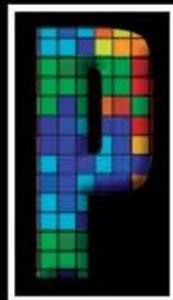


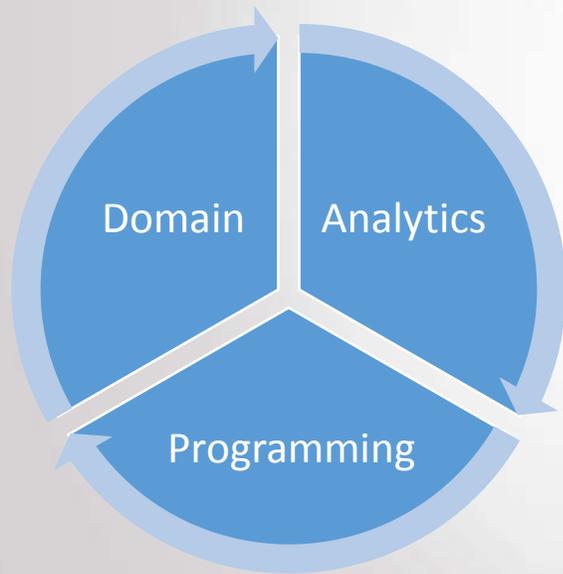
Primera Resources Professional Oil & Gas Consulting



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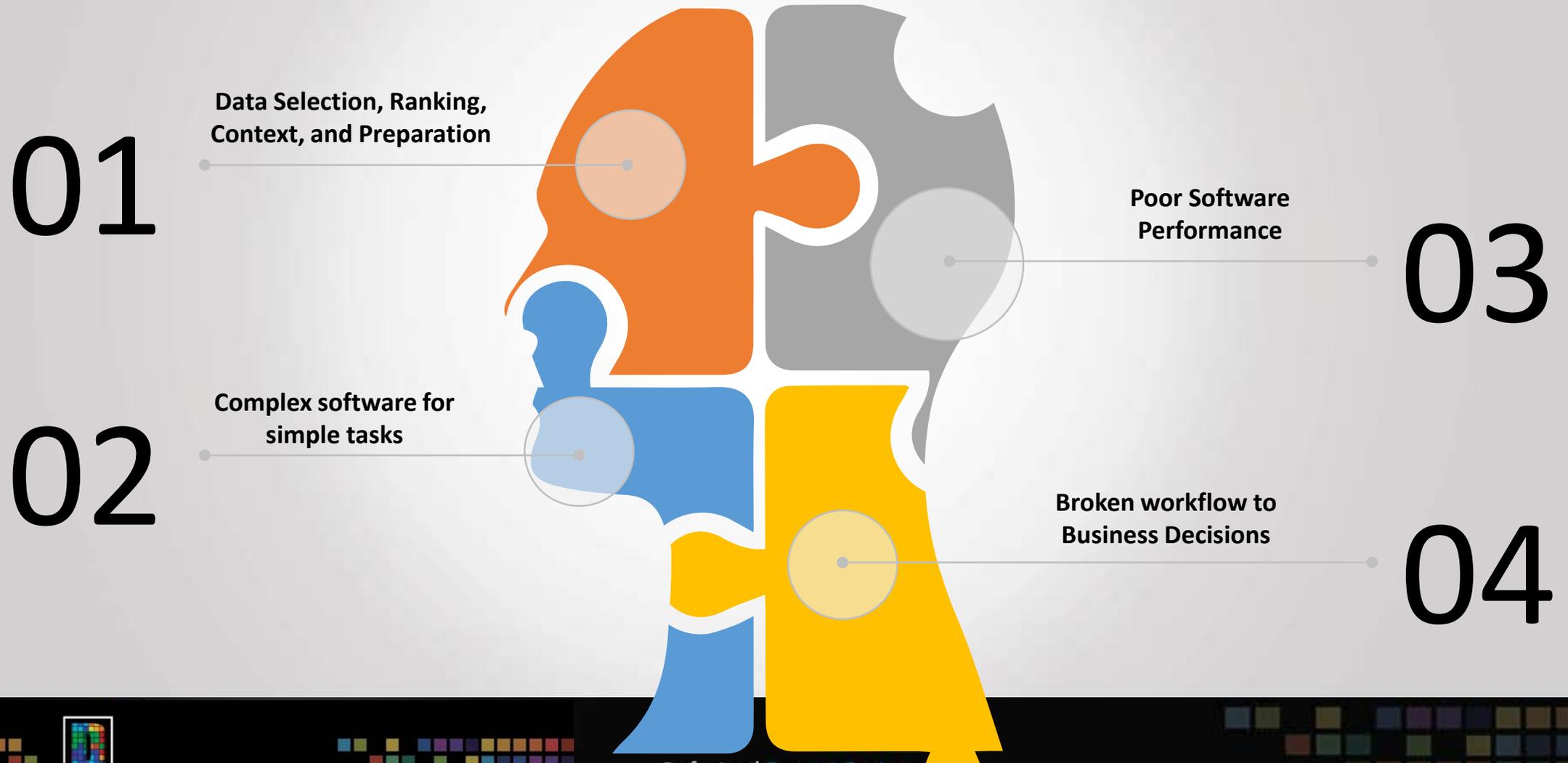
About Primera Resources

- Company established since 2013
- Expertise in numerical reservoir simulation, reservoir management and EOR



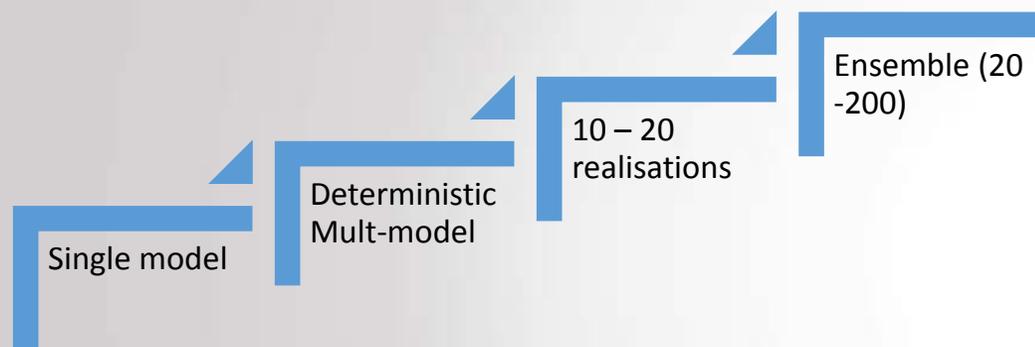
Most Time Consuming Tasks and Pains

For Decision-Making



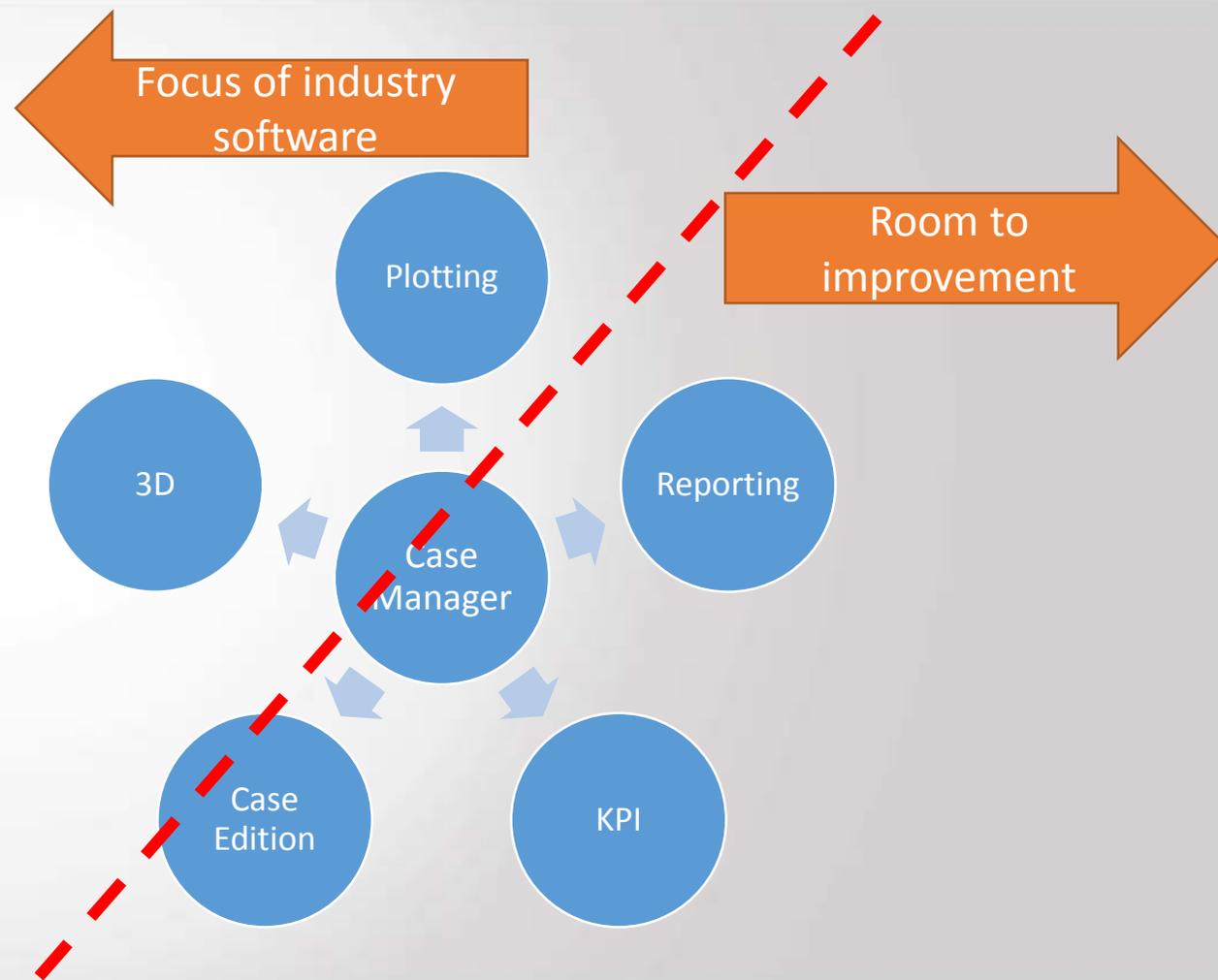
Types of projects (2 dimensions)

MODEL



SCENARIOS

- Facilities debottlenecking
- FDP
- Redevelopment (2nd Phase, EOR)
- Infill campaigns
- Interventions
- History Matching



Examples

How long would it take to conduct the following studies?

01

Infill Drilling

02

History Matching

03

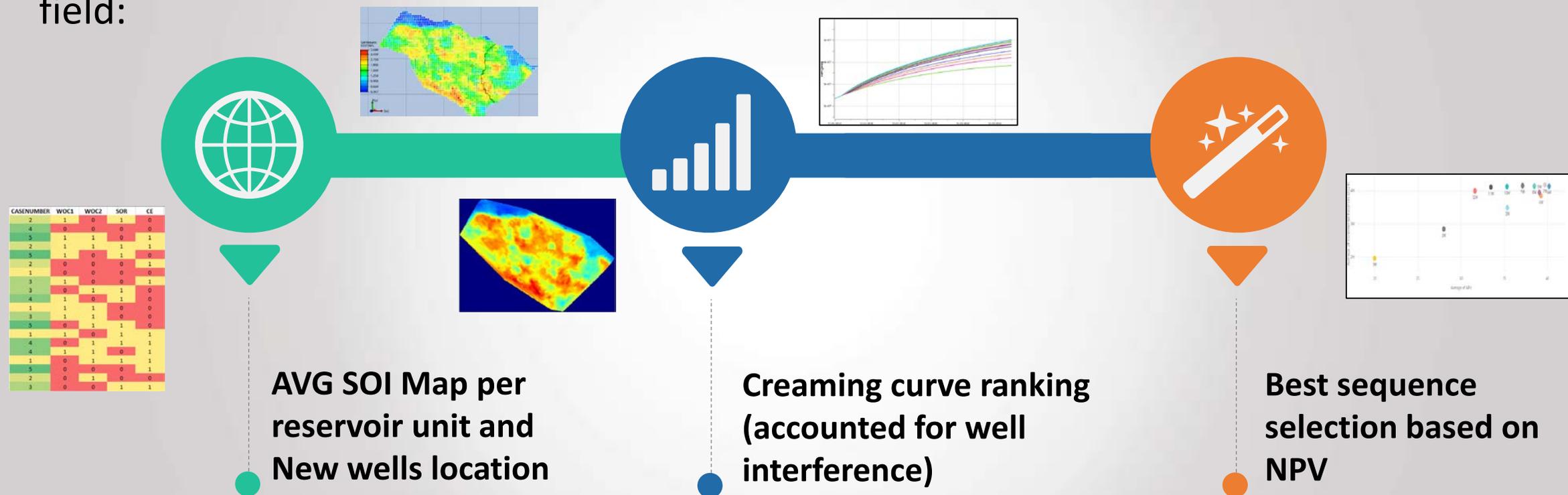
Enhanced Oil Recovery – Concept Selection



Infill drilling

Example: Infill Drilling Campaign

- Example of workflow shown below for an infill drilling campaign for a North Sea offshore field:



- Workflow results in capturing of the whole uncertainty range giving client better information on which to base the decision.



Infill Drilling Campaign

- Design of experiment
- SOI mapping
- Well locations
- Well trajectory optimisation
- Calculation of EUR (estimated ultimate recovery) and NPV
- Identification of optimum infill drilling sequence



Infill Drilling Campaign

TARGETS

- The identification of the well targets was based on Simulation Opportunity Index Analysis (SOI).

