

CHEMISTRY. INNOVATION. SOLUTIONS.



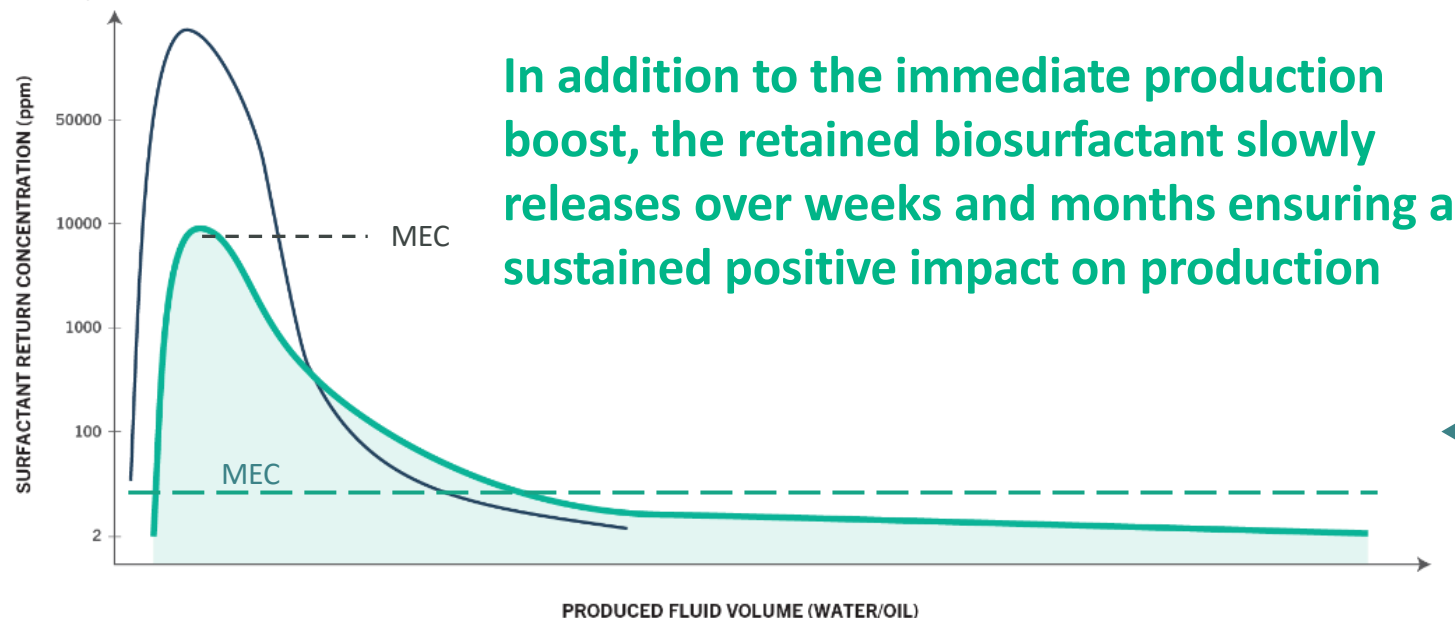
NDIC OGRE Grant Presentation

December 16, 2020

Objective

- To increase production appreciably over the expected production decline of N. Dakota oil producing wells depleting due to formation conditions.
- Creedence aims to prove suitability of novel biosurfactant chemistry, which, due to its incredibly small micelle size (< 2.0 nm) will be able to contact reservoir surfaces previously unreachable.
- The biosurfactant has properties which allow adsorption onto rock surface, allowing for long term chemical effect (>6 months) and sustained production enhancement.
- The highly active biosurfactant will increase production by water-wetting the formation rock (decreasing oil affinity for adhering to rock), reducing the surface tension of fluids (reducing the force needed to lift the fluids to surface), and reducing the interfacial tension of oil and water.
- A minimum 25% increase of produced oil, above projected decline curves are expected based on case histories from > 300 wells in the Appalachia and Permian
- Formally recognized by the Texas RRC as a tertiary EOR Technology qualifying for tax incentives

- **Traditional Surfactants:** Flow back immediately after batching, with no sustained change in wettability, IFT or oil adhesion reduction
- **Biosurfactants:** Slowly desorb over time providing significant extended boosts in oil production for many months after a single batch treatment
- Unlike synthetic surfactants—which do not absorb significantly onto reservoir rocks—up to **50%** of biosurfactants are retained by the minerals in unconventional (shale) reservoirs

