ConocoPhillips' East Vacuum Field CO_2 Update

Doug Pecore

Staff Reservoir Engineer

SENM Permian Conventional

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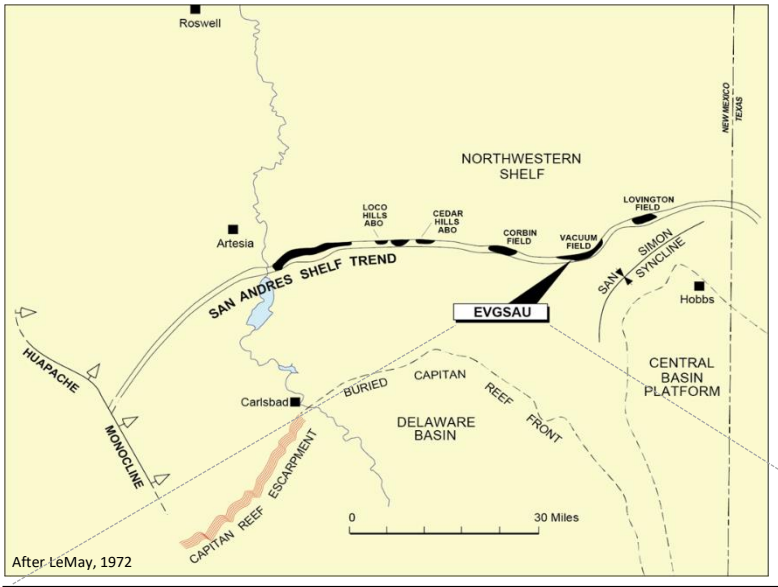
ConocoPhillips

Presentation Topics

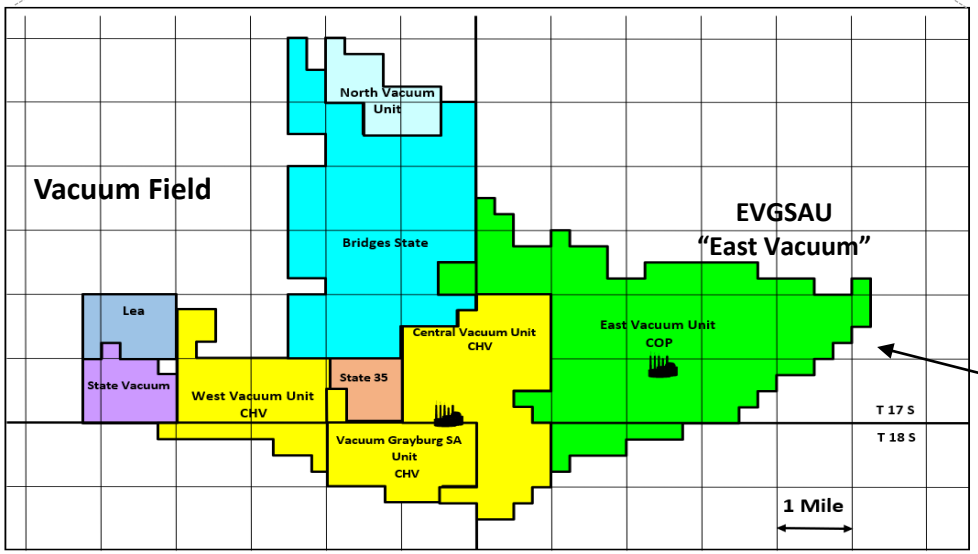
- Background
- Performance Update
- Flexibility in Operation – new WAG methodology
- Compression Expansion
- New Development – TZ/ROZ Phase 1
- Compression Optimization
- 2018 Foam Pilot
- Summary

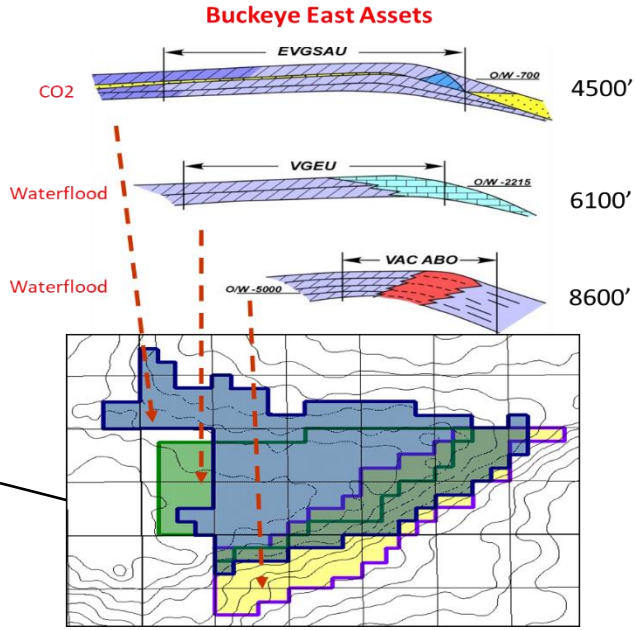
EVGSAU Background



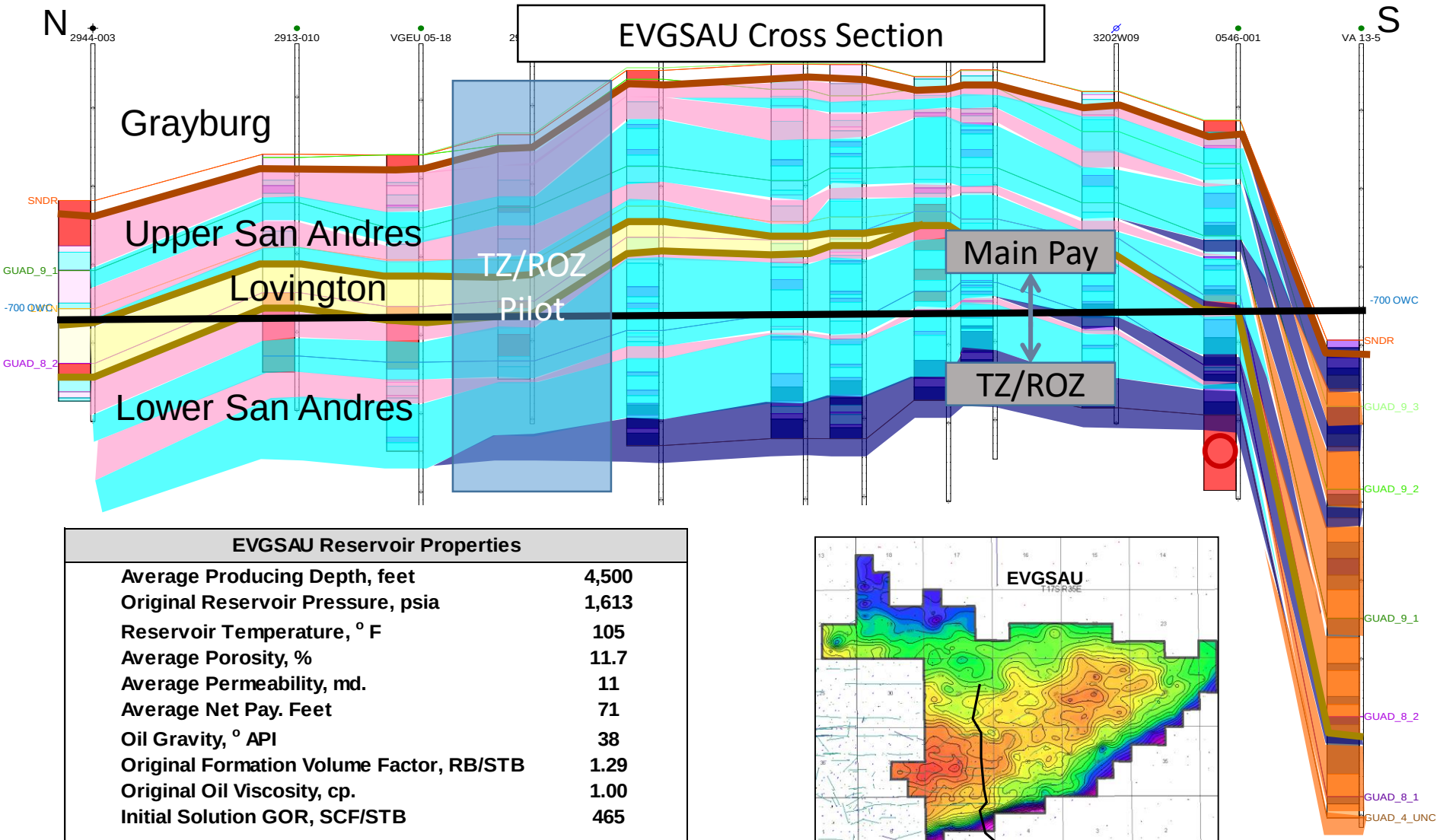
After LeMay, 1972

- Vacuum Field developed in 1938
- GB/SA unitized 1978
- Waterflooding began in 1980
- CO2 Injection commenced in 1985
- Overall RF = 48%
- Earlier Projects include Liquids Plant (1992), 1st Foam Pilot (1992), OH Laterals (2001), Compression Replacement (2010-2011)