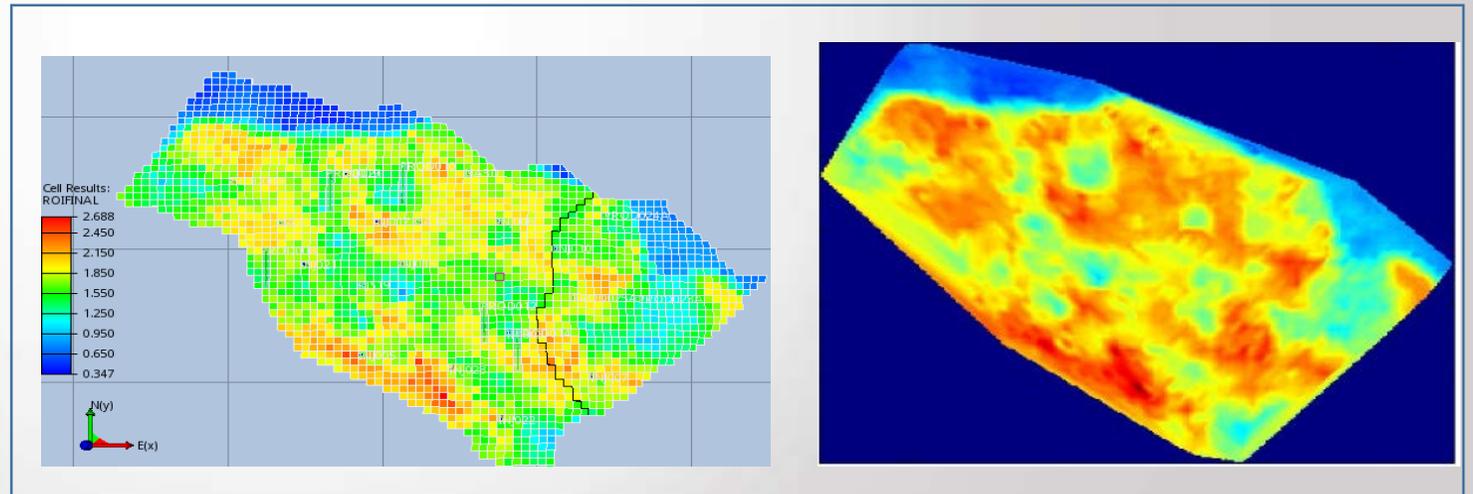
The Opportunity Index analysis is an intelligent method which uses numerical simulation models to identify zones with high potential for production calculated from basic rock and fluid properties (Molina et al. 2009).

The SOI is based on the Reservoir Quality Index and the Remaining Recoverable Volume

$$SOI = \sqrt[3]{RQI * RRV}$$

$$RQI = \sqrt[2]{\frac{K}{\phi}} * 0.0314$$

$$RRV = (S_o@t - S_{or}) * PORV$$



Infill Drilling Campaign

Maps were generated through octave's scripts

- In this case different scripts were written to calculate RQI, RRV and then SOI

RQI

```
RQIFINAL.m x
PORO = riGetActiveCellProperty("PORO");
PERMX = riGetActiveCellProperty("PERMX");
SOIL = riGetActiveCellProperty("SOIL");

RQI2 = ((PORO./PERMX).^0.5)*0.0314
RQIFINAL=SOIL

for i = (1:columns(SOIL))

    RQIFINAL(:,i:i) = RQI2;

endfor

riSetActiveCellProperty(RQIFINAL, "RQIFINAL");
```

RRV

```
RRVFINAL.m x
SOIL = riGetActiveCellProperty("SOIL");
PORV = riGetActiveCellProperty("PORV");
SOILDIFF = SOIL;

for i=(1:columns(SOIL))

    SOILDIFF(:,i)= SOIL(:,i)- 0.2;

endfor

RRVFINAL = ((SOILDIFF).*PORV);

riSetActiveCellProperty(RRVFINAL, "RRVFINAL");
```

SOI

```
ROI.m x
RQI = riGetActiveCellProperty("RQIFINAL");
RRV = riGetActiveCellProperty("RRVFINAL");

ROI= (RQI.*RRV).^0.3

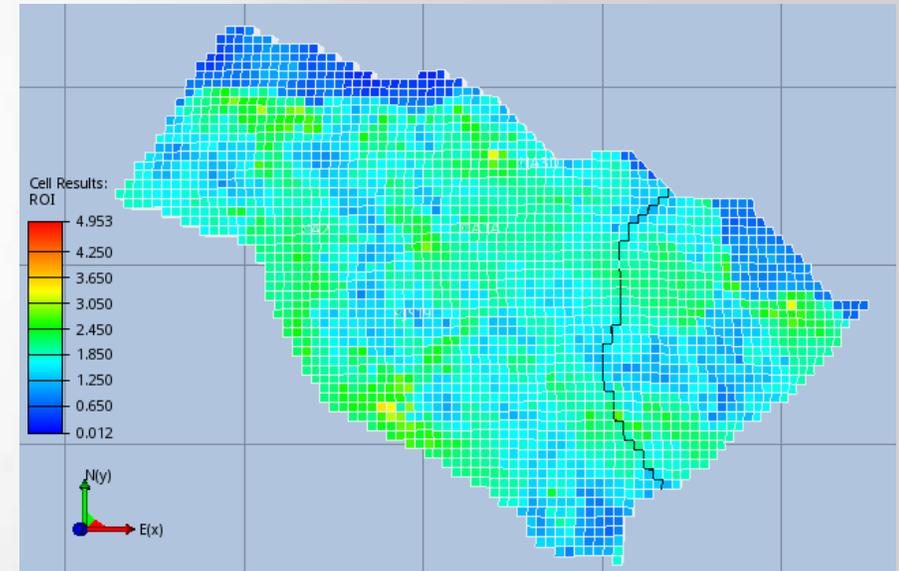
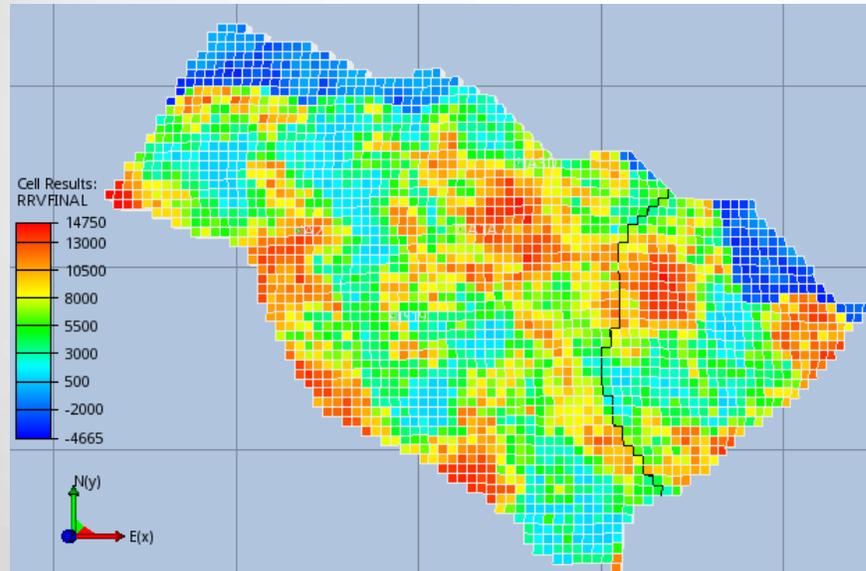
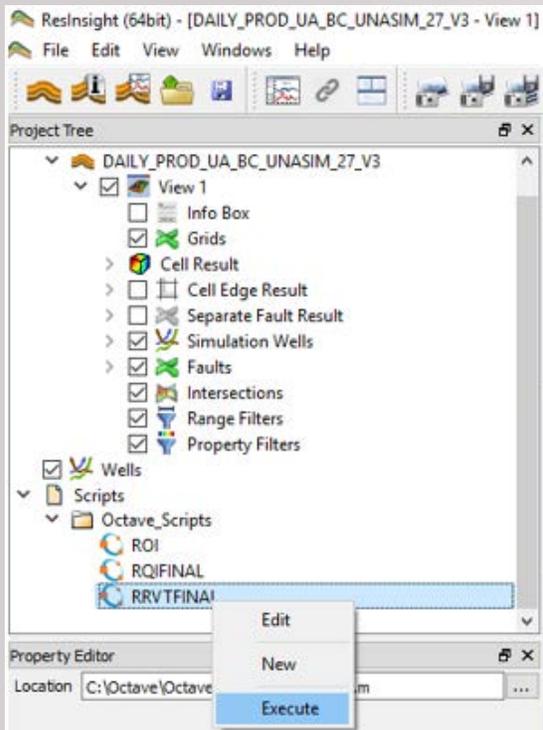
riSetActiveCellProperty(ROI, "ROI");

save ROI
```



Infill Drilling Campaign

- Executing these scripts in ResInsight will generate RQI, RRV and ROI in the grid, from which the map can be obtained for individual layers or the entire reservoir

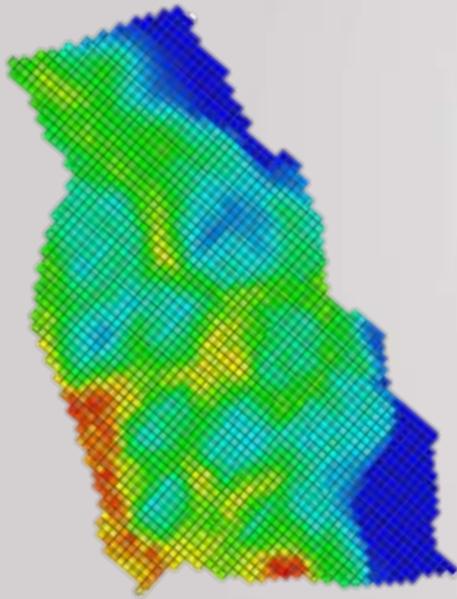


Infill Drilling Campaign

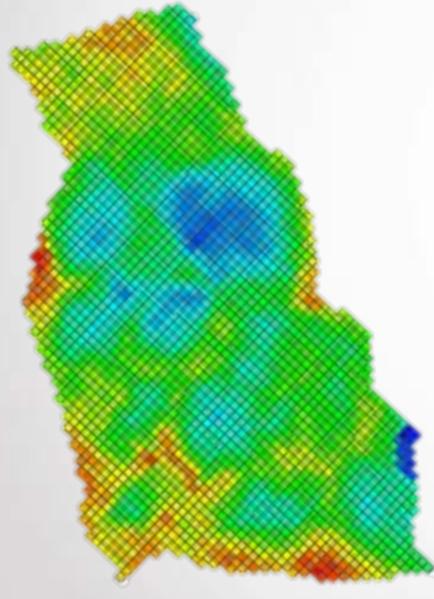
TARGETS

To locate the wells based in the SOI, an average map of SOI was generated out of the 20 realisations.

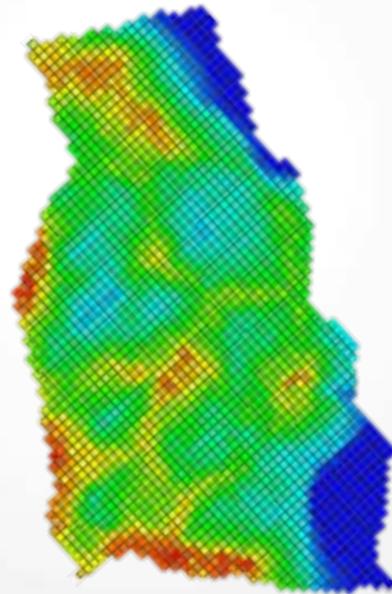
Case2



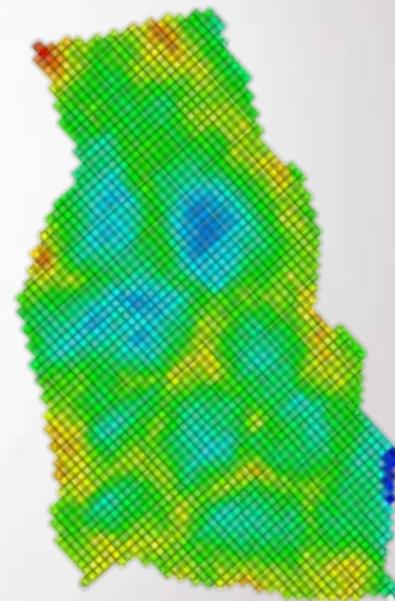
case7



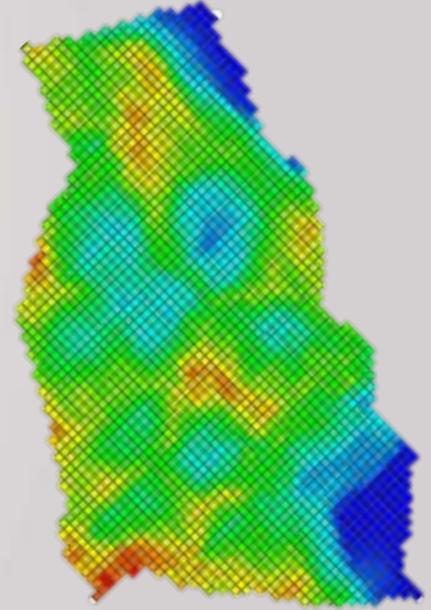
Case12



Case16



Case20



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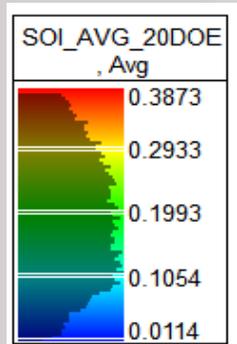
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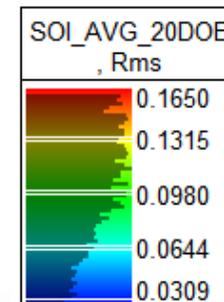
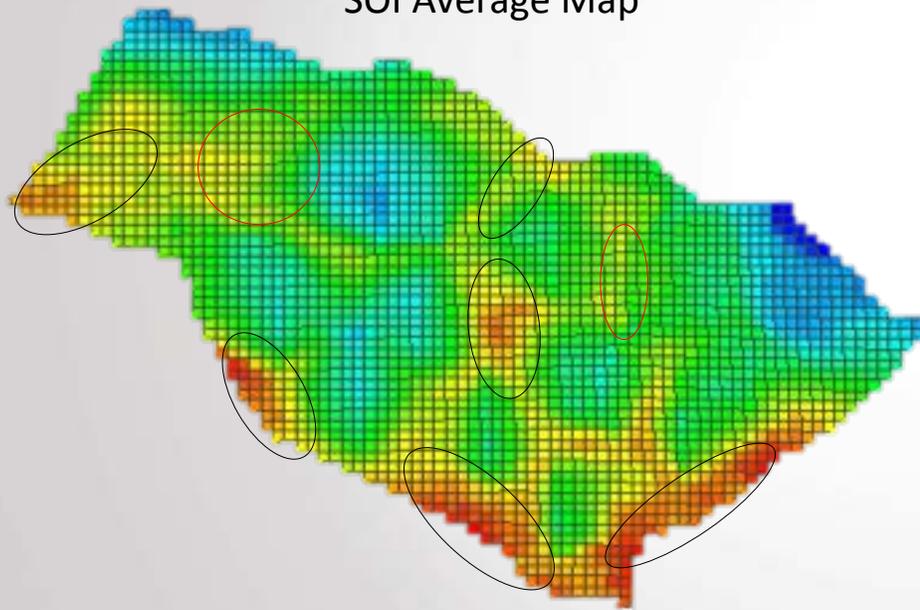
Infill Drilling Campaign

