First Ever Field Pilot on Alaska's North Slope to Validate the Use of Polymer Floods for Heavy Oil Enhanced Oil Recovery (EOR)

a.k.a Alaska North Slope Field Laboratory (ANSFL)

Project Number DE-FE0031606

Abhijit Dandekar (University of Alaska Fairbanks) and
Samson Ning (Hilcorp Alaska LLC)

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National Energy Technology Laboratory
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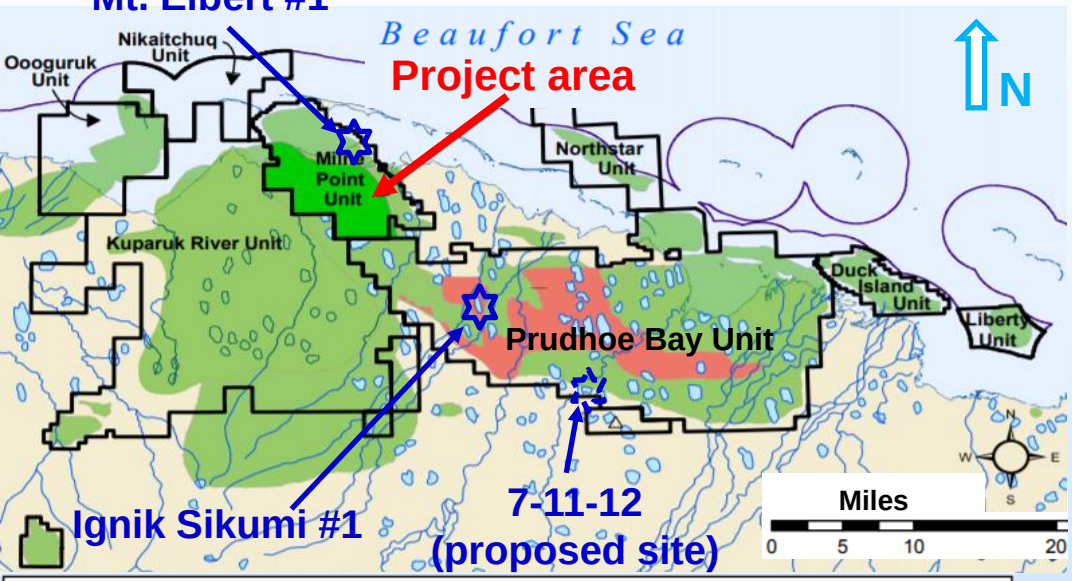
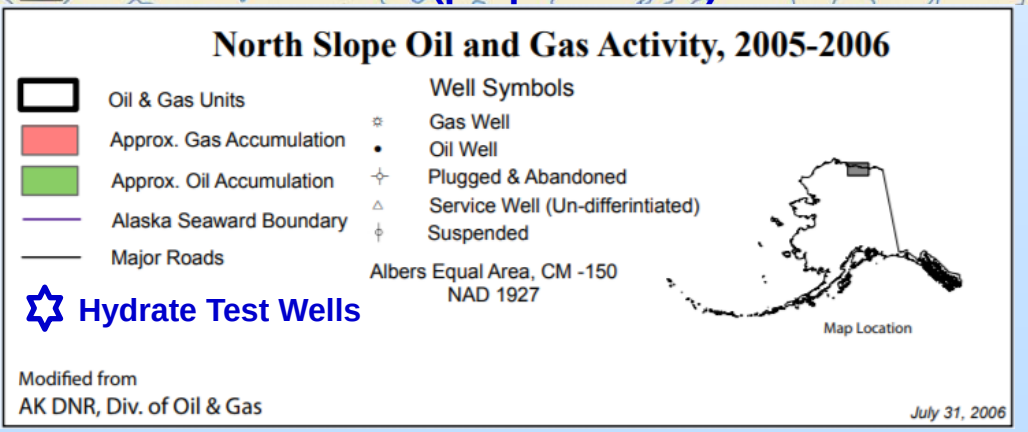
Presentation Outline

- ANSFL Overview
- Pilot Wells, Patterns and Polymer Injection Unit
- Technical Status
- Accomplishments to Date
- Lessons Learned
- Synergy Opportunities
- Project Summary
- Appendix
- Acknowledgements

ANSFL Technology Background

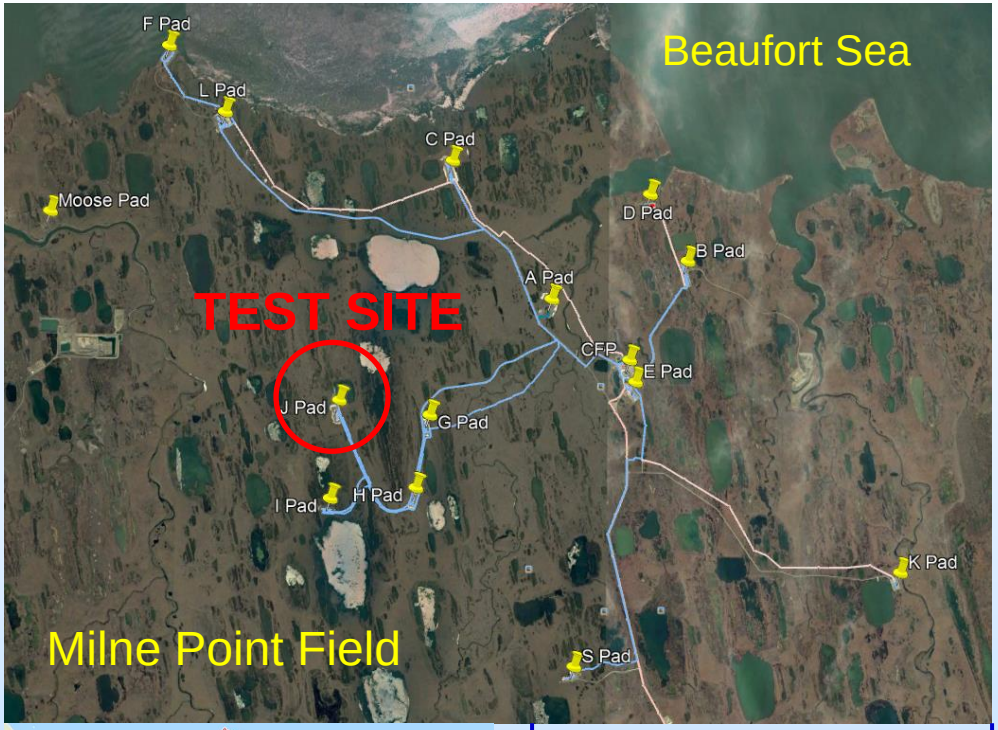


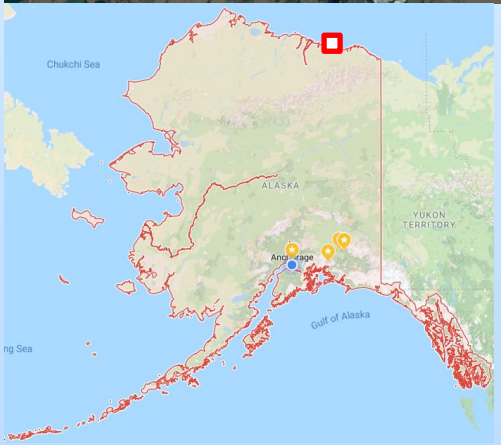


Source: AK DNR, Division of Oil & Gas

- Significant heavy oil resource (20-25 billion bbls); too large to ignore.
- Poor waterflood sweep due to mobility contrast.
- Limitation of deploying thermal methods due to "permafrost".
- Light crude diluent still available for high viscosity oil transport through Trans Alaska Pipeline System.