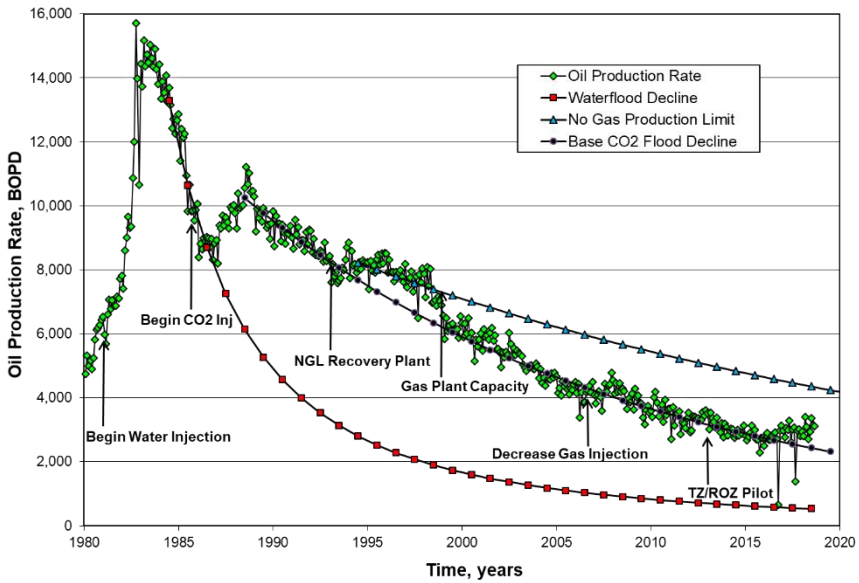


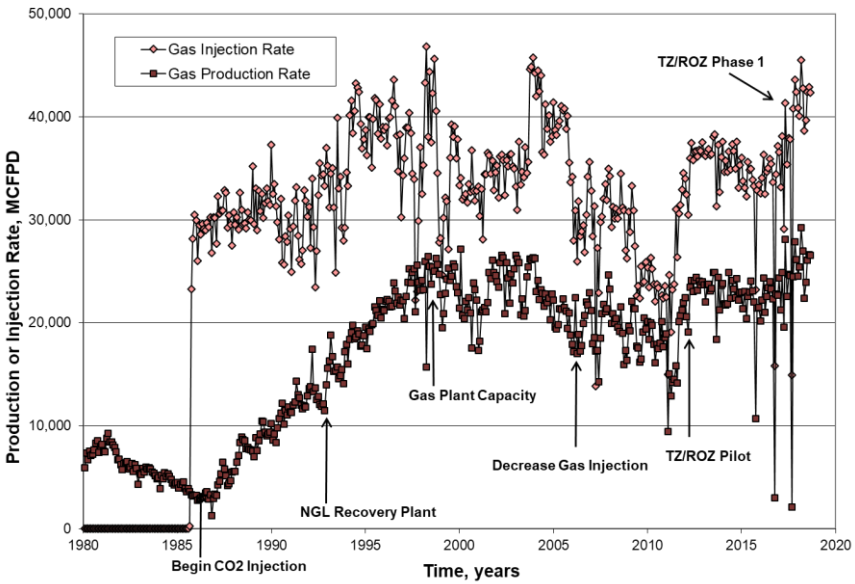
EVGSAU Geology and Properties

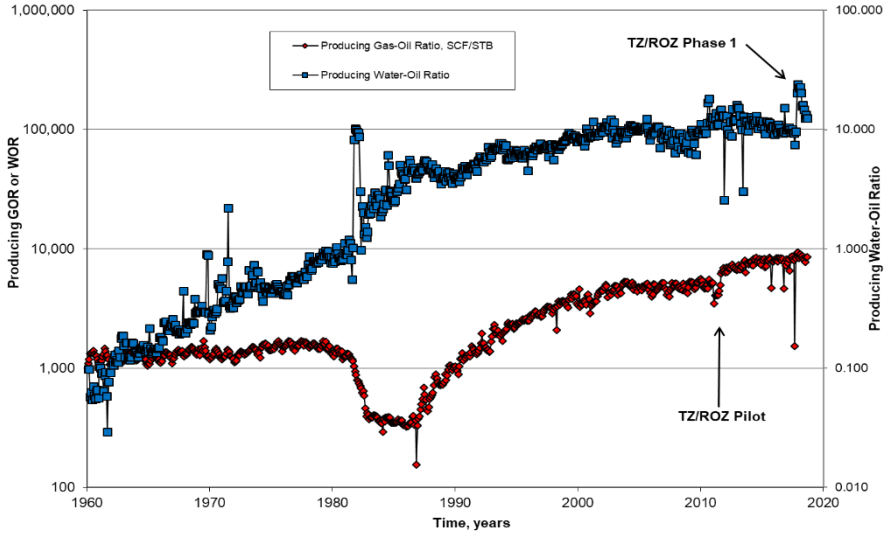


EVGSAU Reservoir Properties	
Average Producing Depth, feet	4,500
Original Reservoir Pressure, psia	1,613
Reservoir Temperature, ^{o} F	105
Average Porosity, %	11.7
Average Permeability, md.	11
Average Net Pay. Feet	71
Oil Gravity, ^{o} API	38
Original Formation Volume Factor, RB/STB	1.29
Original Oil Viscosity, cp.	1.00
Initial Solution GOR, SCF/STB	465

