DEVEX 2026

Incompatible Fluids Can Re-introduce Formation Damage Post a Successful Stimulation Job – case history

Baker Hughes

29th April 2026

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Background – Case History

- Field in Caspian
- Multi-layered reservoir
- Cased and Perf Completion
- Low rate producing wells

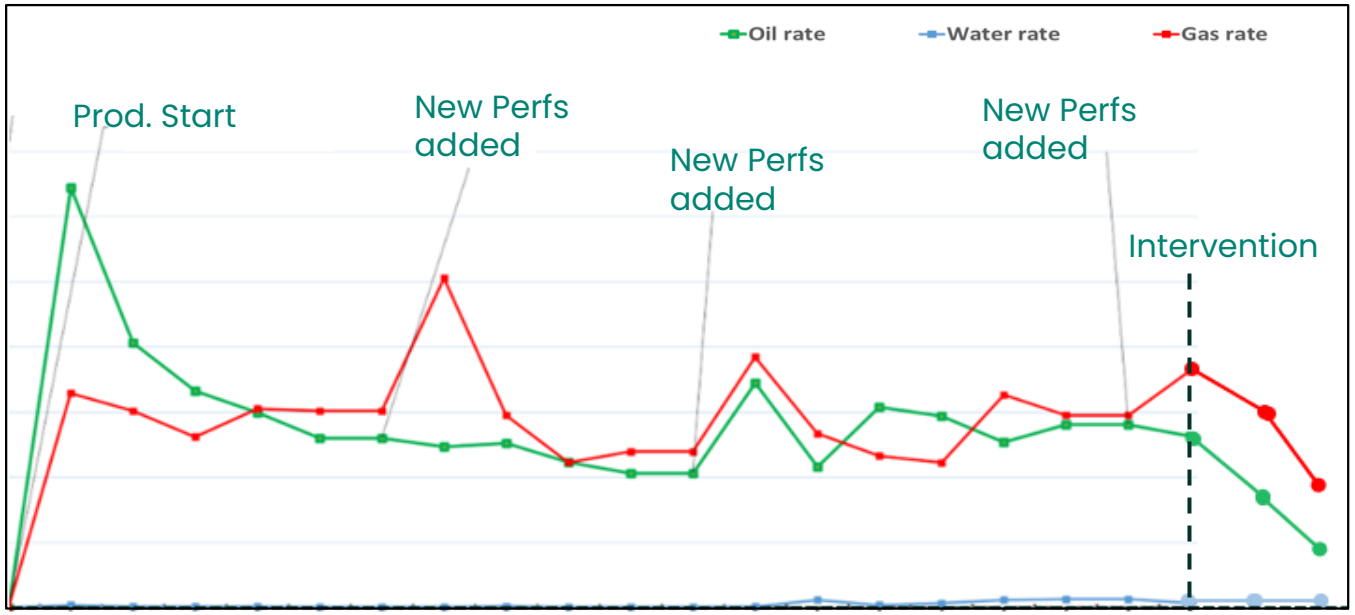
Objective

- Improve Flow production
  - ❑ New Technology Trial

Challenge

- Intervention resulted in reduction in flow

Production History



What caused the negative impact?

