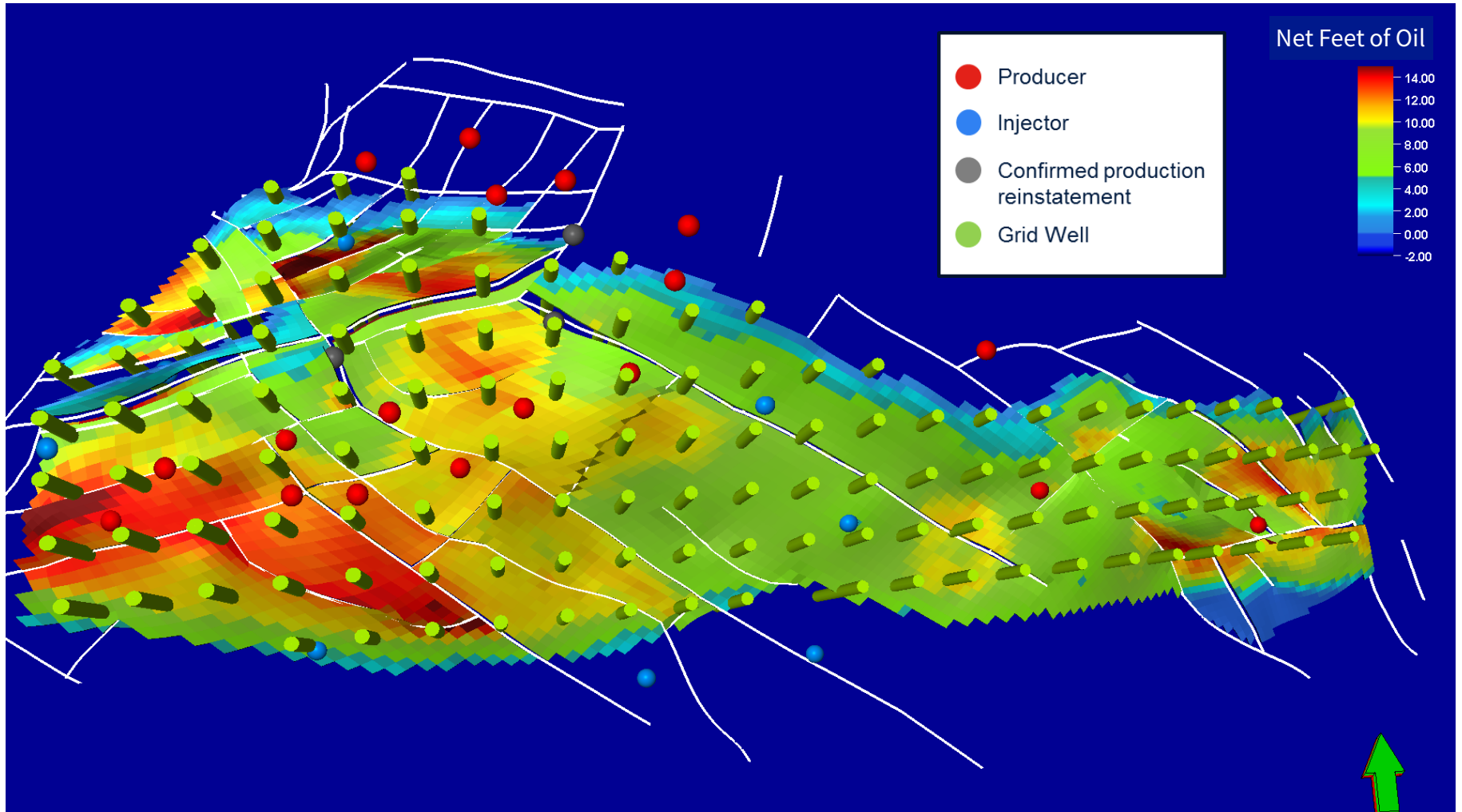
Saturations and Net Feet of Oil at different time stamps (present and COP) are commonly used.



**No single attribute is indicative of incremental production potential. Different combinations are correlated with incremental production in different parts of the field.**