Performance Update

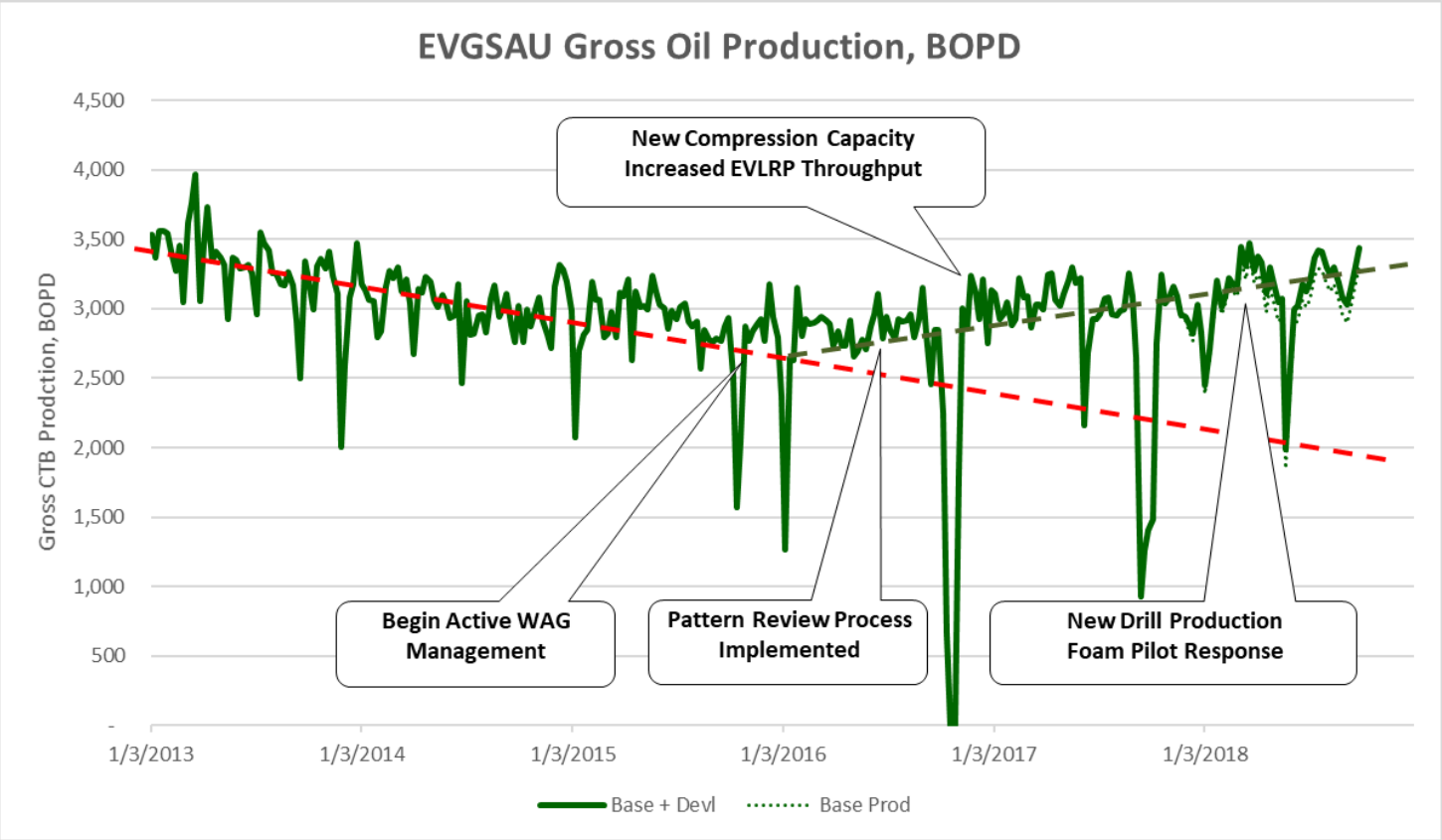






Current Production Metrics		
Oil Production Rate	3,150	BOPD
Gas Production Rate	27,000	Mscfd
Water Production Rate	39,200	BWPD
Gas Injection Rate	43,000	Mscfd
Water Injection Rate	54,600	BWPD
Total RF	48	%
WF RF	16	%
CO2 RF	14	%
Current VRR	1.12	RB/RB
Gross CO2 Utilization Rate	12.9	MCF/BBL
HCPVI CO2	0.47	
HCPVI Water	1.67	
HCPVI Total	2.14	

Performance Update

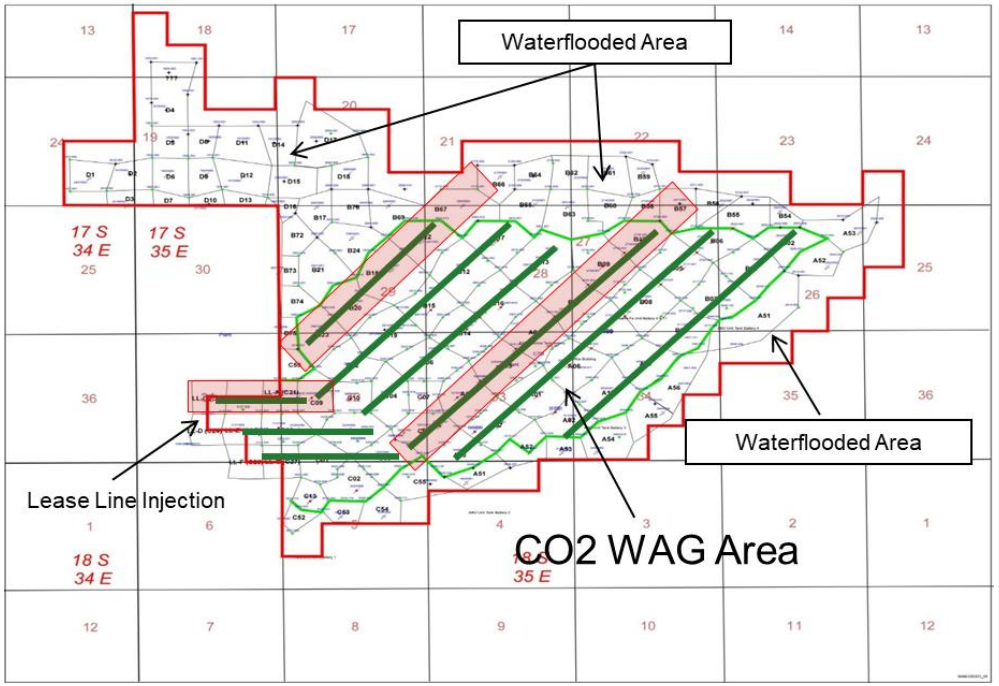


Projects

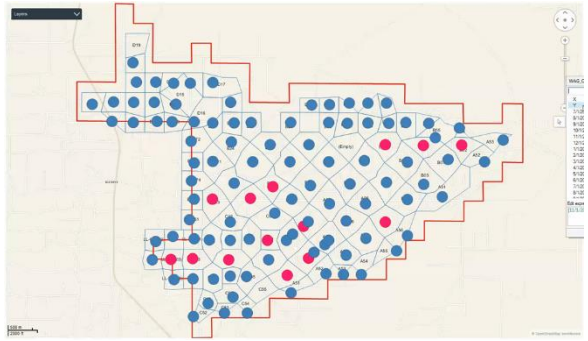
- Compression expansion has added WAG flexibility
- Increased water production handled by other COP operated WFs nearby
- TZ/ROZ Pilot (2011) - large amounts of producible gas found
- TZ/ROZ Phase 1 (2016) – similar high CO2 cut wells found