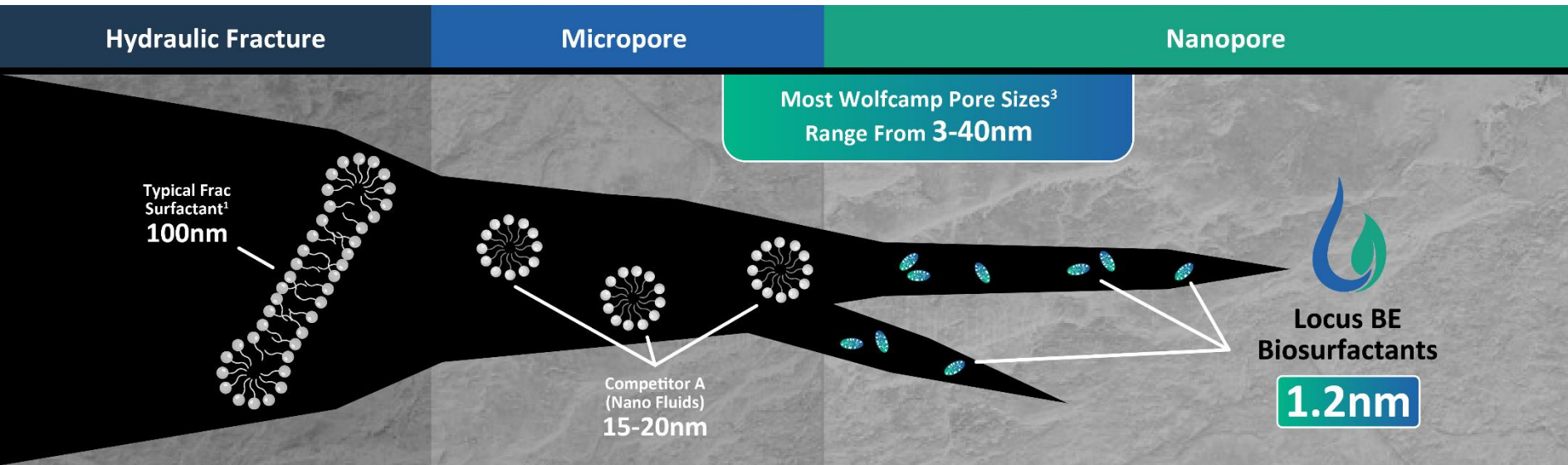


Traditional Surfactants



Creedence Biosurfactants





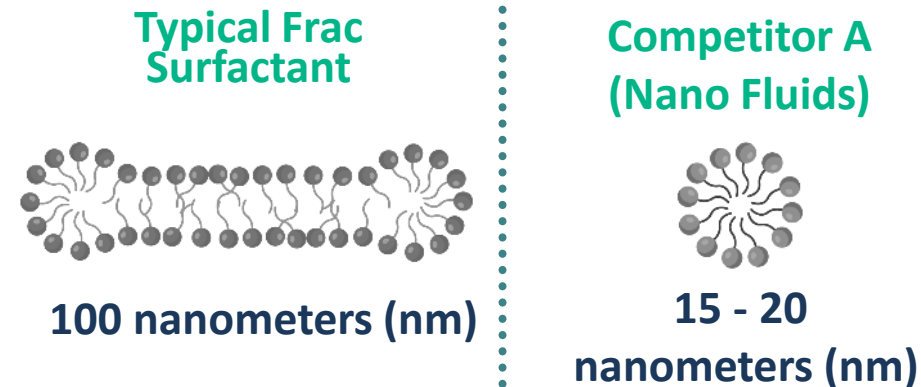
Biosurfactants: Smaller Micelle Size for Better Penetration and Oil Mobilization

Biosurfactants can penetrate pores as small as **2 nm**

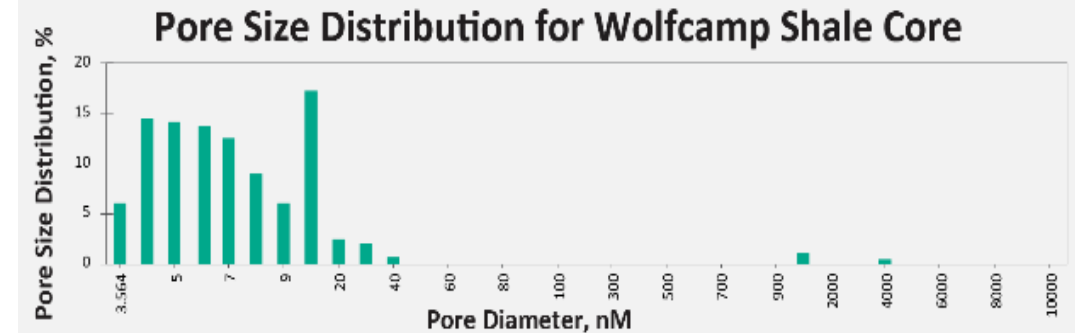
Creedence Biosurfactants 1.2 nm

Comparative Micelle Sizes

Smaller Micelle size and lower dosage requirements mean biosurfactants can **penetrate and mobilize oil from even the tightest shale reservoirs**



Creedence biosurfactants can penetrate into the smallest nanopores and mobilize oil that other treatments cannot.



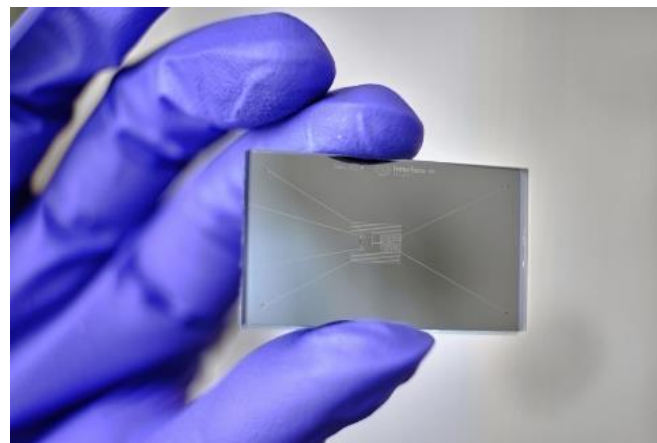
Most Wolfcamp Pore Sizes³ Range From 3-40 nm

¹ Source: *Advances in Colloid and Interface Science*, **2018**, 256, 1–22)

² Source : *Structure of Sophorolipid Micelles Characterized with SAXS, SANS, and MD Simulations*, *J. Phys. Chem. B*, **2015**, 119(41), 13113-13133.