TARGETS

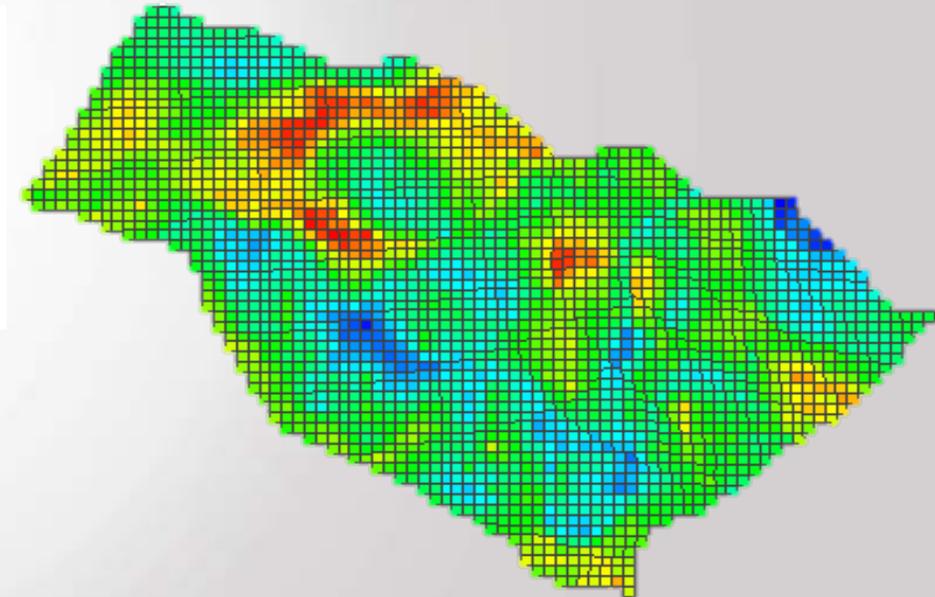
The average SOI map with the SOI standard deviation map were used to place the new wells.



SOI Average Map



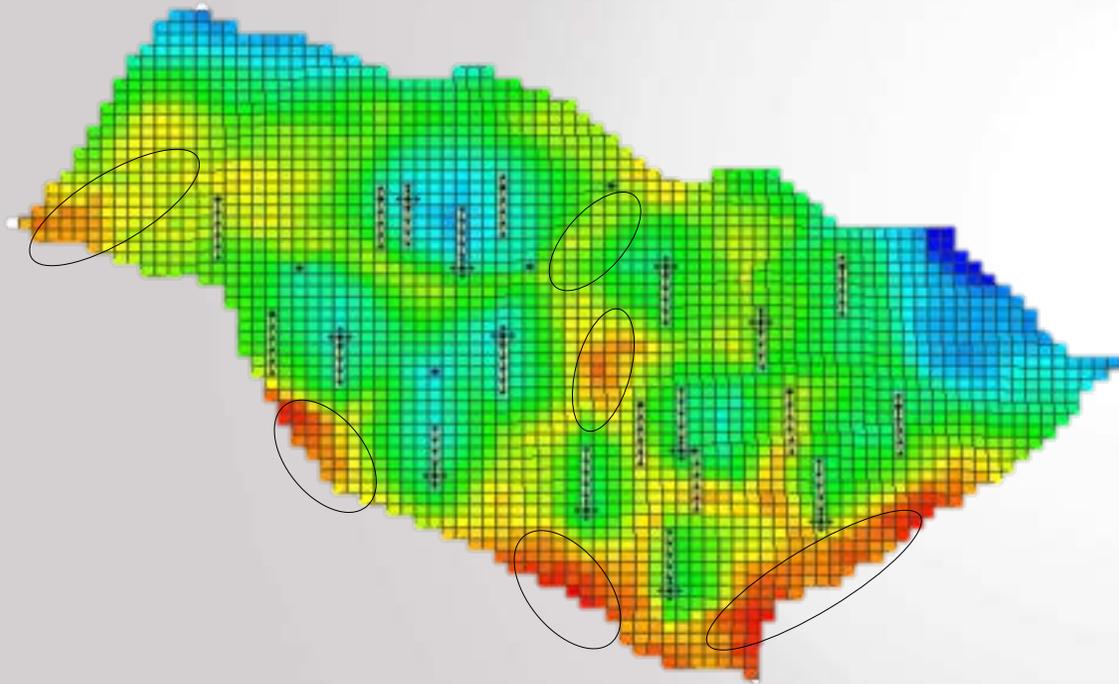
SOI Standard deviation Map



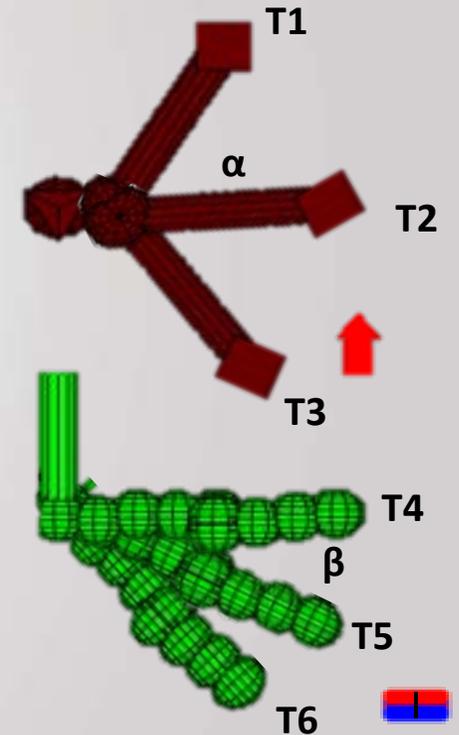
Infill Drilling Campaign

NUMBER OF WELLS & WELLS TRAJECTORIES

With the average SOI sweet spots were located, a preliminary number of wells was proposed and wells trajectories were optimised by defining 6 possible trajectories.



Well	location
PROD026A	52 52 22 27 2 2
PROD027A	43 43 29 34 2 2
PROD028A	54 54 51 56 1 1
PROD029A	38 38 44 49 3 3
PROD030A	7 7 13 18 7 7
PROD031A	22 22 34 39 2 2
PROD032A	17 17 12 17 2 2
PROD033A	44 44 48 53 3 3
PROD034A	57 57 47 51 2 2
PROD035A	44 44 19 24 2 2
INJ024A	11 11 8 13 12 12
INJ025A	22 22 13 18 12 12
INJ026A	70 70 26 31 10 10

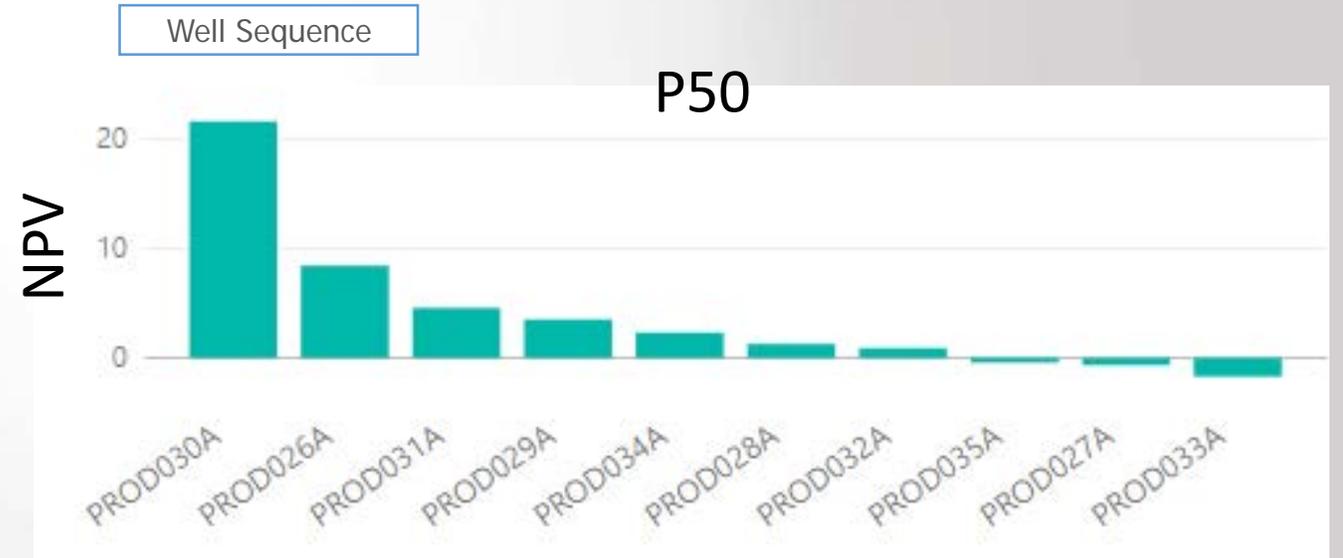
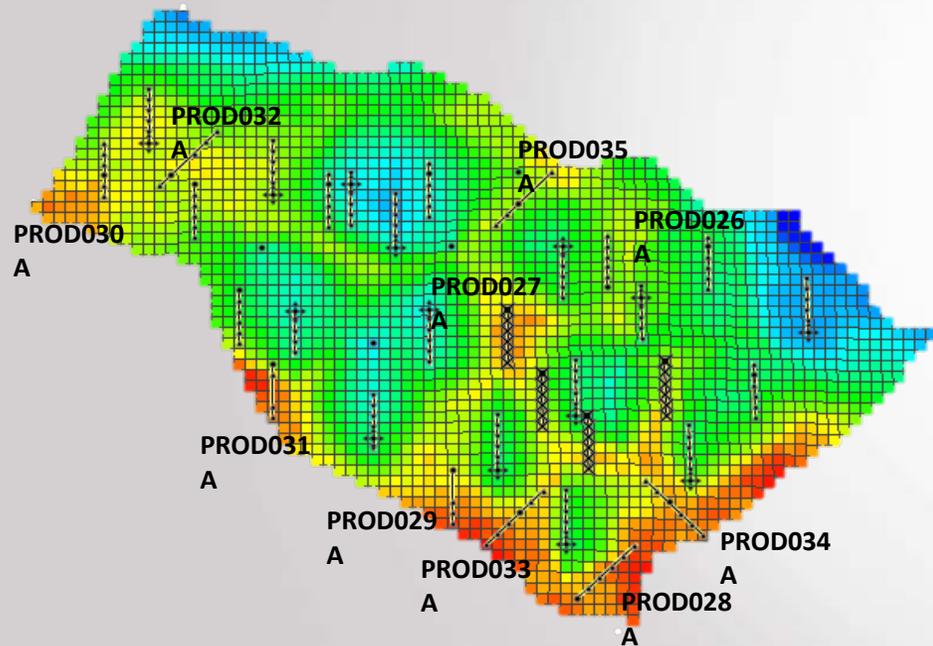


Infill Drilling Campaign

WELLS SEQUENCE

A creaming curve approach was used to rank the wells and select the best sequence based on NPV.