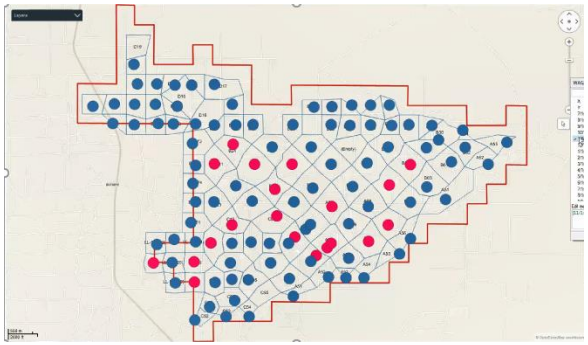
Added Flexibility in Operation

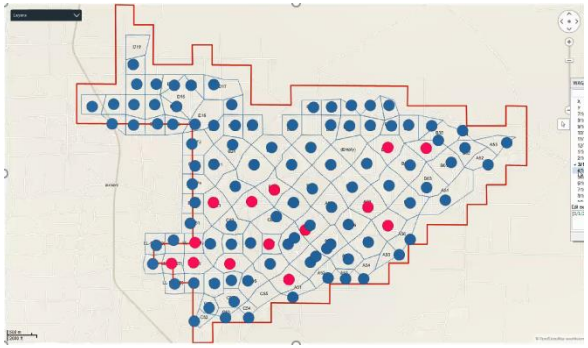
Previous Strategy: Line Drive



Active WAG Management

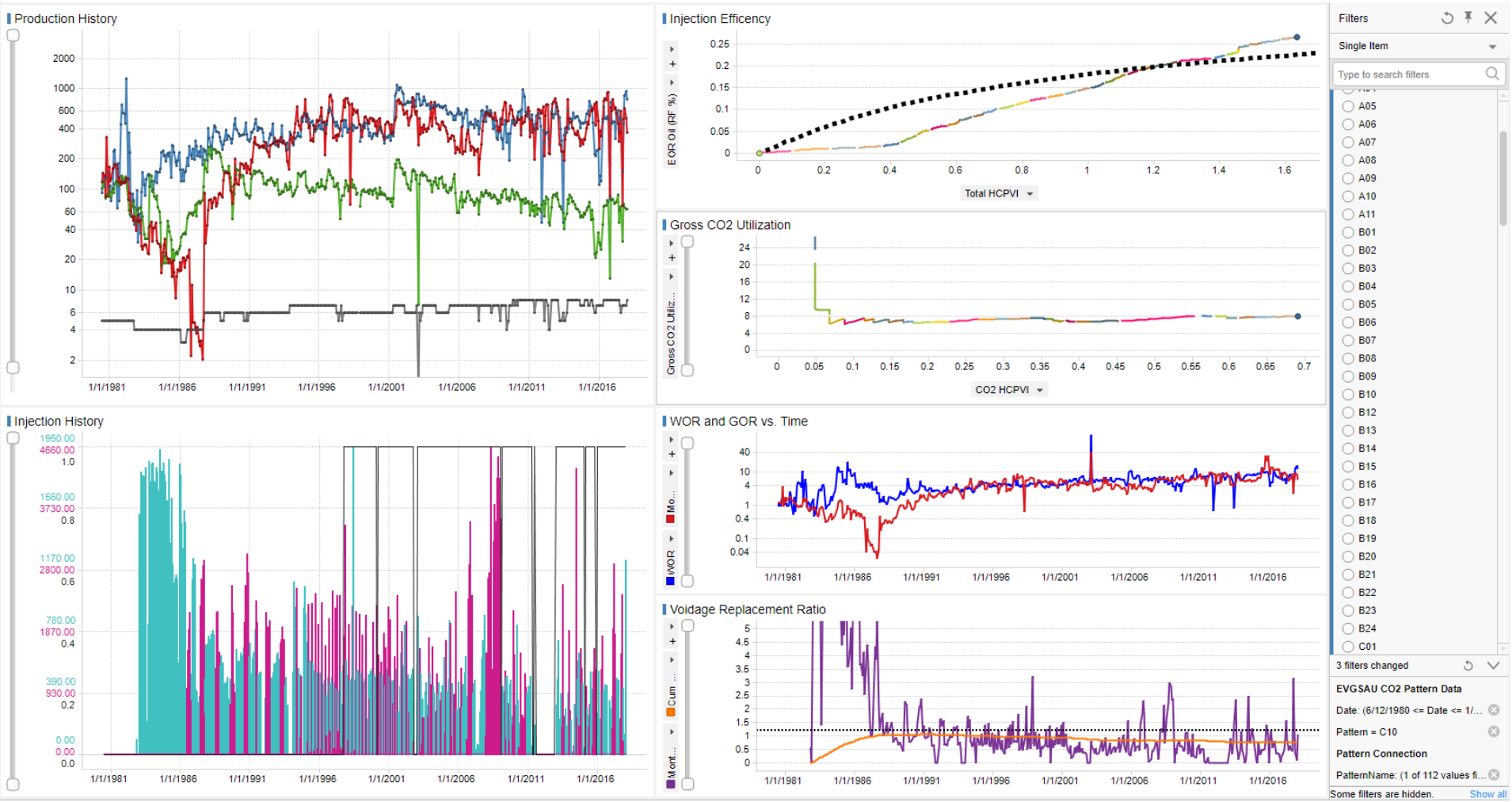






- Line Drive strategy implemented in 2007 out of operational necessity; no noticeable production benefit
- With compression expansion, EVGSAU returned to pattern by pattern injection based on the process of . . .
  - first ranking each pattern using eight pattern health metrics weighted for importance or impact
  - then CO2 utilization further adjusts scales the Individual pattern slug size and WAG ratio

Pattern Surveillance using Spotfire



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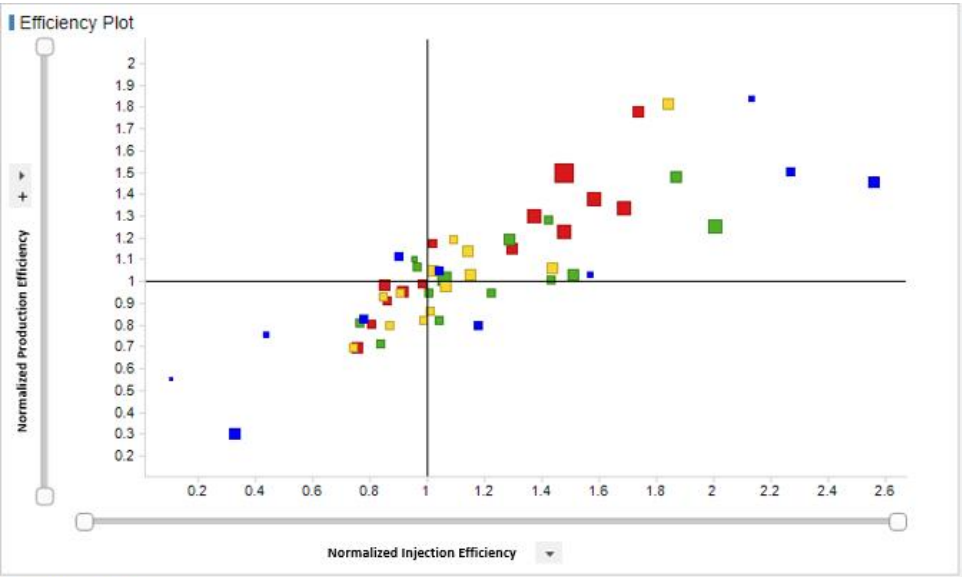
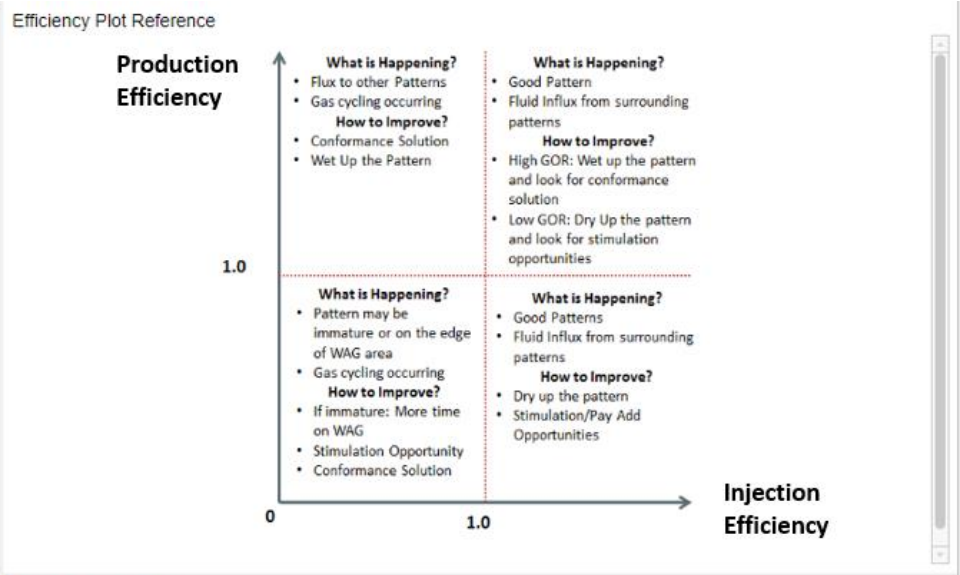
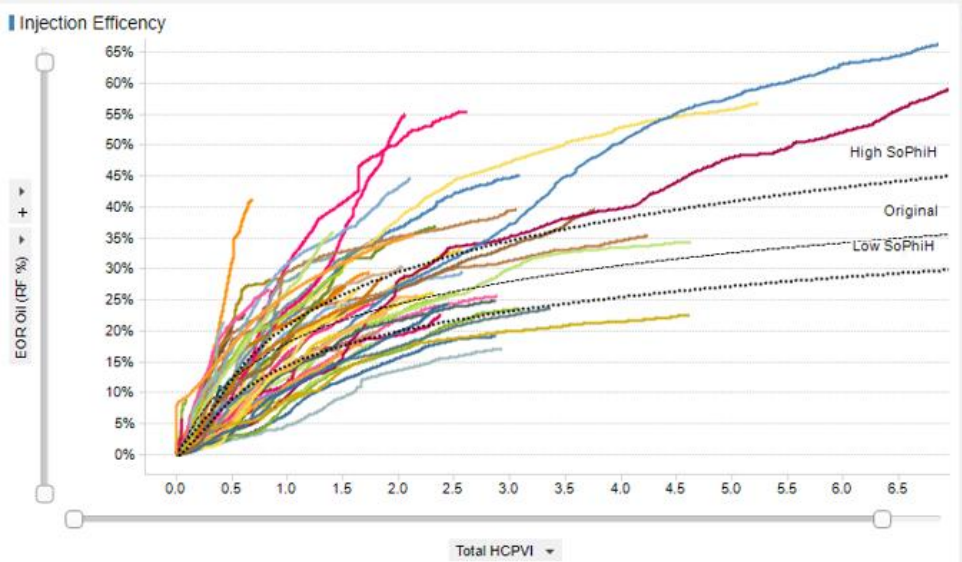
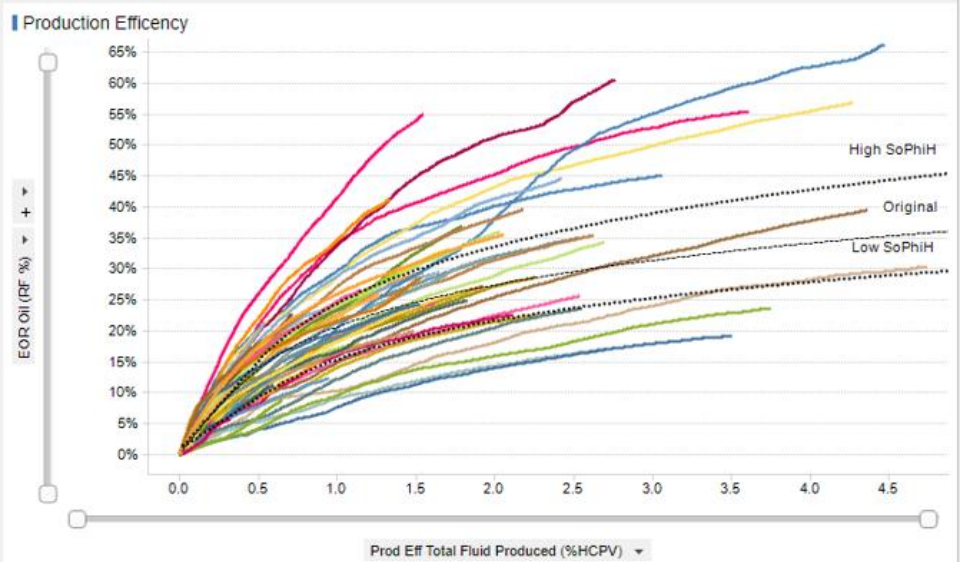