Test Site and Reservoir



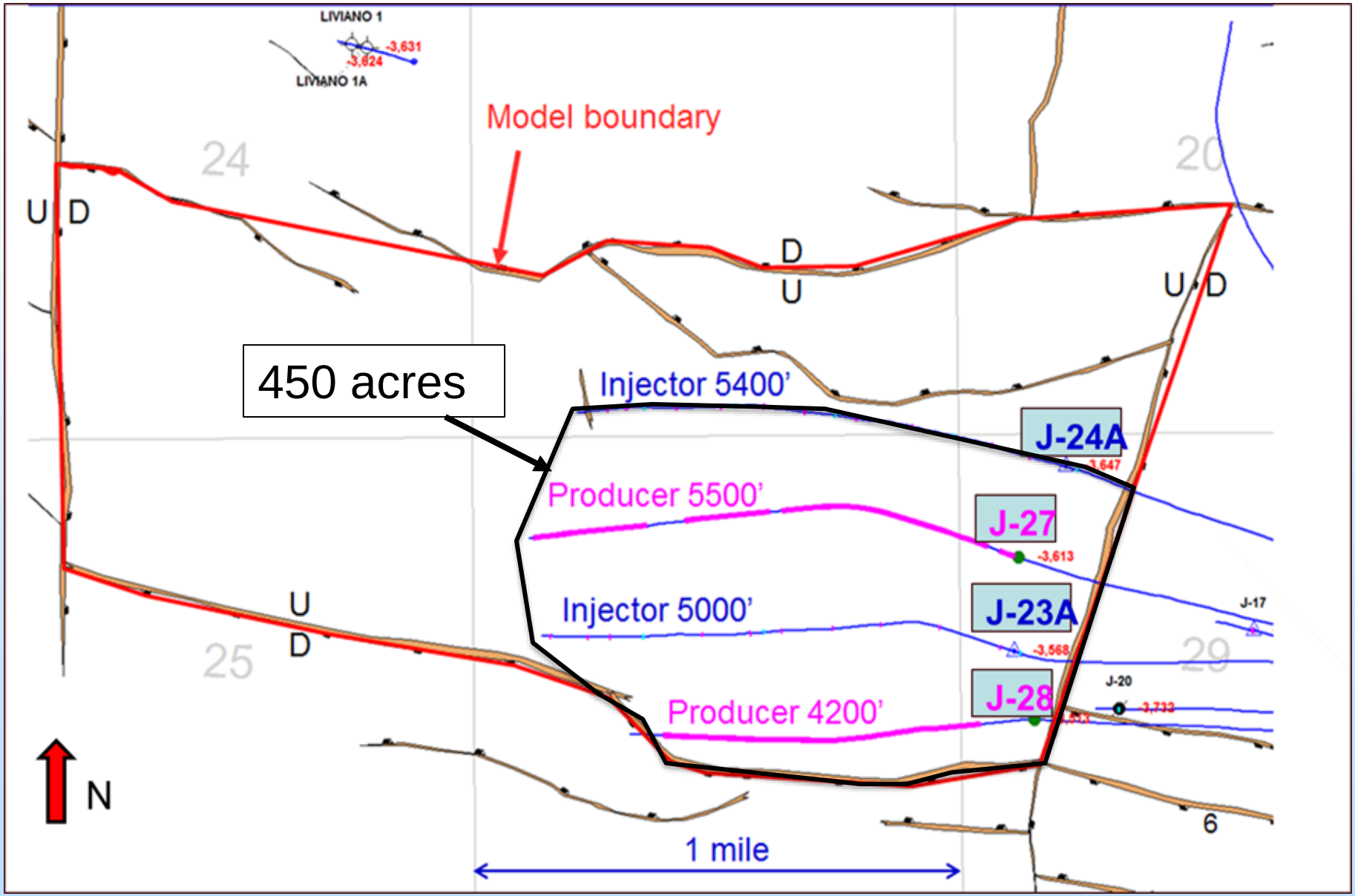


5 miles

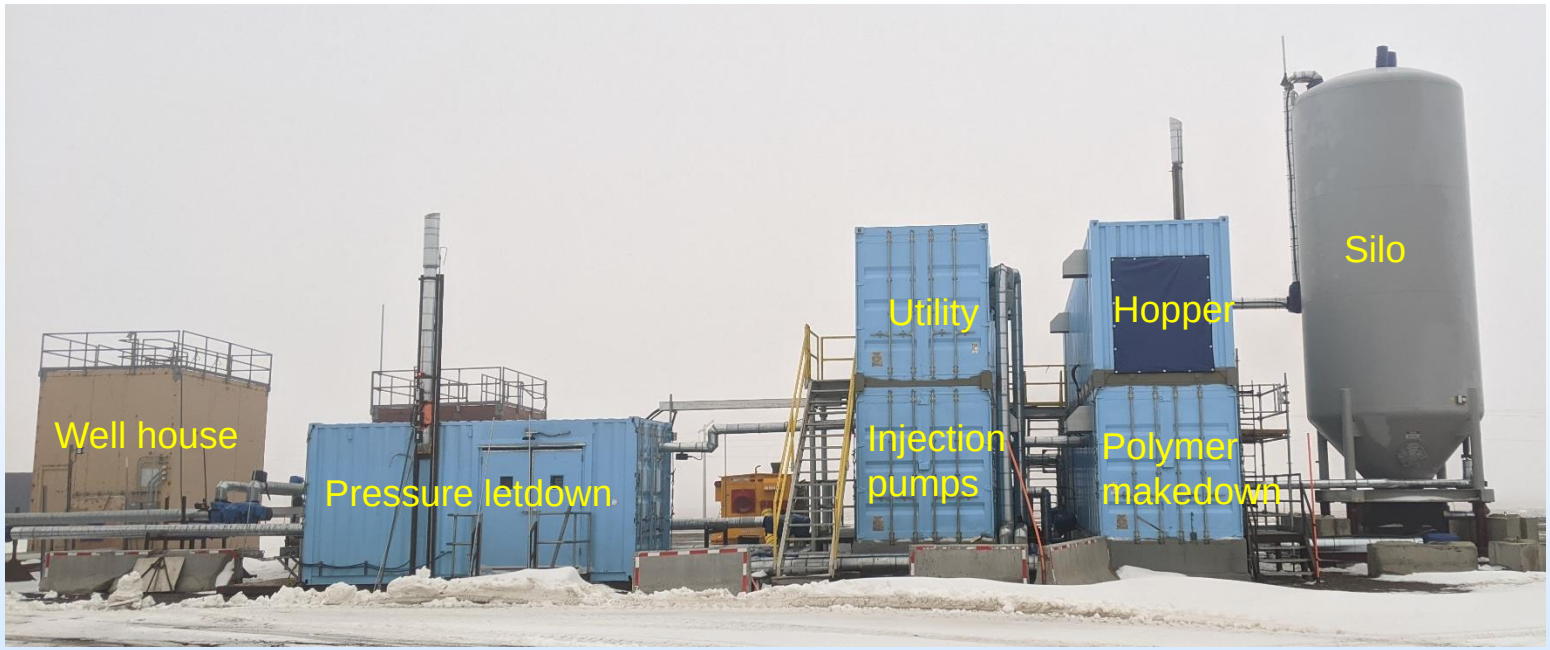
N

- Milne Point (MPU), 30 miles NW of Prudhoe Bay.
- Schrader Bluff formation, Porosity: 31–35%, Permeability: 100–3,000 mD.
- Low reservoir temperature: ~70°F.
- Oil API: ~15 with in-situ oil viscosity of 330 cP.
- Low salinity source water: 2,500 ppm.

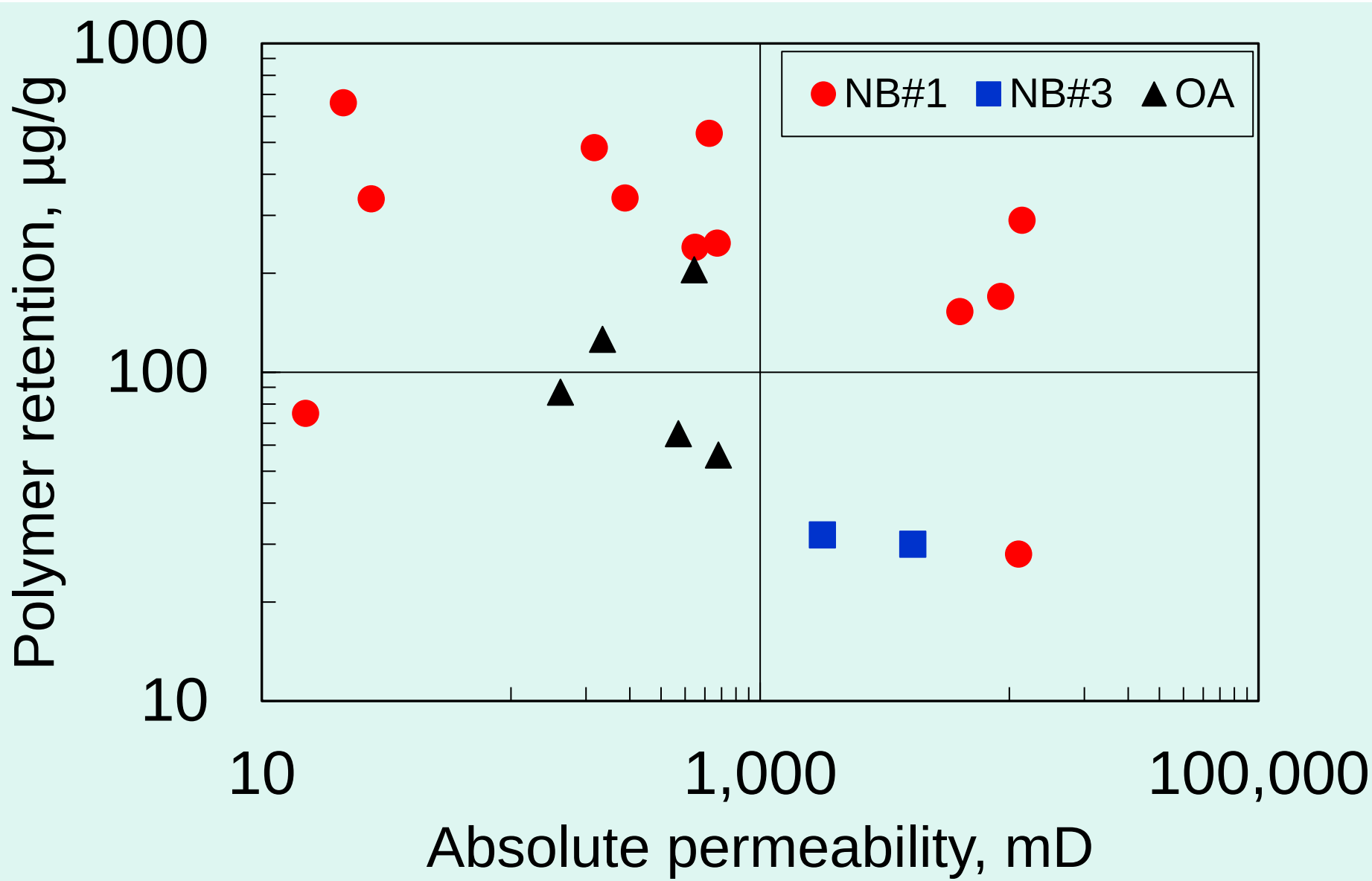
Pilot Wells and Patterns



Polymer Unit

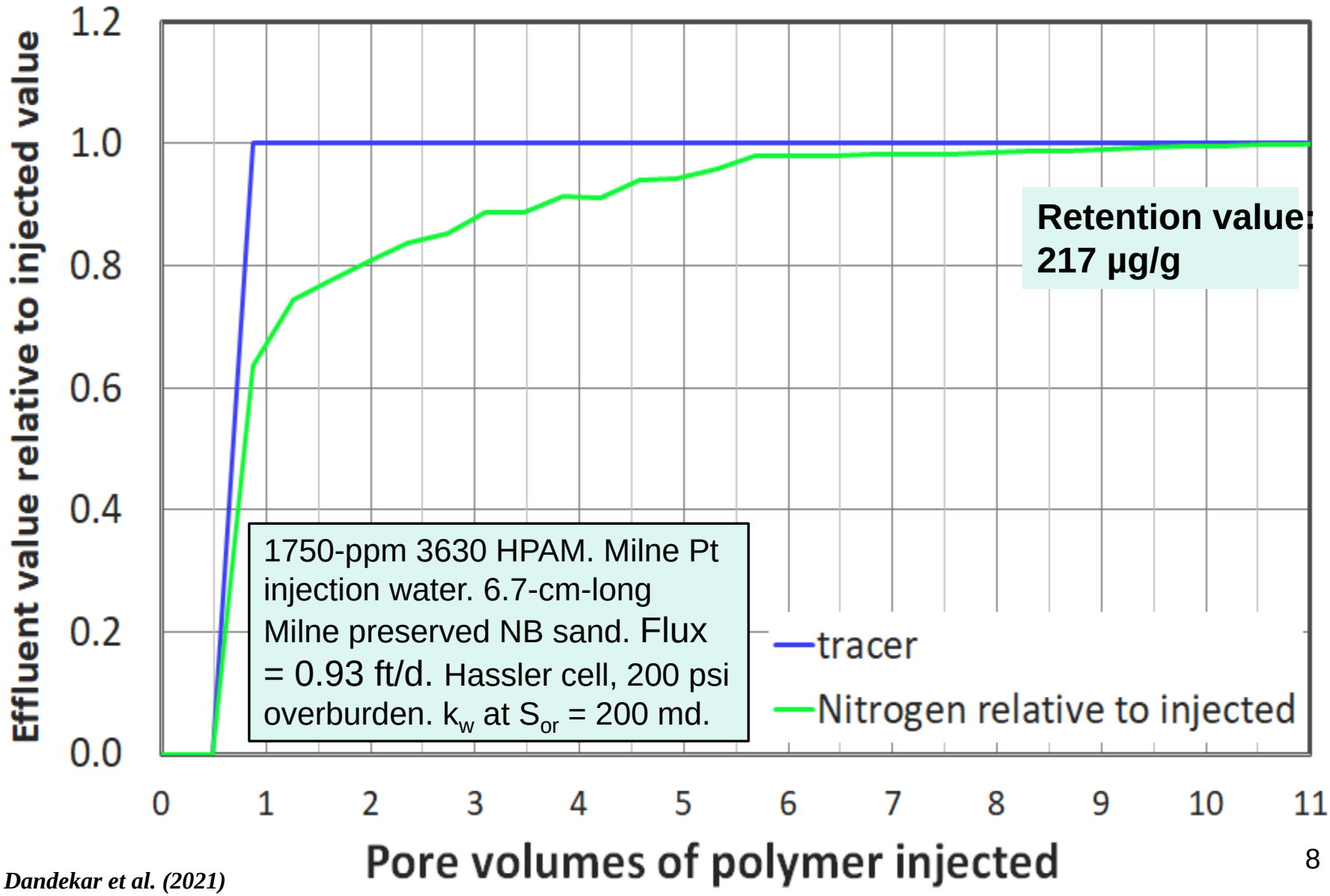


Technical Status: Polymer retention



Dandekar et al. (2021)

What does high retention mean for the pilot?



