GAS ASSISTED ROD PUMP (GARP®)

A CASE STUDY OF MERGING GAS LIFT WITH A ROD PUMP

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A subsidiary of Evolution Petroleum Corp
(EPM- NYSEMKT)

OUTLINE

- Stages of Artificial Lift
- What is the problem w/ conv art lift ?
- What are operator's options?
- What is GARP®? How does it solve the problem?
- Criteria? When to install?
- Results to date
- Pros / Cons
- Future

THE STAGES OF LIFT

- Intermediate – Characterized by High Fluid Levels & High Flow Rates - Gas Lift- ESP-Jet Pump-Rod Pump- PCP
- Mid Life - Fluid levels and rates drop. Sucker Rod Pumping begins to dominate
- Stripper - Sucker Rod Pumping dominates

CONVENTIONAL LIFT IS INADEQUATE:

- Horizontal and Deviated Wellbores - rod/tbg wear, back pressure due to conv tbg anchors restricting flow, poor down-hole gas separation due to design with deviation/slugging issues
- High gas to liquid ratios – gas interference in pumps….worse for small csg sizes
- Deep reservoirs – impractical & very expensive to install and operate
- Long perforated intervals – risk of sticking the tubing anchor/ pump in the perf'd interval

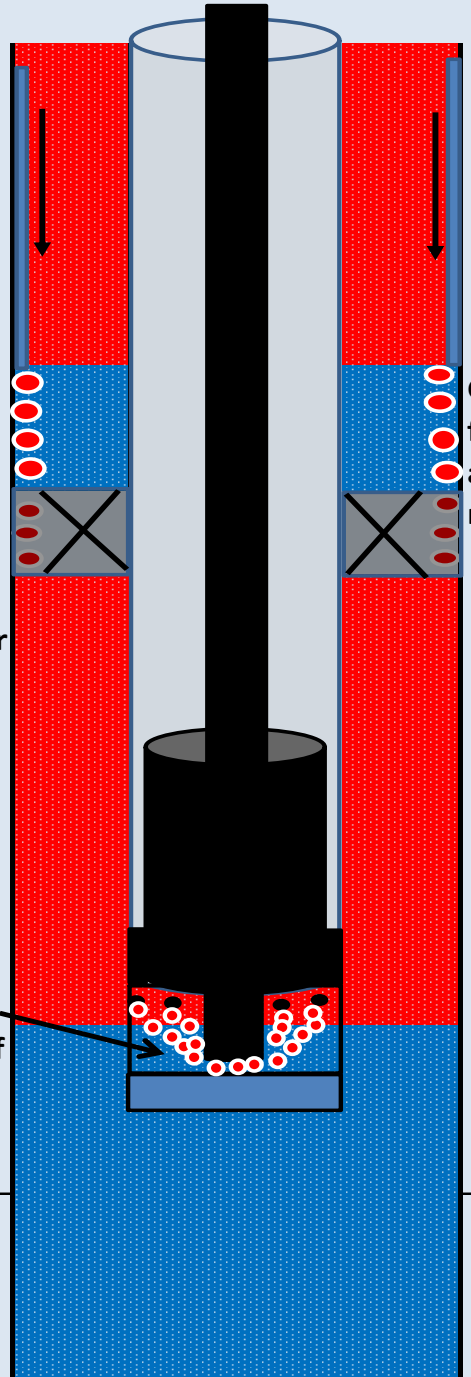
LIMITATIONS-CONV LIFT

- Conv Gas Lift – Exerts high back pressure w/ depth
- SRP/ESP- Issues w/gas & solids interference, depth limits, failures in deviated sections
- PC pumps- Failures in deviations, limitations for depth & high gravity hydrocarbons
- Jet Pumps- Environmental concerns w/ circulating high volumes of power fluid, depth & GLR limits, inefficient & high op costs, monitoring required
- Hydraulic Piston Pumps- issues with gas & solids
- Plunger-soap strings – very limited operating conditions, do not significantly lower BHP

HOW DOES GARP SOLVE THIS PROBLEM?

- Pump remains in the vertical section above the deviated, deep, or extended perforated intervals to keep operating costs low and pump efficiencies high
- Gas lift is used to raise liquids from the described problem regions but only up to the pump (not the surface) so gas lift efficiencies are high and back pressures exerted on reservoirs are low
- Utilizes a packer type gas separator instead of a conventional gas separator and tubing anchor resulting in a more efficient gas separation design
- Gas lift provides the ability to lift from greater depths