# Target Identification – Step 1

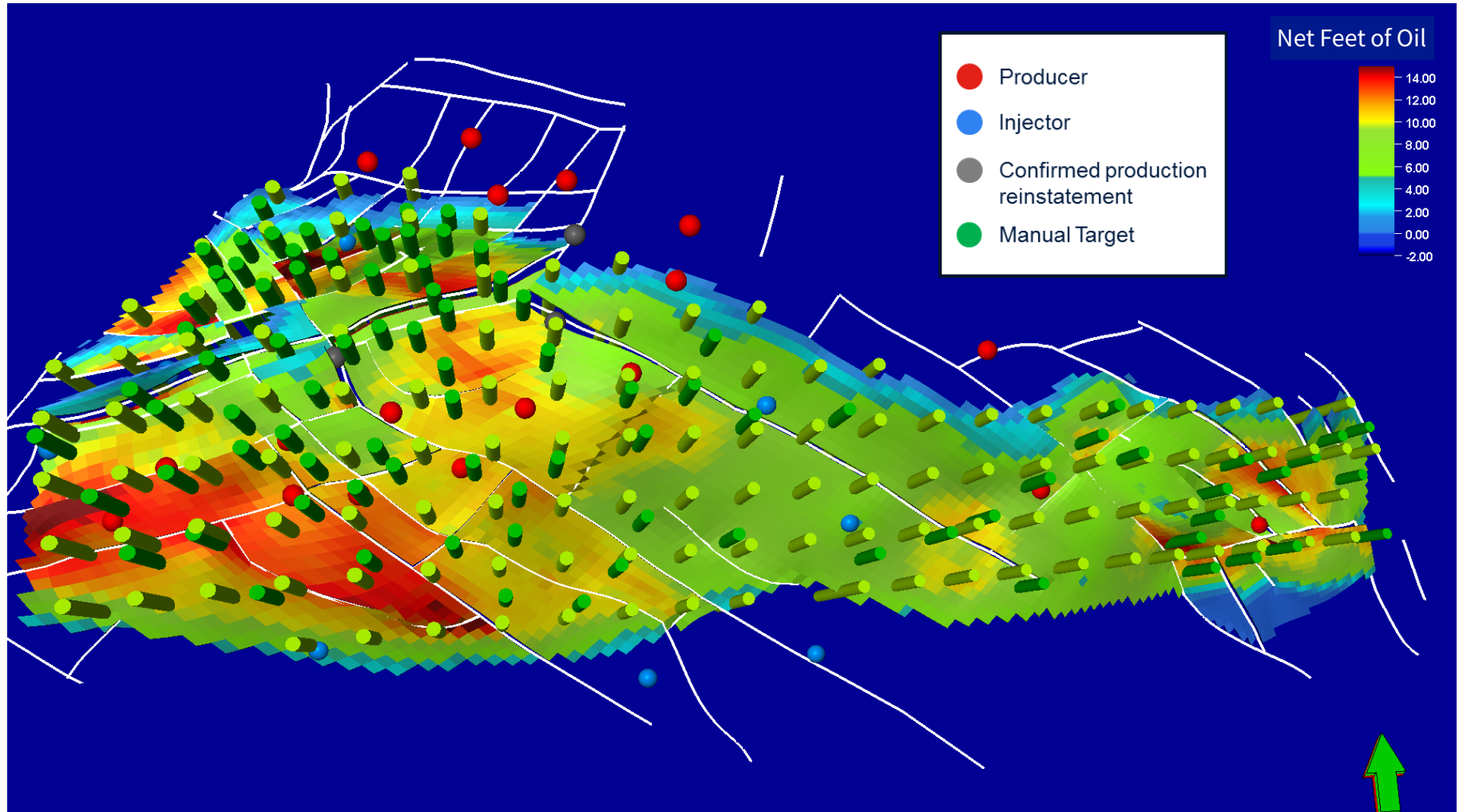
**Solution:** Forecast production incrementals for a grid of wells, one well at a time, one zone at a time.



Example grid wells for the CL6. This analysis was performed for all zones from the CL7 to the Sgiath and ensures comprehensive sampling.

# Target Identification – Step 1

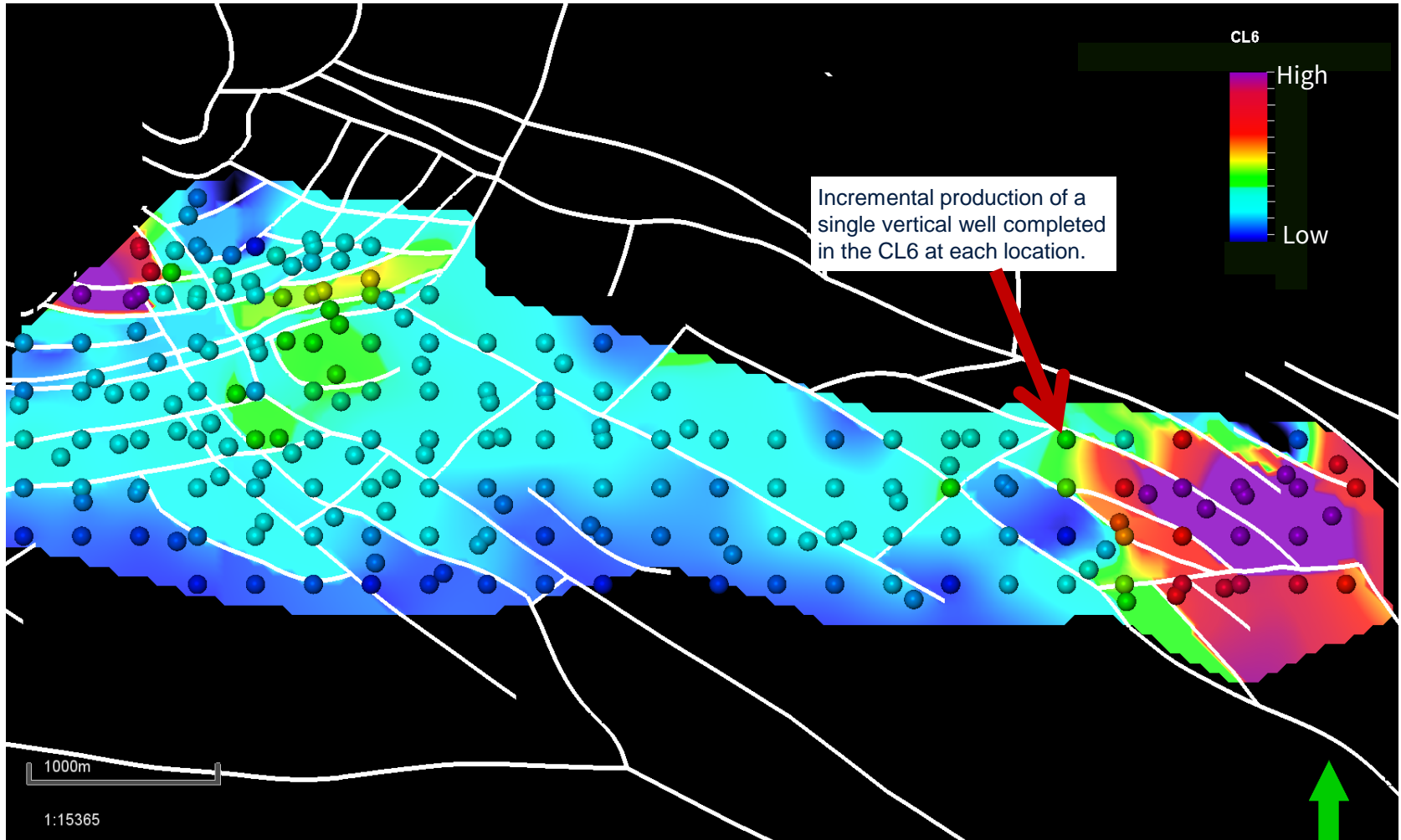
Supplement with manually identified targets in each zone.