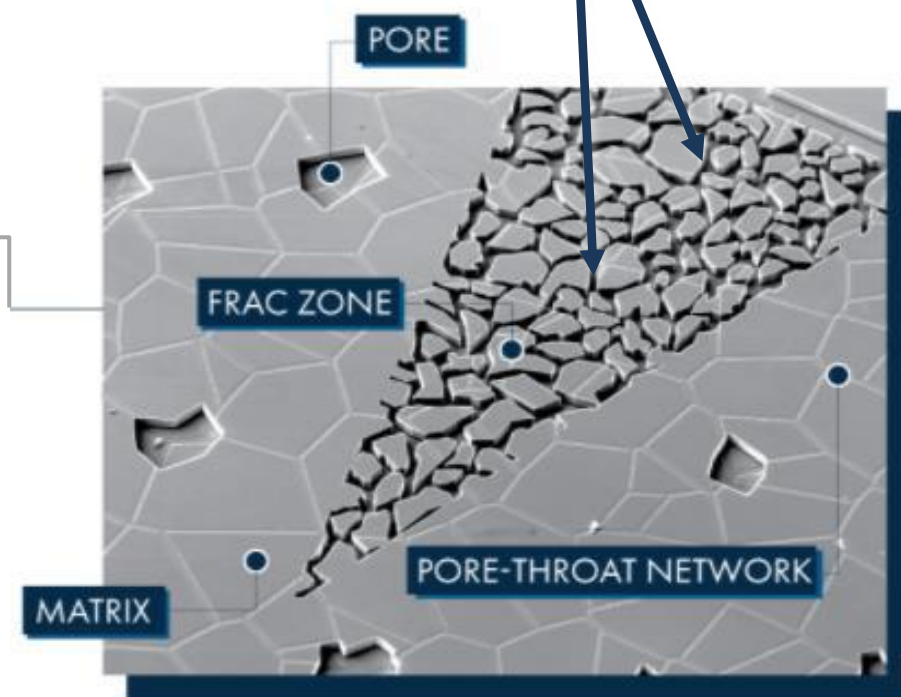
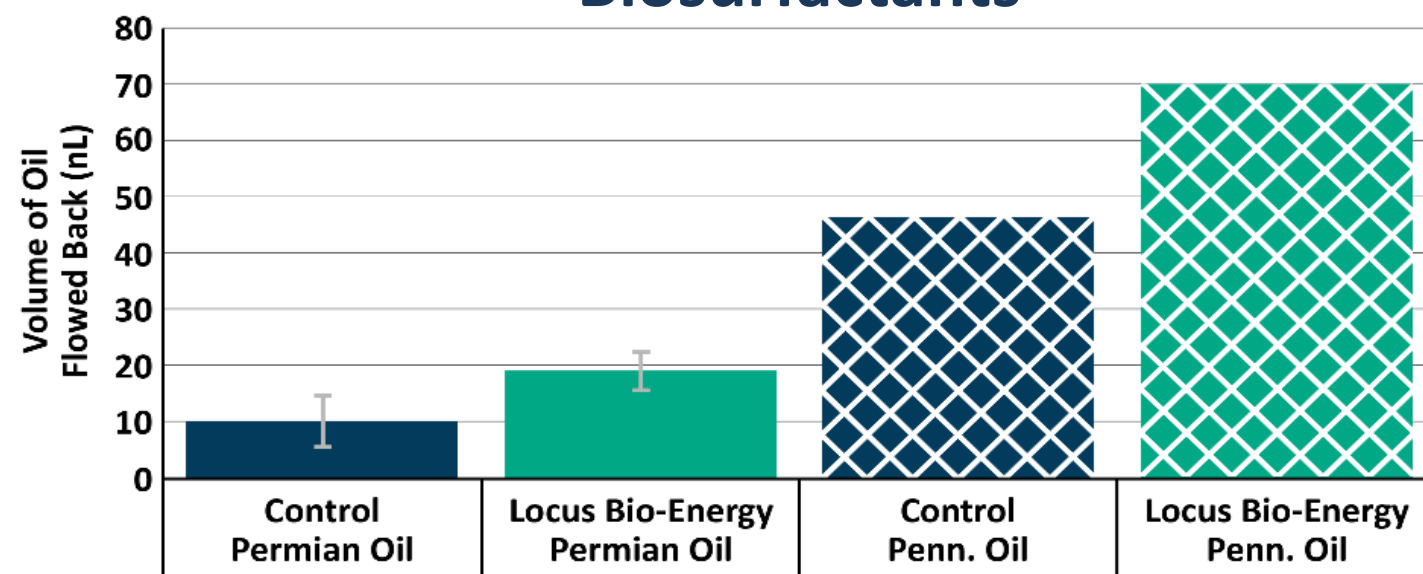
³ Source: *Li et al., Journal of the Taiwan Institute of Chemical Engineers*, **2017**, 78, 317–328. <http://dx.doi.org/10.1016/j.jtice.2017.06.024>

- Microfluidics provide high-resolution simulation of reservoir fluid dynamics
- Reproduces individual reservoir characteristics in microscopic format
- Effective way to compare oil mobilization potentials of different chemistries



Nano-sized pores etched onto a test chip that simulate fluid flow in the natural micro-cracks and pore sizes in a shale reservoir

Biosurfactants

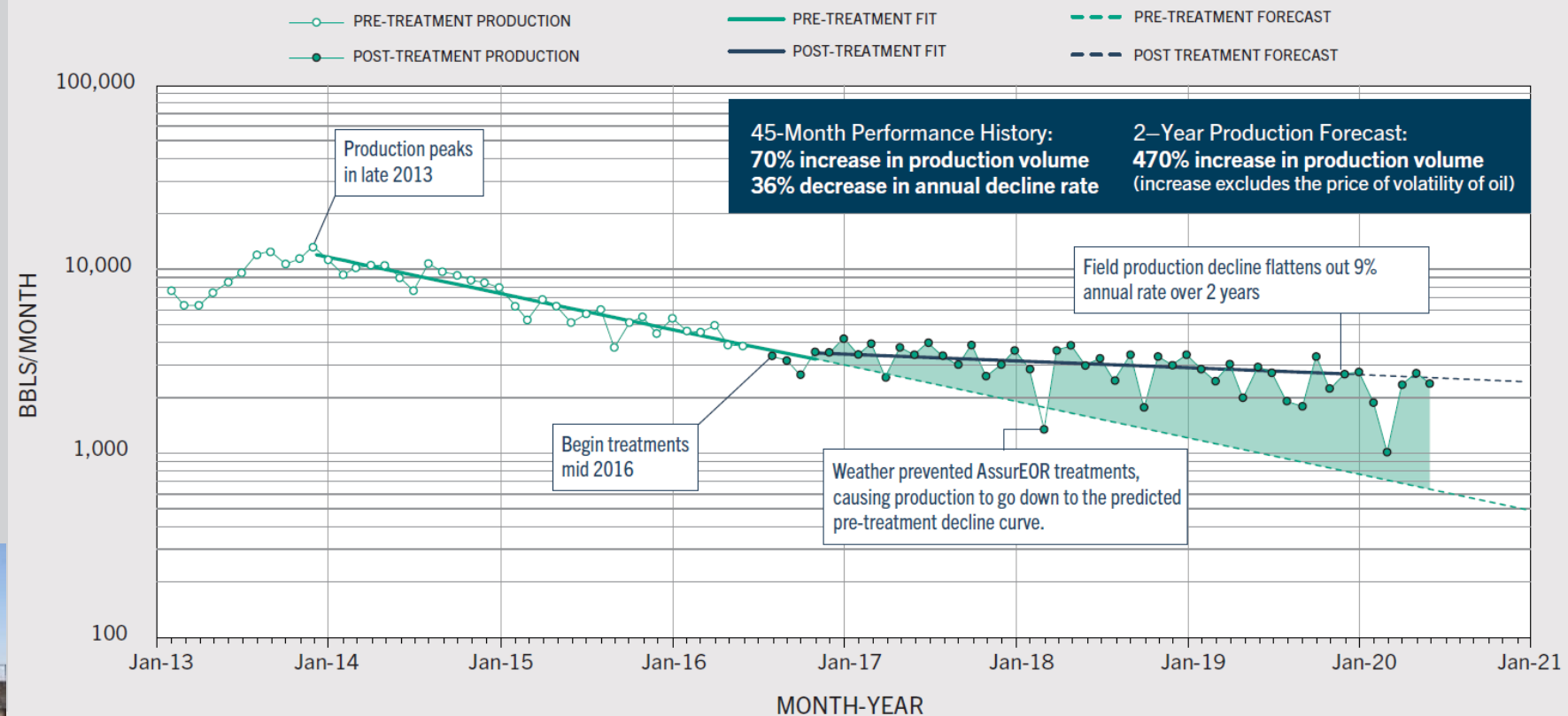


- **70%** increase in oil production rates from a 70-well Appalachian lease
- **45 month** sustained rate with AssurEOR treatments
- **45%** decline rate pre-treatment
- **9%** decline rate post-treatment
- **58,000** incremental bbls recovered using AssurEOR