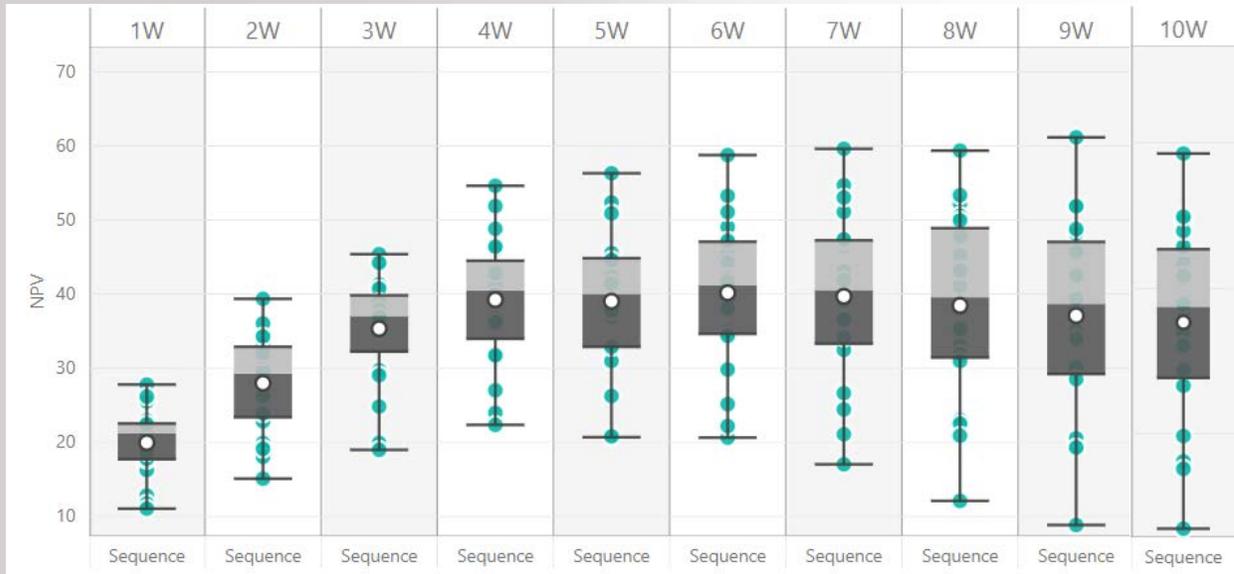
The 6 defined trajectories were assessed using the well estimated ultimate recovery as selection criteria.



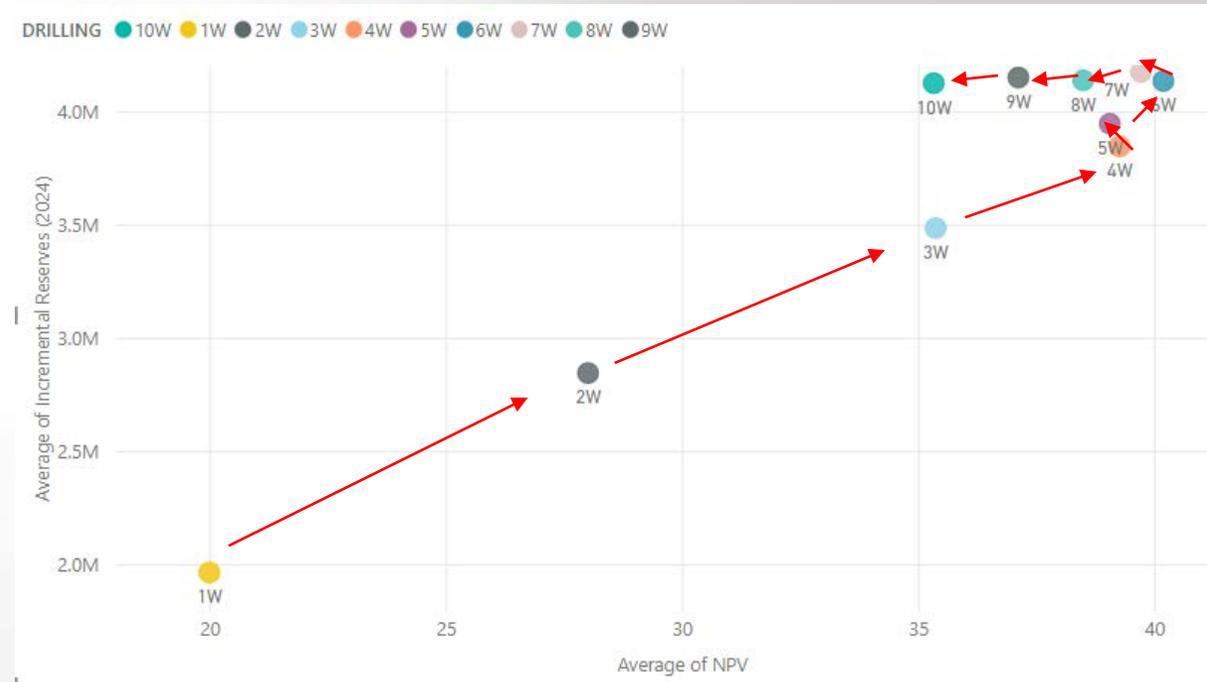
Infill Drilling Campaign

OPTIMUM NUMBER OF WELLS AND FINAL WELL SEQUENCE

Average NPV per Scenario

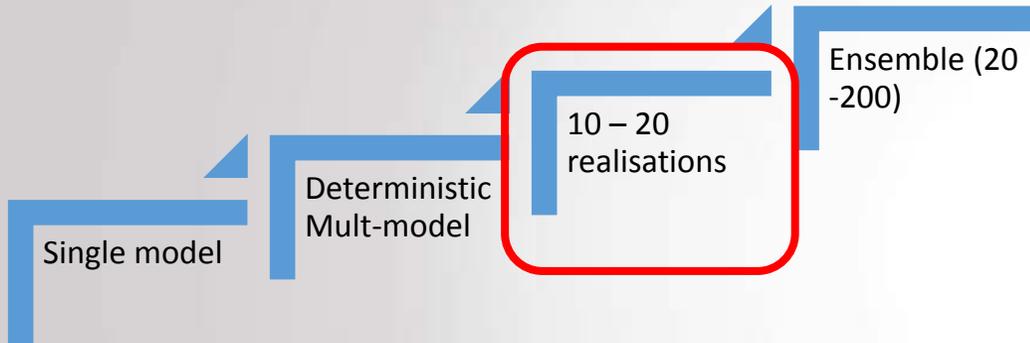


Average NPV Vs Incremental Reserves per Scenario



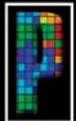
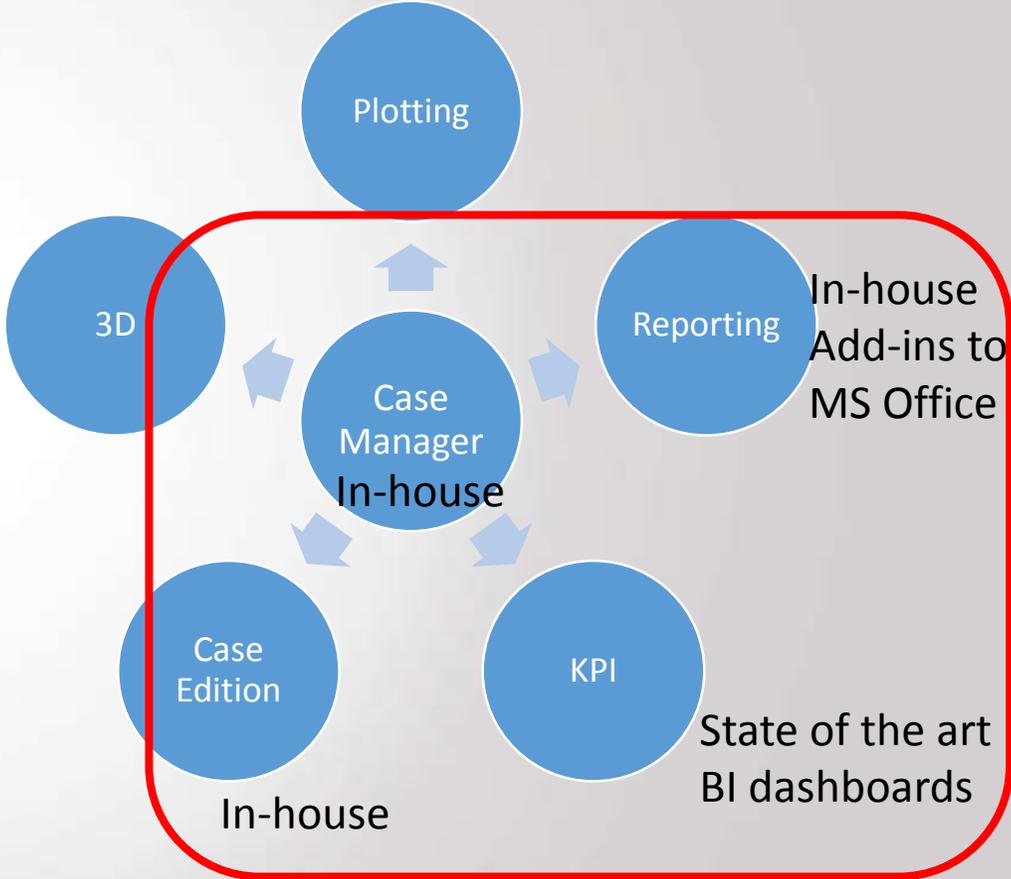
History Matching Example

MODEL



SCENARIOS

- Infill Drilling Campaign
- Drilling sequence



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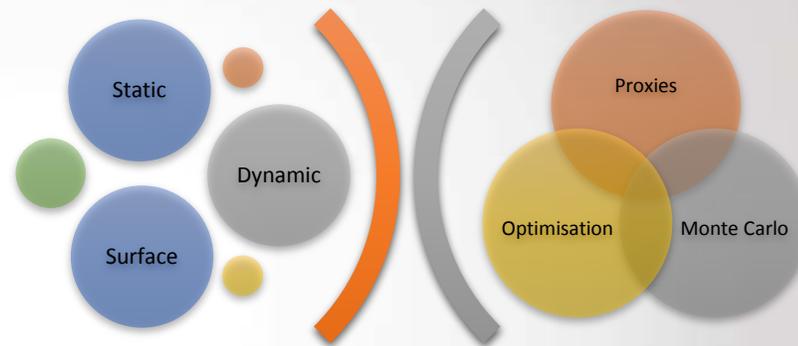
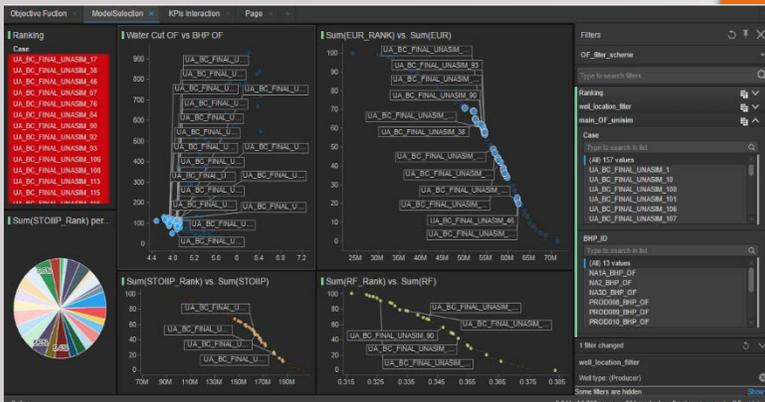


History Matching

Example: History Matching

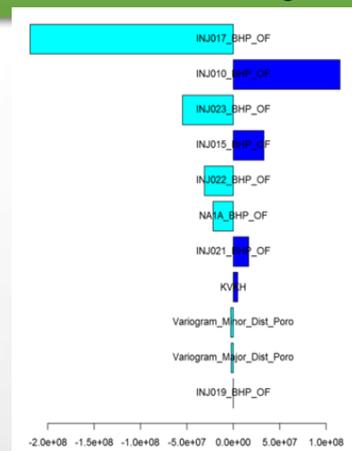
Probabilistic History Matching and Sensitivity Analysis

Uncertainty Analysis & Optimisation

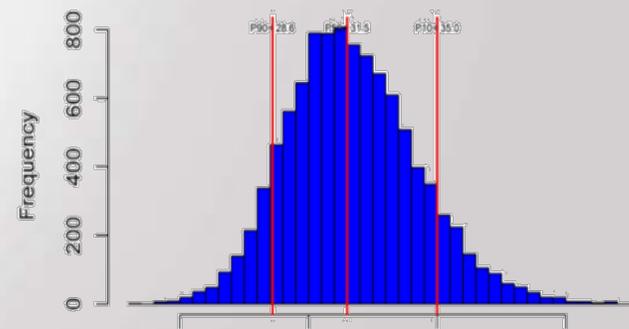


Geomodelling & Numerical Simulation

- Integrated, multi-disciplinary reservoir studies, mainly focused on quantification of subsurface and surface uncertainties around static and dynamic reservoir models.