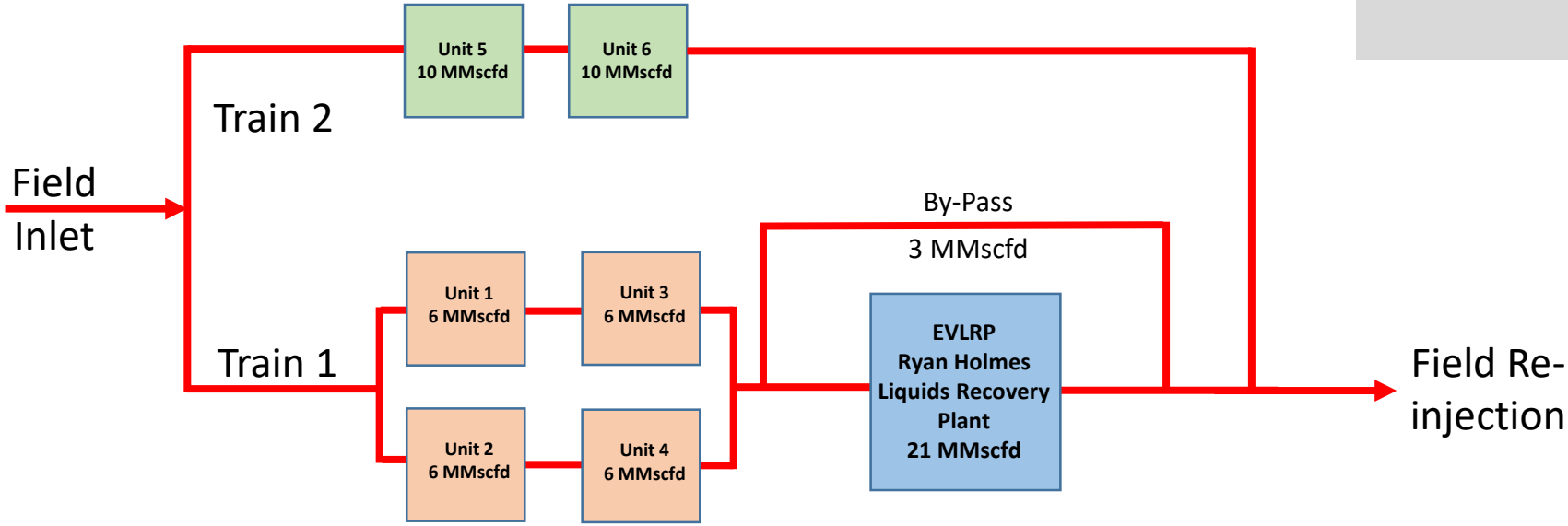






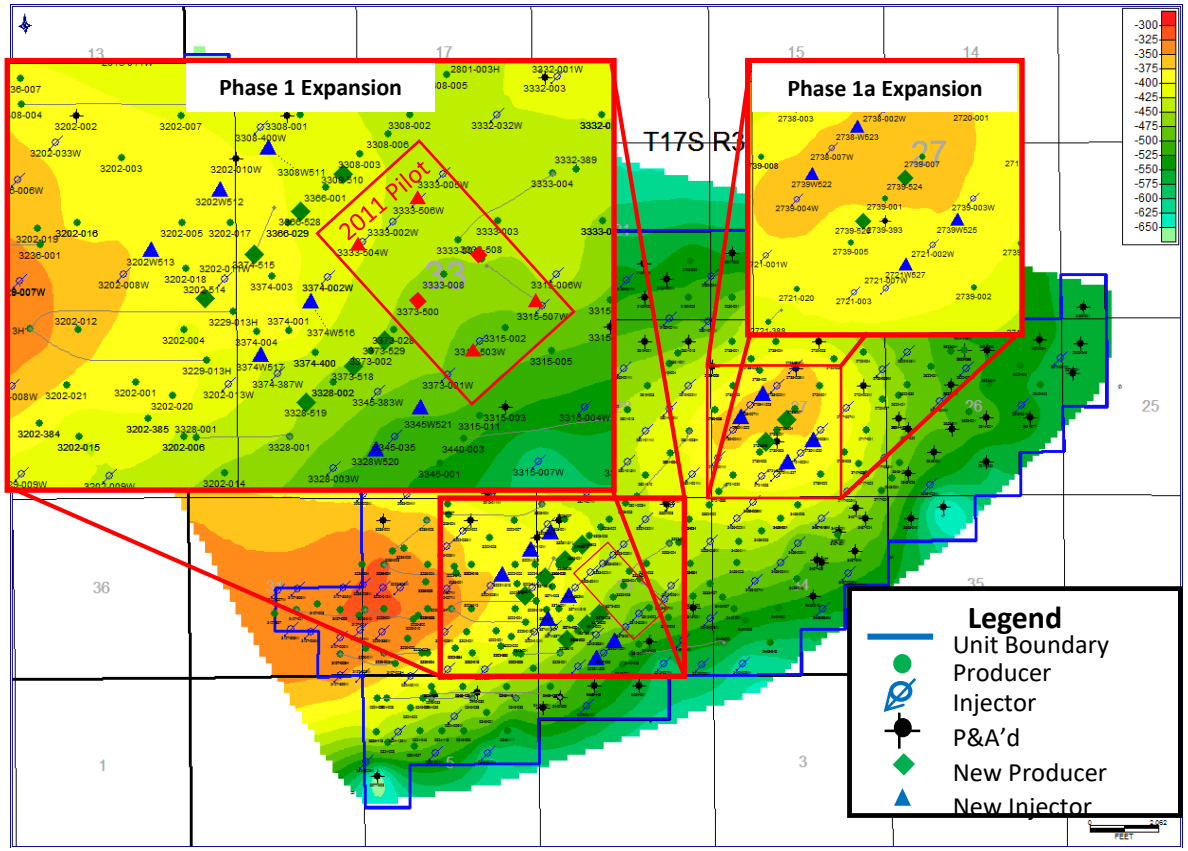
Compression Expansion

- Total Installed Capacity: 44 MMscfd
- Liquid Recovery Technology: Ryan-Holmes
- Compression Expansion: completed for 15% under AFE due to timing and contracting strategy
- Train 1 remains fully loaded to maximize NGL recovery