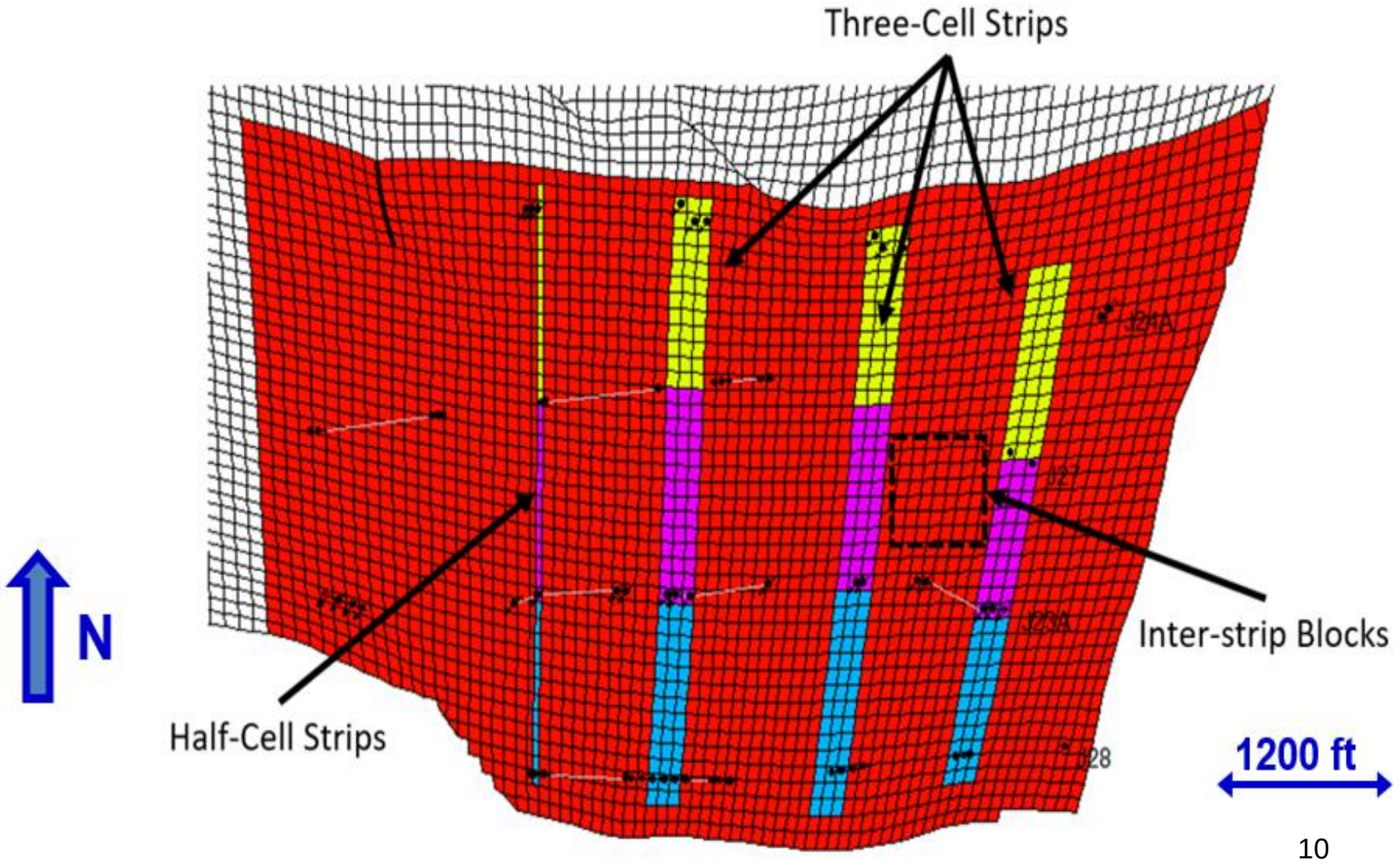
Dandekar et al. (2021)

Low salinity coreflood observations

Sand	Conditions	No. of tests	Incremental recovery, % OIIP			
			LSW after HSW	HSP after HSW/LSW	**LSP** after HSW/LSW	**LSP** after HSP
Silica sand	Old SIB=4945 ppm (still termed as LSW) kw=50-1400 mD	7	1-6	4-5	8-12	No tests in this way
NB sandpack	From well Liviano-01A Depth: 3755' Used in native status Kw=200-16,000 md	10 (four failed due to low Kw)	***3-9***	5-8	10.6 (one test)	***3-9***
NB sandpack (cleaned)	From well Liviano-01A Depth: 3755' Cleaned with solvent; Use mineral oil (173 cP) to establish Swi	1	No tests in this way	13 (one test)	No tests in this way	0.7 (one test)
NB core plug (cleaned)	From well Liviano-01A Depth: 3760' Label: core 3-7 Received from Weatherford in cleaned condition	4 (three failed due to low Kw or crush of core plugs)	No tests in this way	No tests in this way	9.1 (one test)	No tests in this way

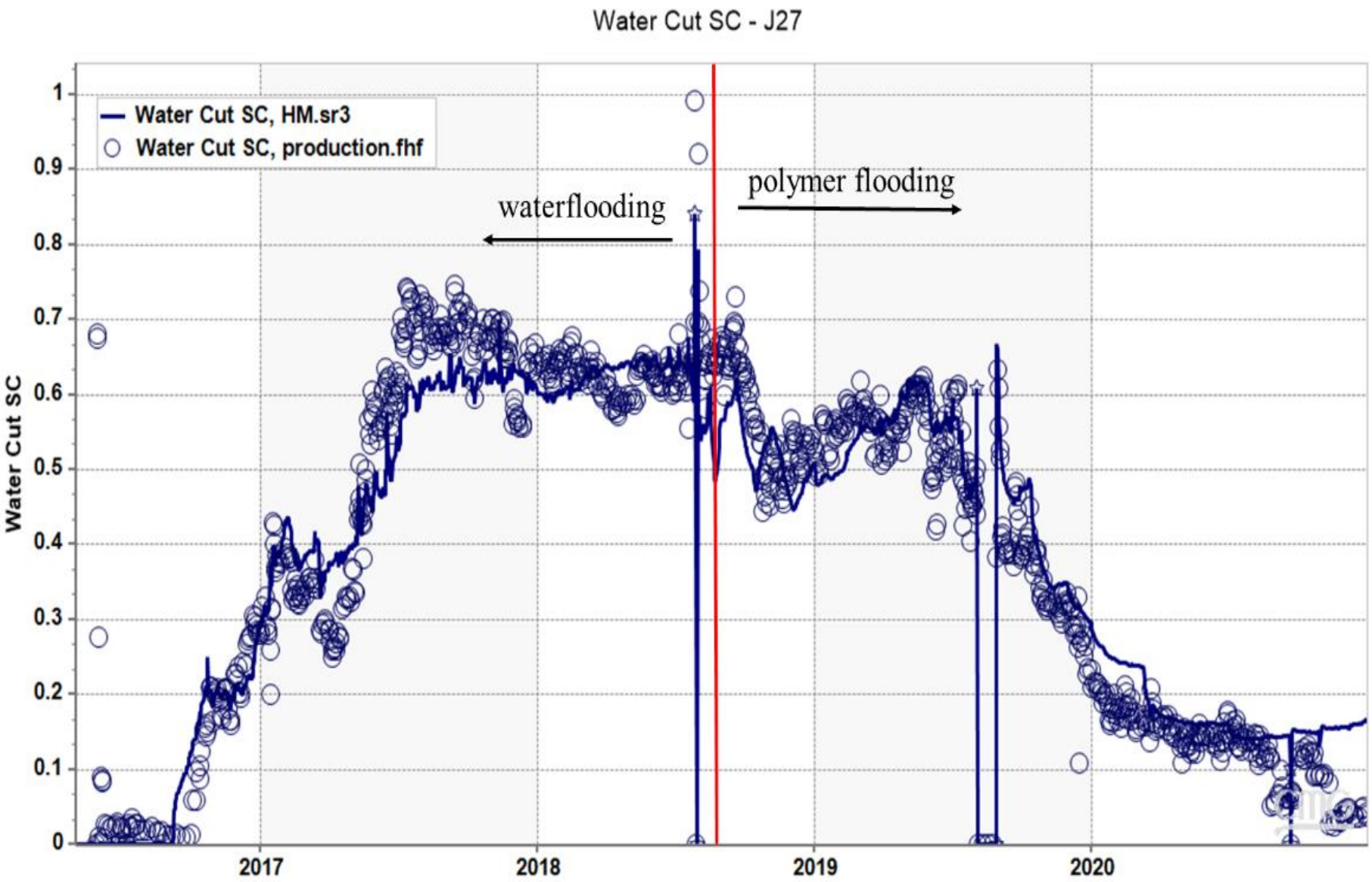
Dandekar et al. (2021)

Reservoir simulation grid model



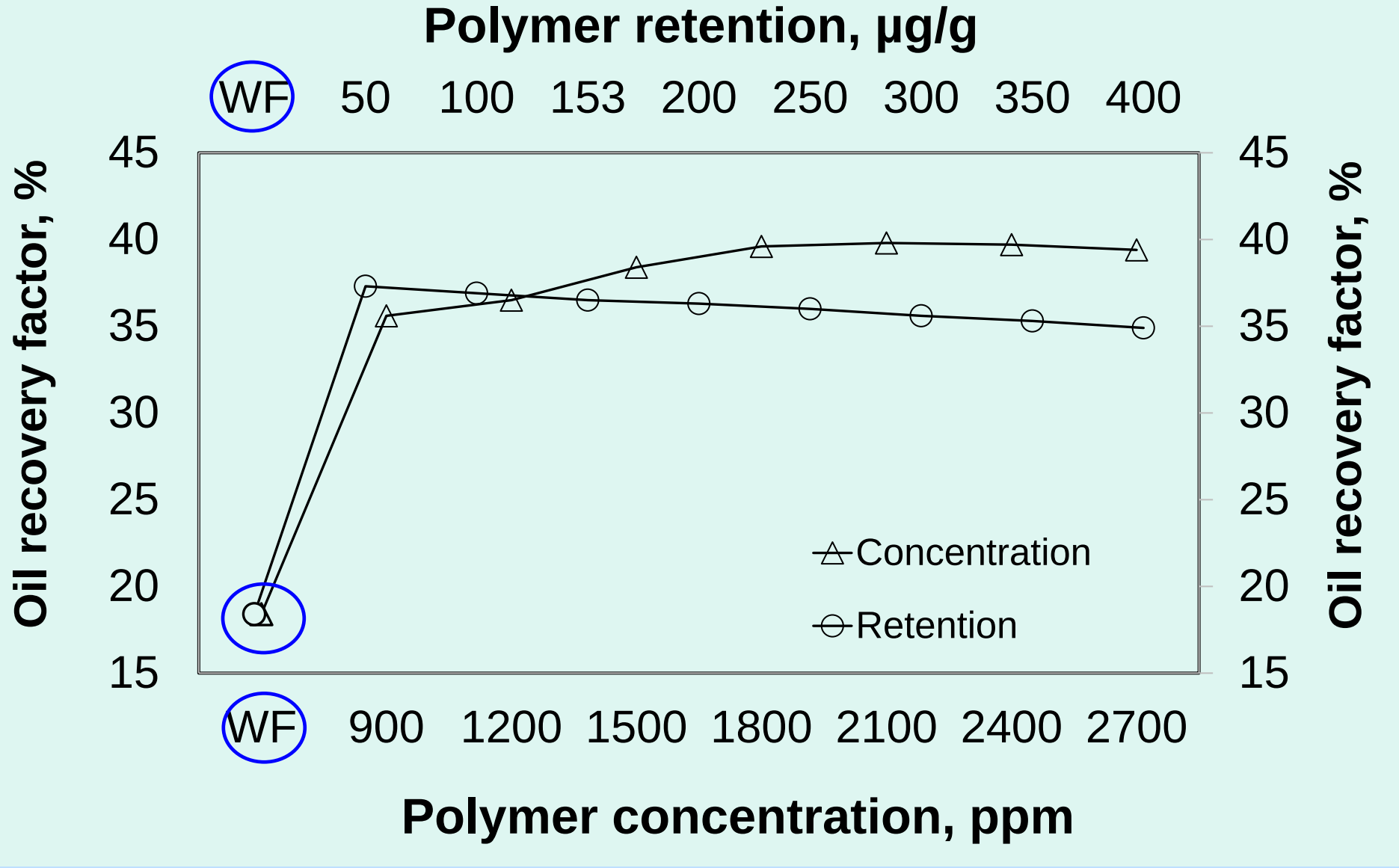
Dandekar et al. (2021)