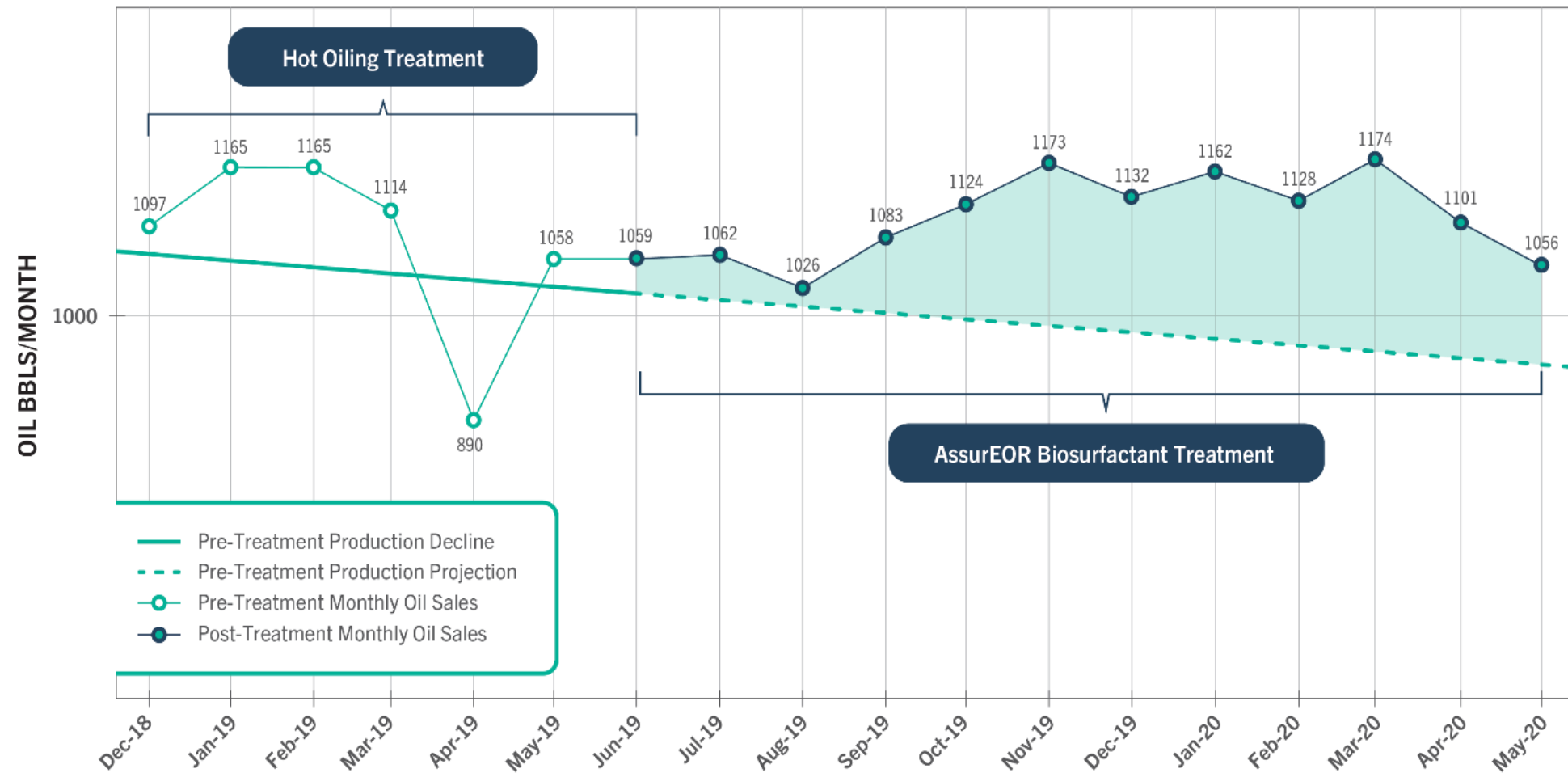
Well Production History Before & After Treatments

45-Month Composite Production Analysis 70 Well Lease



Well Production History Before & After Treatments

Permian Basin Lease Production



15% increase

in oil production rates from a 9 well Permian lease (Sprayberry/Wolfcamp) using Locus Bio-Energy's AssuEOR

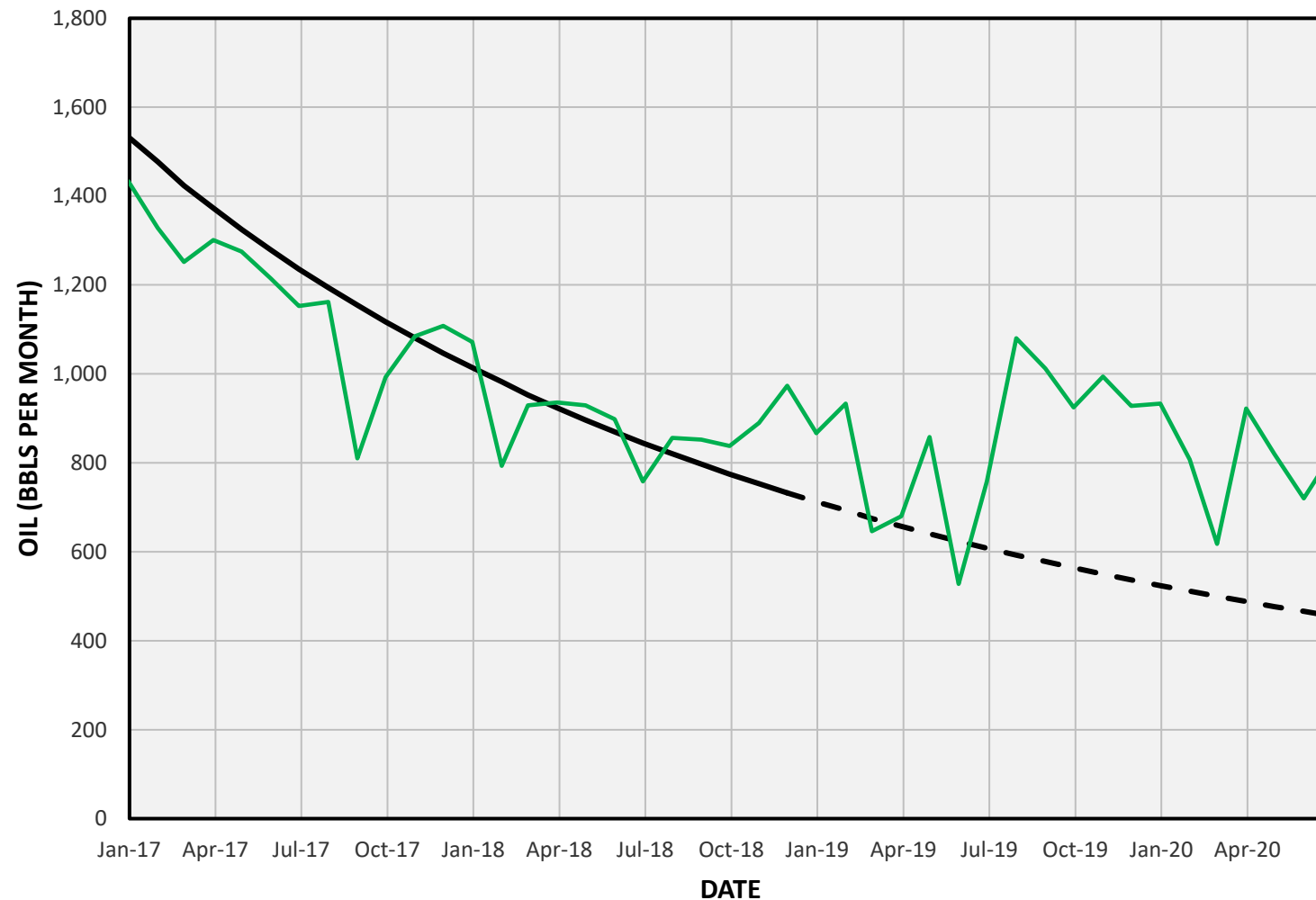
Increase in production maintained for over **9 months** to date