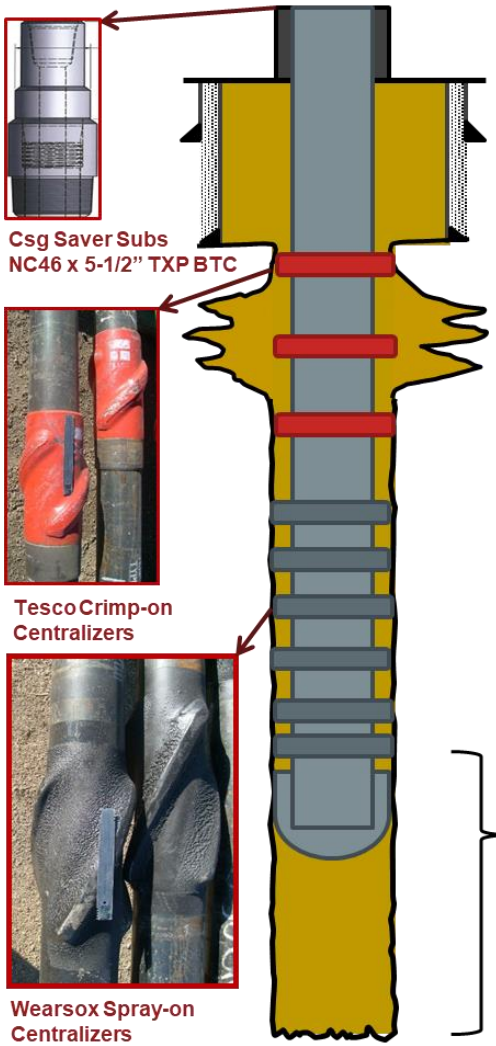


TZ/ROZ Phase 1: Development

- TZ/ROZ Pilot started in 2011. 4 injectors and 2 producers
- 1 producer has cum. production = 300 MBO
- Other producer can make 5,000 MCFD gas likely from fracture
- Performed 2 conformance projects to remedy unbalanced injection vertically and high GOR
- Phase 1 sanctioned in 2015



TZ/ROZ Phase 1: Drilling Redesign



CONDUCTOR: 16"; 65.0#; H-40; @ 100'

9-5/8"; 40.0#; J-55; BTC CSG @ 1630' ; Inside "RUSTLER Form"

800' of Severe Loss / Charged Zones

TD WELL @ 5100'

Drilled 6 wells in late 2015. Half the wells in the program encountered severe losses and flows at the same time. Halted the drilling in early 2016

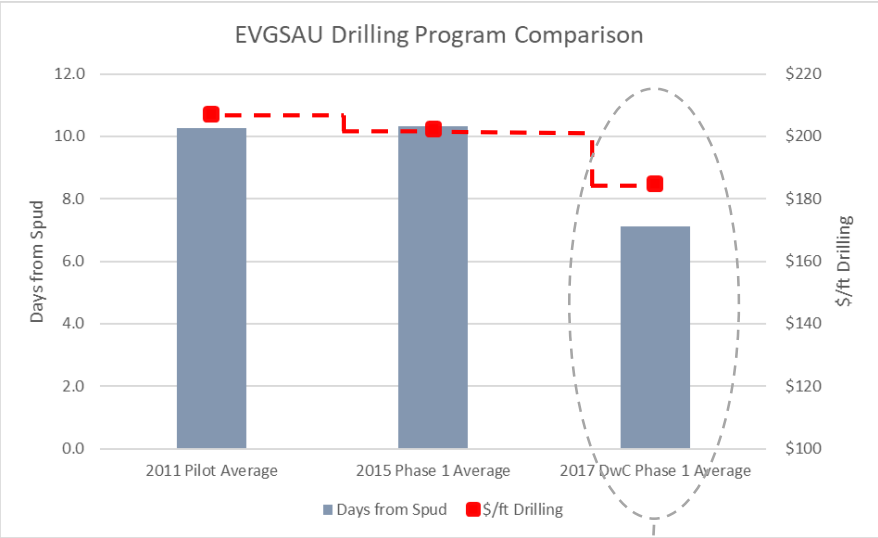
Pros:

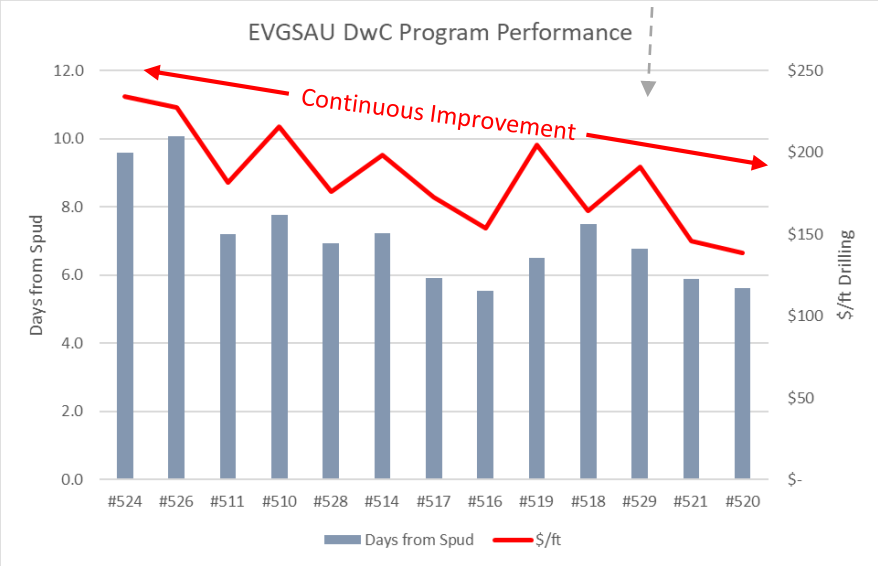
- Eliminate trouble time associated with controlling the well and POOH to run casing.
- Casing on bottom when well TD.
- Smear Effect – Less chances of severe losses or diff sticking

Cons:

- Require TXP BTC connections & Centralization – Increase Csg Cost.
- Susceptible to buckling, casing wear and fatigue – Twist-Off.
- Slower ROP with non-motor assist and packed/stabilized assemblies.
- Cannot run OH logs

TZ/ROZ Phase 1: Drill with Casing (DwC)