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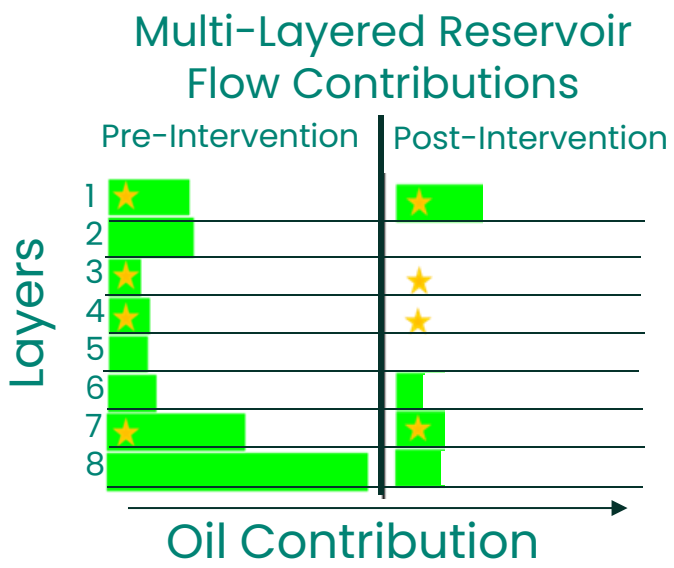
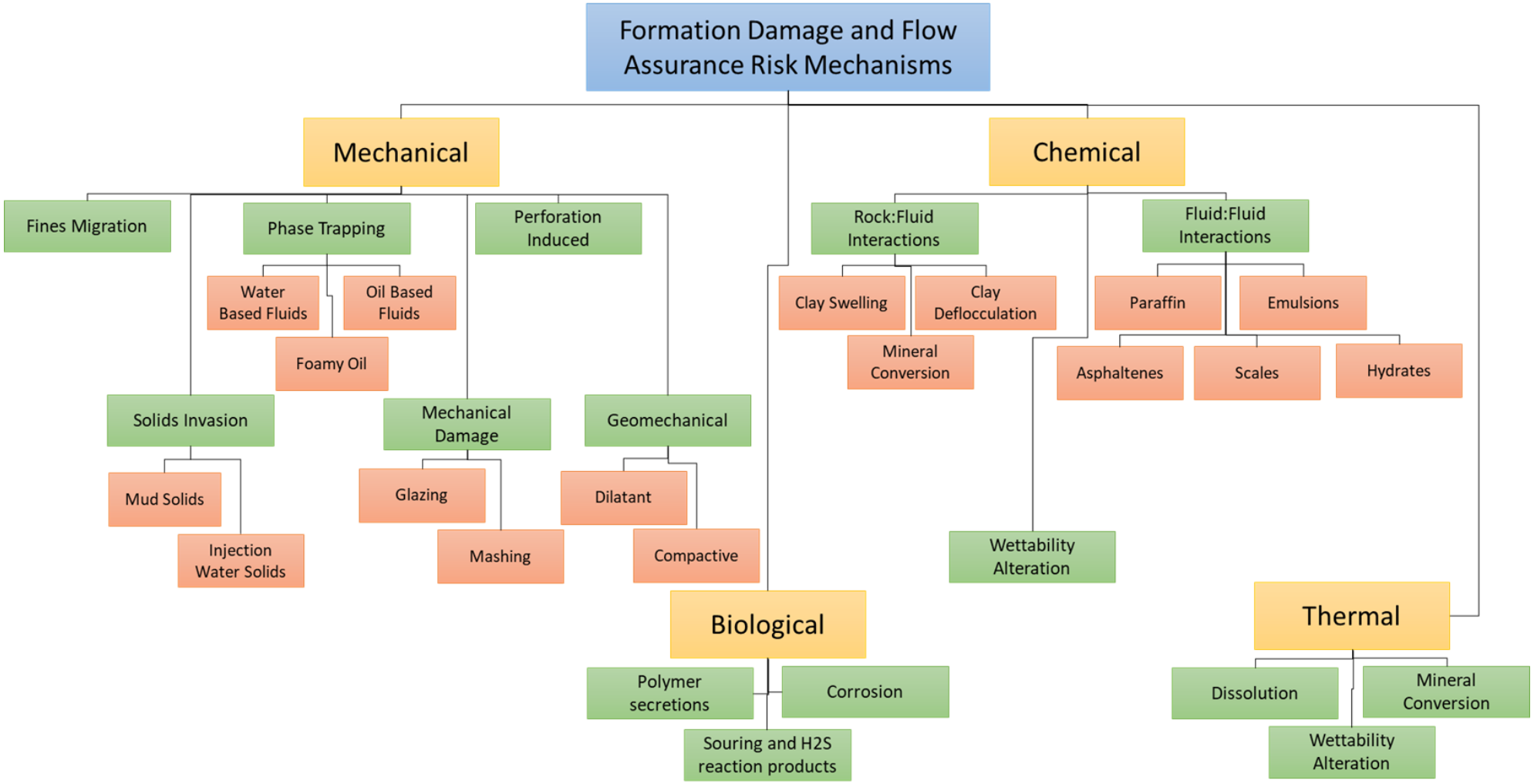
Investigation

- Is it
  - The Intervention solution?
  - Operational issue?
- PLT had indicated damage to nearly all intervals
  - Impact on Intervals that weren't even intervened
- Incompatible fluids?
- Re-introduce Mechanical Formation Damage?