Optimized well locations based on property maps and structure.

# Target Identification – Step 1

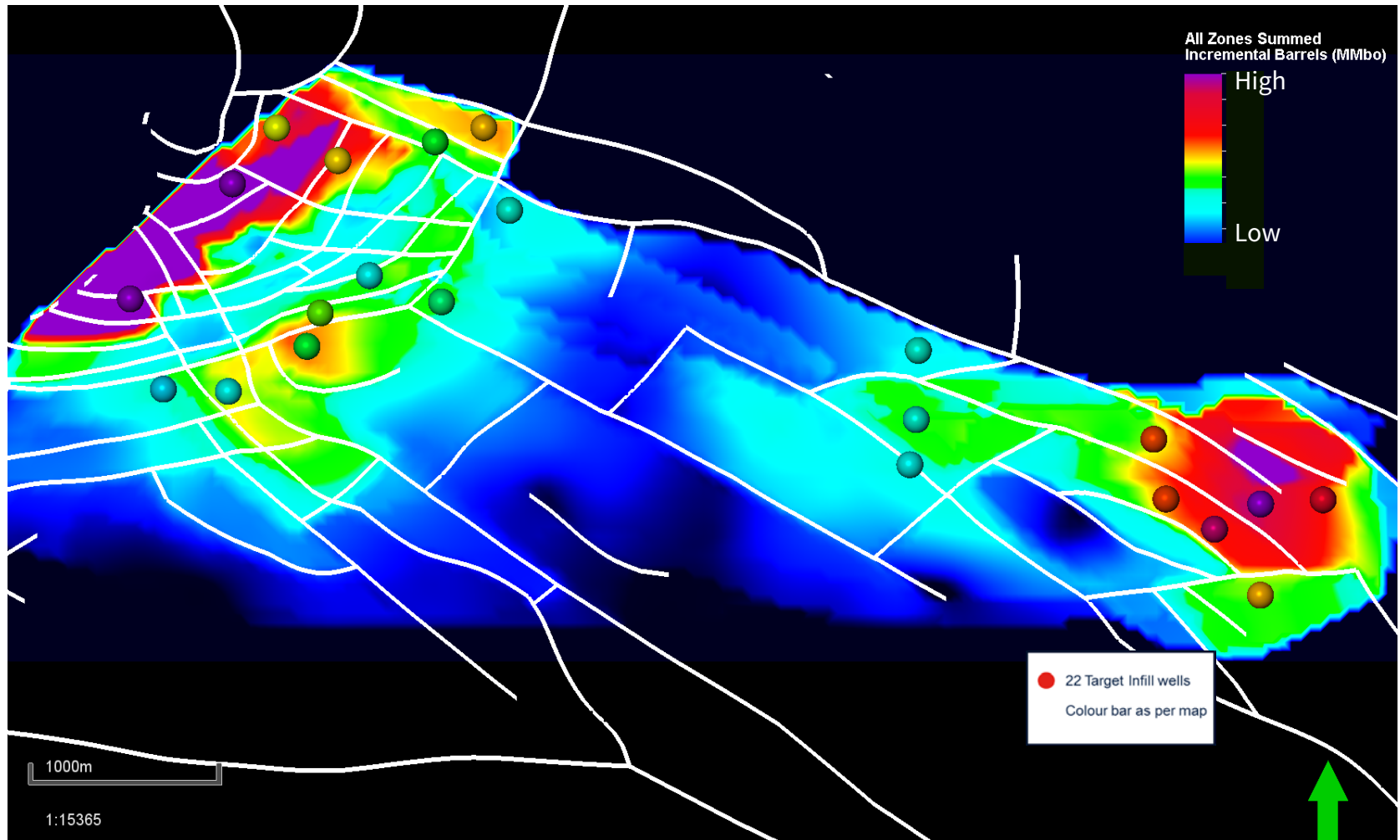
Convert production incremental values into a map.