WC History Match



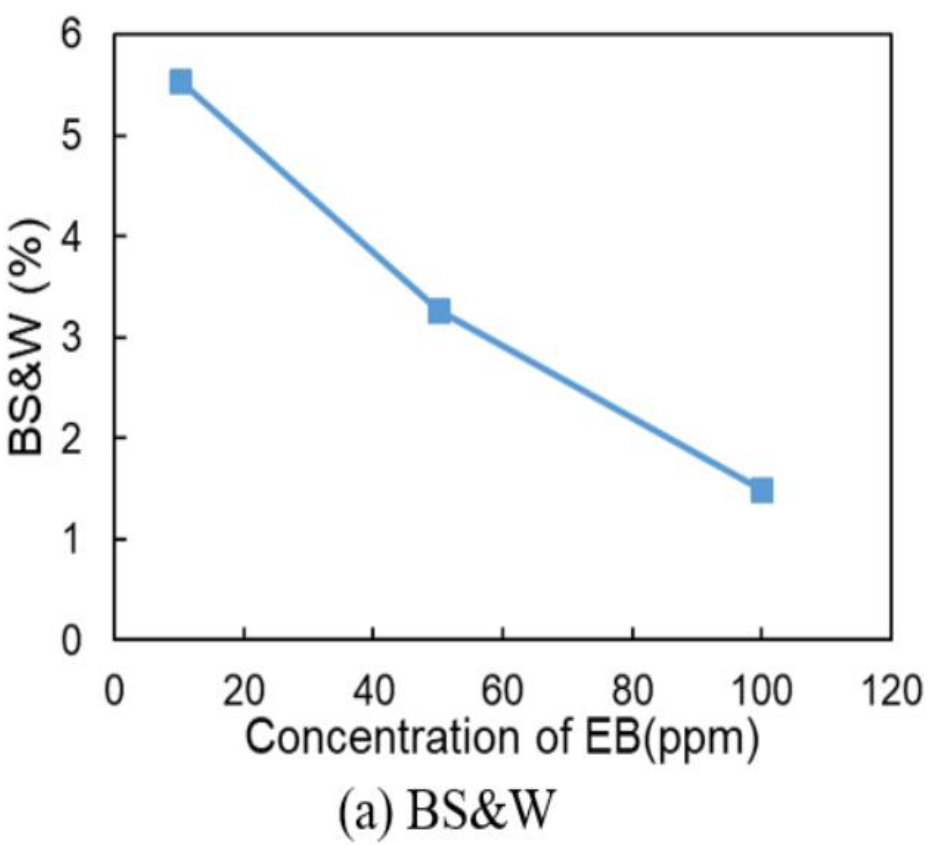
Dandekar et al. (2021)

Sensitivity & Forecasting

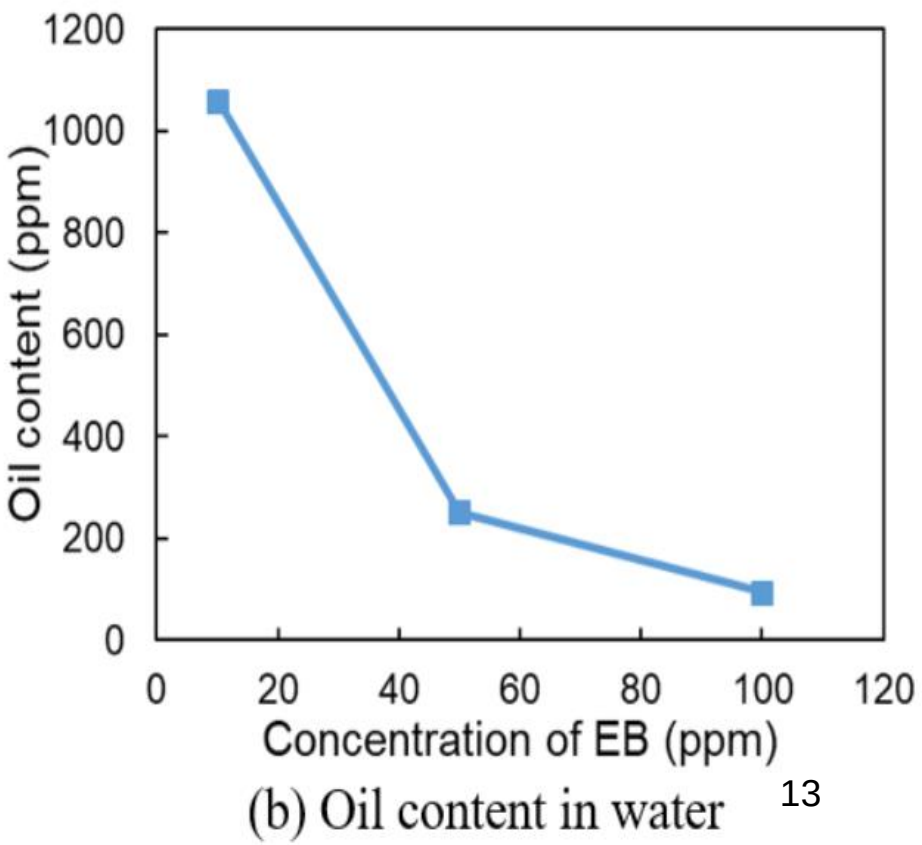


Dandekar et al. (2021)

Screening of emulsion breakers



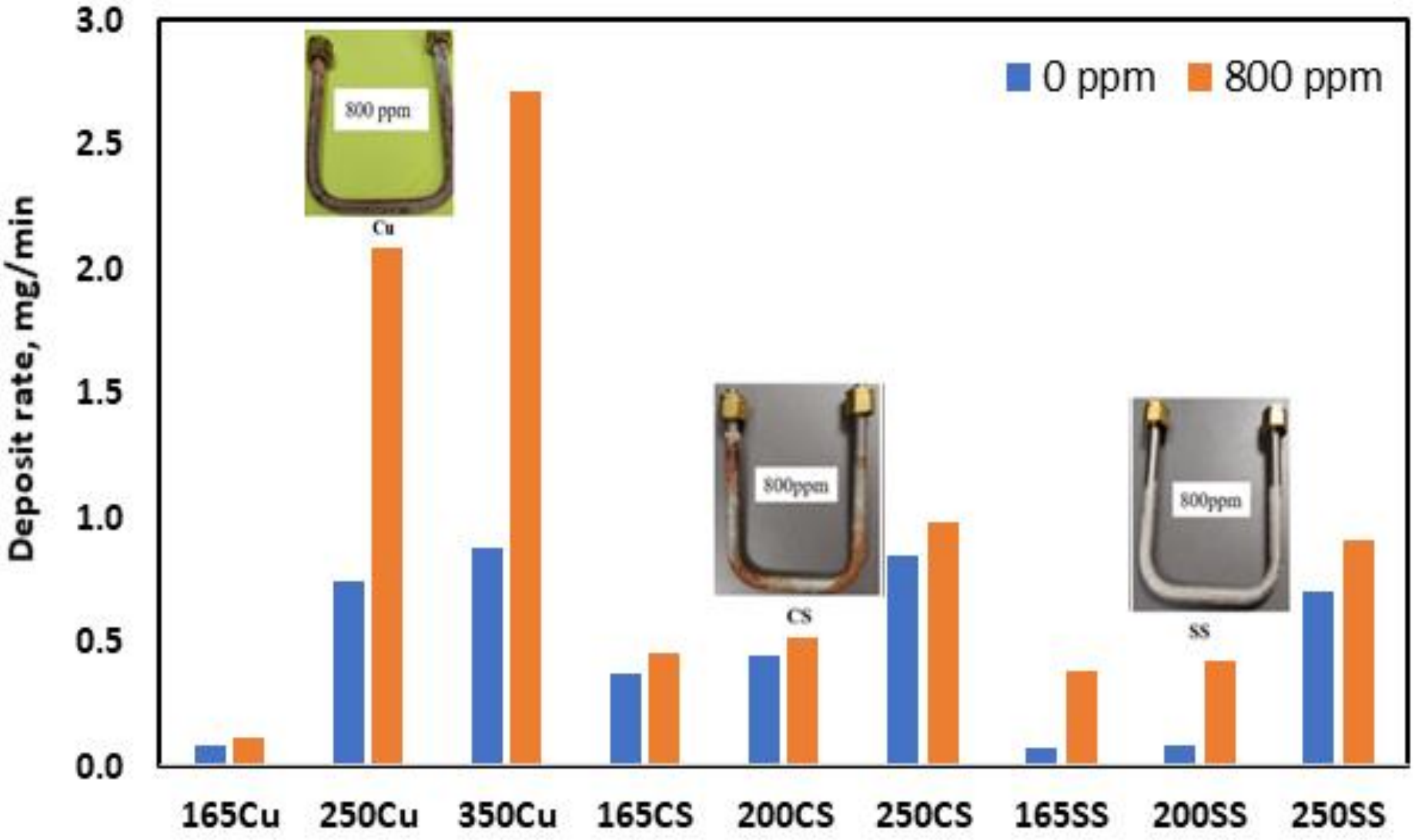
(a) BS&W



(b) Oil content in water

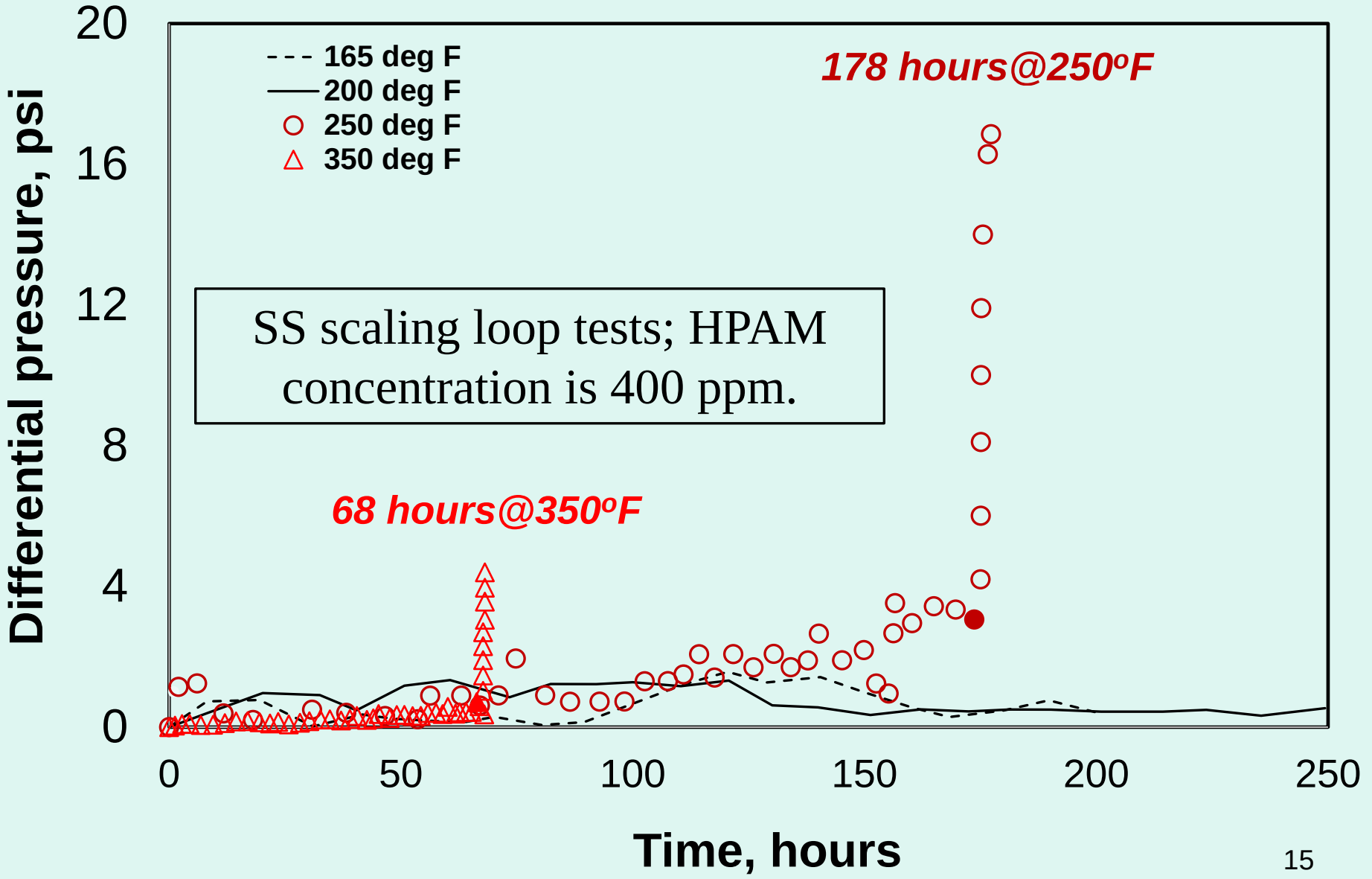
Dandekar et al. (2021)