Repr1: - Original COS - Incremental.Discouted.Barrels



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History Matching

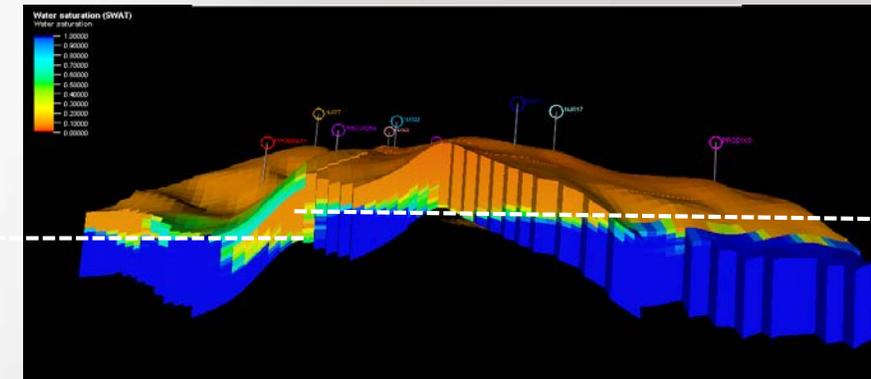
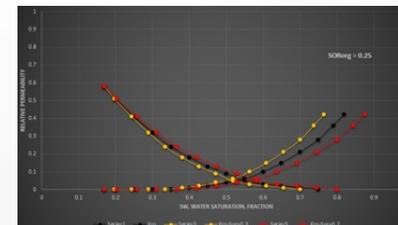
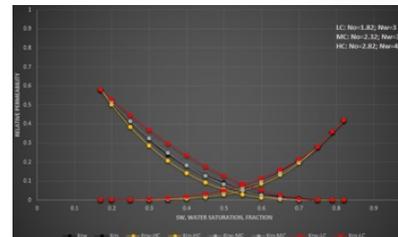
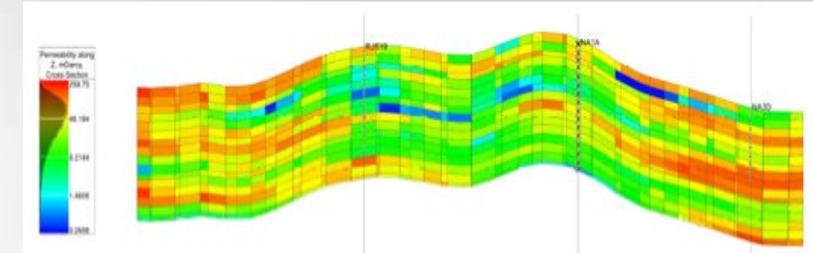
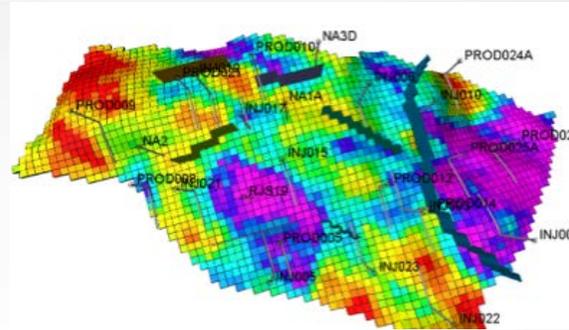
UNCERTAINTIES

Faults: Transmissibility across 7 infield faults were defined as independent uncertainties, covering the entire range from fully closed to fully open.

KVKH ratio: Vertical permeability was defined as a function of the areal permeability and a range was imposed considering the sand units.

Relative Permeability: Two core based rock types were identified with different fractional flow schemes. Corey exponents and Sors were varied

FWL: Due to the geometry of the reservoir two initial water-oil contacts were defined as independent uncertainties.



Other uncertainties related to the stochastic property population were considered, including **Minor Orientation** of the property variogram and **Mean distribution** for Porosity and Permeability.



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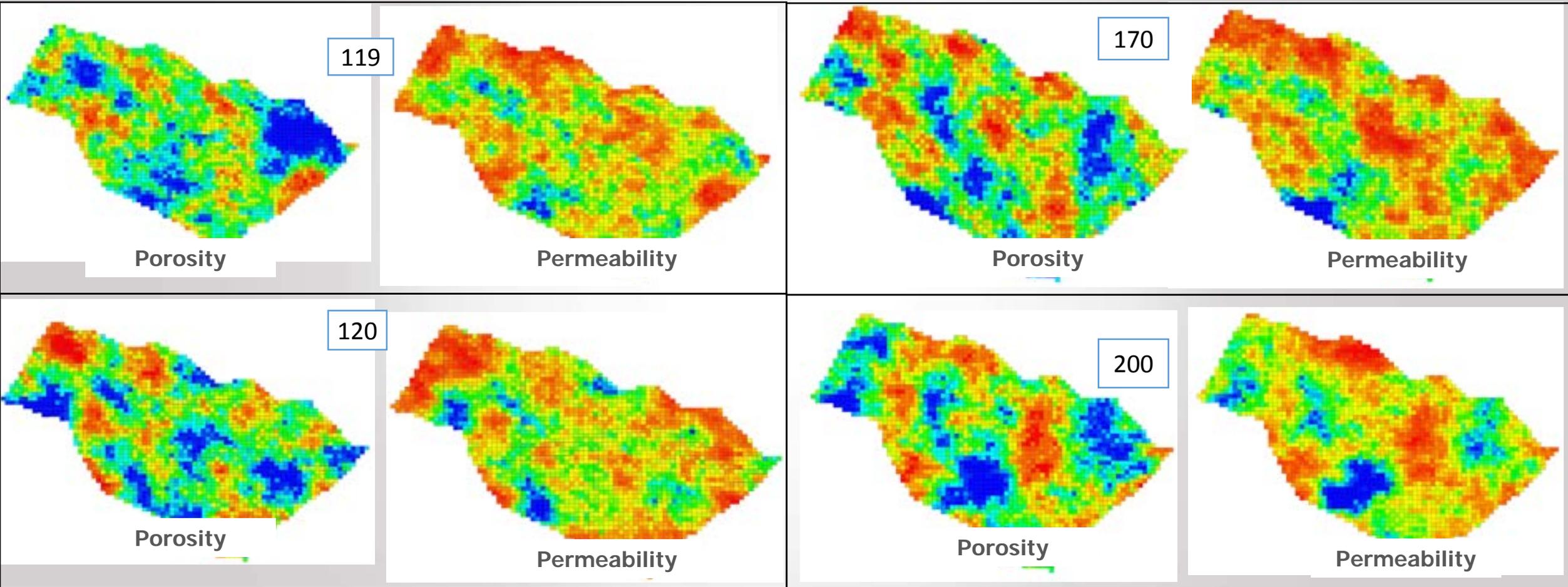
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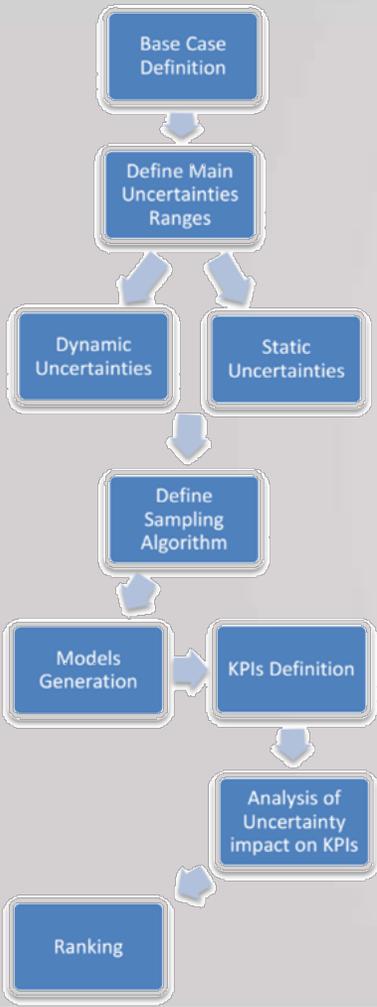
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Ensemble of models



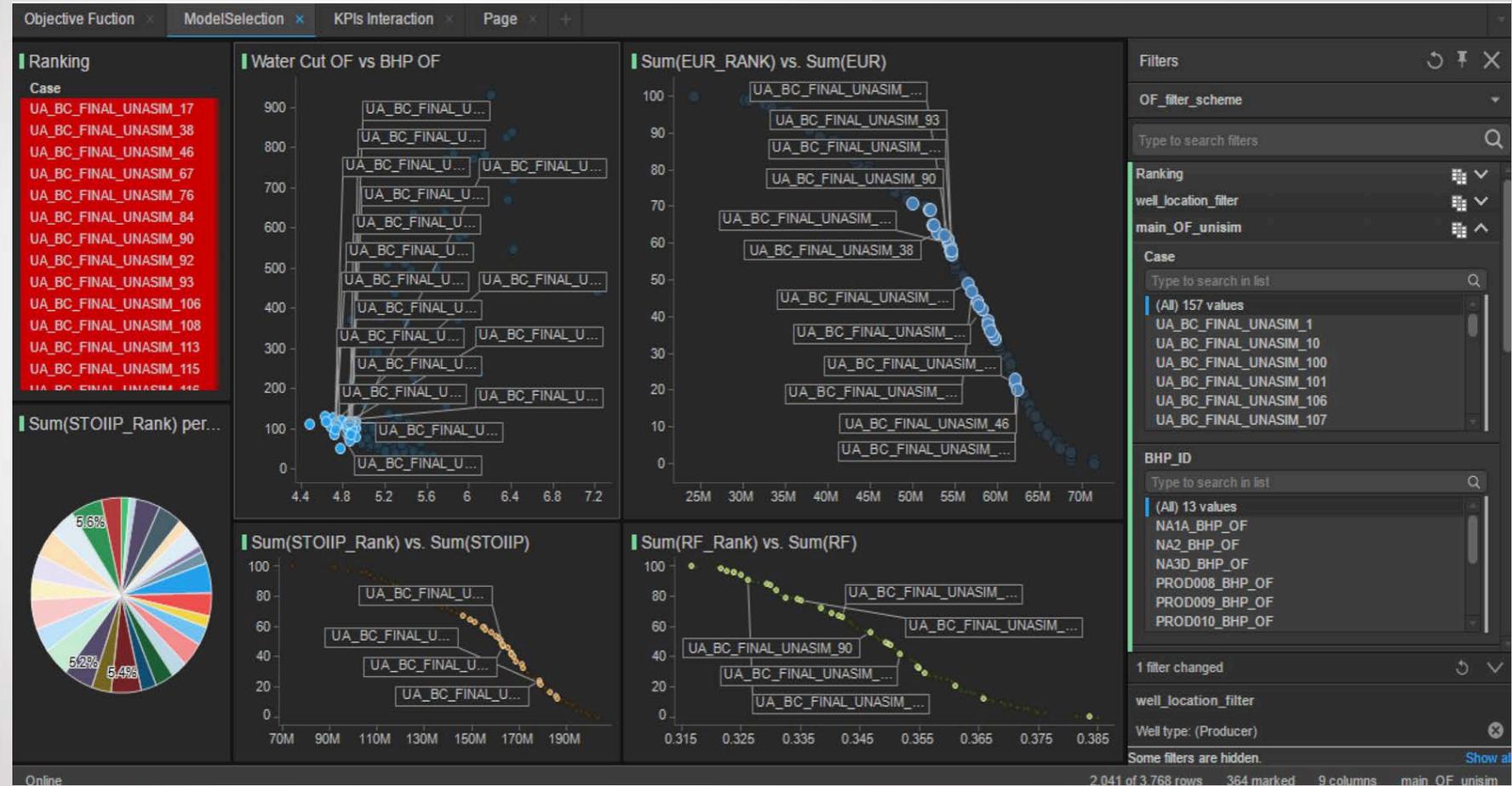
Example: Model Selection



Faults,
KVKH, FWL

Latin
Hypercube
Sampling

Water cut
& BHP



<https://goo.gl/WNqNNU>



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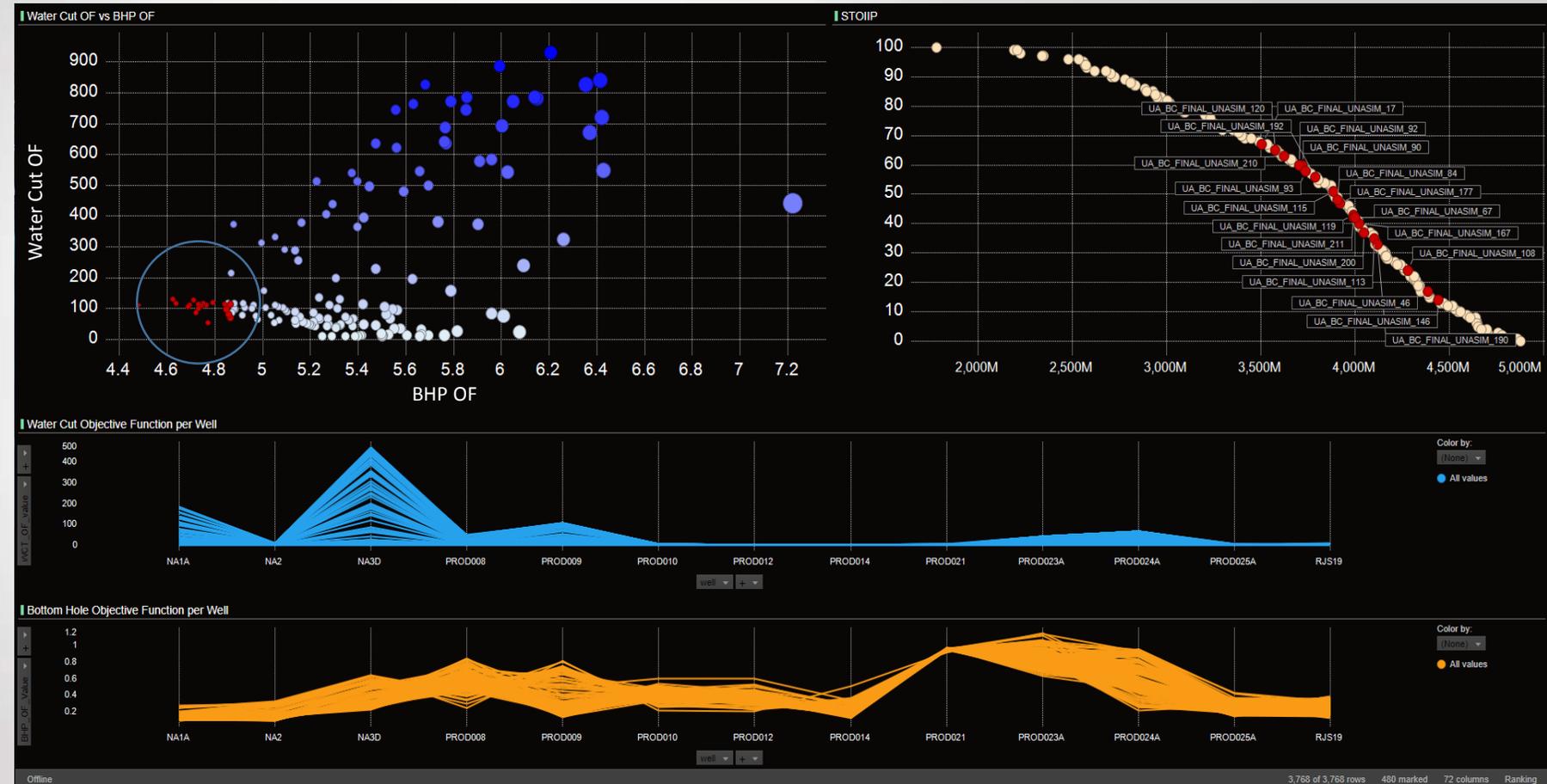
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Models Selection

From a total of 200 realisations, 20 were selected, considering as a main selection parameter the field level history matching quality.