One map per zone (CL6 example shown).

## Target Identification – Step 1

Add maps from all zones to get the total MAC potential map. This map was used to identify target locations.

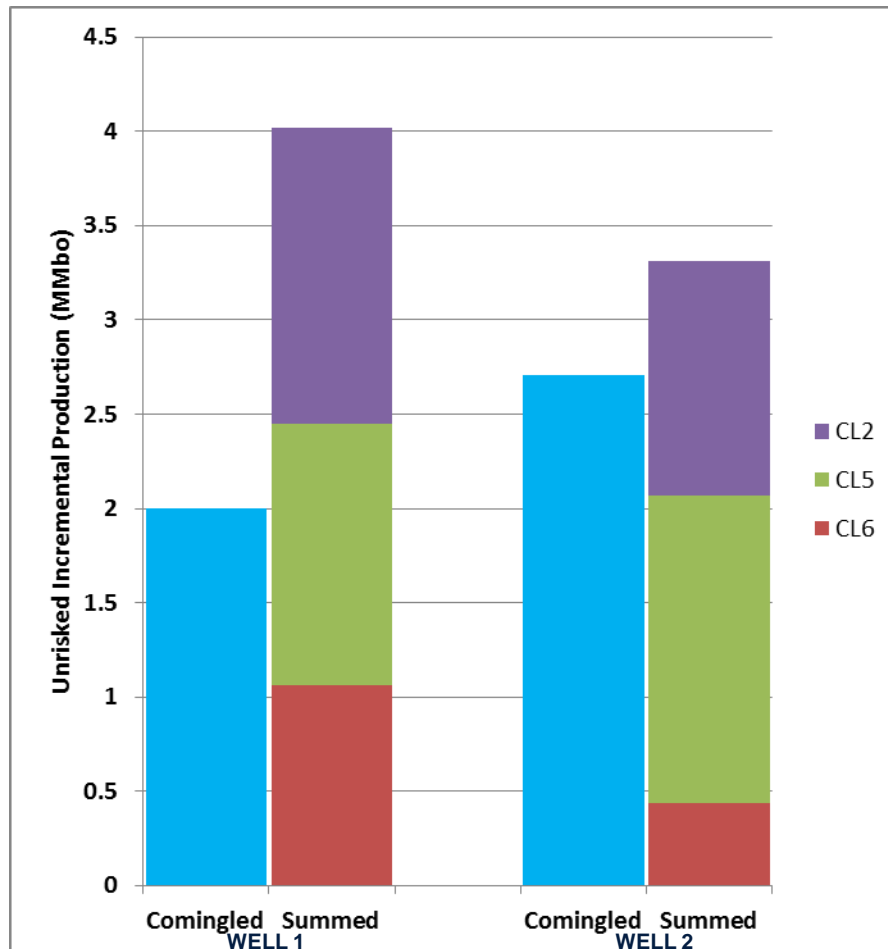


55 target wells initially selected. 22 well selection based on incremental production, sub-surface understanding or to capture uncertainty variance. (Iterate subsequent steps 2,3 and 4)



## Target Optimization – Step 2

Many target wells intersect multiple zones.  
The whole is equal to less than the sum of the parts!



Summing per zone incremental production potential gives a theoretical maximum target well resource.

**MACRO assumed comingling.**  
(Completion strategies will be re-considered for all targets at the well design stage.)

Higher permeability (pressure) zones back out production from lower permeability zones.

Run forecasts to assess all completion combinations (up to 5 zones) for all 22 target wells. The combination with the highest incremental production was selected for each well.