Polymer & Mineral fouling of heater tubes



Dandekar et al. (2021)

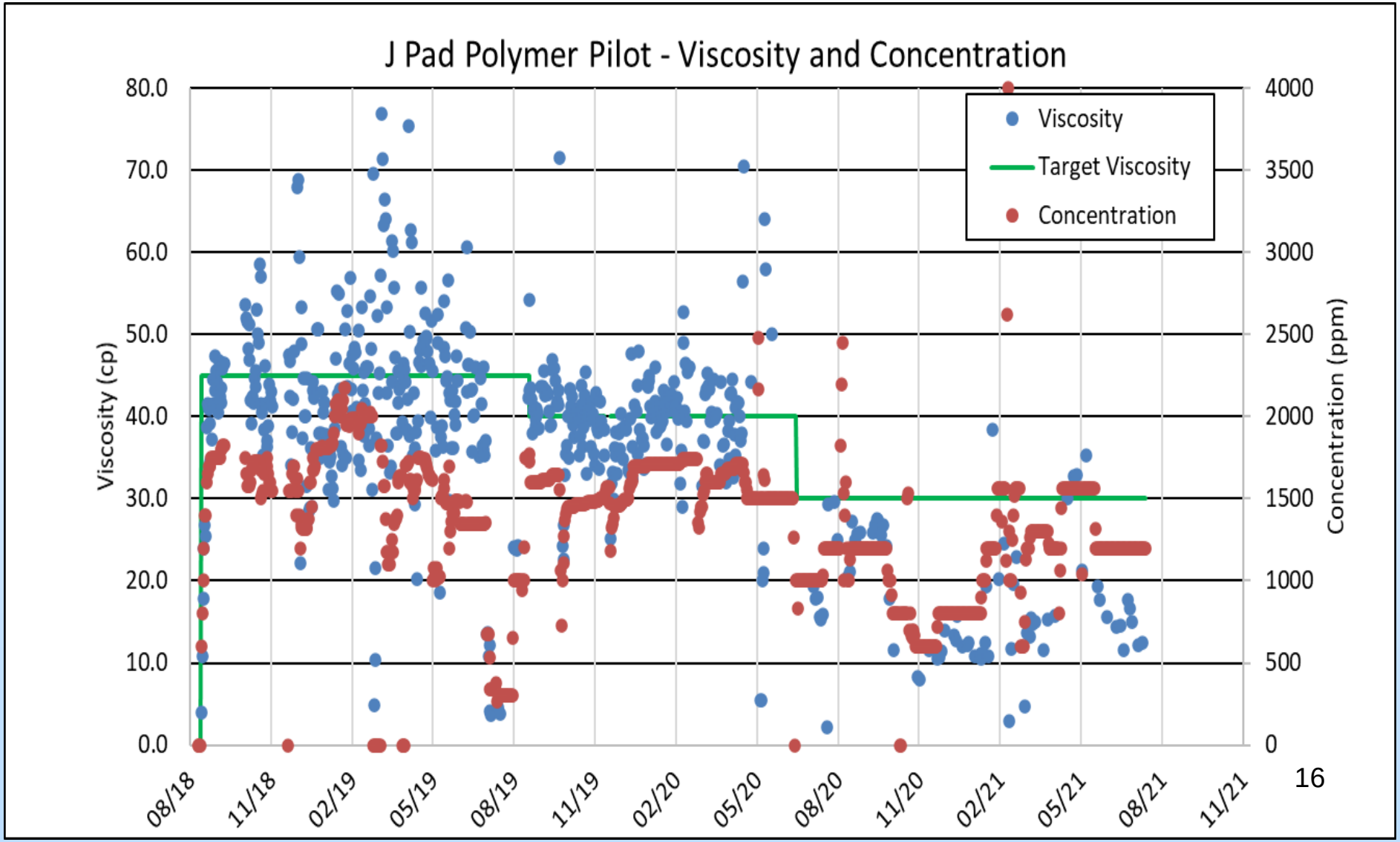
Dynamic fouling studies



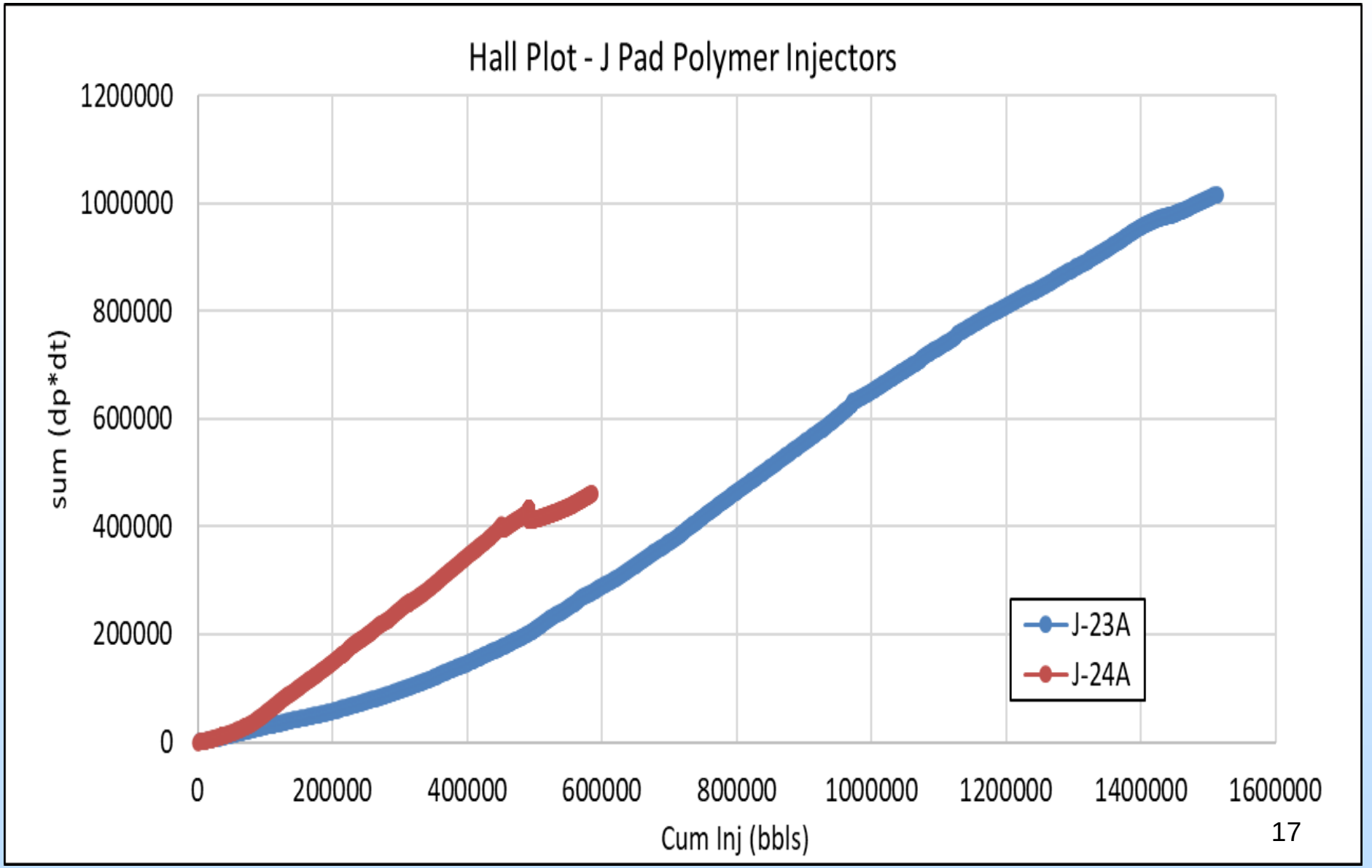
Dandekar et al. (2021)

Polymer concentration/viscosity

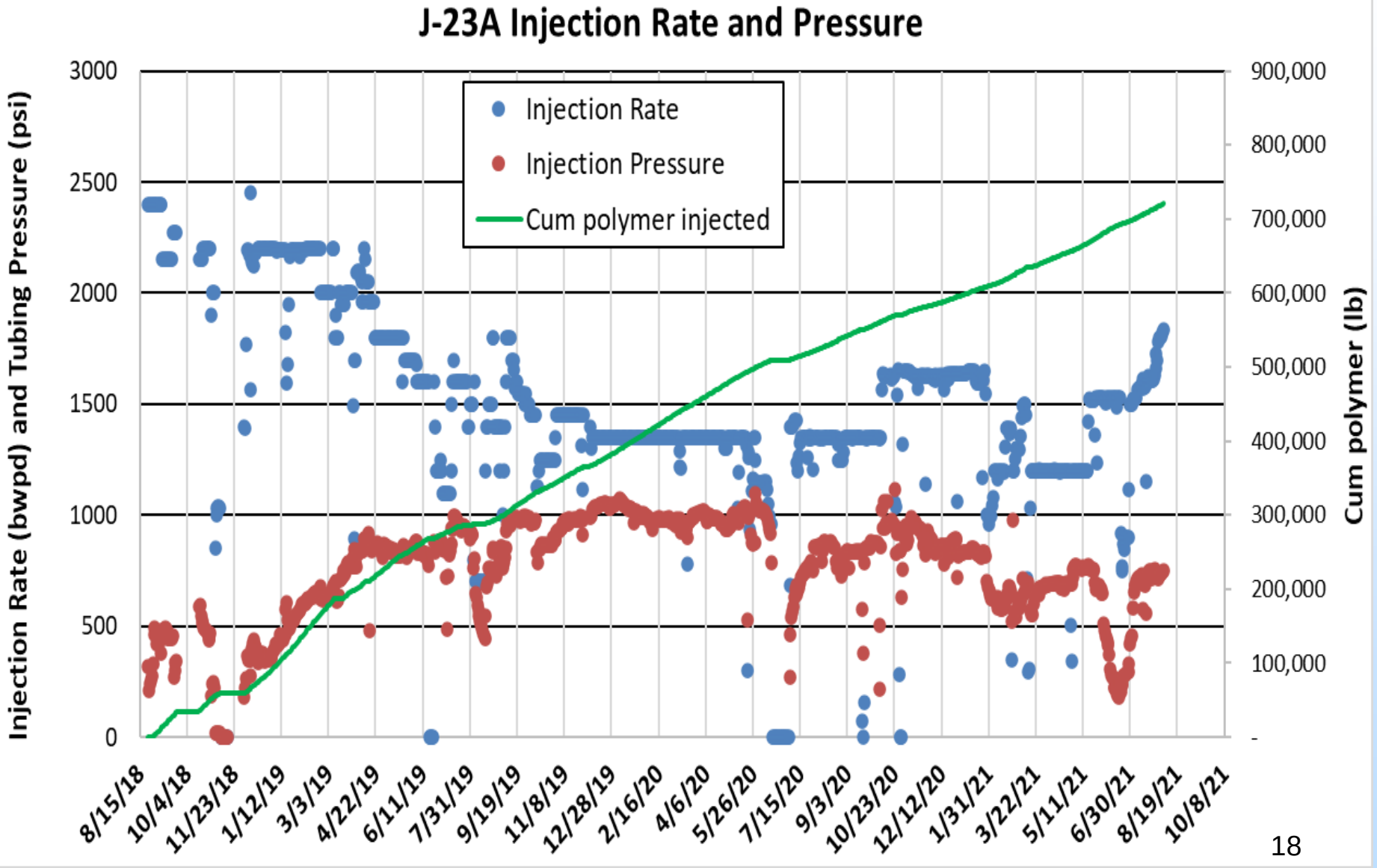
- *Current concentration: 1200 ppm*
- *Cum polymer injected: 1,013,000 lbs*