Why Rod Pumping a High GLR Well Can Be Ineffective



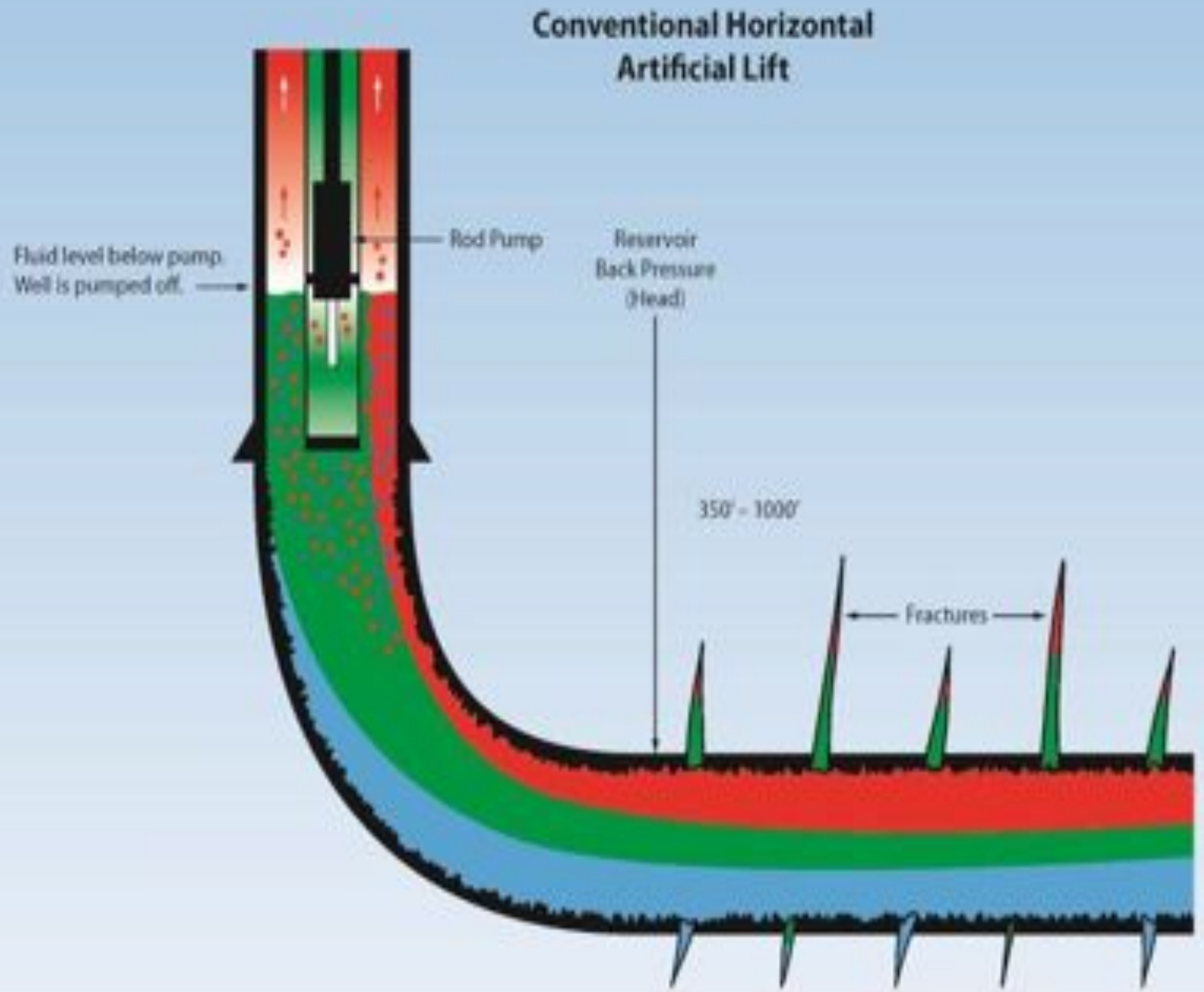
Tbg anchor can restrict gas flow in small csg sizes placing back pressure on the reservoir & causing gas to back up under the anchor

Also gas anchors in small casing sizes have a insufficient cross sectional area resulting in too high of a velocity for gas break out i.e., gas will enter intake

Condensation raining down from casing wall can collect and stack above anchor restricting gas and liquid flow