Others KPIs such as STOIIP and connected volume were considered as well as secondary selection metrics.



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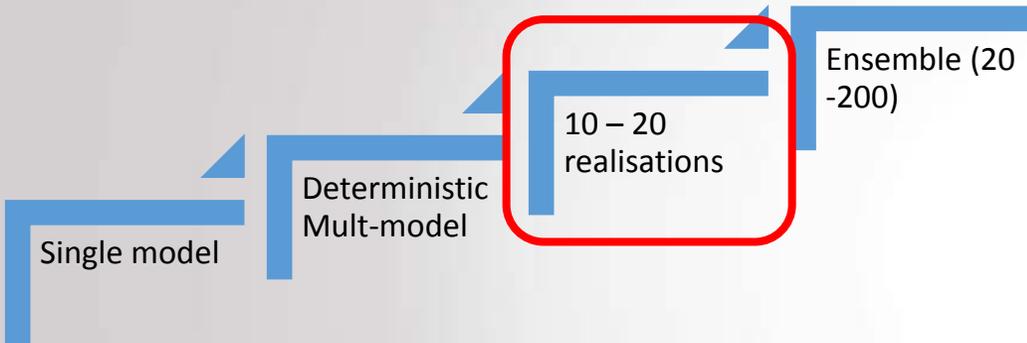
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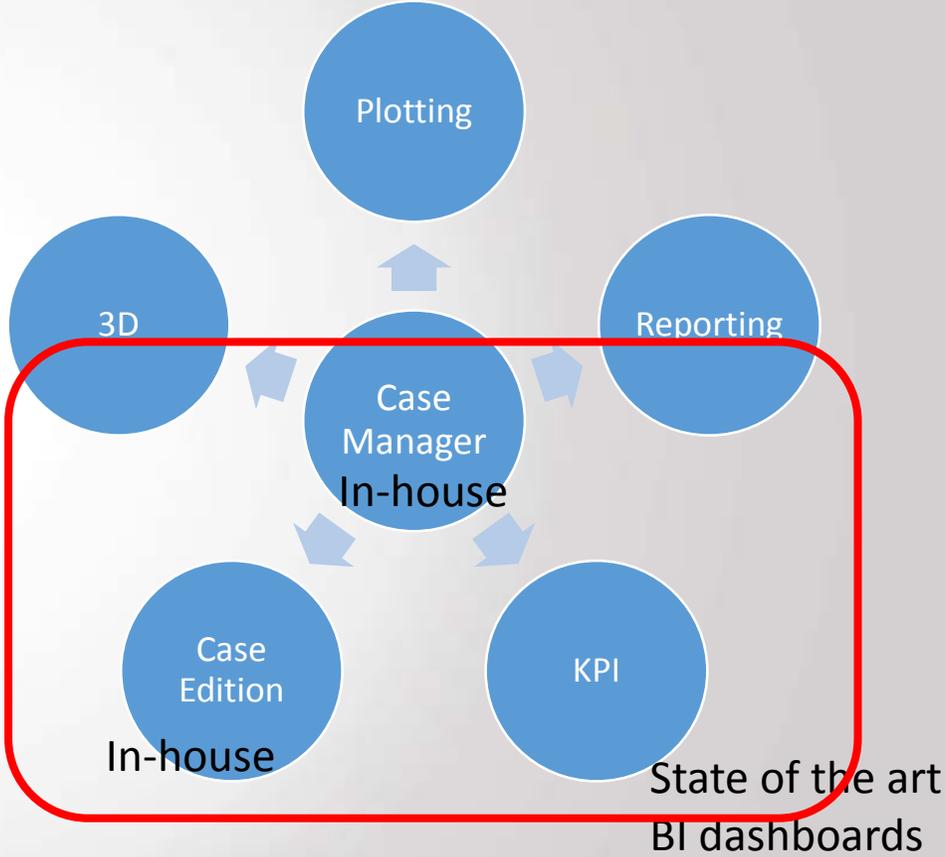
History Matching Example

MODEL



SCENARIOS

- History Matching



Enhanced Oil Recovery



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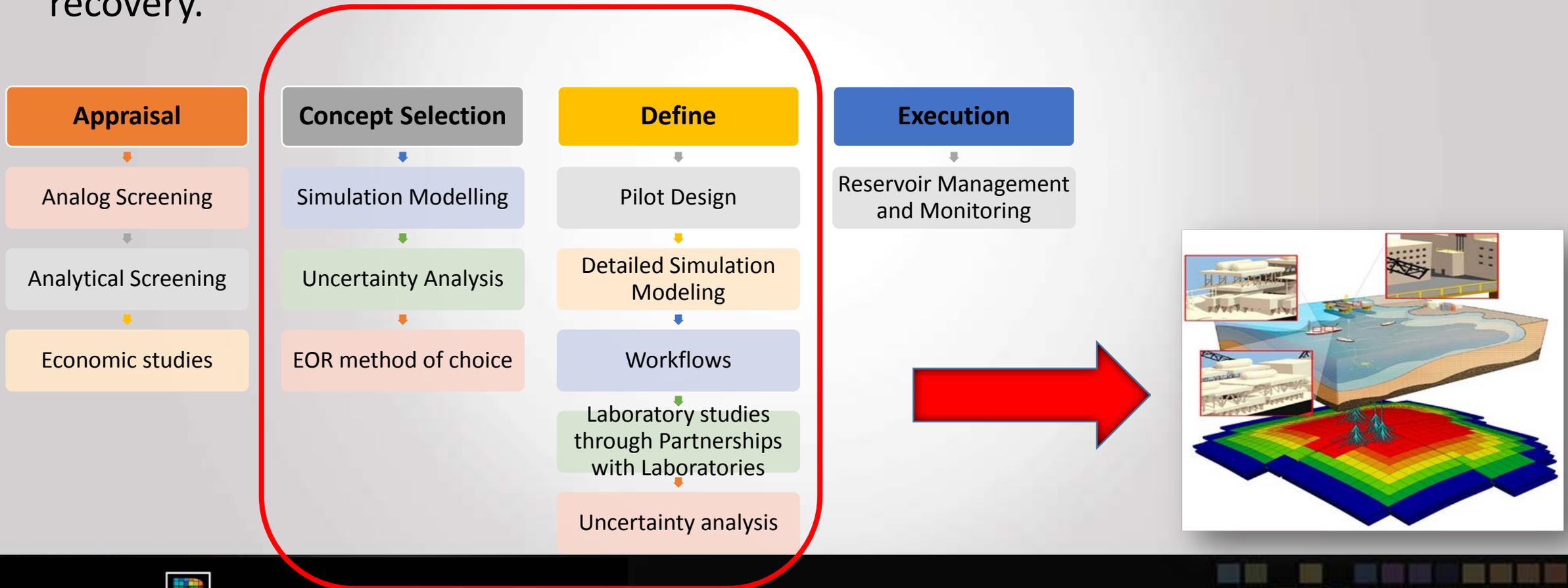
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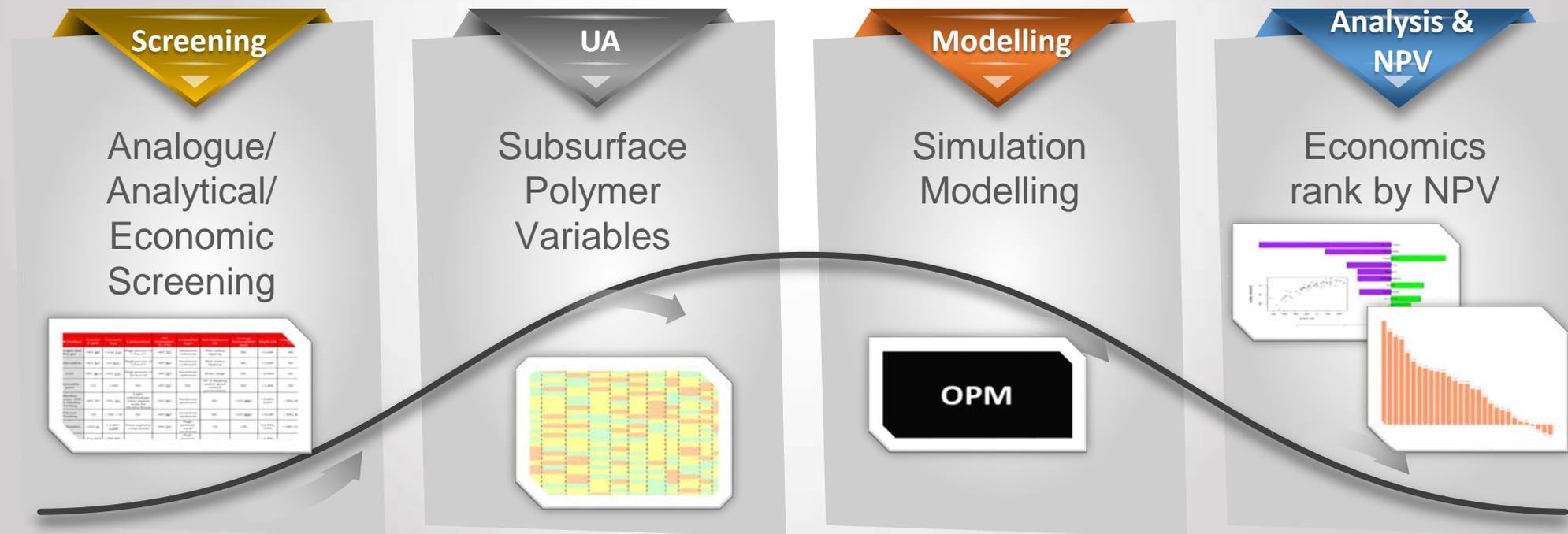
EOR: Introduction

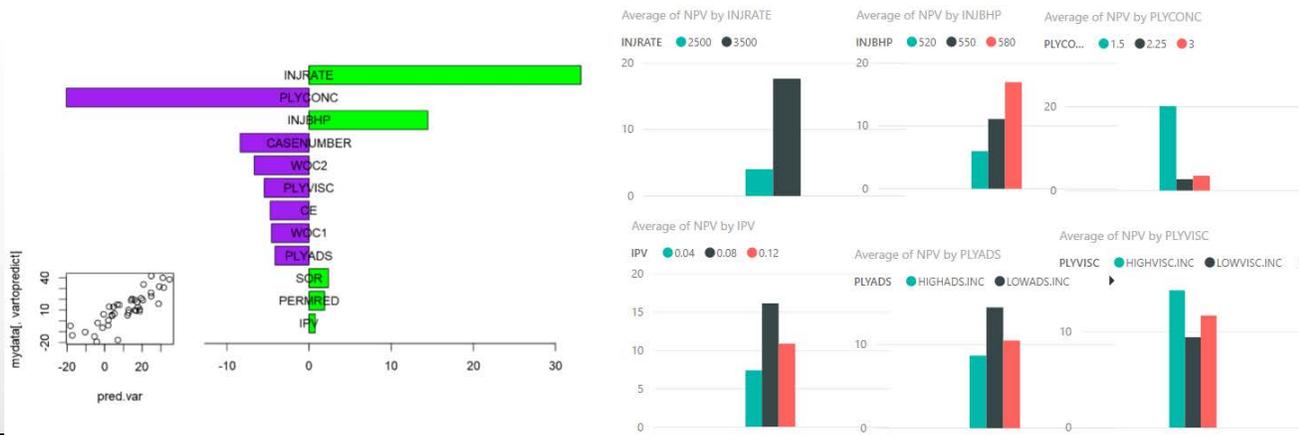
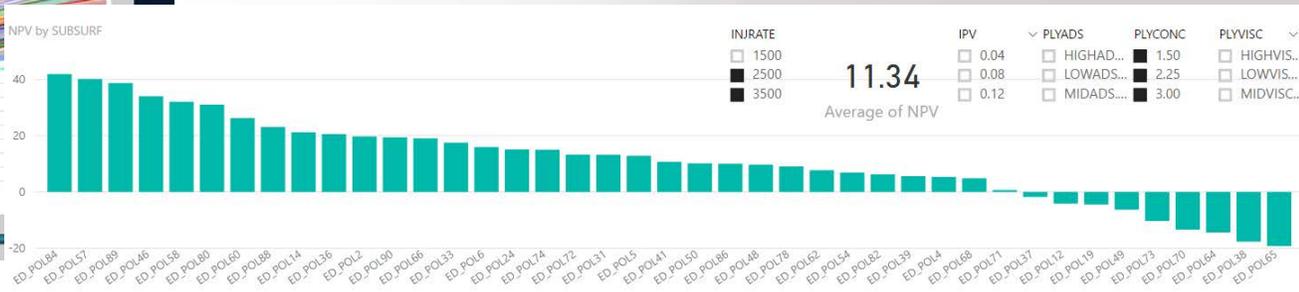
- We are focused on improving RF by bringing together leading technologies to improve water quality and injection, leading oil field chemicals and services to maximize oil recovery.



Example: Polymer Flooding

- Example of workflow shown below for an EOR campaign for an offshore field
- Workflow results in capturing of the whole uncertainty range giving client better information on which to base the decision.