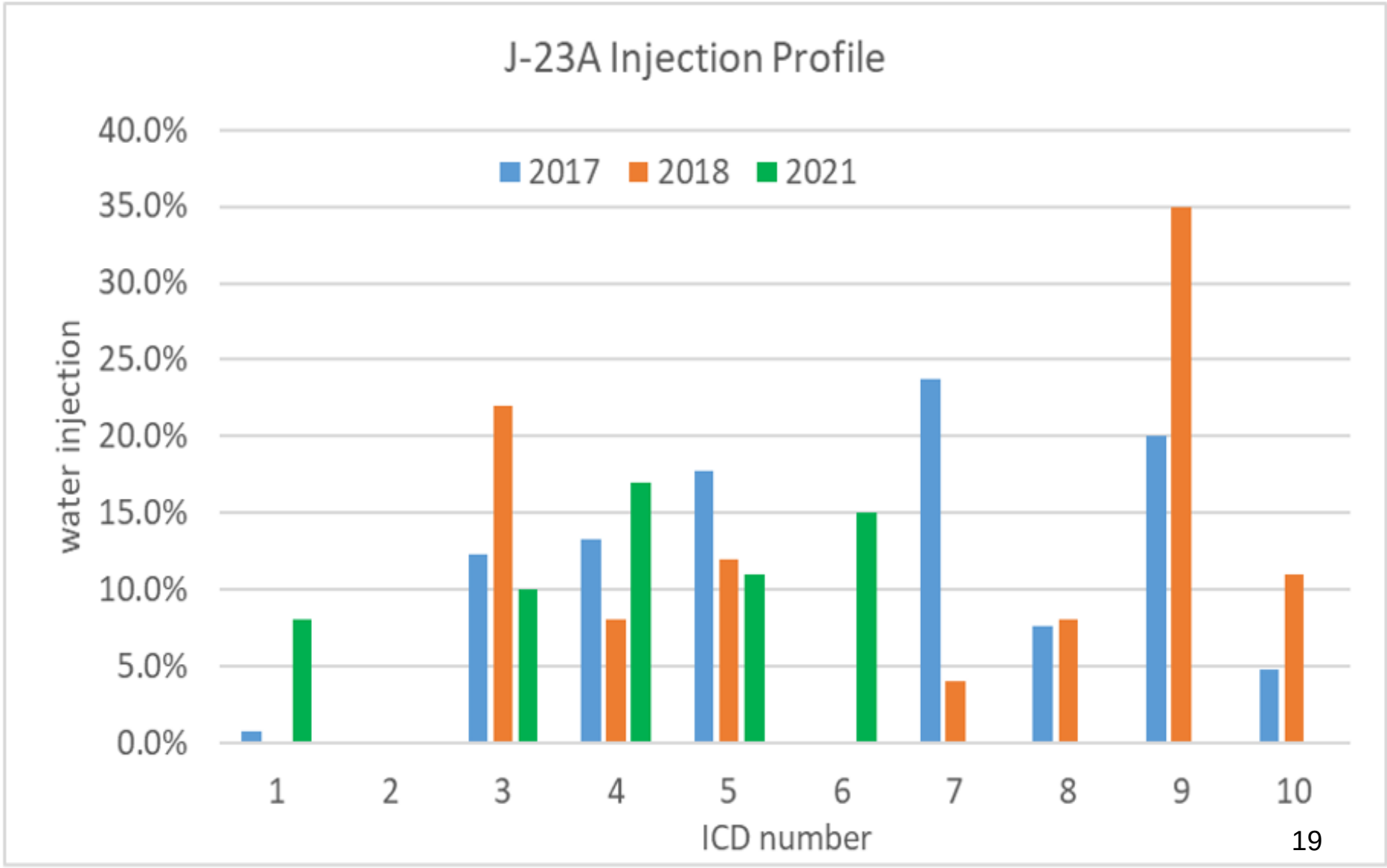
Hall plot of J-23A and J-24A



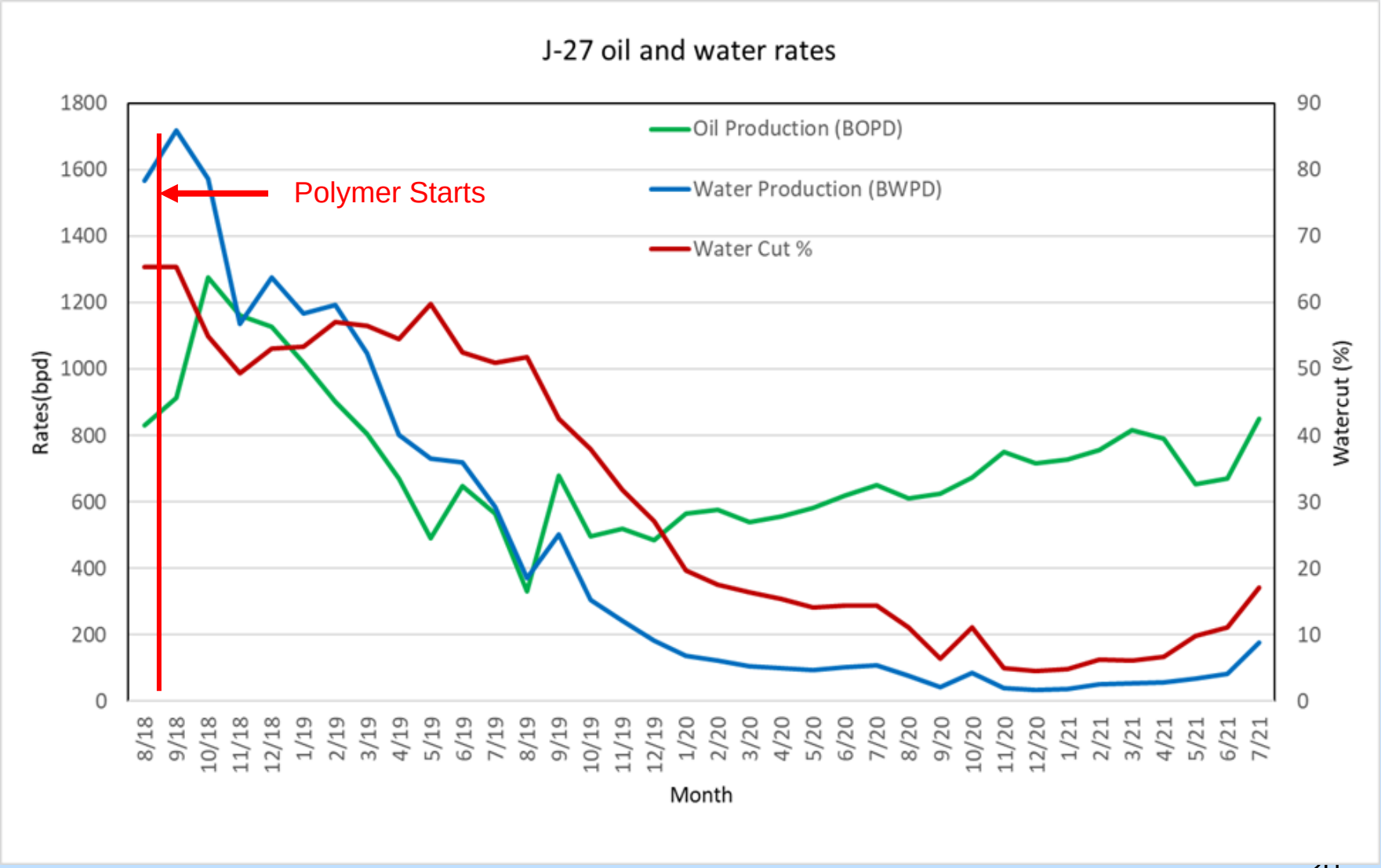
J-23A injection performance



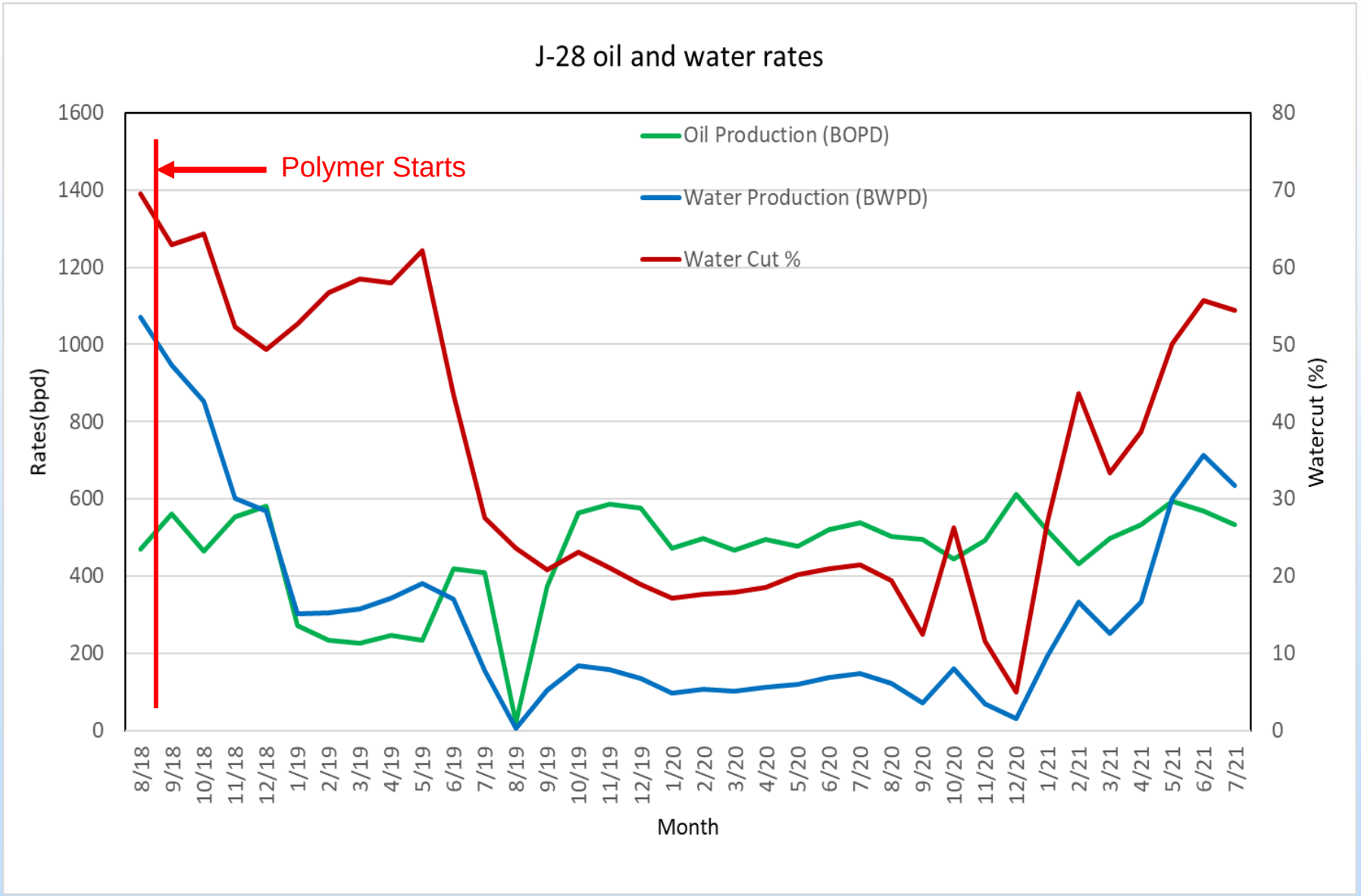
J-23A injection profile log



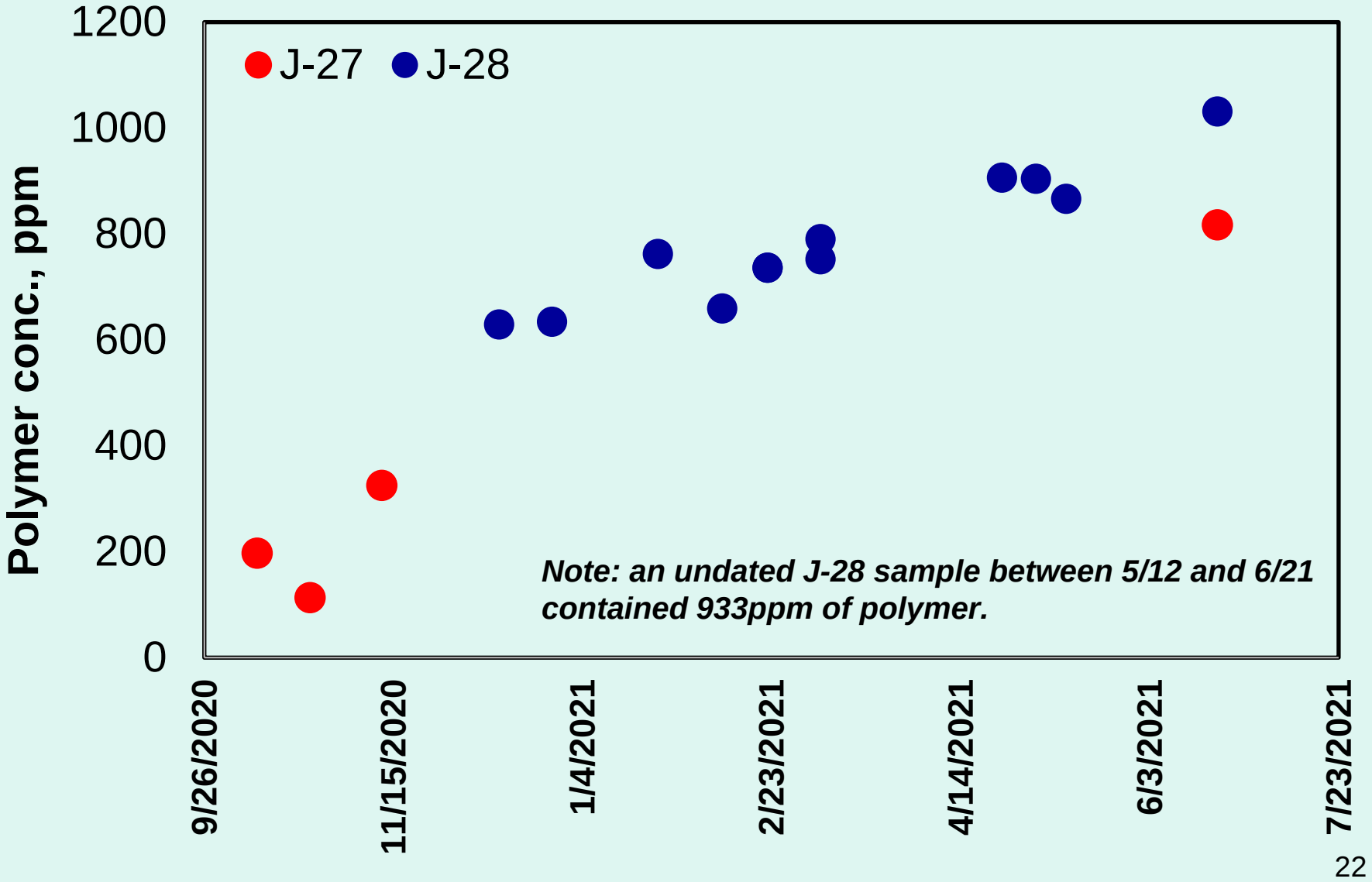
J-27 production performance



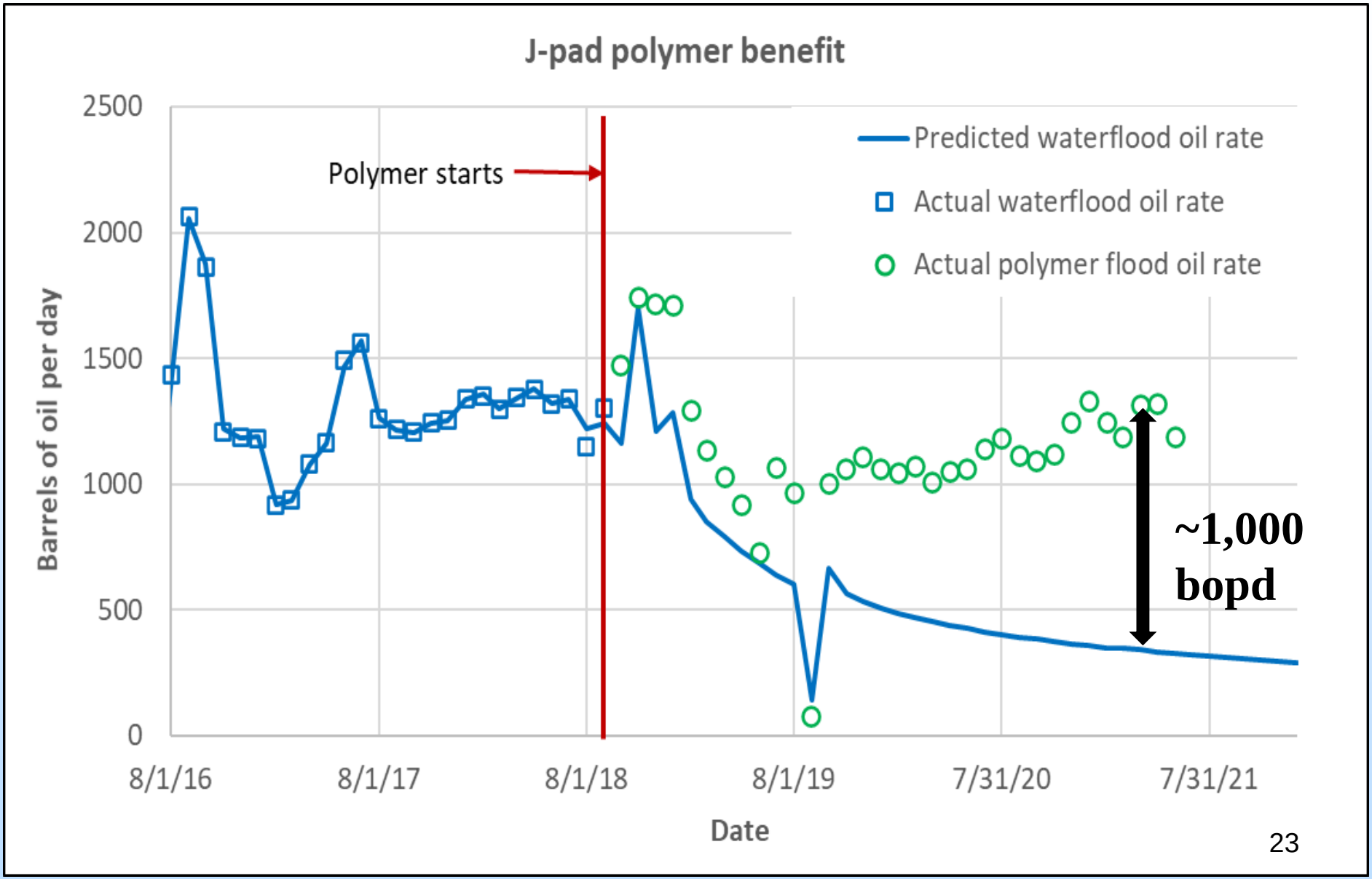
J-28 production performance



Monitoring polymer BT



EOR benefit


J-pad polymer benefit
Barrels of oil per day
2500
2000
1500
1000
500
0
Polymer starts
Predicted waterflood oil rate
Actual waterflood oil rate
Actual polymer flood oil rate
~1,000 bopd
8/1/16
8/1/17
8/1/18
8/1/19
7/31/20
7/31/21
Date

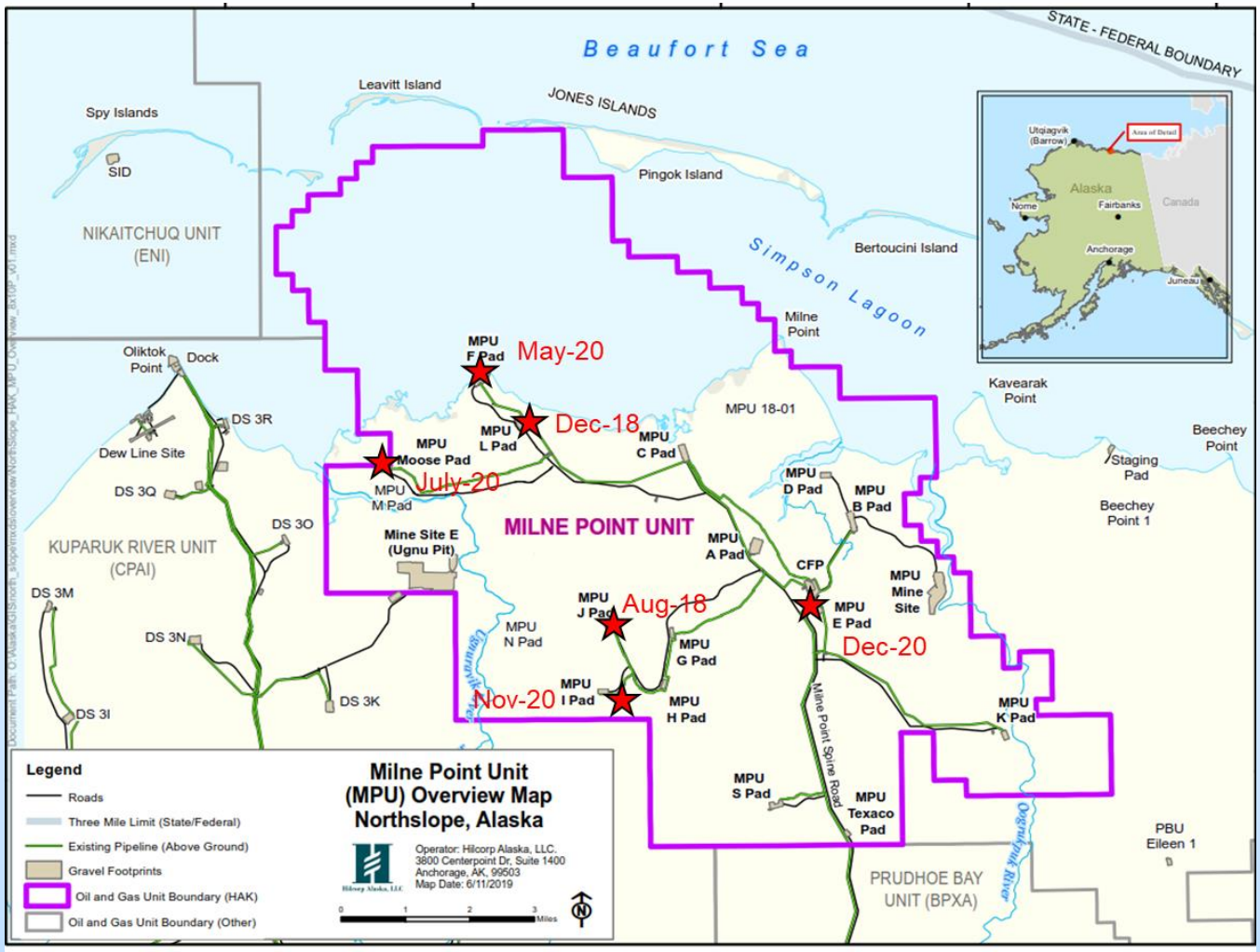
Accomplishments to Date

- Several refereed journal papers and conference proceedings, media attention and outreach.
- Comprehensive polymer retention database for NB & OA sands. Practical significance of high retention established.
- Consistent observation of low salinity effect in S_{or} reduction. Post-gel treatment oil recovery performance quantified.
- Robust history matched reservoir simulation model in the waterflooding and polymer flooding period, which is being used for forecast.
- Barring some operational events, polymer flood pilot has continued seamlessly. Polymer EOR benefit realized with low polymer utilization factor.
- Downstream flow assurance concerns addressed.

Lessons Learned

- As a team we learned a lot about polymer properties, polymer facilities and onsite QC required.
- QC is more important for polymer flooding compared to standard oilfield practices.
- Injecting poorly hydrated polymer, or bad polymer quality will have a direct impact on the reservoir.
- Important to ensure polymer units can handle fines and gas in the source water and have sufficient residence time.
- Polymer retention values are high but do not negatively impact the pilot performance.

Synergy Opportunities



- EOR benefit extends to polymer flood expansion at MPU.
- The (success) of this project will be an excellent segue into unlocking the stranded heavy oil in the Ugnu area.