# Target Uncertainty – Step 3

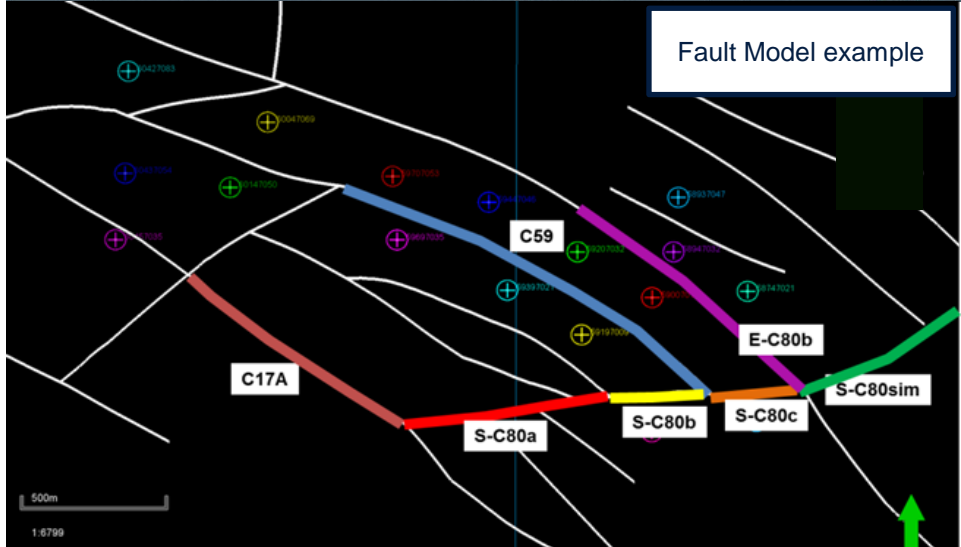
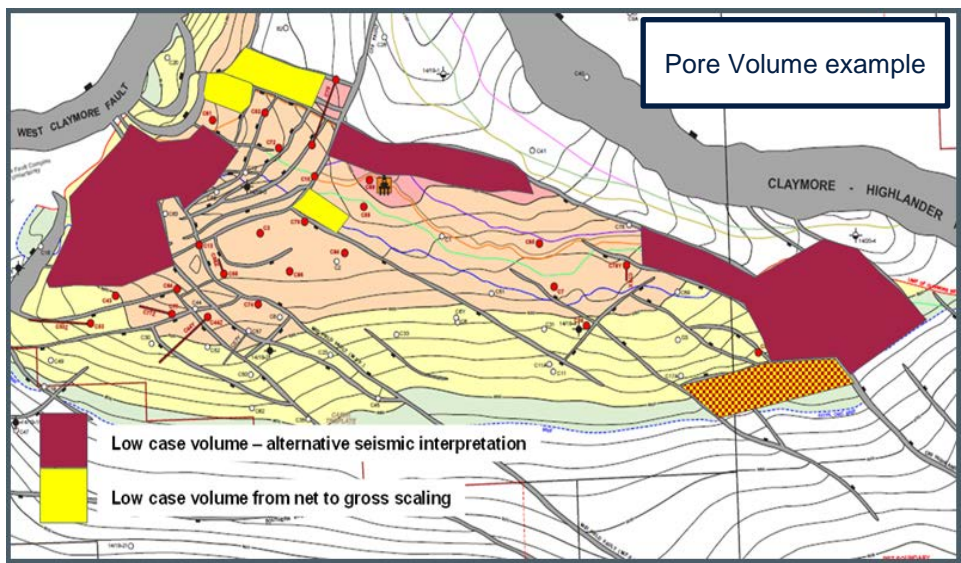
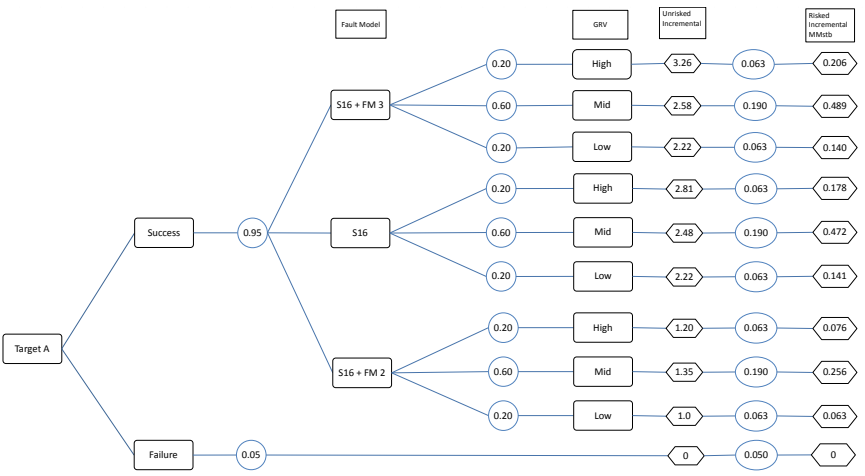
Run forecasts with different static and dynamic realisations to capture uncertainty.

## Key uncertainties

- 1) Gross/Pore volume
- 2) Fault transmissibility
- 3) Well productivity/performance
- 4) Low Case/Failure leg – what uncertainty do the models not capture?