Back pressure

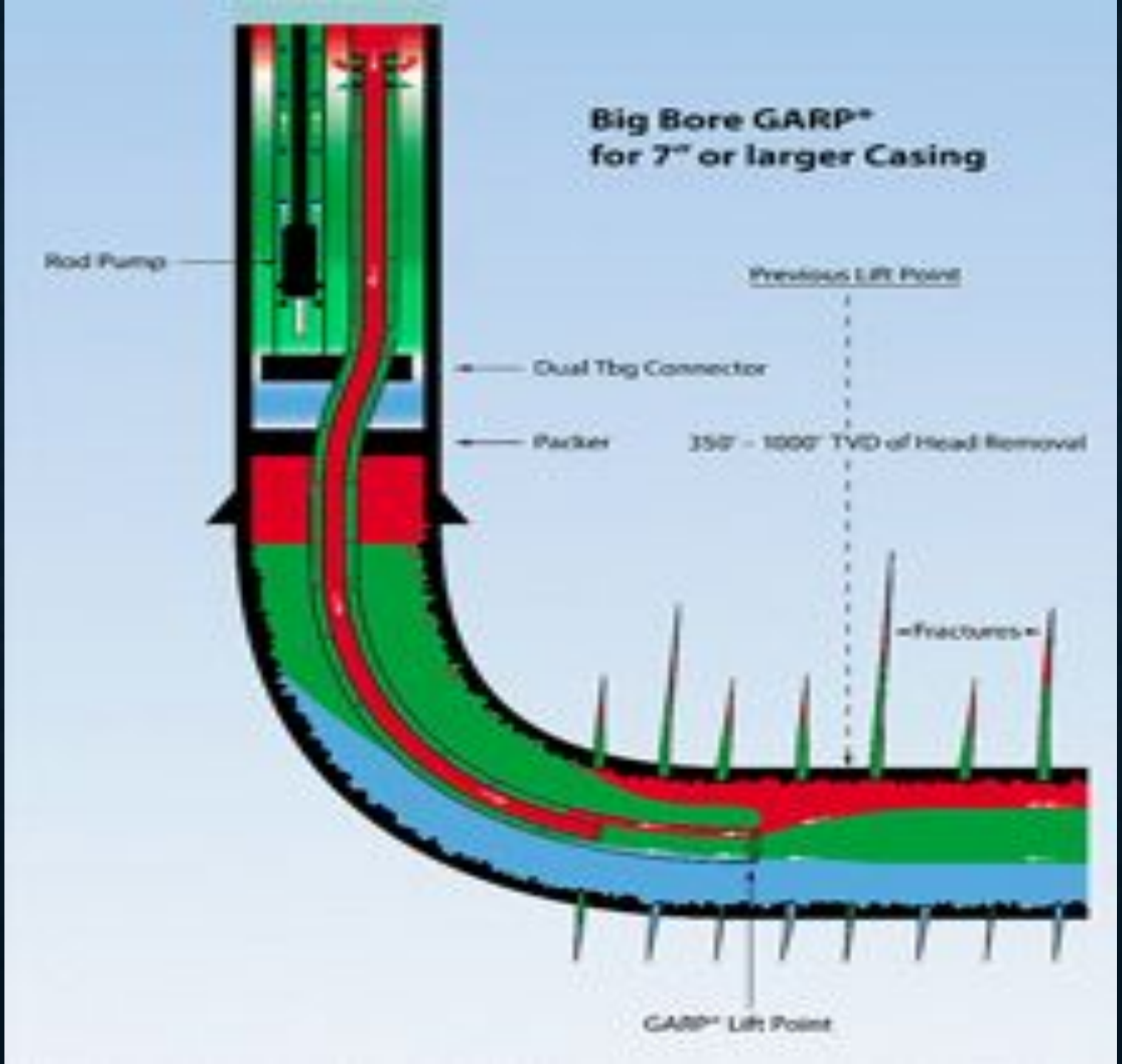
Reservoir

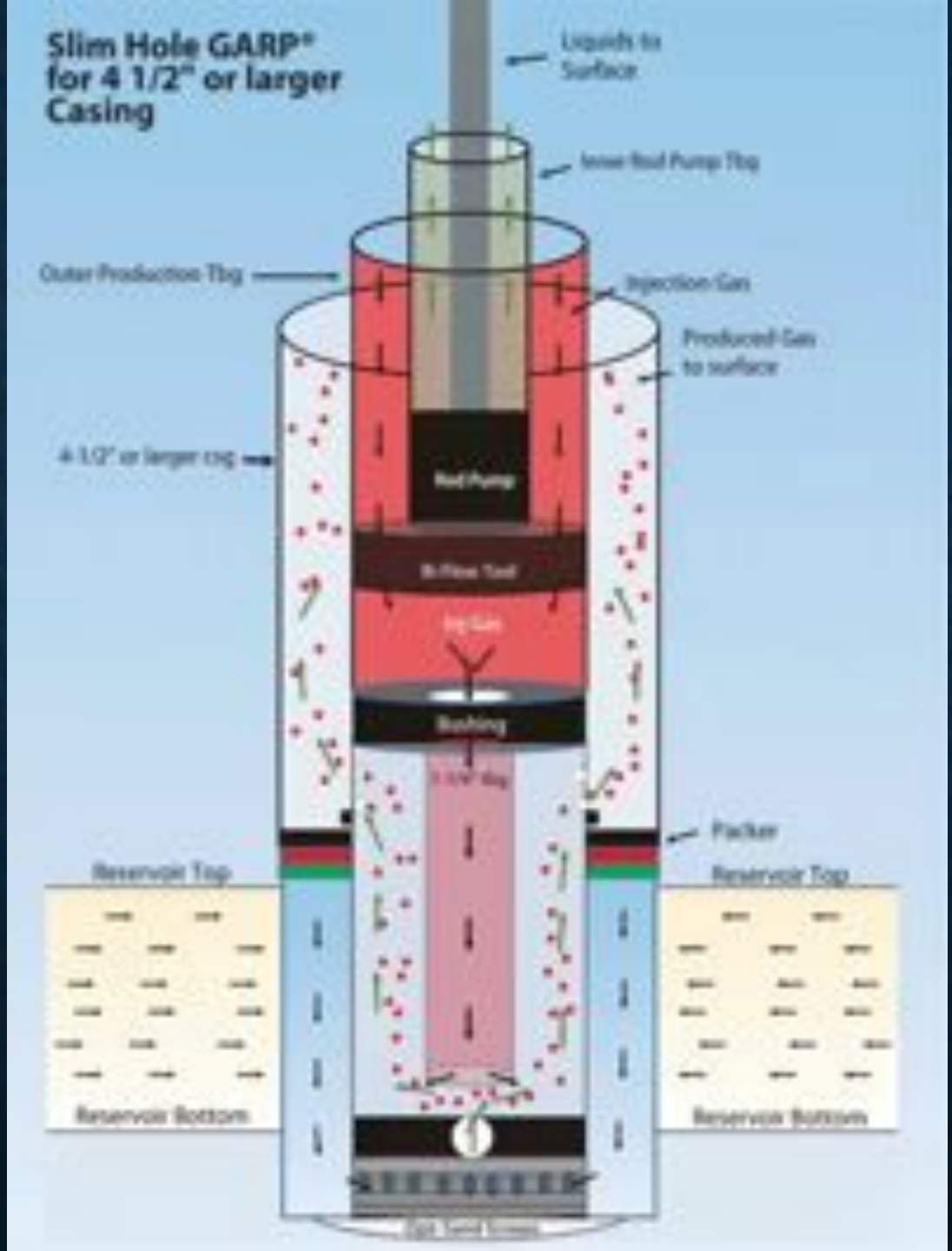

Conventional Horizontal
Artificial Lift
Fluid level below pump.
Well is pumped off.
Rod Pump
Reservoir
Back Pressure
(Head)
350' - 1000'
Fractures

WHAT IS GAS ASSISTED ROD PUMP?

- Patented technology that combines rod pump w/ gas lift in a two stage lift process
- Two designs - dedicated tbg strings for each lift
  -Slim Hole (4-1/2"+) conc tbgs w/ a single WH
  -Big Bore (7" +) side by side tbgs w/ dual WH
- Utilizes two well understood and popular lift methods combining strengths from each method
  -Rod Pump- very efficient lift, achieves low BHP

  -Gas lift – won't gas lock, solids friendly
- Also utilizes a small low volume-low rate compressor w/ a discharge of 100- 500 psig with as low as 100 MCFD (depending on fluid rate/ depth)


Big Bore GARP®
for 7" or larger Casing
Rod Pump
Previous Lift Point
Dual Tbg Connector
Packer
350' – 1000' TVD of Head Removal
Fractures
GARP® Lift Point