Underperformance Cause Identification



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XRD Data

- The red square highlights the most concerning clay type, illite
- It is notorious for fines related impairment
- Formation Damage Index (FDI)
  - The score of 7 to 8 indicates a high potential impairment to permeability

Illite

Formation Damage Index

Sample	ite/Smecti	Illite+Mica	Kaolinite	Chlorite	Quartz	K Feldspar	Plagioclase	Calcite	Dolomite	Siderite	Pyrite	Total	FDI
6	0.2	13.9	TR	3.2	58.5	3.4	8.2	10.9	1.7	0	0	100	
12	0.2	11.7	TR	2.9	59.6	4.5	9.1	10.7	1.3	0	0	100	
26	0.3	11.3	TR	2.7	59.4	4.1	8.9	11.9	1.4	0	0	100	7
30	0.2	10.6	TR	3	60.5	4.4	9	11.1	1.1	0	0	100	
46	0.4	10	TR	3.9	61.8	4.1	8.8	9.5	1.5	0	0	100	
54	0.2	9.1	TR	2.8	63.1	3.7	9.1	10.5	1.5	0	0	100	8
72	0.4	14.5	TR	3.1	57	4	8.8	10.7	1.6	0	0	100	
134	0.7	13.5	TR	3.6	57.7	4.6	8.5	10.1	1.3	0	0	100	7
154	TR	11.5	TR	2.8	61.2	5.3	8.6	9.3	1.3	0	0	100	
186	TR	11.4	TR	2.6	59.6	3.8	8.4	13.1	1.1	0	0	100	
214	TR	14.3	TR	3.3	57.4	4.2	8.3	11.2	1.3	0	0	100	
230	0.4	8.4	TR	2.9	60.1	4	8.3	13.8	2.1	0	0	100	
266	TR	7.6	TR	2	59.1	4.9	7.4	16.7	2.4	0	0	100	
318	0.4	9.1	TR	2.6	60.6	4.4	8.9	11.5	2.5	0	0	100	
322	1	7.4	TR	1.8	62.2	4.5	8.1	12.3	2.8	0	0	100	
323	0.6	6.1	TR	1.8	65.1	4.6	8.1	11	2.8	0	0	100	
335	1.1	8.3	TR	2.4	64.7	4.7	8.3	8.7	1.8	0	0	100	8
350	0.6	7.1	TR	2	64.1	5.1	10.3	9.3	1.7	0	0	100	
351	0.4	8.2	TR	2.2	65.7	4.3	9	9.1	1.3	0	0	100	
372	0.9	8.9	TR	1.9	62.7	5.2	8.7	10.1	1.5	0	0	100	
379	0	9.7	TR	2.3	58.7	4.6	7.6	15.5	1.6	0	0	100	
397	0	7.9	TR	2.2	62.5	4.4	8	13.7	1.2	0	0	100	
398	TR	9.1	TR	2.2	61.4	4.1	8.4	13.6	1.3	0	0	100	
402	0.4	15.9	TR	2.7	56.3	4.2	7.5	11.6	1.4	0	0	100	7
410	0.6	14.3	TR	3.2	55.1	5.1	9.8	10.3	1.6	0	0	100	
422	0.9	17.5	TR	3.6	53.3	5.2	8.6	9.4	1.6	0	0	100	
424	TR	8.3	TR	2.8	58.3	3.9	9.8	14.7	2.2	0	0	100	8