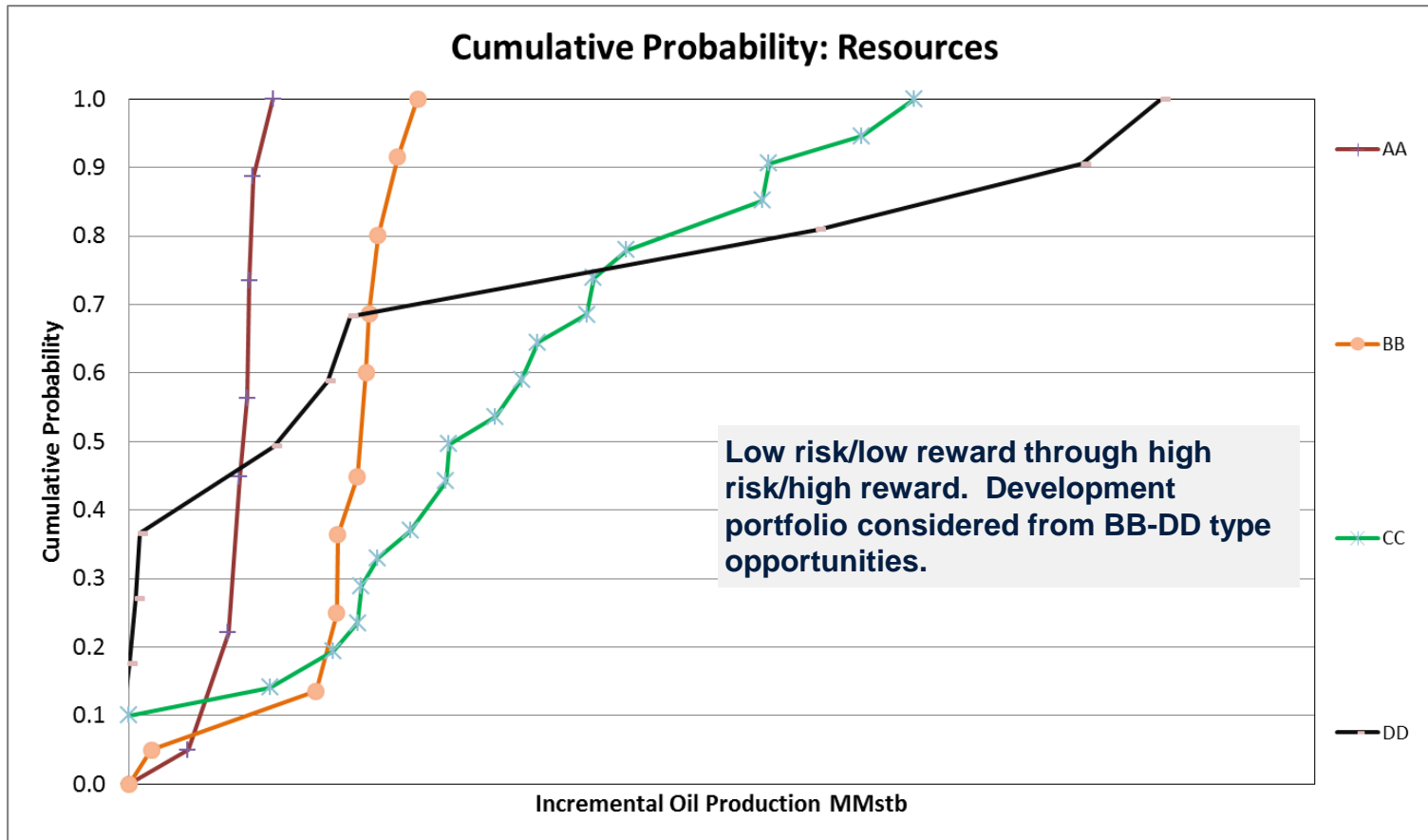
## Combine in a decision tree

Decision Tree example



# Target Ranking – Step 4

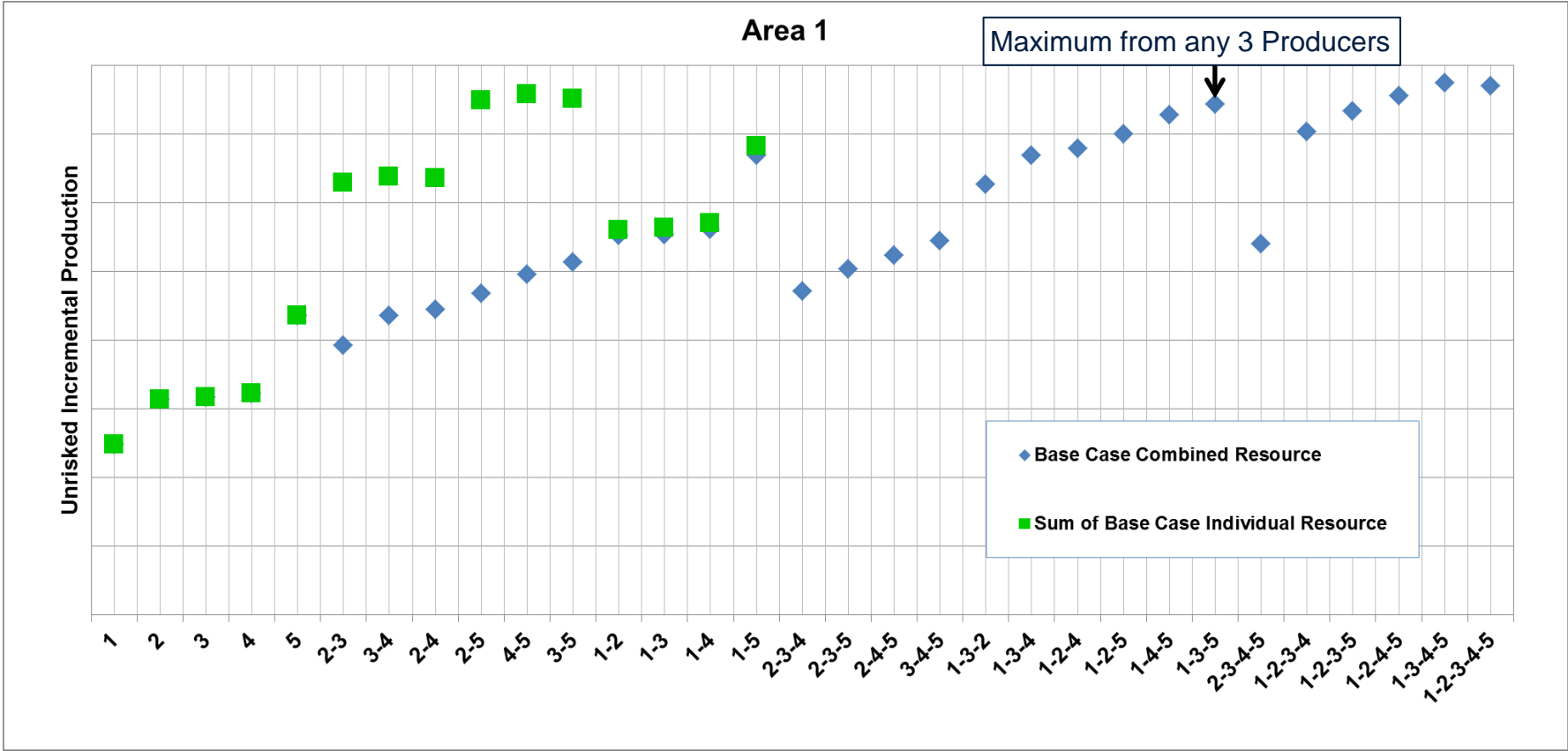
Decision Trees define the probabilistic (risky) resource for a target well.  
Cumulative Probability Distribution Functions for 4 of the 22 wells depicted.