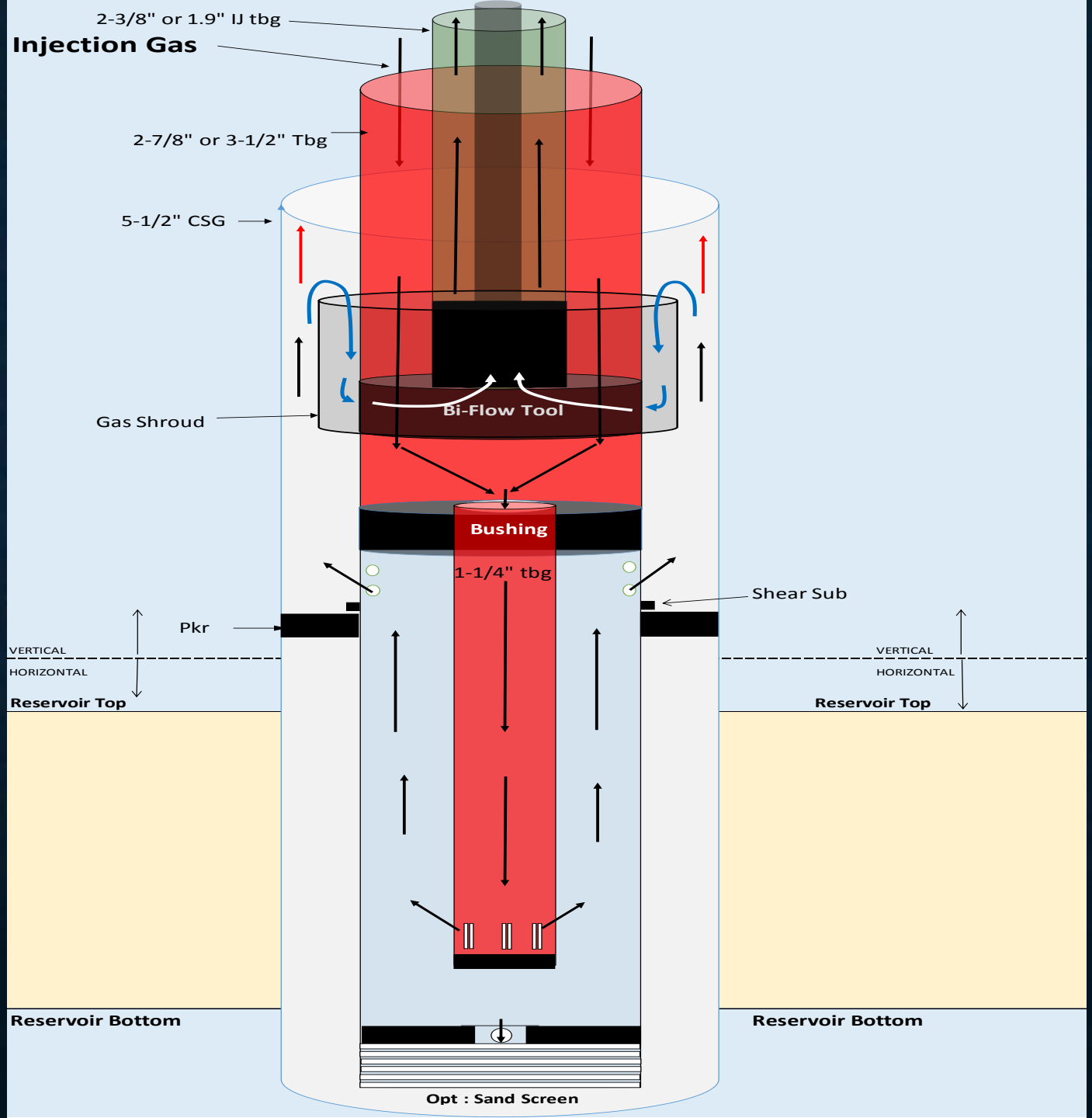

Slim Hole GARP®
for 4 1/2" or larger
Casing
Liquids to
Surface
Inner Rod Pump Tbg
Outer Production Tbg
Injection Gas
Produced Gas
to surface
4 1/2" or larger csg
Rod Pump
Bi-Flow Tool
Inj Gas
Bushing
Packer
Reservoir Top
Reservoir Top
Reservoir Bottom
Reservoir Bottom


Stinger or On-Off tool


Dual String Connector


Bi-flow tool for concentric design
Bushing used in both SBS string and concentric string designs


Bi-flow tool for concentric design


2-3/8" or 1.9" IJ tbg
Injection Gas
2-7/8" or 3-1/2" Tbg
5-1/2" CSG
Gas Shroud
Bi-Flow Tool
Bushing
1-1/4" tbg
Shear Sub
Pkr
VERTICAL
HORIZONTAL
Reservoir Top
VERTICAL
HORIZONTAL
Reservoir Top
Reservoir Bottom
Reservoir Bottom
Opt : Sand Screen

OPERATOR OPTIONS AND RESULTS

1. Reluctantly install conventional art lift into these regions or conditions – unsuccessful installations are high from gas interference, mechanical failures, operating costs
2. Opt to not install art lift or place lift equip in the vertical section many hundreds to thousands of feet above the reservoir

- All the above options are inadequate and lead to lower production and reserves resulting in pre-mature well abandonment with a potential for loss of leases

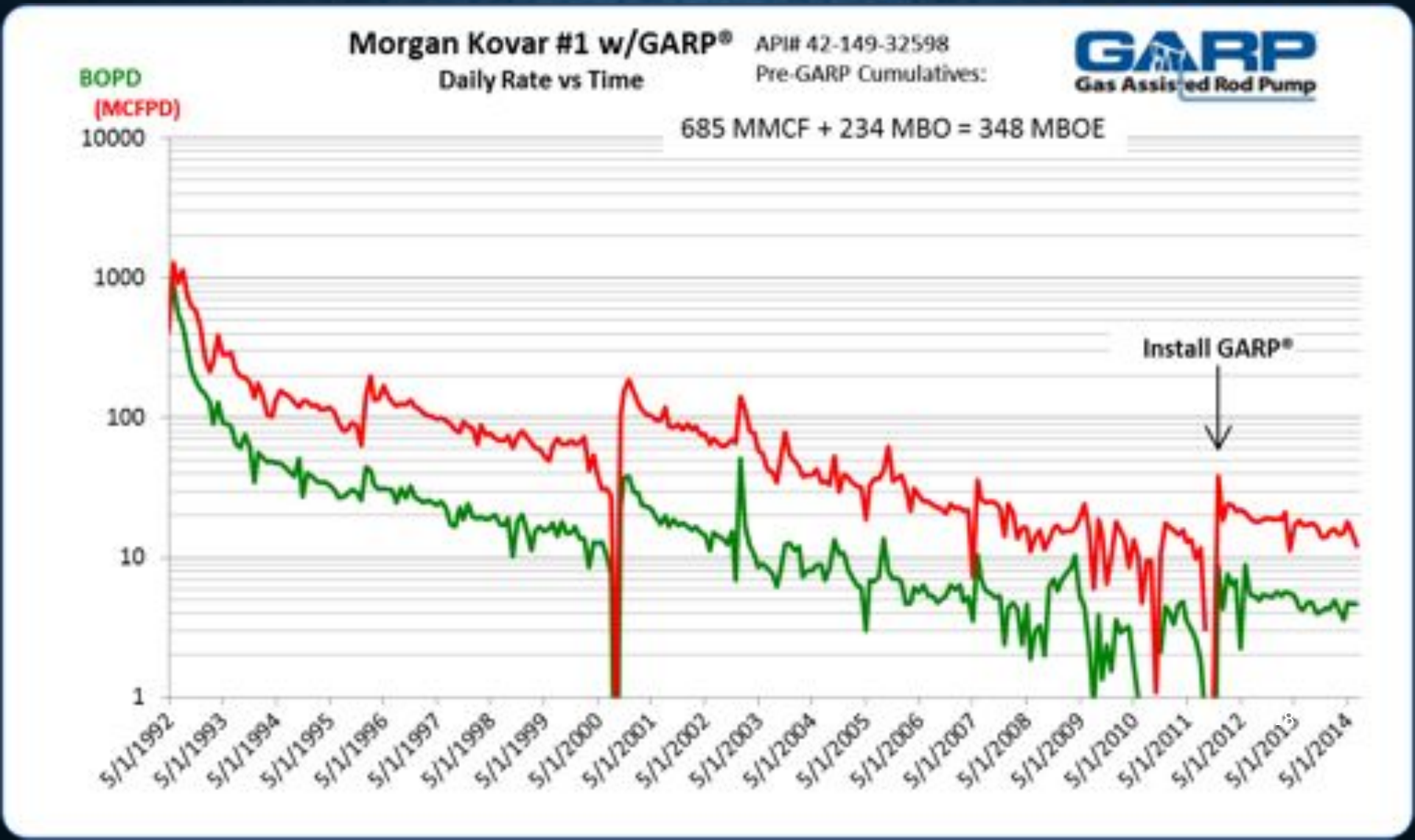
WHEN TO INSTALL ?