1340

Incremental barrels recovered

Case History 2 – Wolfcamp/Sprayberry

AssuEOR Case History (1 Well)



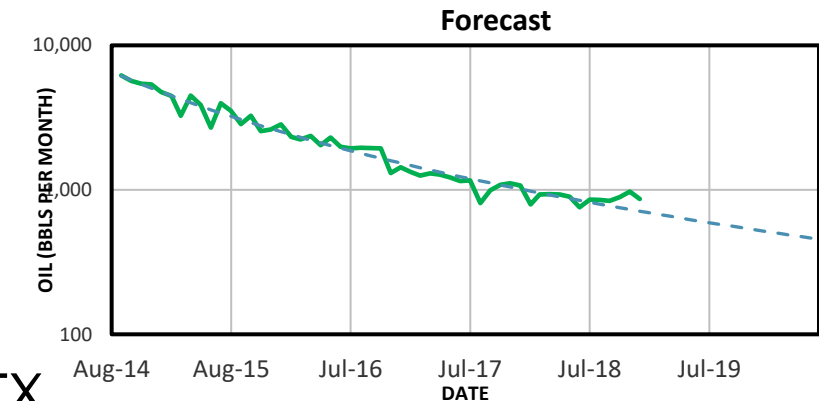
Well Information

1-well lease
Glasscock County, TX
Wolfcamp/Sprayberry
Pre-treatment production rate: 21 bpd

Performance

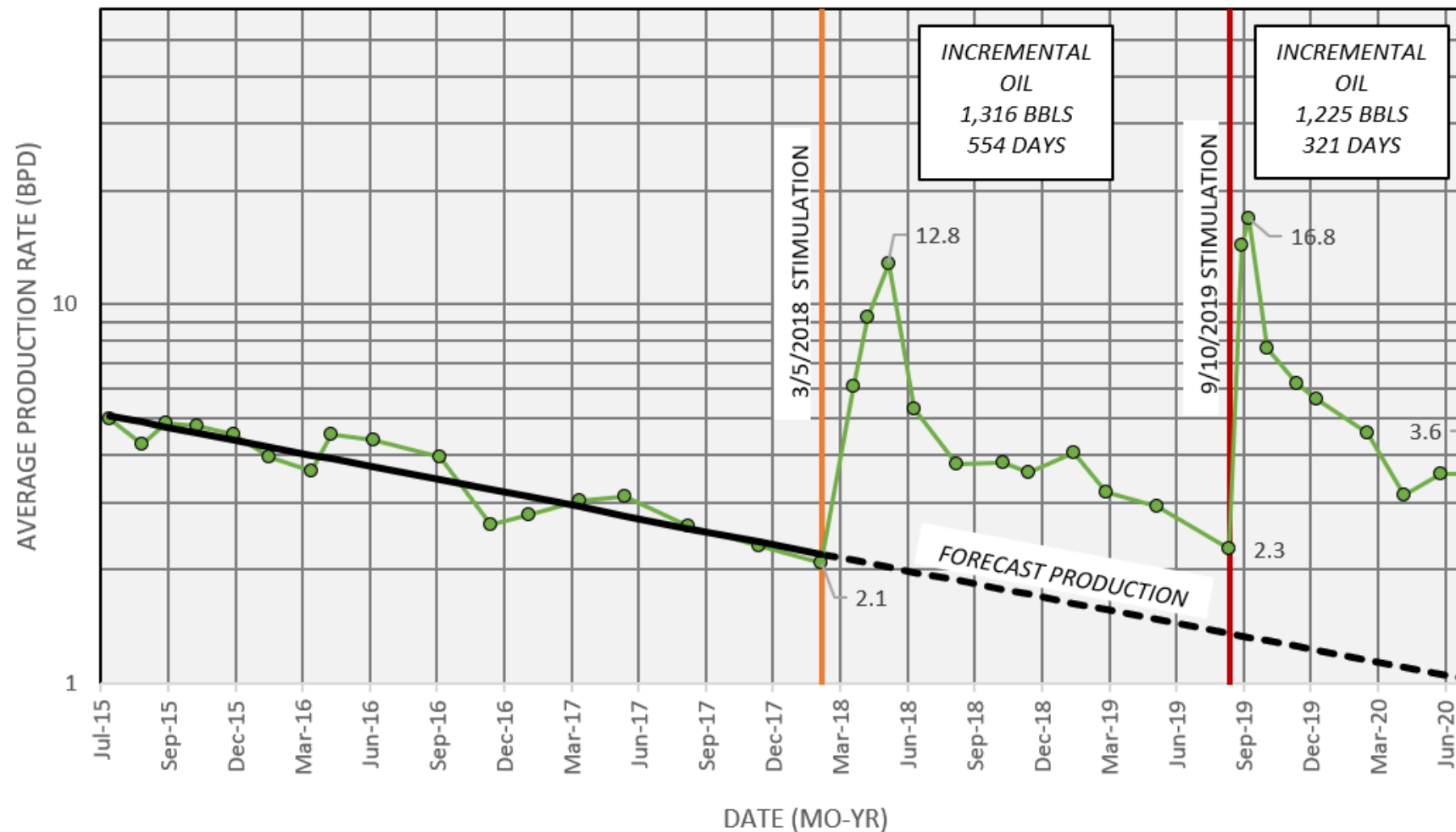
12-month average production rate: 32 bpd
Incremental oil: 4,336 bbls (above forecast)
Payback period: 32 Days @ \$35/bbl oil
Percent Increase: 69% (incremental/forecast)
ROI* (3-month period): 2.6
ROI* (12-month period): 8.6