Project Summary

- The project is currently on track and within budget, progressing toward meeting stated objectives and deliverables.
- Valuable field data that supports the interdependencies of other project tasks continues to be collected.
- Promising results of this pilot have provided impetus to Hilcorp Alaska to apply polymer flood technology in the Schrader Bluff reservoir throughout the Milne Point Field.
- Next Steps:
  - Need to inject polymer till end of project;
  - Monitor produced polymer concentration and the effect on processing facilities;
  - Conformance control strategies, given the increased WC in J-28;
  - Refine history match using polymer BT data;
  - Assess the feasibility of commercial application of polymer flood in ANS heavy oil reservoirs.

Appendix

– These slides will not be discussed during the presentation, but are mandatory.

Benefit to the Program

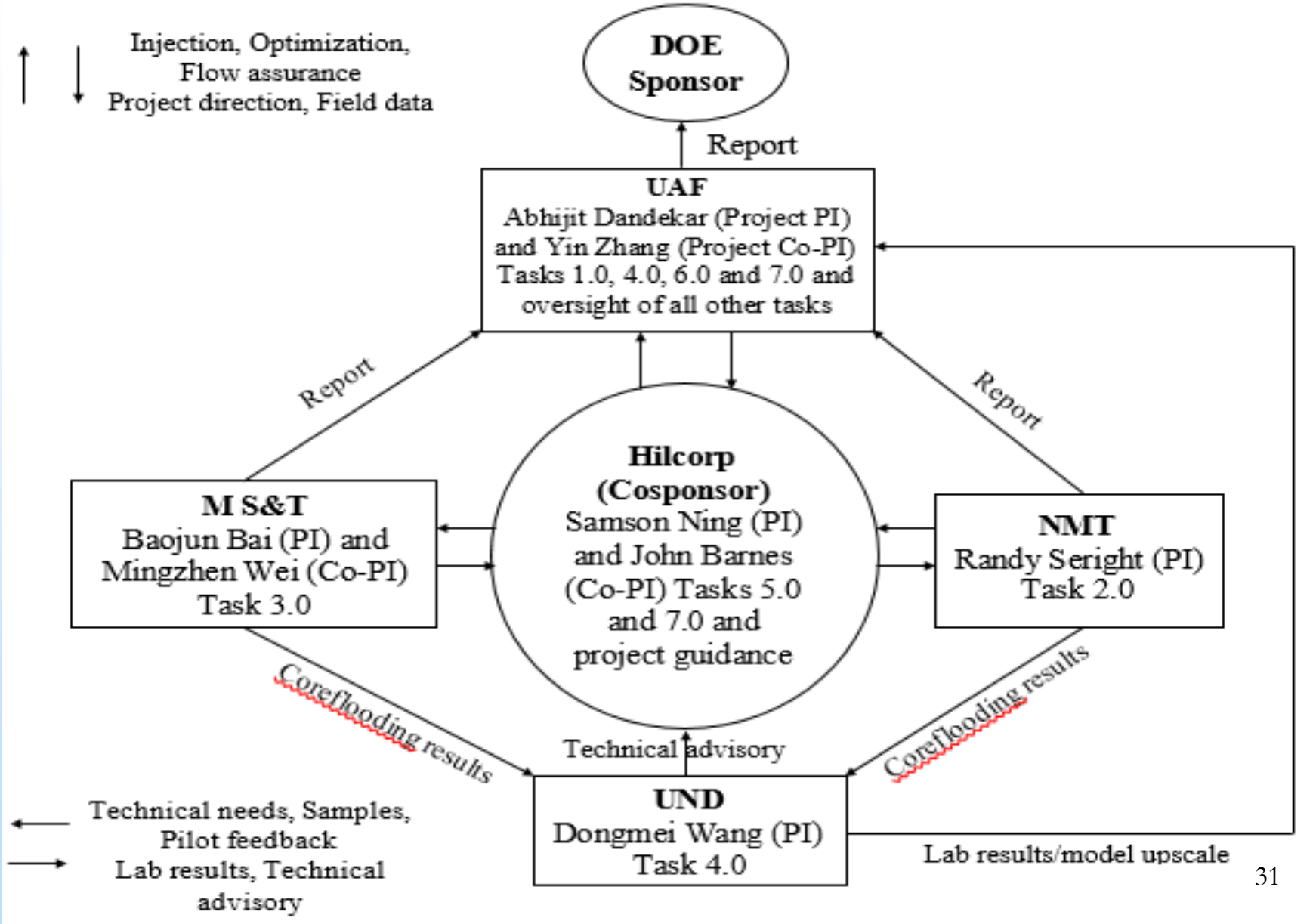
- The primary goal of ANSFL project is to validate the use of polymer floods for heavy oil Enhanced Oil Recovery (EOR) on Alaska North Slope (ANS).
- Benefits to accrue from the proposed research:
  - 8-10% of OOIP recovery increment over waterflooding.
  - Extrapolate the results to the heavier Ugnu oil deposits on ANS.
  - Extend the life of the Trans Alaska Pipeline System.
  - Environmentally friendly EOR method.

Project Overview

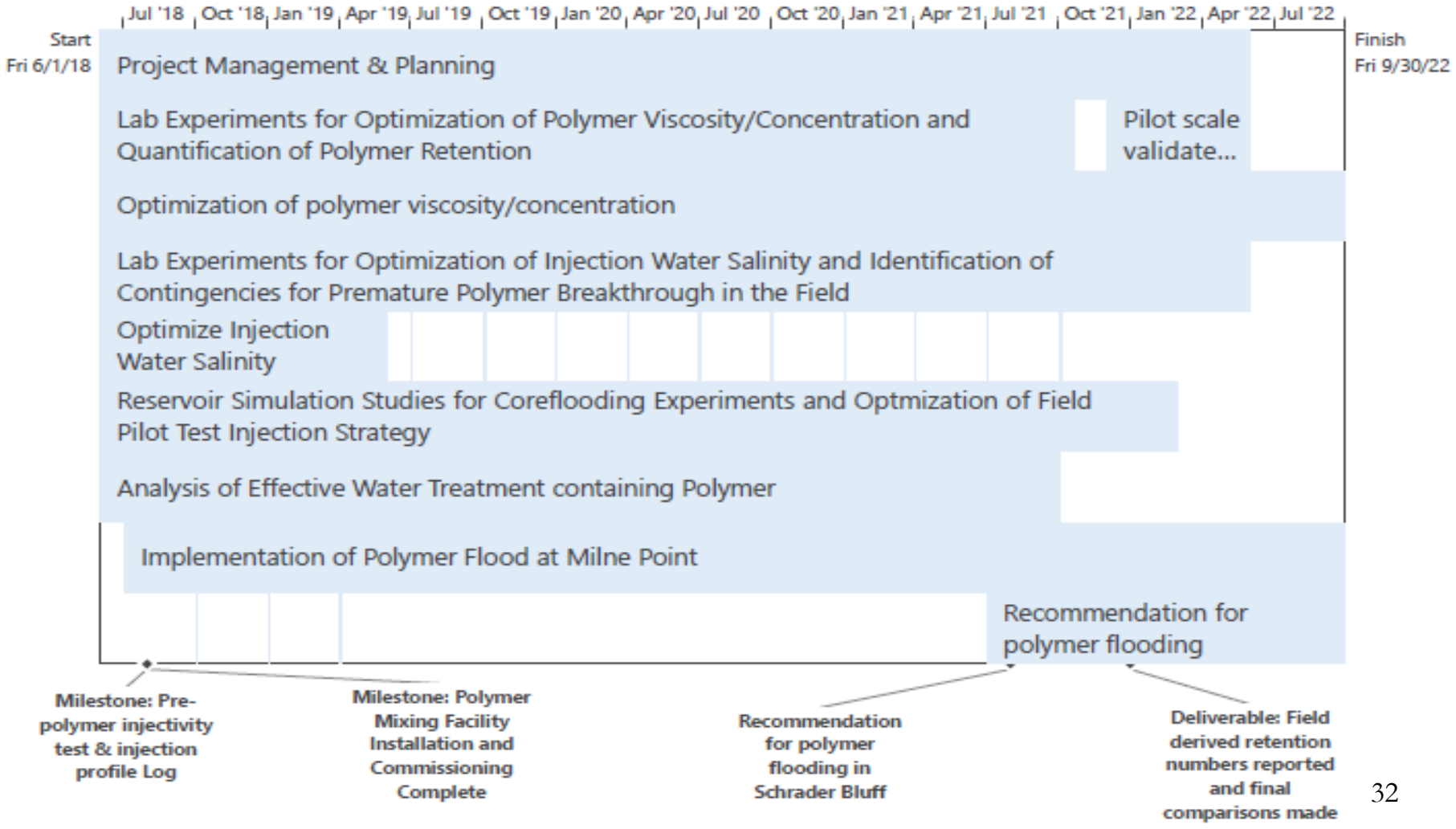
Goals and Objectives

- The specific objectives that would enable the achievement of project goals:
  - assess polymer injectivity into the Schrader Bluff formations
  - evaluate water salinity effect
  - estimate polymer retention
  - assess incremental oil recovery vs. polymer injected
  - assess effect of polymer flow back on surface facilities
- Major decision points and the success criteria based on:
  - polymer injectivity
  - conformance control
  - impact of produced polymer on facilities
  - switching from polymer to water injection
  - commercial feasibility of polymer flood

Organization Chart



Gantt Chart


Jul '18
Oct '18
Jan '19
Apr '19
Jul '19
Oct '19
Jan '20
Apr '20
Jul '20
Oct '20
Jan '21
Apr '21
Jul '21
Oct '21
Jan '22
Apr '22
Jul '22
Start
Fri 6/1/18
Finish
Fri 9/30/22
Project Management & Planning
Lab Experiments for Optimization of Polymer Viscosity/Concentration and Quantification of Polymer Retention
Pilot scale validate...
Optimization of polymer viscosity/concentration
Lab Experiments for Optimization of Injection Water Salinity and Identification of Contingencies for Premature Polymer Breakthrough in the Field
Optimize Injection Water Salinity
Reservoir Simulation Studies for Coreflooding Experiments and Optmization of Field Pilot Test Injection Strategy
Analysis of Effective Water Treatment containing Polymer
Implementation of Polymer Flood at Milne Point
Recommendation for polymer flooding
Milestone: Pre-polymer injectivity test & injection profile Log
Milestone: Polymer Mixing Facility Installation and Commissioning Complete
Recommendation for polymer flooding in Schrader Bluff
Deliverable: Field derived retention numbers reported and final comparisons made

Bibliography–Refereed Journals

1. *Zhao, Y., Leng, J., Lin, B., Wei, M., Bai, B. 2021. Experimental study of microgel conformance control treatment for a polymer flooding reservoir containing super-permeable channels.* ***SPE Journal, April 2021****.*
2. *A. Dhaliwal, Y. Zhang, A.Y. Dandekar, S. Ning, J.A. Barnes, R. Edwards, W. Schulpen, Cercone, D. and J. Ciferno: Experimental Investigation of Polymer Induced Fouling of Heater Tubes in The First Ever Polymer Flood Pilot On Alaska North Slope.* ***SPE Production & Operations February 2021****.*
3. *Zhao, Y., Yin, S., Seright, R. S., Ning, S., Zhang, Y., Bai, B. 2020. Enhancing Heavy Oil Recovery Efficiency by Combining Low Salinity Water and Polymer Flooding.* ***SPE Journal, November 2020.***

Bibliography–Refereed Journals

4. *H. Chang, Y. Zhang, A.Y. Dandekar, S. Ning, J.A. Barnes, R. Edwards, W. Schulpen, D. Cercone, J. Ciferno: Experimental Investigation On Separation Behavior of Heavy Oil Emulsion for Polymer Flooding On Alaska North Slope.* ***SPE Production & Operations Journal, June 2020****.*
5. *Wang, D., Li, C. and Seright, R.S.: Polymer Retention Evaluation in a Heavy Oil Sand for a Polymer Flooding Application on Alaska's North Slope,* ***SPE Journal, February 2020****.*

Acknowledgements

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