- Basically whenever lowering the bottom hole pressure will lead to a production/reserve increase that will justify the costs of the installation
- RATE ACCELERATION - Intermediate & mid-life
- INCREASE in RATE, RESERVE, LIFE - Stripper stage
- Predictive Methods – PI/IPR or Decline Curve
- To date, the technology has demonstrated a reserve increase from ~20-35% of the prior cumulative production with a 10+ fold rate increase for marginal wells

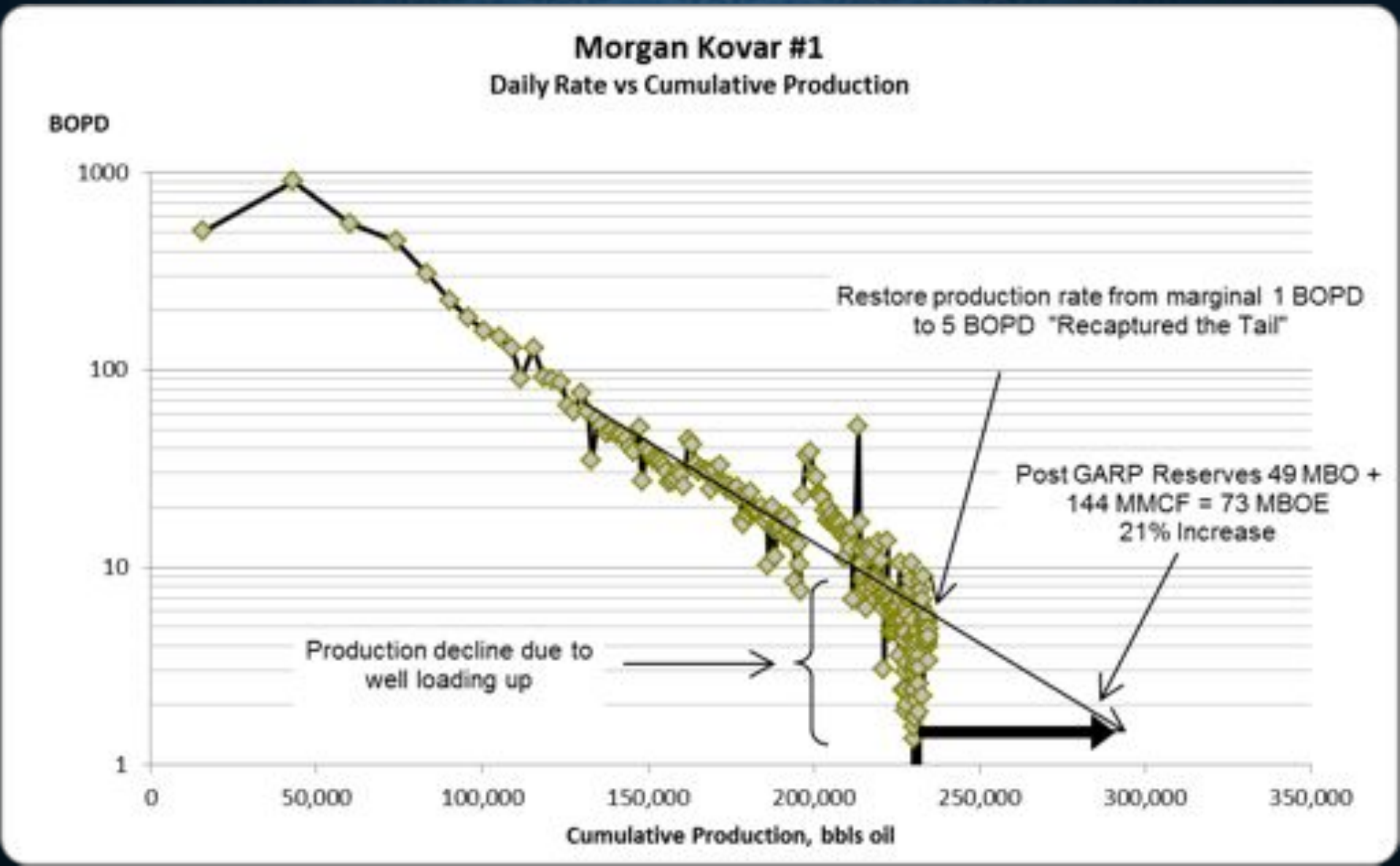
APPLICATIONS TO DATE

- To date the technology has only been installed on marginal wells. Seeking higher rate wells for acceleration test
- Company and third party owned
- Giddings Field –Central Texas
- All horizontal TVD ~ 9000’ – 11,000’
- Drilled in the early 1990’s