*ROI = Incremental revenue / Cost @ \$35/bbl oil



Gospel Church 10H – Case History

GOSPEL CHURCH 10H
(Jul 13, 2015 - July 27, 2020)



3/15/2018 AssurEOR Performance

Initial Forecast Prod Rate = 2.1 BPD
 Peak Production Rate = 12.8 BPD (28-Day Avg)
 Analysis Begin-End = 3/15/2018 – 7/27/2019
 Analysis Period = 554 Days
Incremental Barrels = 1,316
 Terminal Rate (554 Days) = 2.3 BPD
 BPD Uplift (Average) = 2.4 BPD (554 Days)
 BPD Uplift (Percent) = 140%
 Net Oil Price = \$35/Bbl
 ROI (90 Days) = 2.5
 ROI (180 Days) = 3.3
Payback Time = 48 Days

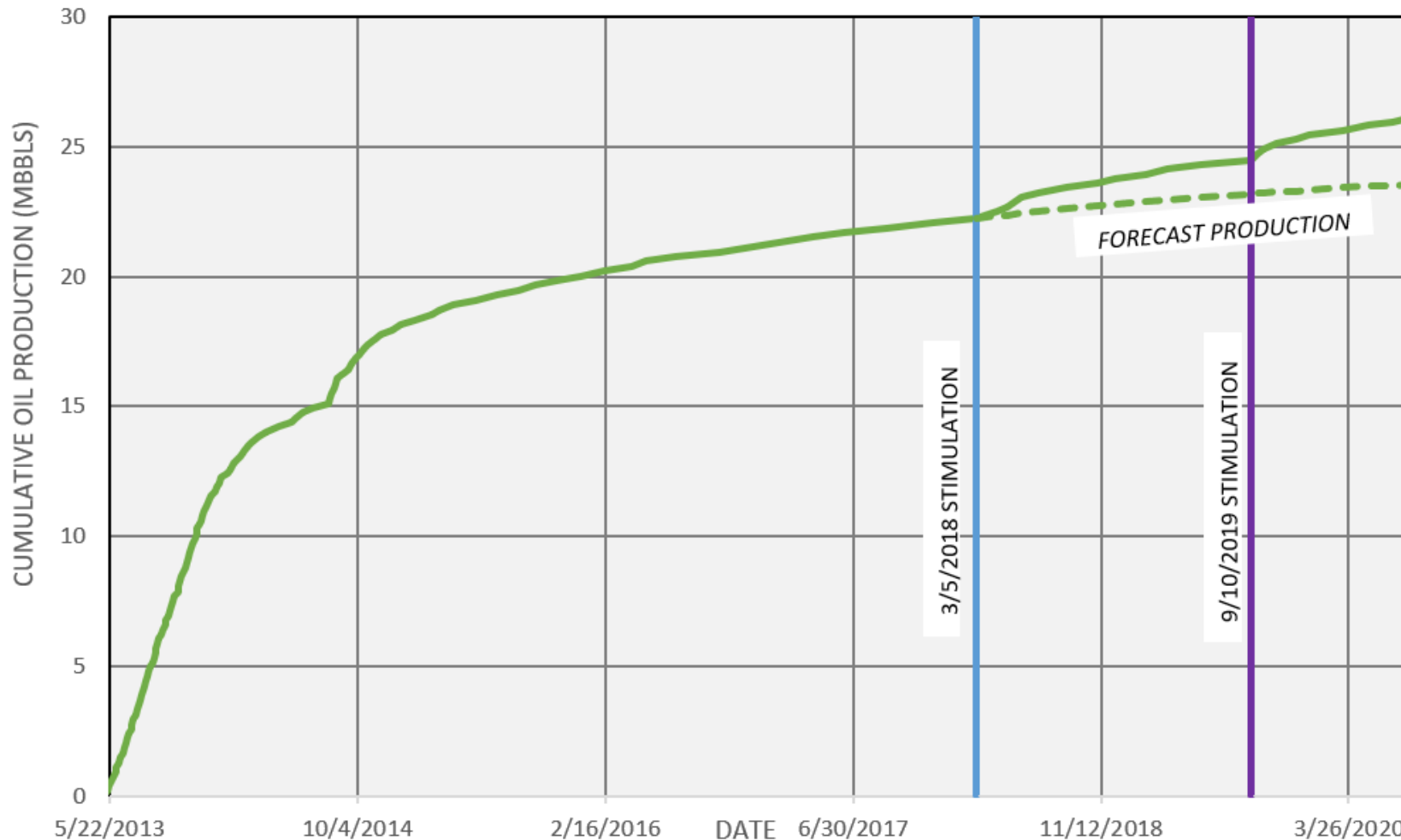
9/10/2019 AssurEOR Performance

Initial Forecast Prod Rate = 1.4 BPD
 Peak Production Rate = 16.8 BPD (11-Day Avg)
 Analysis Begin-End = 9/10/2018 – 7/27/2020
 Analysis Period = 321 Days
Incremental Barrels = 1,041
 Terminal Rate (321 Days) = 3.7 BPD
 BPD Uplift (Average) = 3.8 BPD (321 Days)
 BPD Uplift (Percent) = 329%
 Net Oil Price = \$35/Bbl
 ROI (90 Days) = 1.5
 ROI (180 Days) = 2.1
Payback Time = 34 Days