Each point on every curve has an associated production profile. These were used to investigate other metrics – for example NPV.

# Target Interference – Step 5

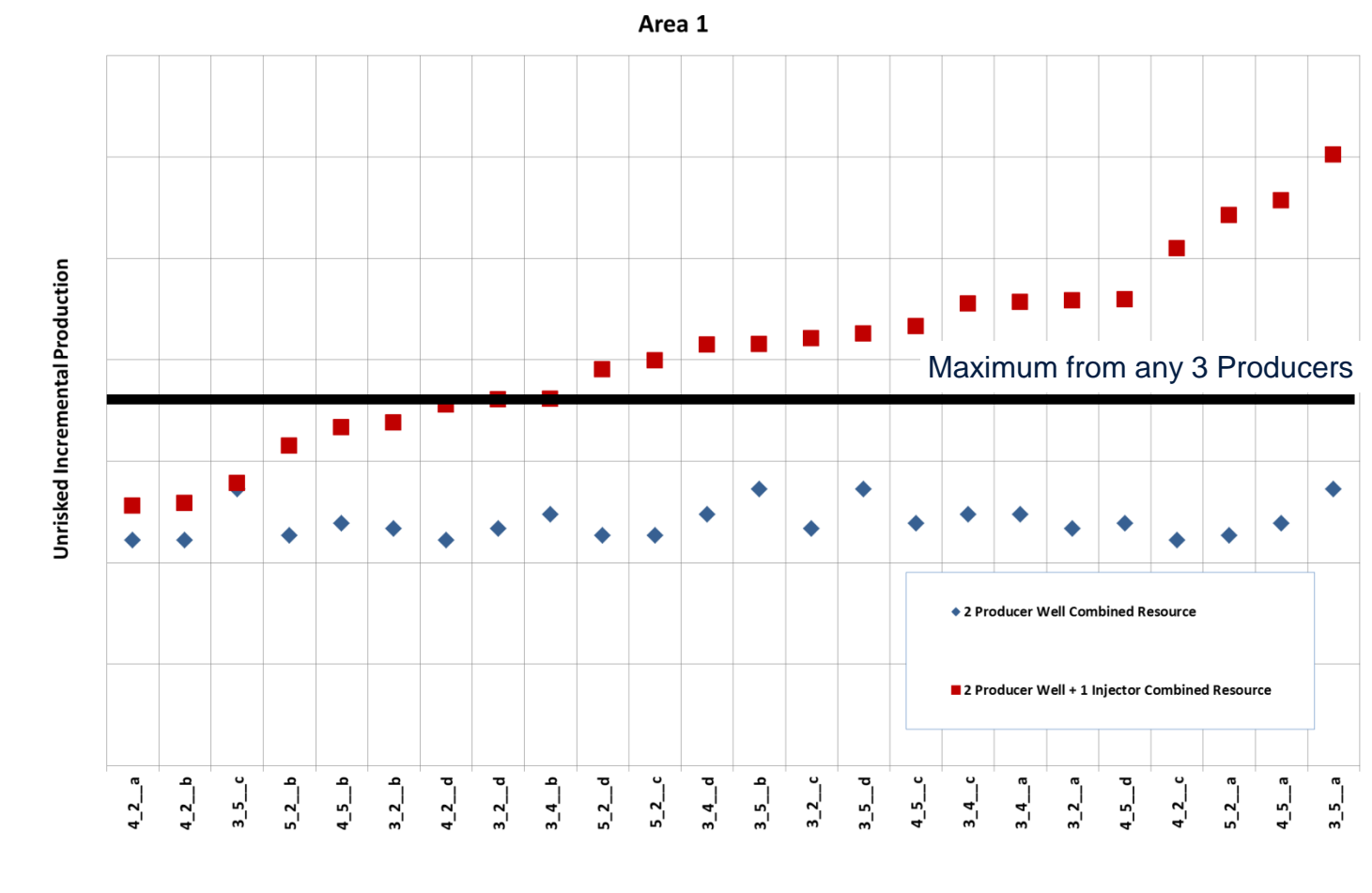
What is the impact of more than one infill well producing at the same time?  
 Practically we can divide MAC into four different areas which are independent of each other.