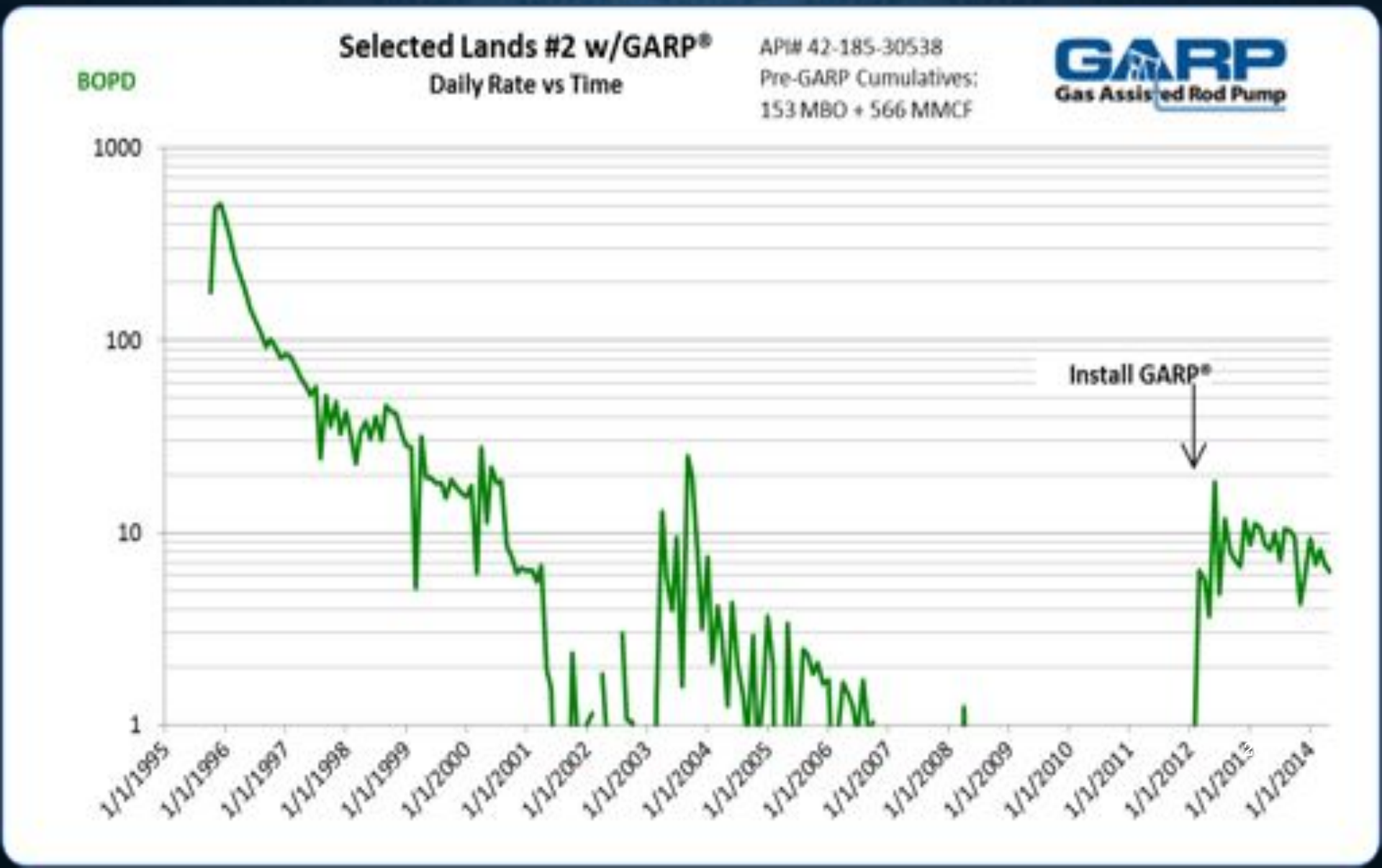
MORGAN KOVAR #1
RATE VS TIME



MORGAN KOVAR #1
RATE VS CUM



SELECTED LANDS #2
RATE VS TIME