Gospel Church 10H – Case History

GOSPEL CHURCH 10H

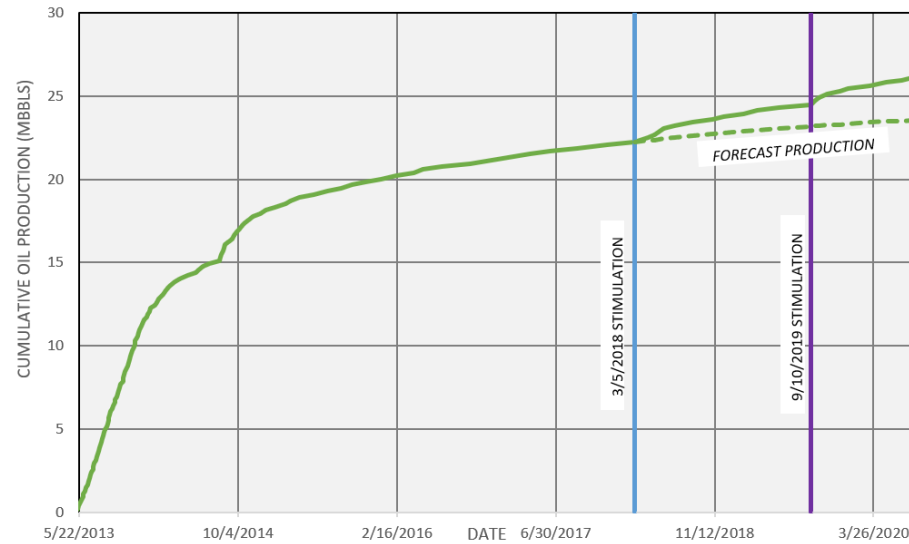
(May 22, 2013 - July 27, 2020); Cumulative Production



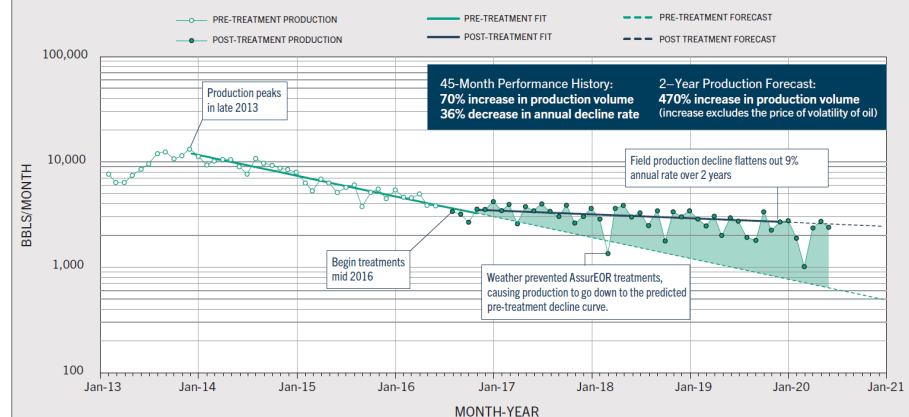
Program Summary

Initial Cumulative Oil =	22,245
Analysis Begin-End =	3/15/2018 – 7/27/2020
Analysis Period =	875 Days
Final Cum Oil =	26,100 Bbls
Final Cum Oil (Forecast) =	23,560 Bbls
Incremental Barrels =	2,541 Bbls
Percent Uplift Cum Oil =	11% (875 Days)
Initial Production Rate =	2.1 BPD
BPD Uplift (Average) =	2.9 BPD (875 Days)
BPD Percent Uplift =	193% (875 Days)

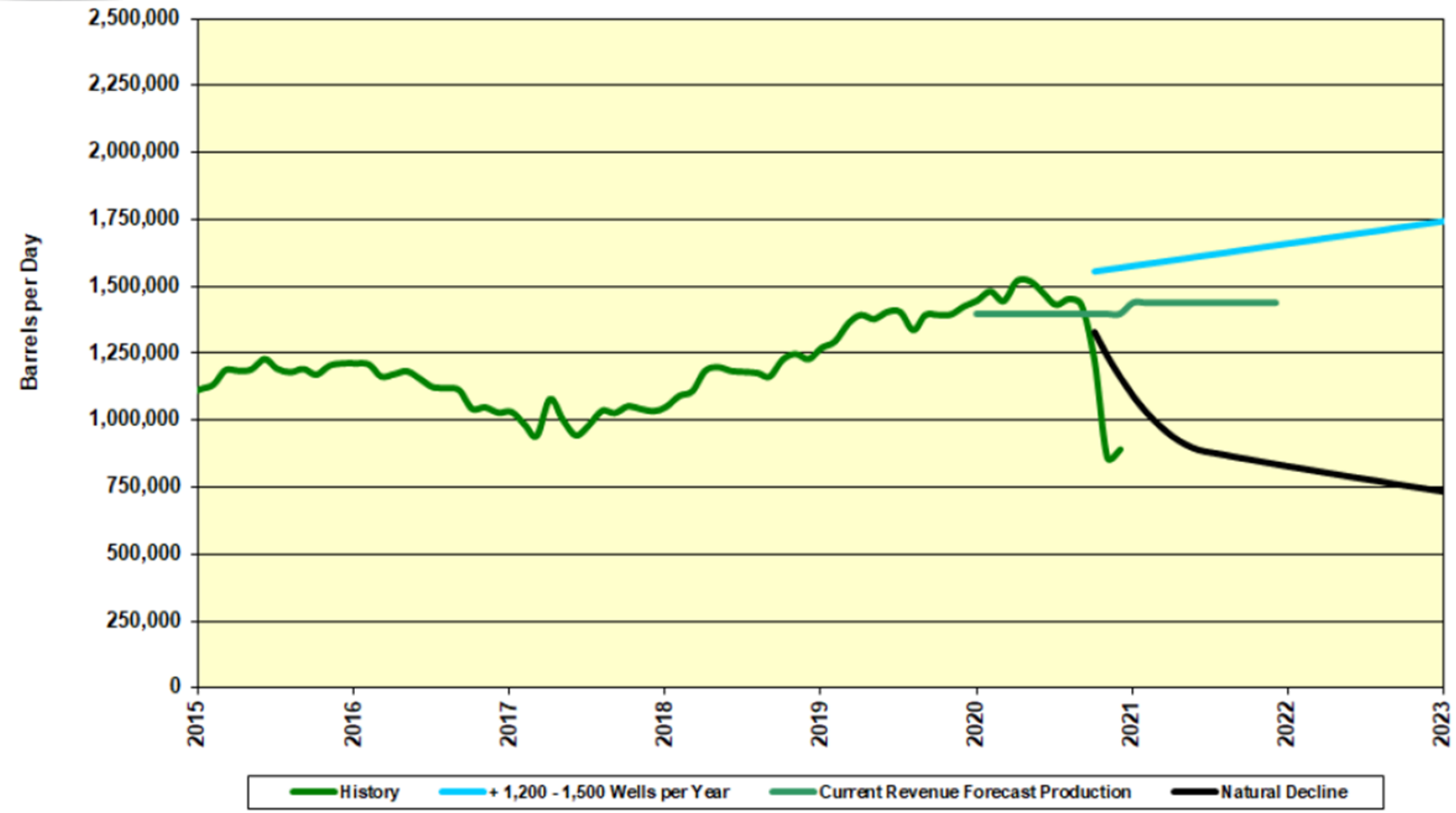
GOSPEL CHURCH 10H
(May 22, 2013 - July 27, 2020); Cumulative Production