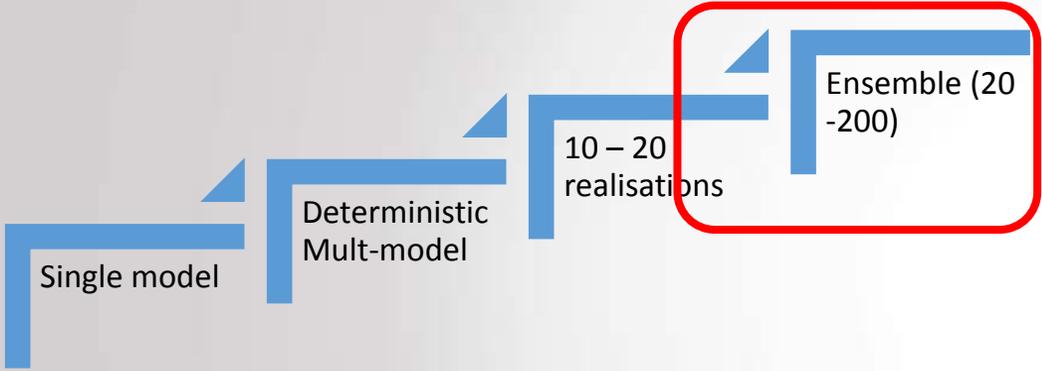


Multi-realisation performance

What is the incremental recovery of the probabilistic polymer flooding cases?

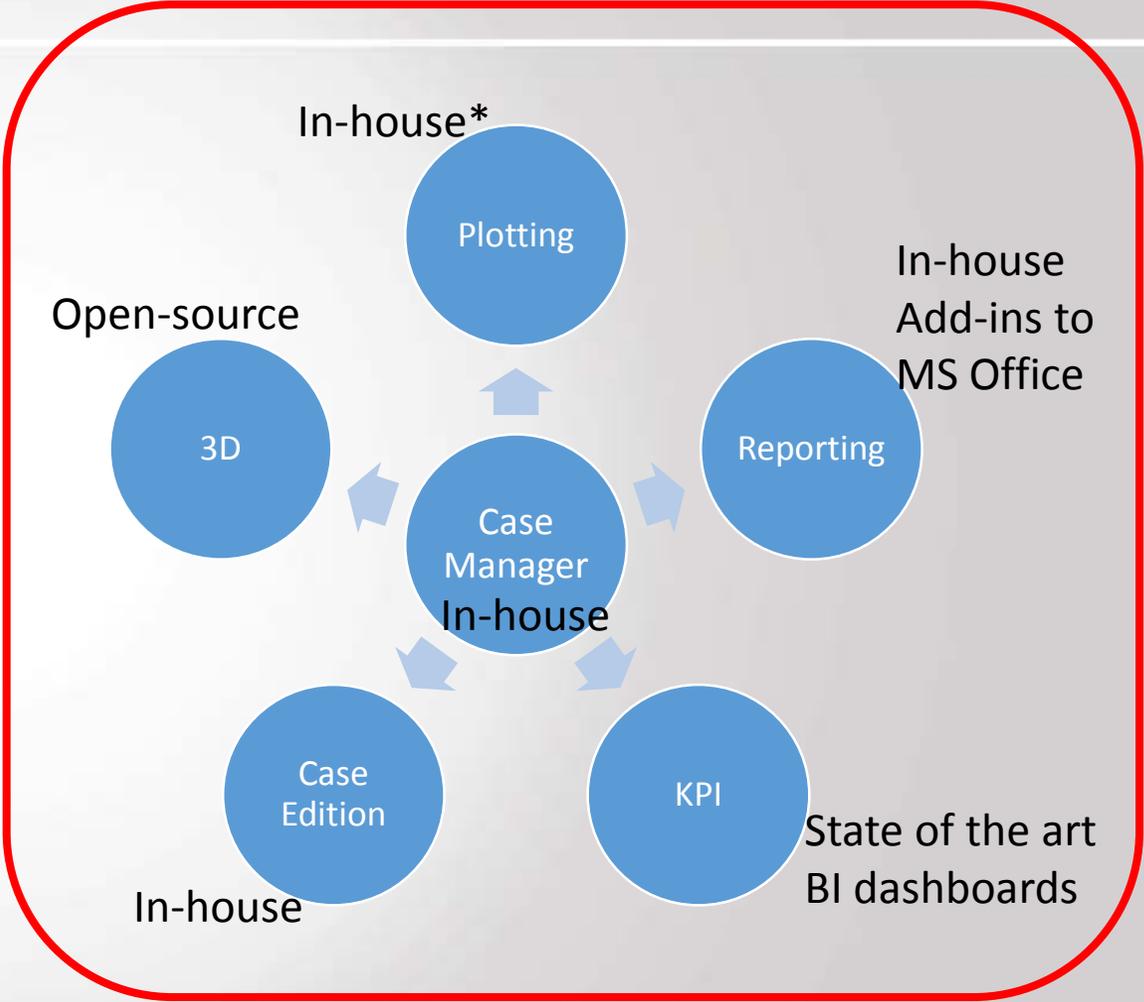
History Matching Example

MODEL



SCENARIOS

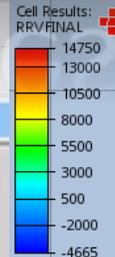
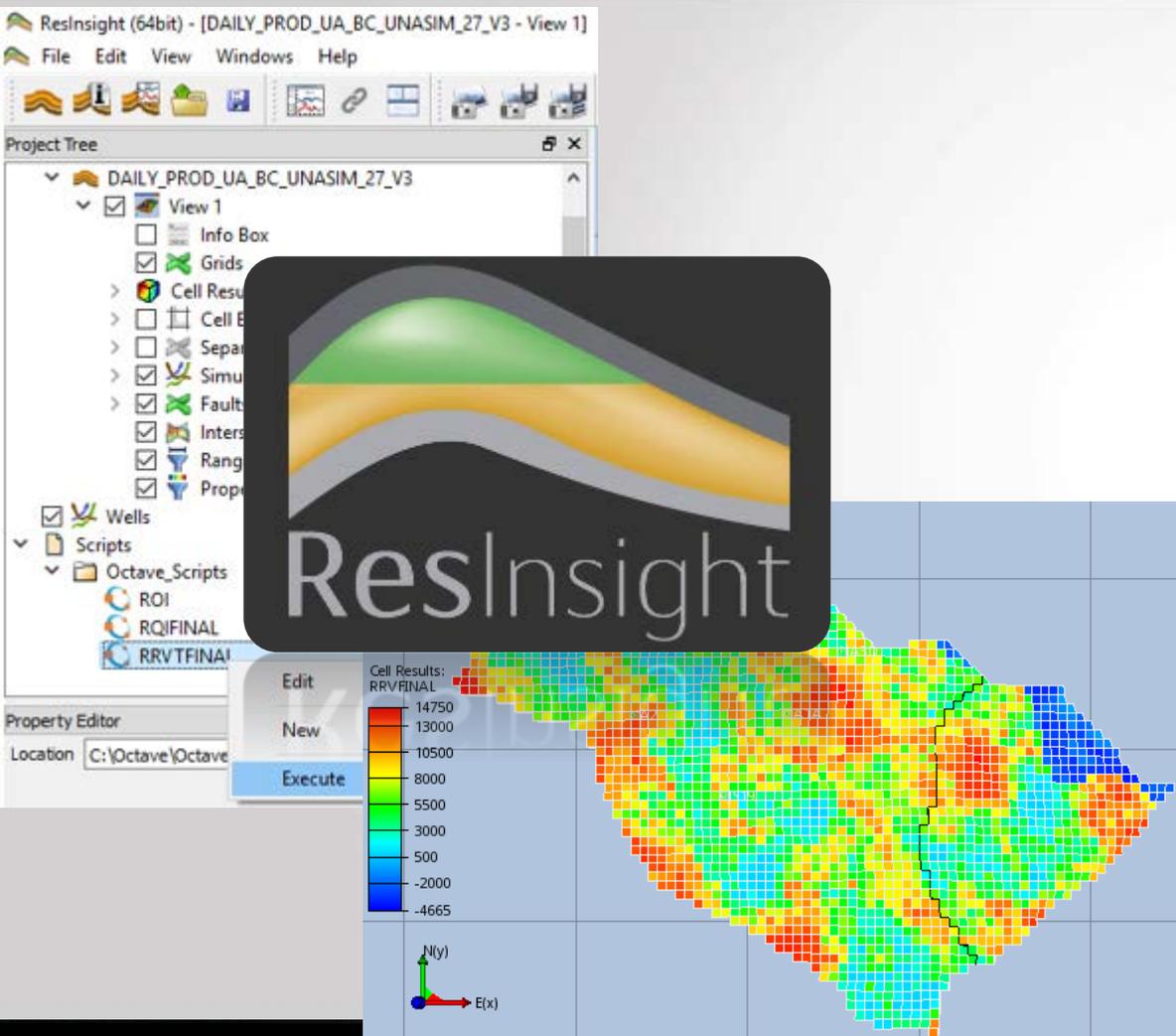
- Ranking EOR projects
- Detailed Design of Polymer flooding



Paradigm shifts

- Focus on incremental production value where applicable
- Integrate economics in your studies.
- Streamline the postprocessing of large amount of data
- Make iterations a standard practice
- There is a lot of value in open source
- Cheap could be now top notch
- Plug your results into dashboards
- KPI everything
- Implement a consistent approach to Case Management

Simulation workflows (Open Source)



$$\sqrt[3]{\left(\frac{2K}{\phi} \times 0.0314\right) \times ([So@t - Sor] \times PORV)}$$

RQIFINAL.m x

```

PORO = riGetActiveCellProperty("PORO");
PERMX = riGetActiveCellProperty("PERMX");
SOIL = riGetActiveCellProperty("SOIL");

RQI2 = ((PORO./PERMX).^0.5)*0.0314
RQIFINAL=SOIL

columns(SOIL))

RQIFINAL(:,i:i) = RQI2;

riSetActiveCellProperty(RQIFINAL, "RQIFINAL");
                
```

$$\sqrt[3]{\left(\frac{2K}{\phi} \times 0.0314\right) \times ([So@t - Sor]}$$

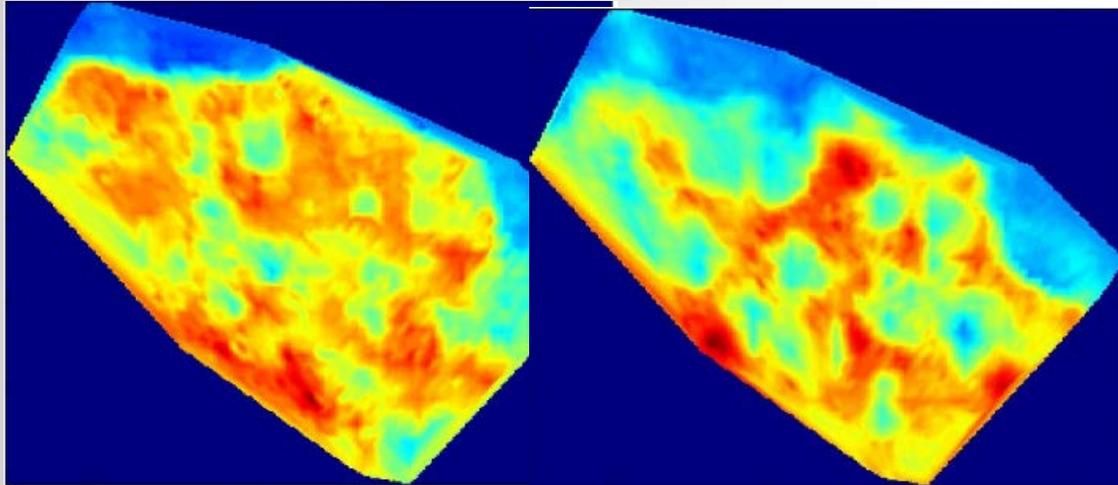
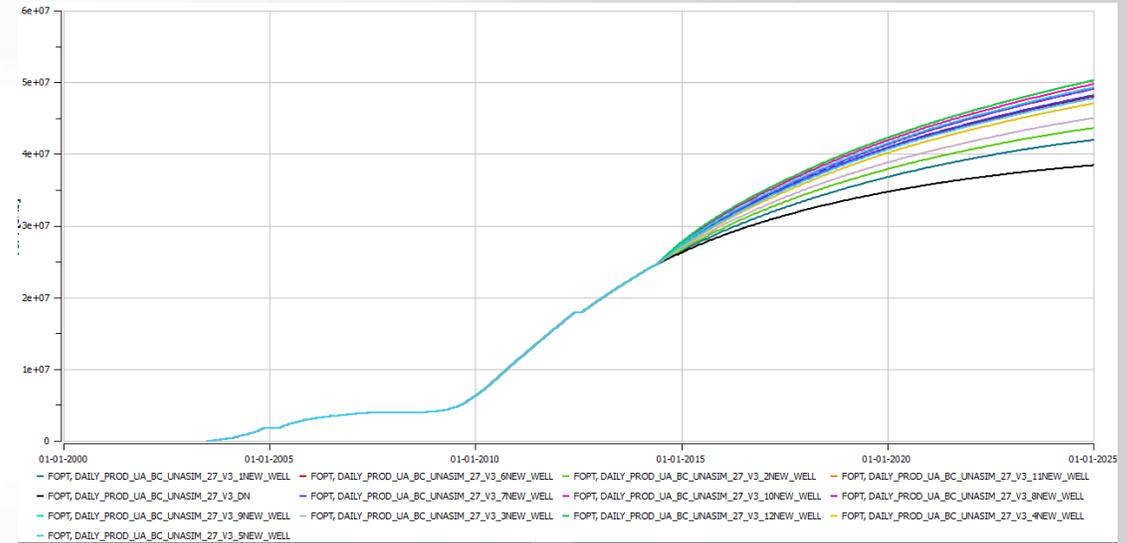
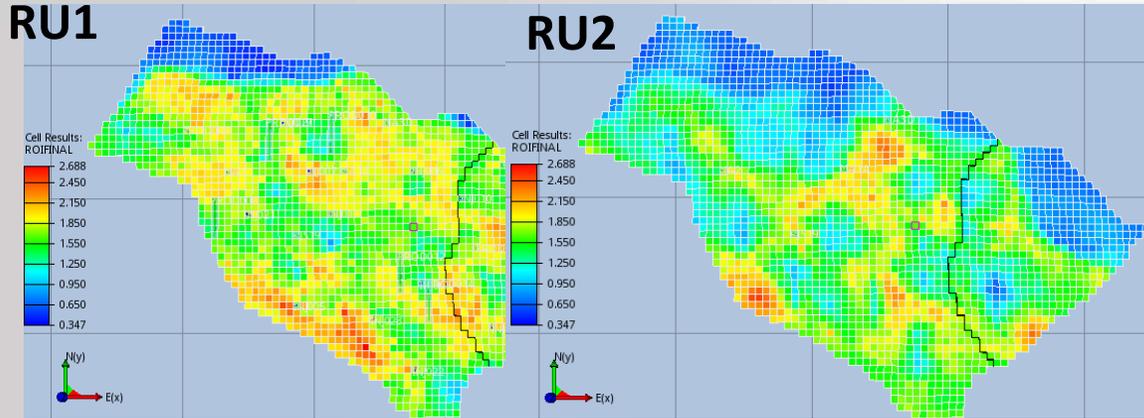
```

riSetActiveCellProperty("SOIL");
riSetActiveCellProperty("PORV");
.L;

for i=(1:columns(SOIL))
    SOILDIF(:,i)= SOIL(:,i)- 0.2;
endfor

RRVFINAL = ((SOILDIF).*PORV);
riSetActiveCellProperty(RRVFINAL, "RRVFINAL");
                
```