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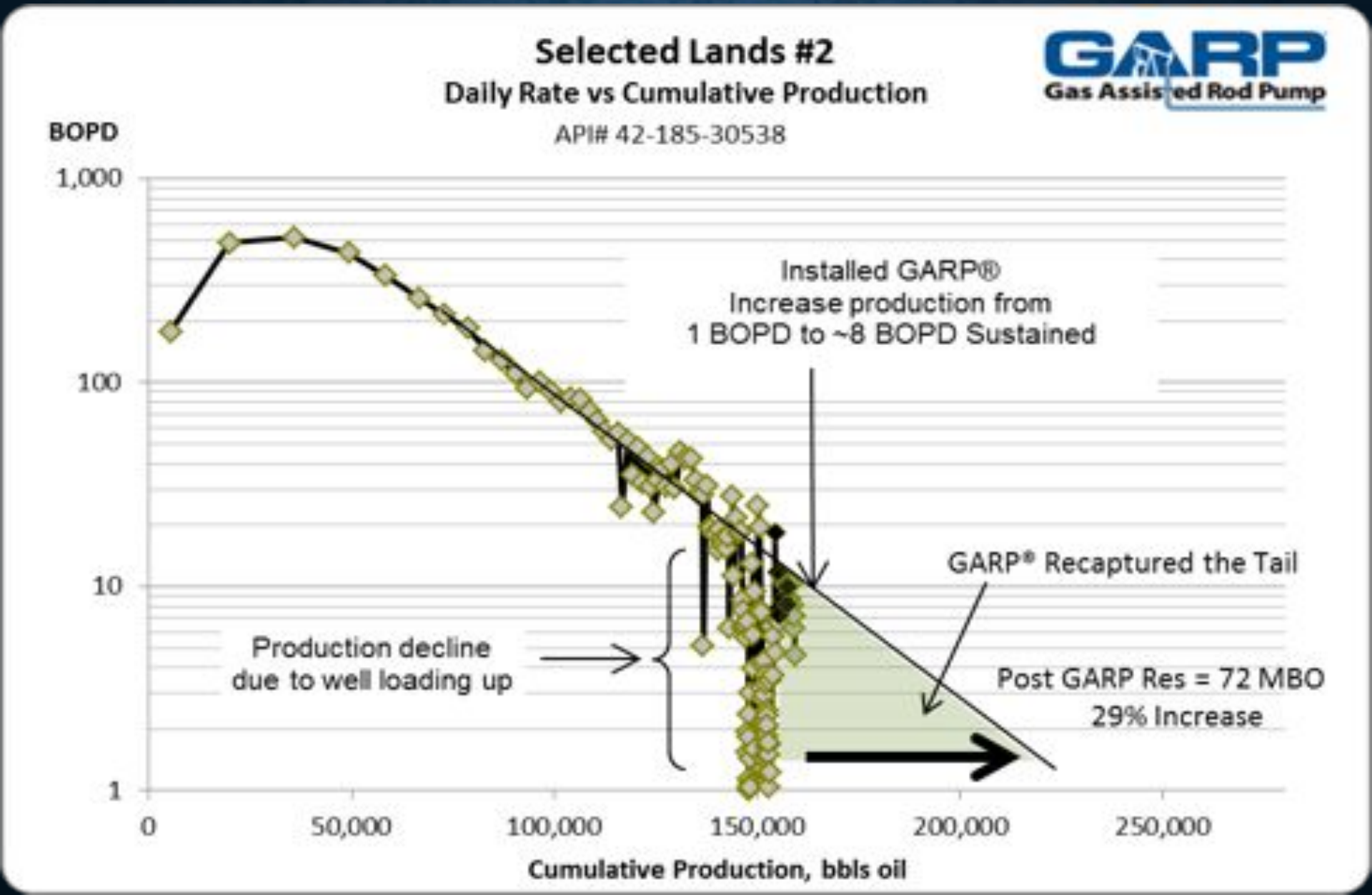
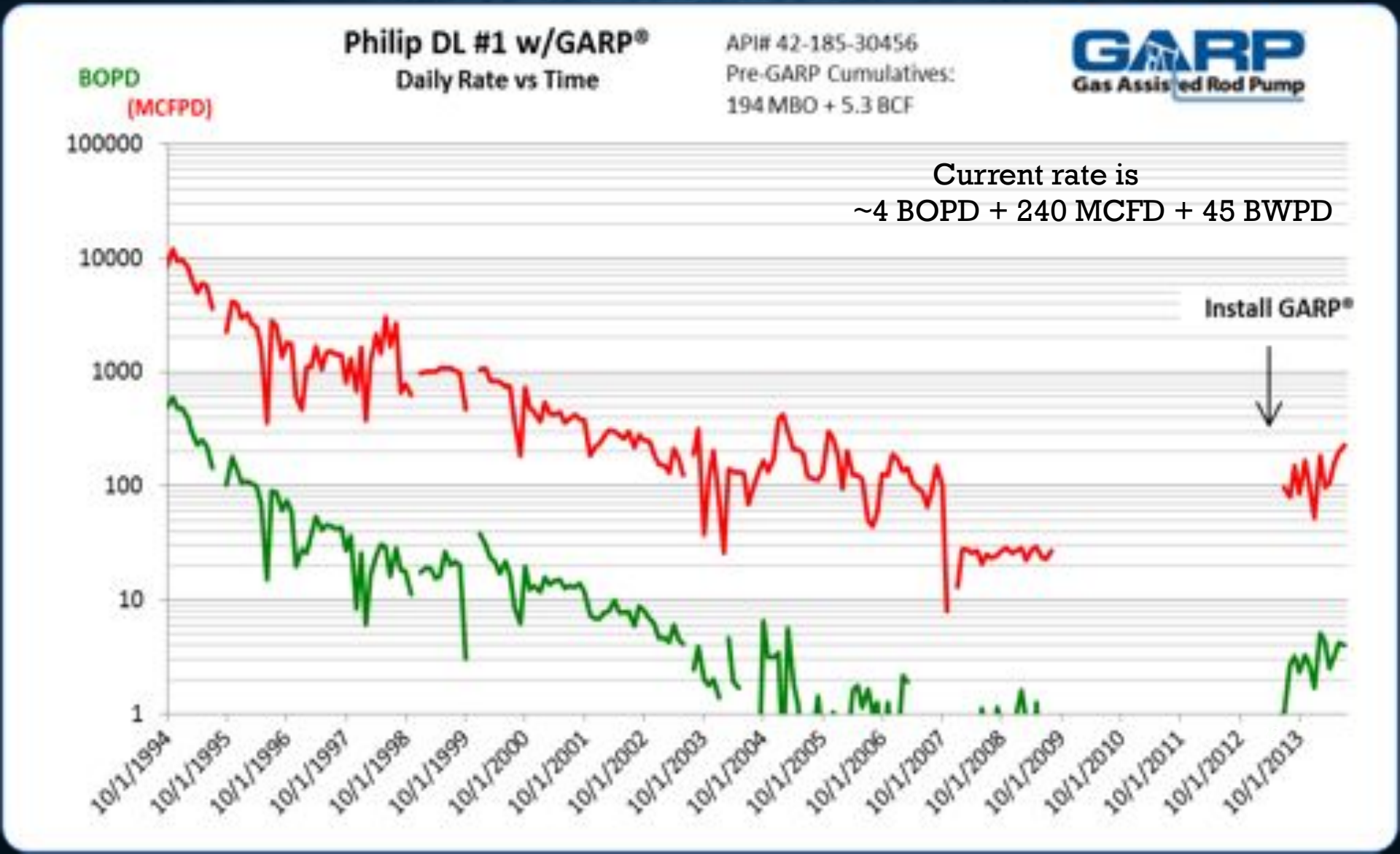