FDI based on SPE 14317, P.B. Basan Qualitative Assessment

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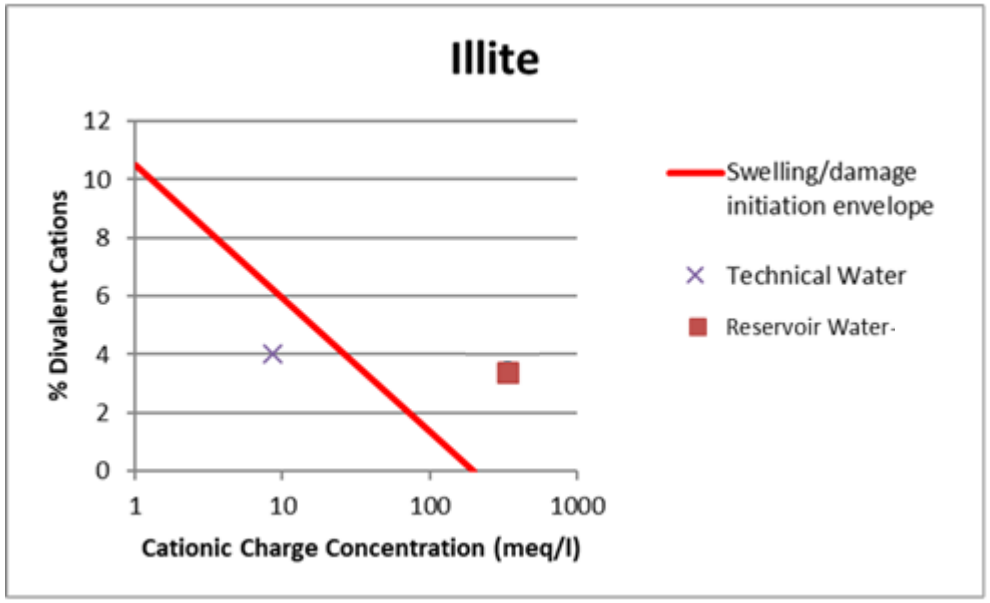
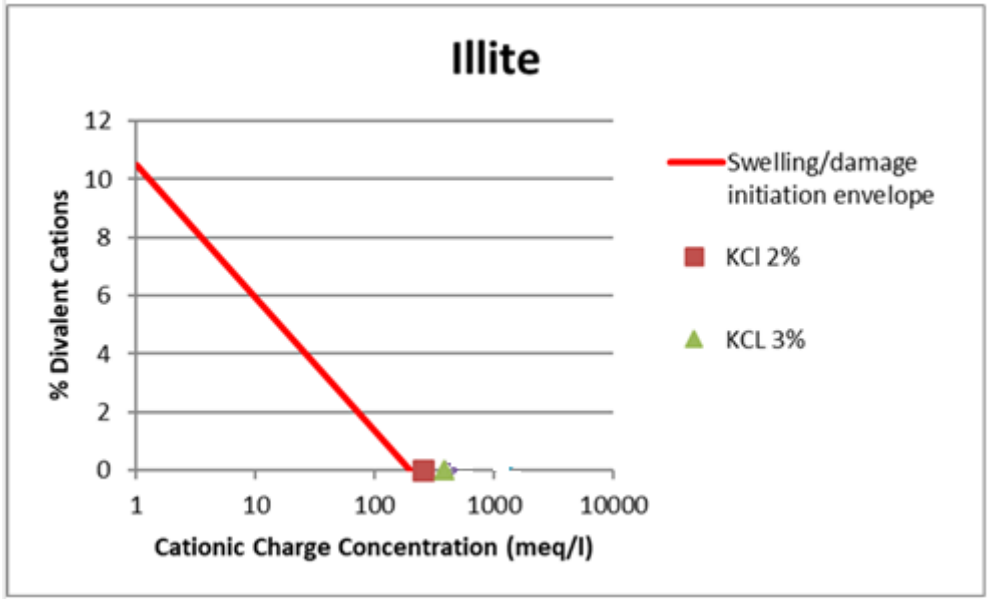
Compositional Fluid : Clay Compatibility