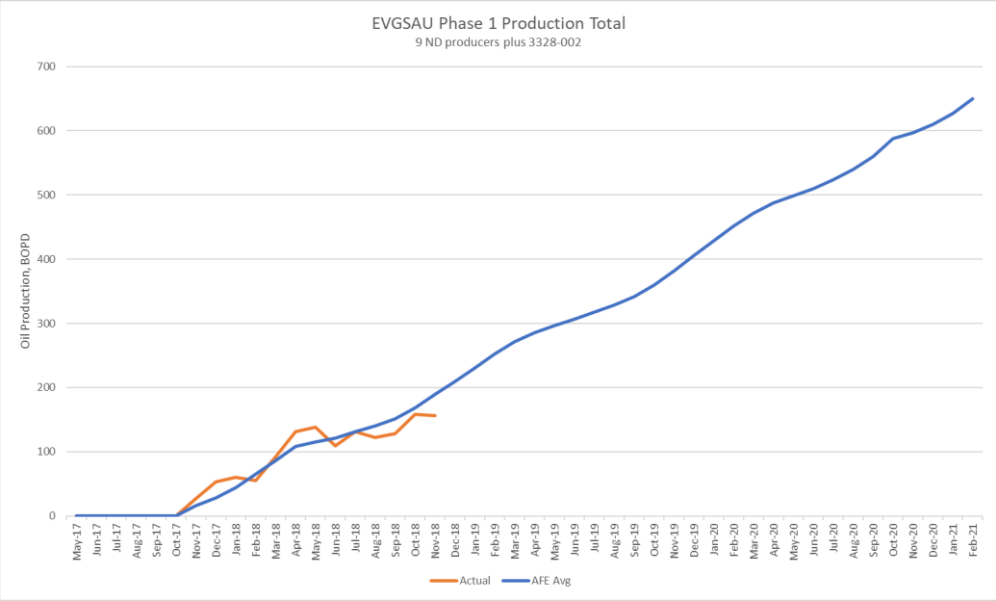




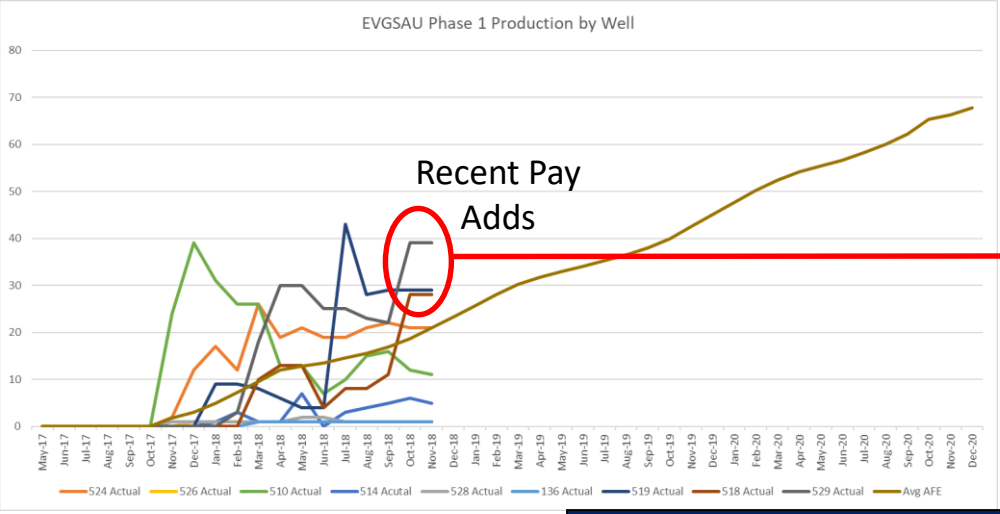
- No trouble time associated with casing drilling encountered during DwC program
- Clear learning curve – continued to innovate during program
- No flows or losses encountered
- QC of tubulars imperative to prevent over-torque downside
- 31% improvement in Days from Spud over 2011 program
- 10% improvement in drilling costs over 2011 program

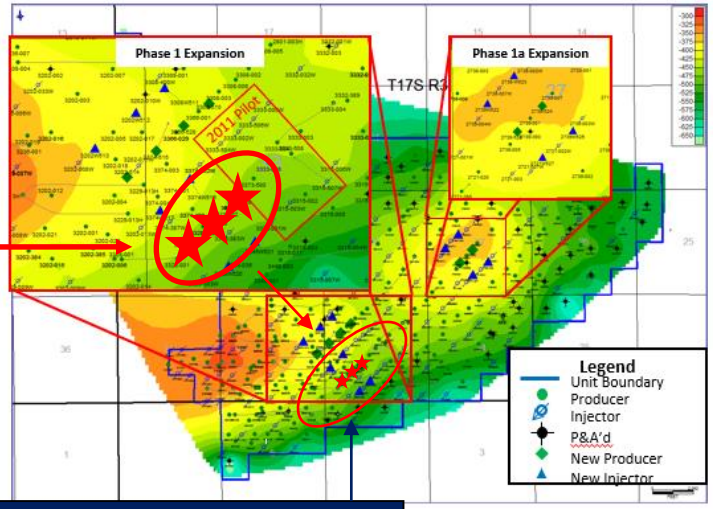
Tangible solution to support future development activity at EVGSAU and other EOR fields

TZ/ROZ Phase 1: Performance



- Producers on track with AFE
- Hindered by lack of OH logs
- Locating "sweet spots" through pay adds
- 3 other producers have encountered high gas rates due to fractures in lower San Andres
- Plan to run IPL logs to measure vertical conformance





Best performance in Phase 1 TZ/ROZ wells are on the flank as reservoir drops into Delaware Basin

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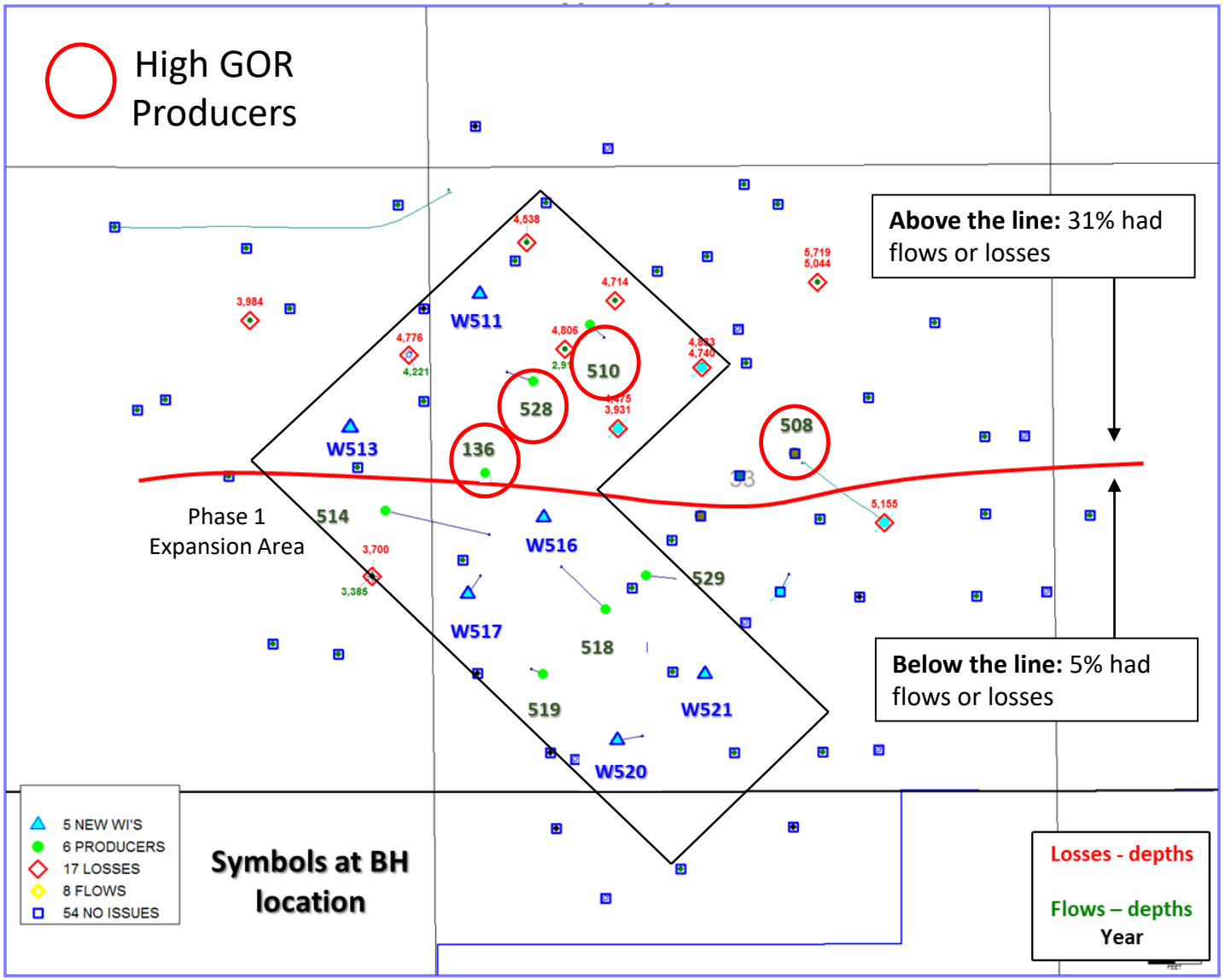
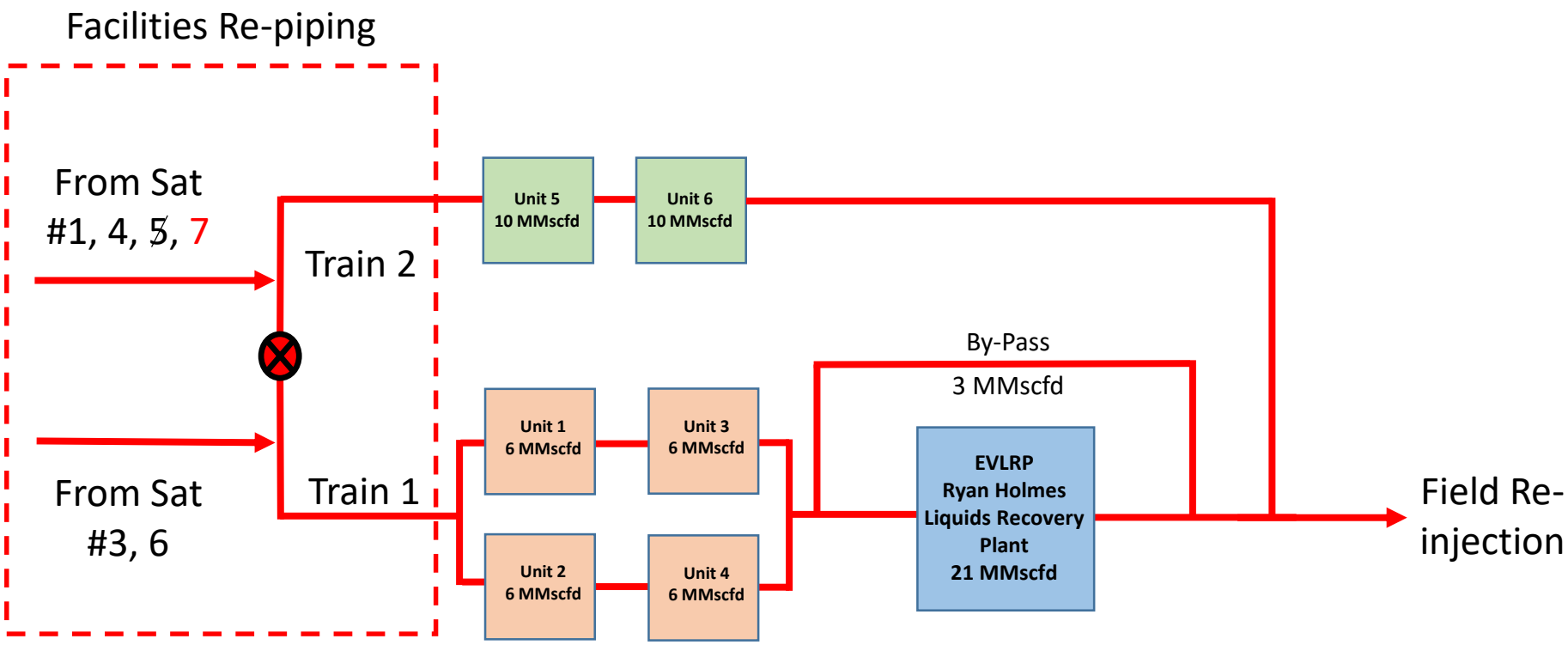
Compression Optimization