45-Month Composite Production Analysis
70 Well Lease



North Dakota Oil Production



Project Duration: 6 to 18 months

Total Project Cost: \$205,750

- \$32,000 for lab equipment
- \$112,500 for 50% cost share of 3 proof of concept trials for 2-mile laterals
- \$52,500 for 50 % cost share of 3 proof of concept trials for 1-mile laterals
- \$8,750 for 50 % cost share of 5 proof of concept trials for 5 vertical wells

Participants: Creedence Energy Services and Locus Bio-Energy Solutions



NDIC Share

- 50% of estimated chemical cost of application
- Lab equipment purchase cost

Private Share

- 50% of estimated chemical cost
- 115 hours of reservoir engineer job design time
- Sample collection time
- >\$100,000 of lab analysis (at commercial rates)
- Pump charges, freshwater, and heating costs

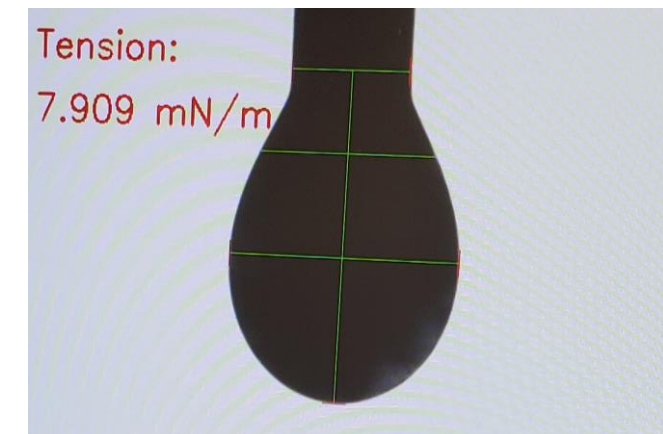
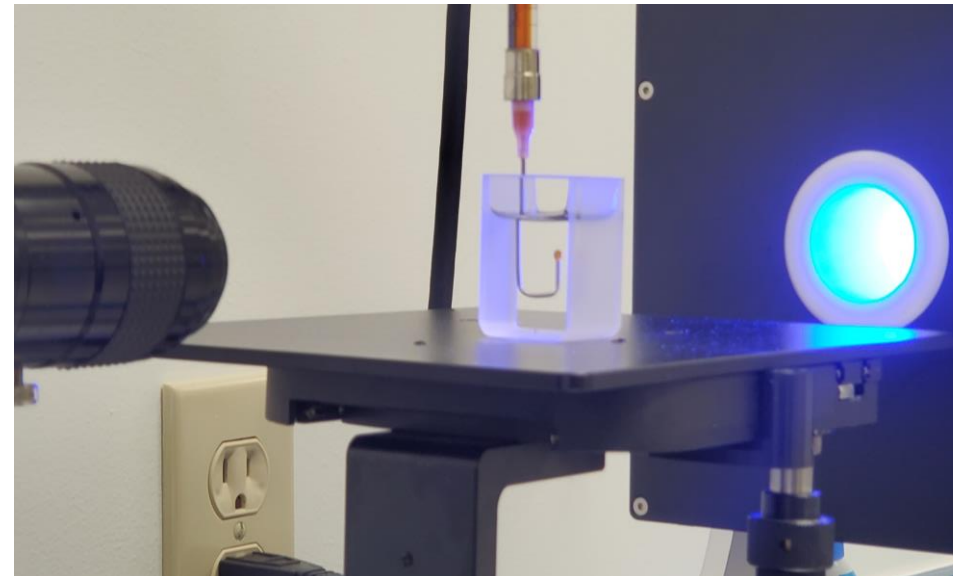
Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Amott Cells	\$2,000			
Surface Tensiometer	\$10,000			
Drop Shape Analysis Instrument	\$20,000			
Initial Lab Analysis Time			\$61,837.50	
Job Design Time			\$17,250	
Sample Collections			\$15,300	
Post Job Lab Analysis			\$45,900	
50% Cost Share of 3 2-Mile Lateral Jobs	\$112,500	\$112,500		\$45,000
50% Cost Share of 3 1-Mile Lateral Jobs	\$52,500	\$52,500		\$45,000
50% Cost Share of 5 Vertical Jobs	\$8,750	\$8,750		\$12,500

- All measurements and KPIs to be communicated to Research Council at regular intervals
- Produced fluid volumes will be used to assess well response
- Oil-Water interfacial tension measured to assess application life and effects

Meeting	Timeline	Purpose
Pre-Treatment	Prior to Treatment	Review treatment design and anticipated production increase forecasts
Post-Treatment I	Within 1 Week of Treatment	Review execution of treatment to ensure proper procedures were followed
Post-Treatment II	1 Month After Treatment	Review forecast to actual production data and interfacial tension measurements
Post-Treatment III	3 Months After Treatment	Review forecast to actual production data and interfacial tension measurements
Post Treatment IV	6 Months After Treatment	Review forecast to actual production data and interfacial tension measurements

Sampling/Testing Schedule

- Weekly samples for first 9 weeks
- Every other week testing for next 9 weeks
- Monthly sampling/testing for remainder of treatment life





- If successful Biosurfactants can be manufactured in North Dakota
- Fermentation plants are low CAPEX and Scalable
- New plant can be constructed and operational in ND within 6 months
- Raw Materials will be Local Vegetable Oil & Sugar
- Employment opportunities for local personnel
- Production process does not require an advanced degree to operate.
- Products are environmentally friendly:
 - Fully biodegradable with low acute toxicity. Studies¹ demonstrate no affect on Daphnia reproduction
 - Chronic toxicity is an order of magnitude lower than that of reference surfactants, with a no-observed-effect concentration (NOEC) of 11.3 mg/L as compared to approximately 1 mg/L

Data to Remain Confidential

- Manufacturing Process
- Job Design Parameters
- Chemical Concentration in Treatment Pills
- Chemical Formulations