Reservoir & Technical Water



Technical water application would introduce instability in the clay

KCl



KCl (Intervention fluid) application would not introduce instability in the clay

Based upon Schuerman and Bergerson, 1990

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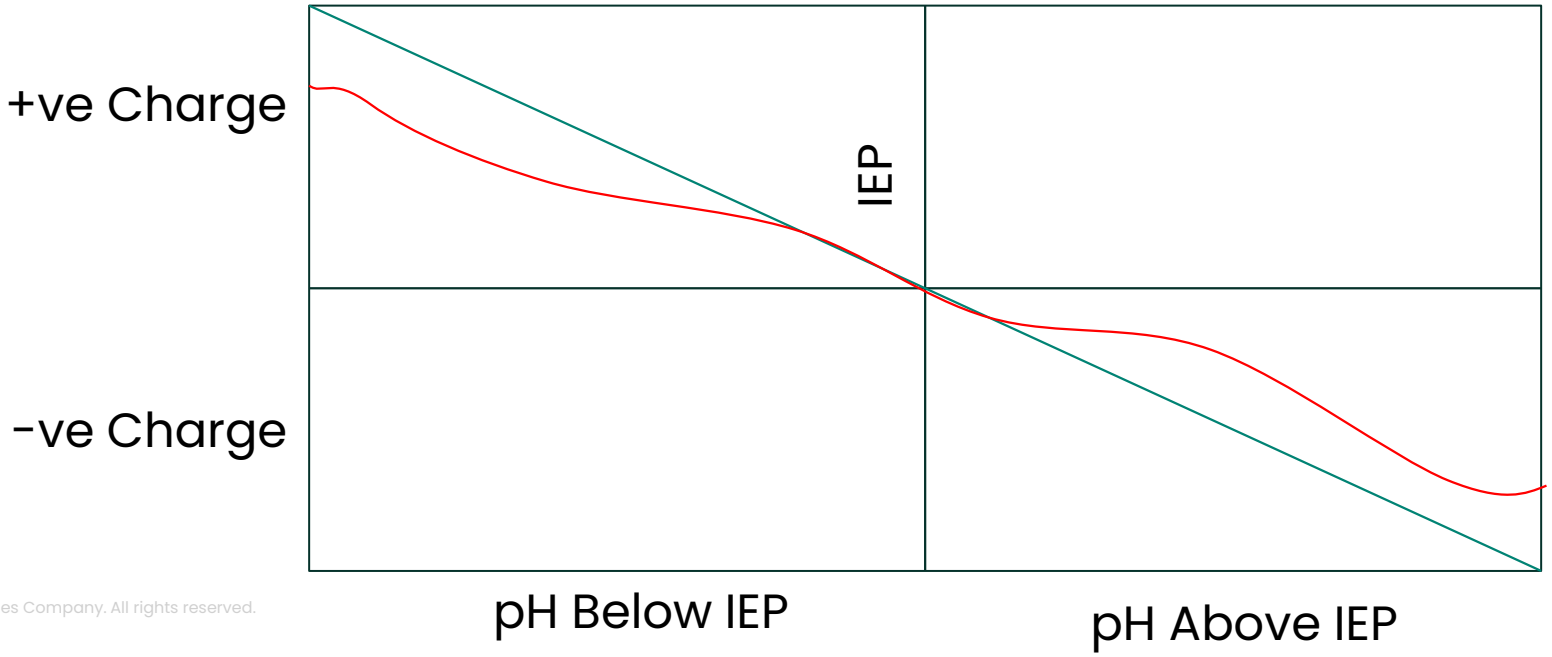
IEP – Iso-electric points effect on mineral surface charges

- Typically governed by pH of contacting aqueous solution
- At low pH surface sites have a more positive or less negative charge due to accumulation of hydrogen and/or neutralisation of hydroxides to water at surface sites and within double diffuse layer
- At high pH surface charge is less positive or more negative due to neutralisation of hydrogen and/or accumulation of hydroxides at surface sites or in double diffuse layer
- At IEP surface charge is zero, applies to all surfaces in contact with water