Within each of the four areas examine the incremental production when more than one well produces at the same time. There is interference between 4 of the 5 wells. Well 1 is independent.

# Impact of Additional Injection – Step 6

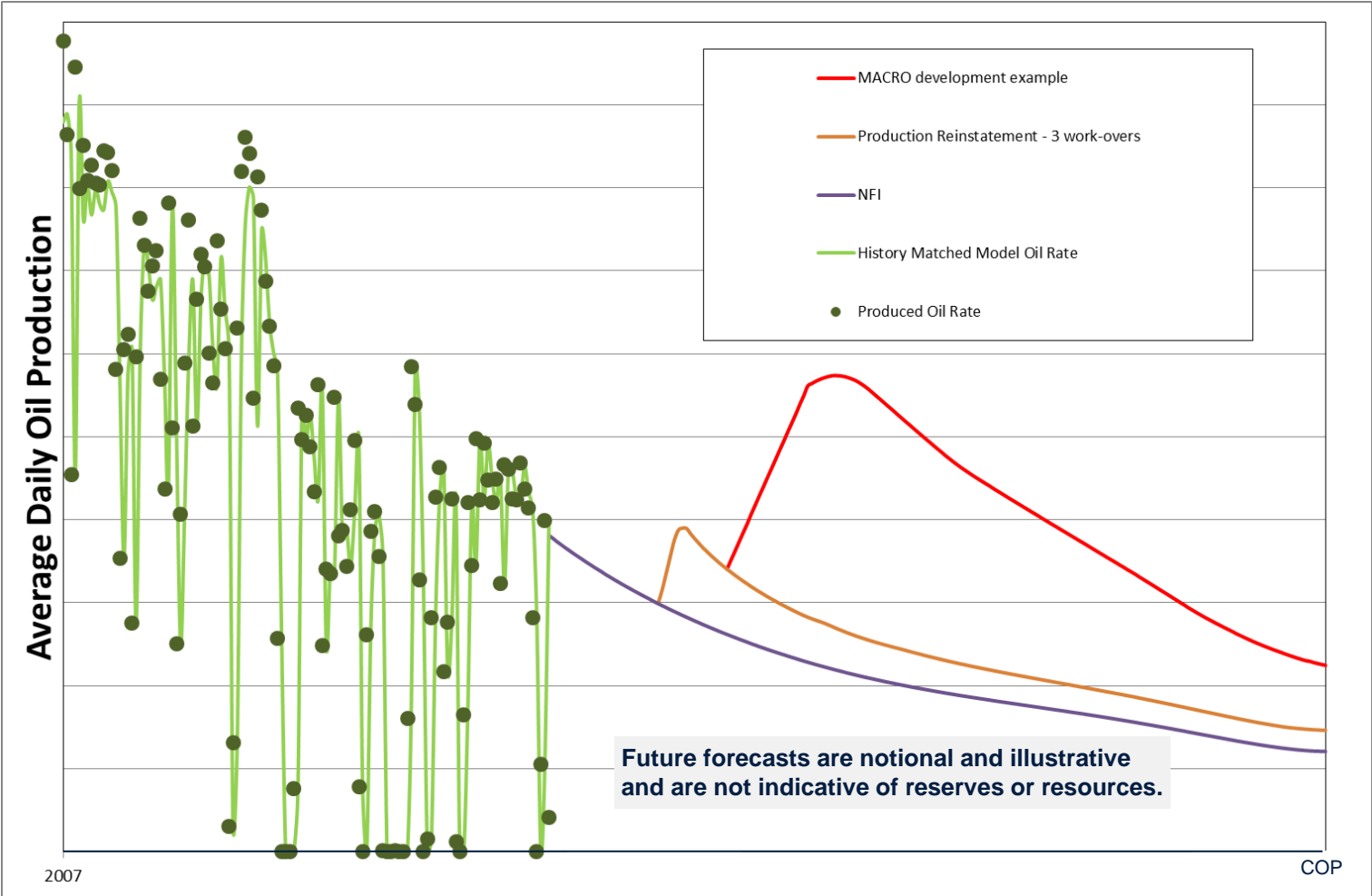
What is the impact of additional water injectors? Consider selected producers in each of the four field areas. This plot shows forecast results for 2 producers + 1 injector combined.



Clearly, additional injectors are an important consideration in maturing alternative development scenarios.

# Consider Alternative Development Scenarios – Step 7

Use the building blocks to examine notional development options. The MACRO development example displayed is a combination of infill producers and injectors.



Currently maturing alternative risked scenarios as part of the long term drilling development plan.

# Key Study Success Factors

- Automation and workflows.

  - Invaluable – test and validate

  - Independence – compare serial vs parallel or results from two REs...

- Make appropriate assumptions at different stages in the process.

  - Start simple and realistic - add uncertainty as the portfolio matures.

- Analyse, track and review results critically.

  - Does it make sense – is it geologically and dynamically reasonable?

  - If a result looks unusual or has changed find out why.

We are interpreters – not software operators.

*"The most that can be expected from any model is that it can supply a useful approximation to reality: All models are wrong; some models are useful".*

George Box et al



# Acknowledgements

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