Simulation workflows (Open Source)



	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9	Well 10	Well 11	Well 12
X	352736	354654.7	355115.7	356528.1	355182.2	354212.9	355427.8	353474.7	354184.5	354916.7	355023.3	355102.1
Y	7518408	7515196	7517594	7515474	7517568	7516970	7515563	7515681	7517028	7516861	7514857	7517453
Reservoir Unit	1	1	1	1	2	2	2	2	3	3	3	3
Sum ROI within 300metres	769.2799	885.8232	789.6046	769.7736	848.6185	737.9046	771.6636	836.5811	770.8262	744.0045	731.2544	649.8435
Well Ranking for runs	8	1	4	7	2	10	5	3	6	9	11	12



DATA FILES >>

BRILLIG R

+ Add

ID CLASS

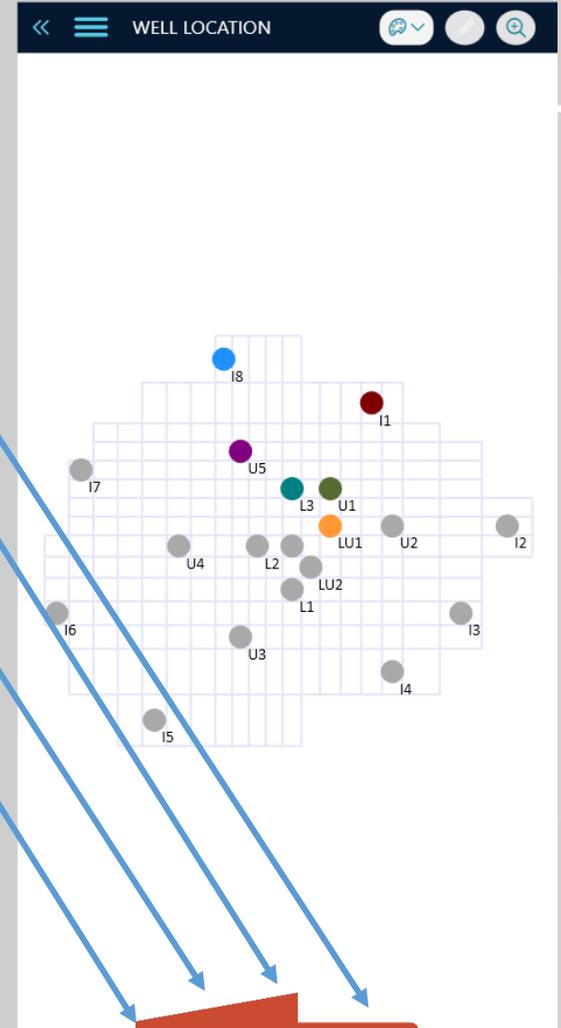
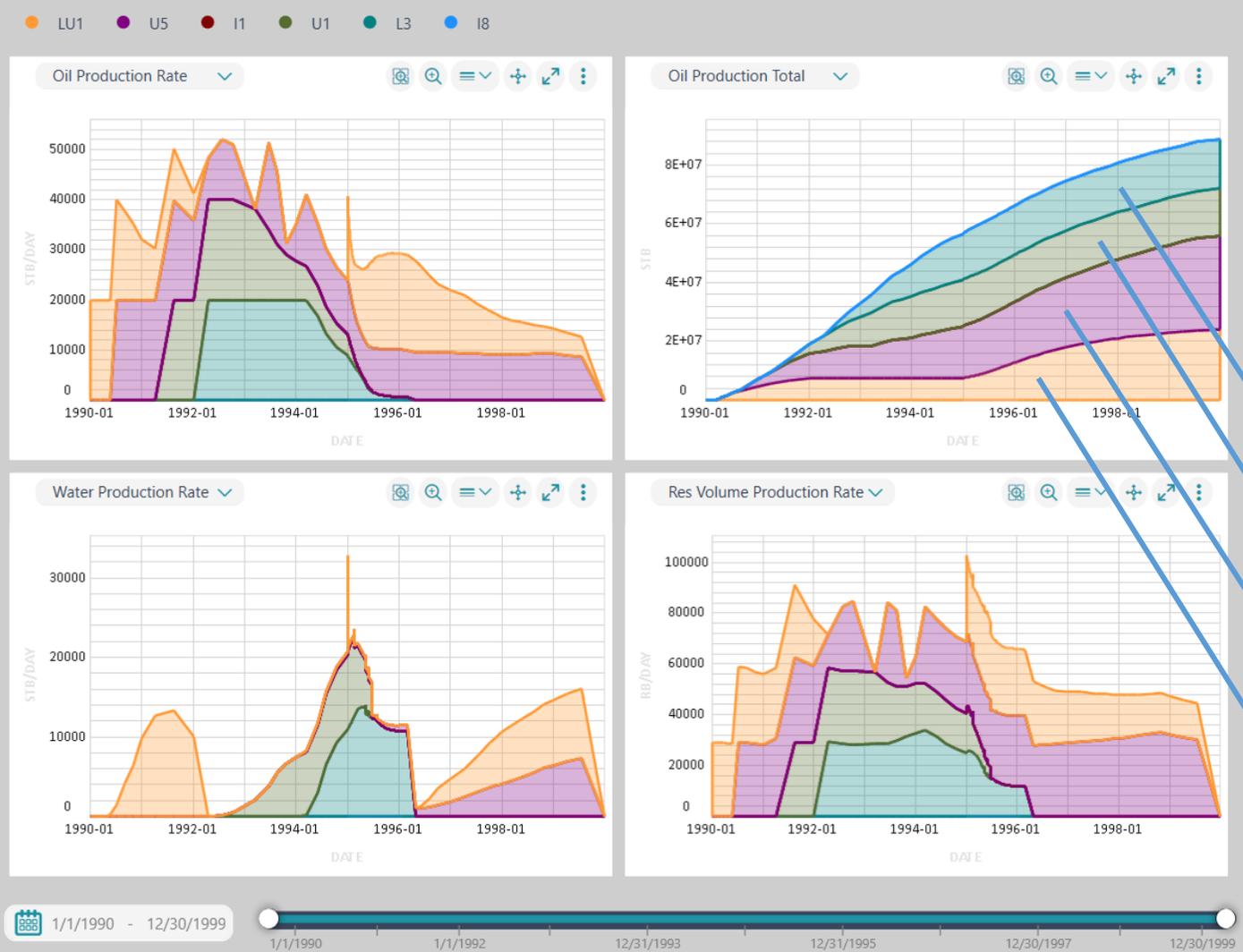
- Field
- Group
- Well
- Completion
- Connection

ID LIST

Alphabetic

Filter by Name

- LU1
- G1
- I1
- I2
- I3
- I4
- I5
- I6
- I7
- I8
- L1
- L2
- L3
- LU2
- U1



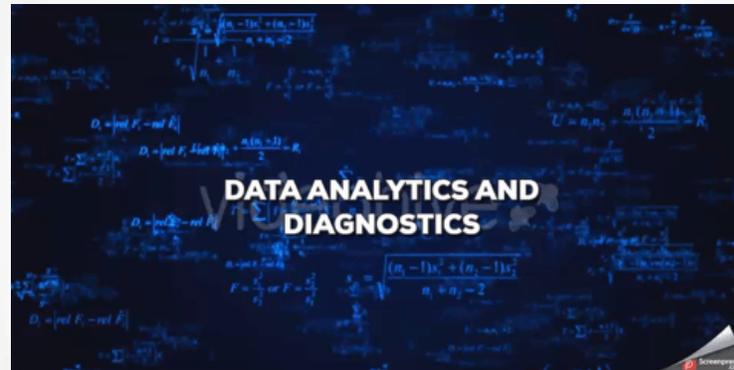
Relevant Reservoir Engineering Analysis



Visualisation & Data analytics



Key Performance Indicators in a Dashboard



Data Analytics



Specialised Data Driven Analysis

- Reservoir Management



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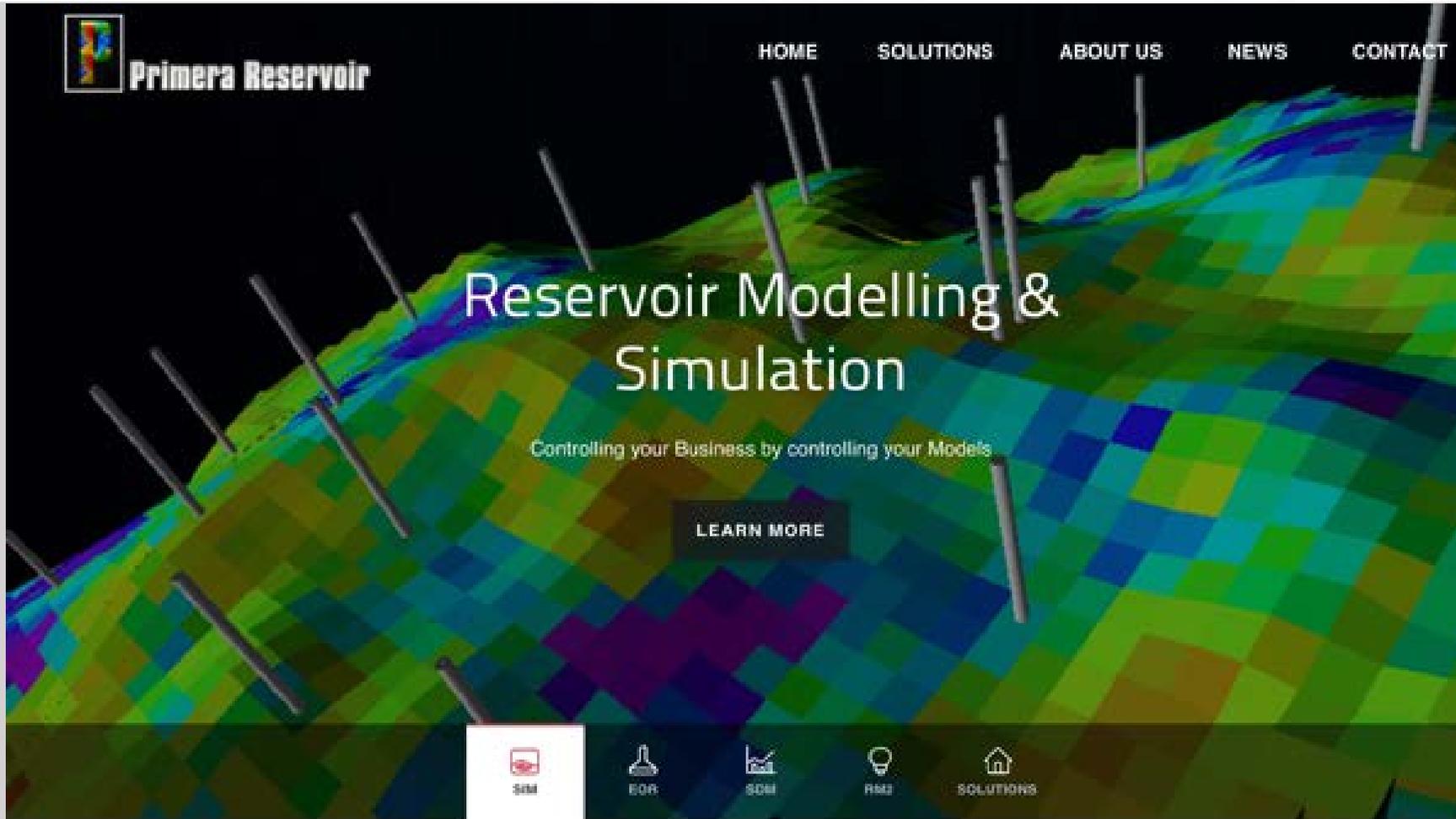
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Thank you



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