Fines Mobilisation – Reservoir Fluid and Technical Water

Clay Type	IEP Lower Bounds	IEP Upper Bounds	Reservoir Fluid (possibly suppressed to pH 6.5)	Technical Water (pH 8.62)
Kaolinite	5	6.5	Neutral Charge. Neither strongly attracted by or repelled from quartz	Above IEP bounds. –ve charge will repel quartz and clays.
Illite	3	5	Above IEP bounds. –ve charge will repel quartz and clays.	Above IEP bounds. –ve charge will repel quartz and clays.
Illite/ Smectite	3	5.5	Above IEP bounds. –ve charge will repel quartz and clays.	Above IEP bounds. –ve charge will repel quartz and clays.
Smectite	2	6.5	Neutral Charge. Neither strongly attracted by or repelled from quartz	Above IEP bounds. –ve charge will repel quartz and clays.
Calcite / dolomite	8.5	11.2	Below IEP bounds. +ve charge. Strong attraction.	Below IEP bounds. +ve charge. Strong attraction.

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Recommendations for avoiding repetition of Damage

- All formations will be in some state of sensitivity with respect to clay migration potential
- The in-situ fluids themselves, are not self scaling, but have sufficiently high enough pH to raise concerns over the natural mobility of certain clays, due to surface charges on clay particles
- Post intervention, no circulation is recommended
  - Fluids used during intervention and any pre-treatment/ circulation of the well should be minimum 3% KCl to prevent illite migration, the fluids themselves should contain shale inhibitors (5% amine based clay stabilizer/ inhibitor products), again as a mitigation for clay instability
- Ideally the fluids should be tested through core flooding to validate shale inhibition methodologies for this type of application
  - Pre-test permeability, soak in fluids, slow initial flow, build to point where damage is observed (for each formulation)

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New Candidate wells

- The scope of this work was to:
  - Review and rank candidate wells
  - Examine wellbore stability for top candidates
  - Estimate potential incremental production due to intervention

- Summary of Analyses
  - The presence of illites must be considered in all layers in all wells, and those fines will be sensitive in their natural state
  - Orientation of laterals does not make a significant difference to wellbore stability
  - Modelling results simulated a low production uplift
  - Client proceeded with intervention in the top candidate well
    - Intervention was planned for one layer only