- Revisit execution performance
- Examined 131 well files
- Found a pattern of drilling related issues
- Seismic confirms apparent facies change form N-S
- Coincides with high GOR producers



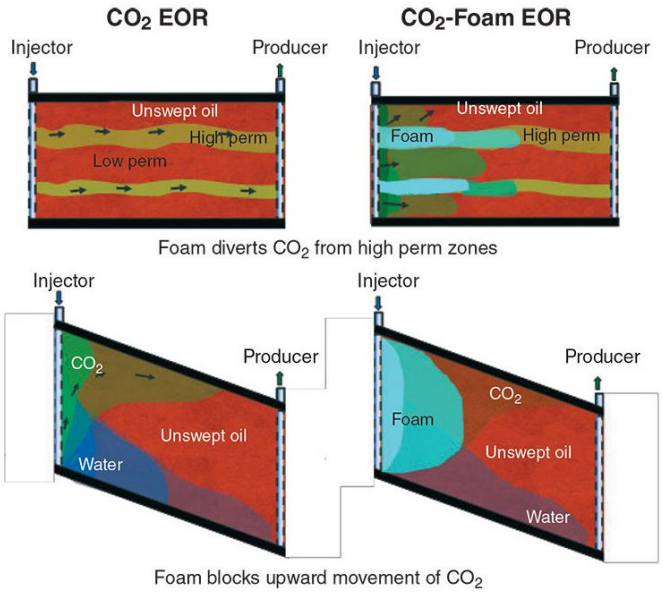
Compression Optimization



1. Lower production and operating expenses by 20% by 2020 through utilization of banked CO2
2. Construct high CO2 content satellite (#7) facility south of EVLRP and pipe to Train 2
3. Re-pipe EVLRP inlet to concentrate rich gas to Train 1
4. Install isolation valve in common inlet to direct gas to desired train

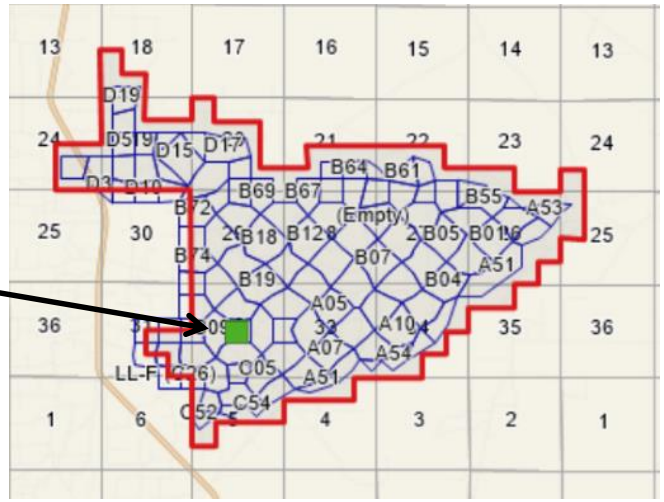
Foam Pilot

CO2-Foam Process



From SPE 190312, "CO2-Foam Field Pilot Test in Sandstone Reservoir: Complete Analysis of Foam-Pilot Response" Dow Chemical, et al

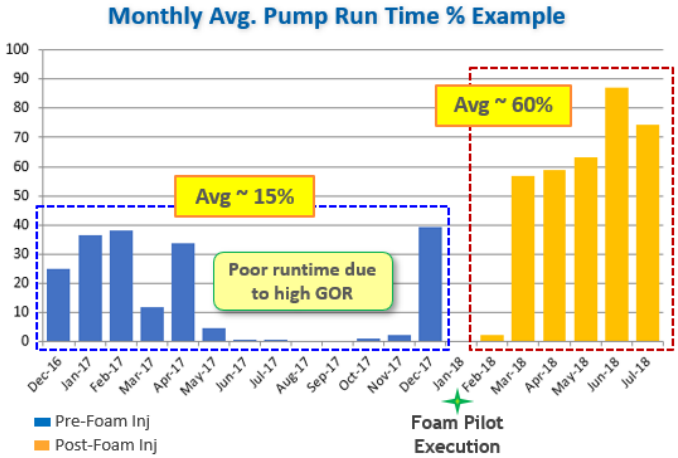
Foam Pilot Pattern



Vertical Profile Modification

	Zonal % Gas Distribution			
	Baseline	Post Foam - 4 mo	Post Foam - 8 mo	Post Foam - 9 mo
Upper San Andres	23%	38%	40%	46%
Lovington SS	0%	0%	0%	0%
Lower San Andres	77%	62%	60%	54%

Improved Run Time



Summary

- Strong production response from dynamic WAG and use of Spotfire-based data analytics tool in pattern optimization and problem diagnosis
- Drill-with-Casing (DwC) technology allows for low-cost infill and TZ/ROZ development in future
- Upside from flank ROZ projects in possible Phase 2
- Upside from compression utilization via production and operating cost reduction
- Encouraging results from foam trial