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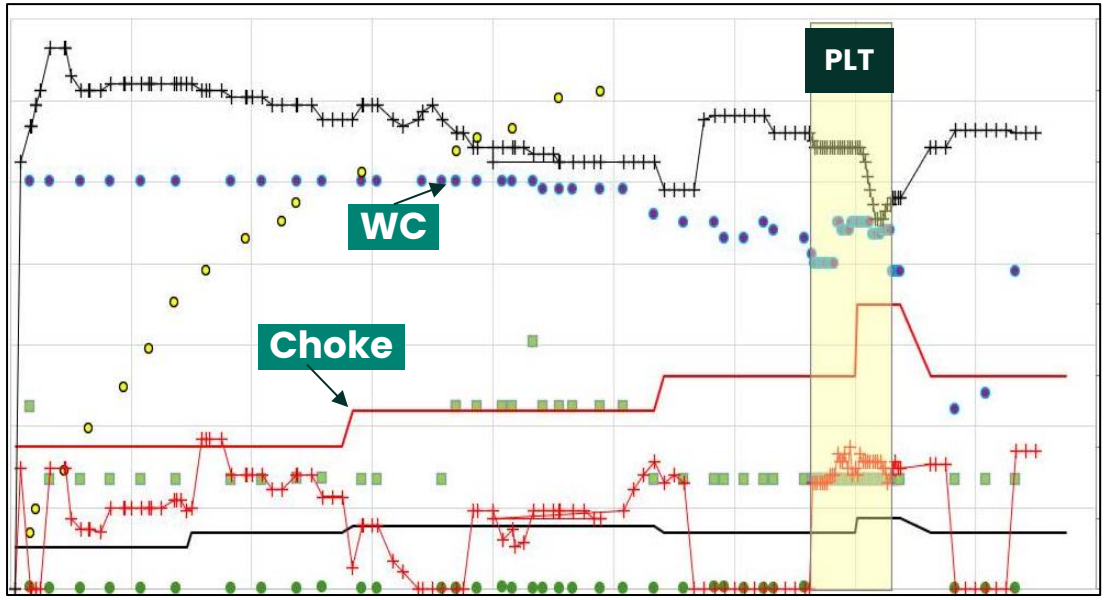
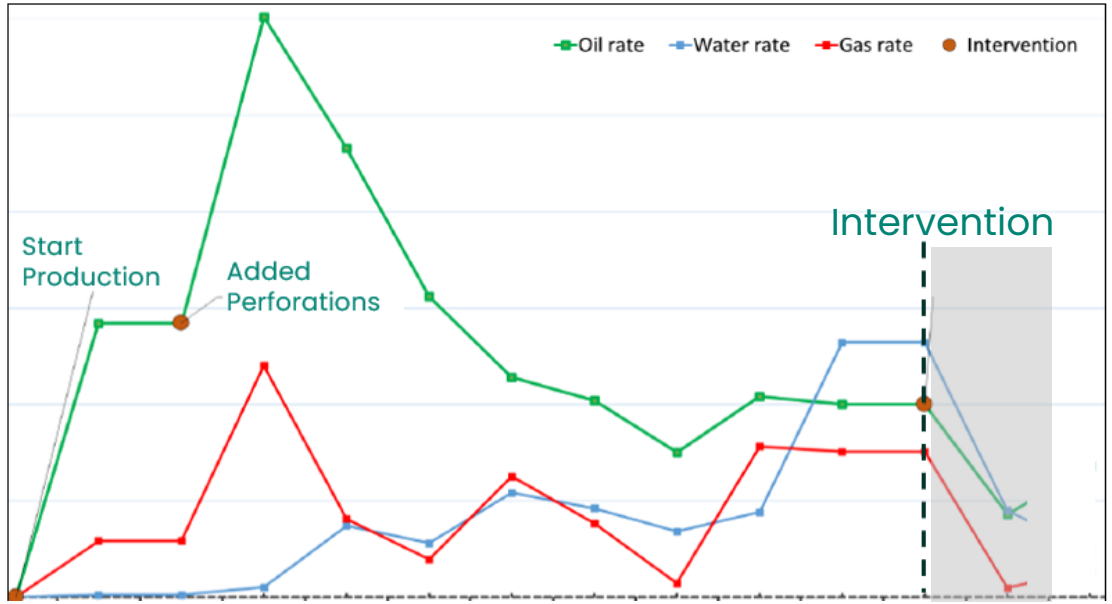
Post Intervention

Cleaning-up & Unloading the well

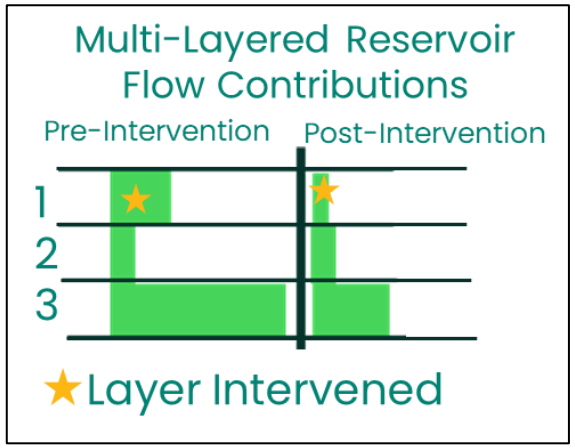


Production History



- Total Liquid dropped by 60 %
- THP and GL Inj. Rate same as Pre- Intervention

PLT



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Outcome

- Intervention operation was performed successfully

- But despite clear recommendations around avoiding post intervention circulation with produced water, this was still performed
  - No clay stabilization and no pH modification was applied to the waters
  - The routine practice to limit potential well control events was still performed as per previous programmes and not adhered to the current recommendations

- To remediate the damage now present, normally HF/HCl stimulation would be recommended for clay removal
  - However high calcite content of formation may lead to precipitation of secondary minerals which are harder to remove
  - Further analysis was required

- Previous track record of the intervention was hugely positive in other projects
  - No means to measure benefits of intervention, as results in these wells are altered/masked

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Conclusion

- Identifying the right stimulation technique and design to mitigate formation damage is key to achieving the productivity objective.

- However, through improper operational sequences or practices during and immediately after intervention can create more damage than good by re-introducing formation damage.

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