PHILIPS #1
RATE VS TIME



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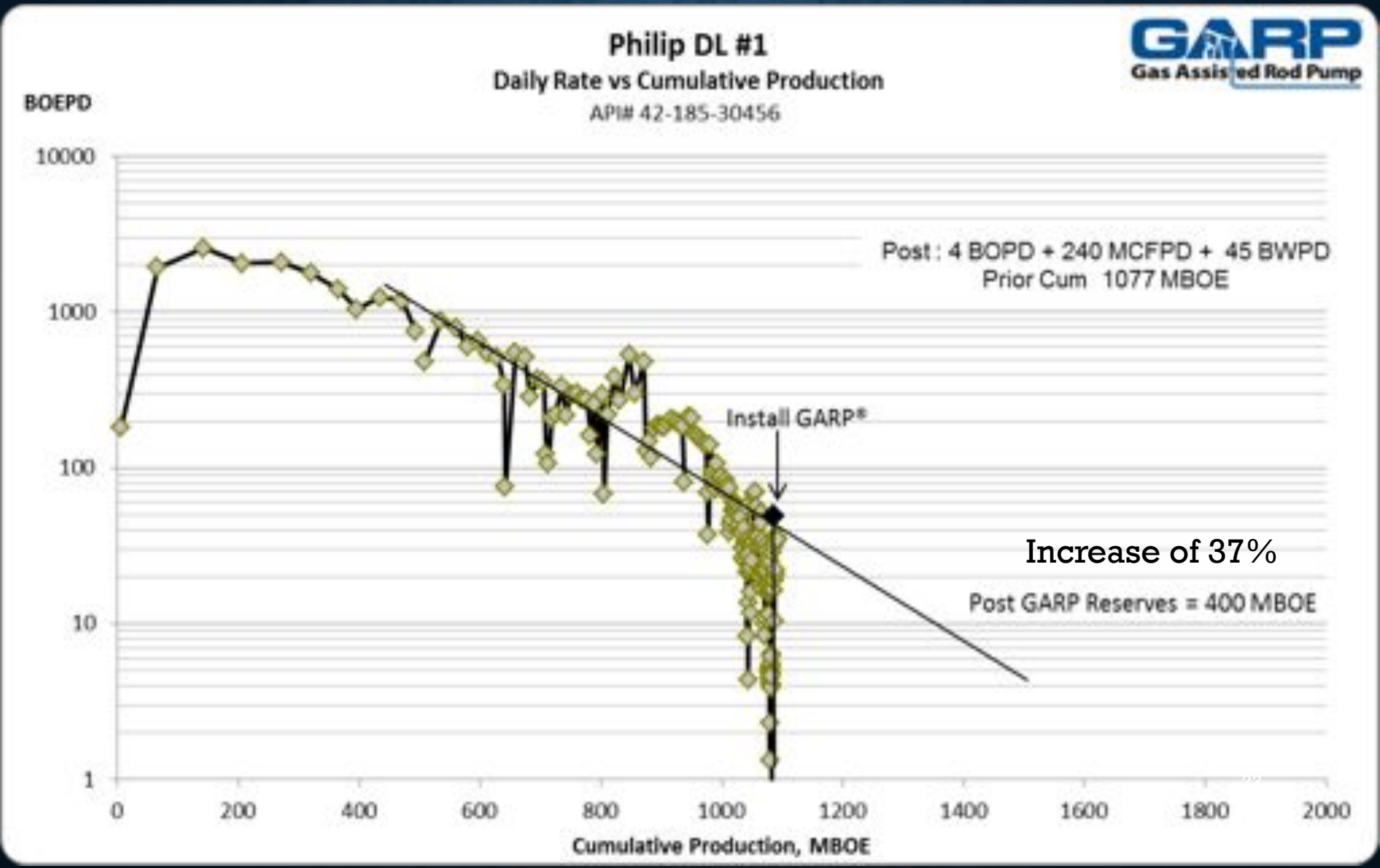
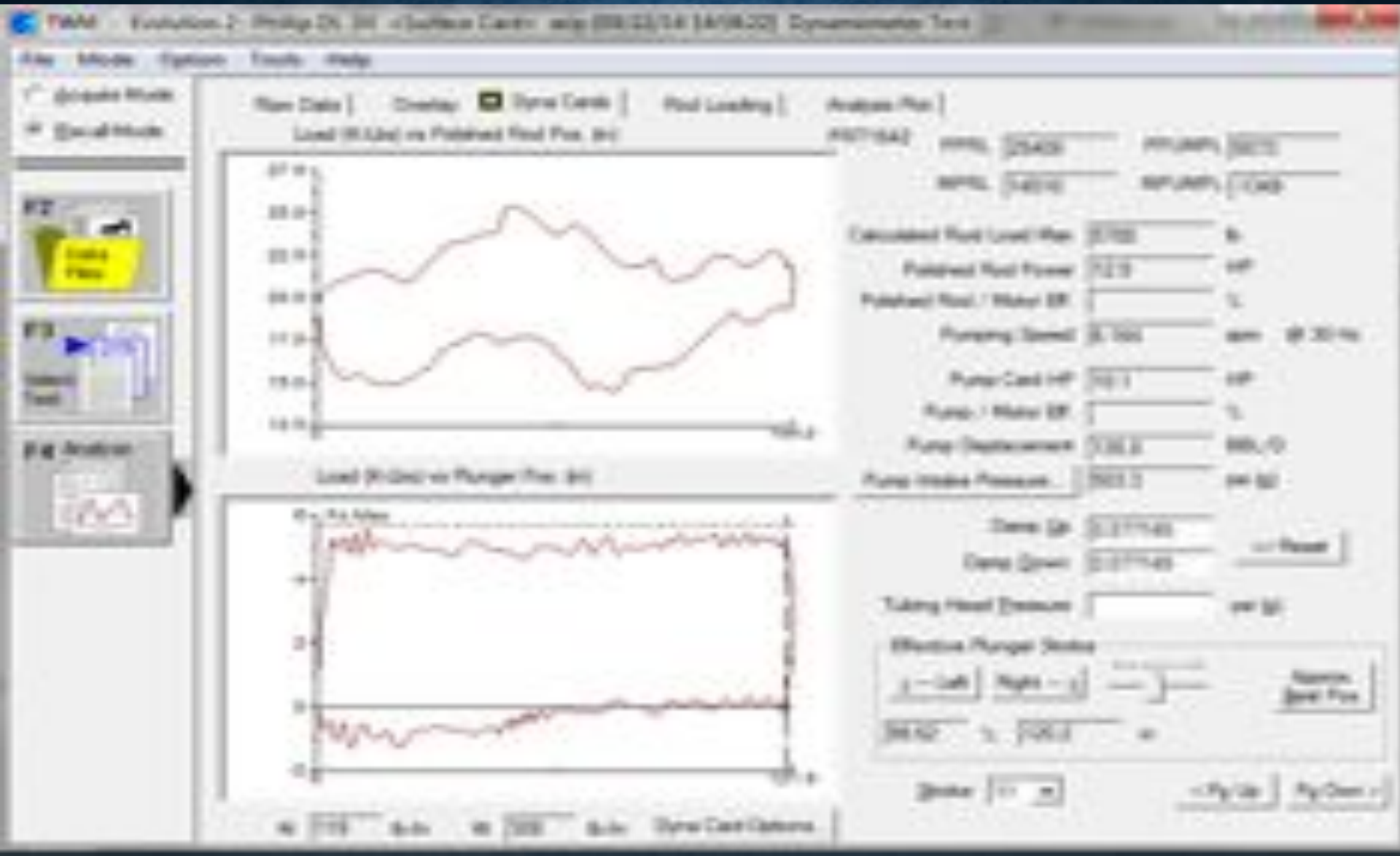
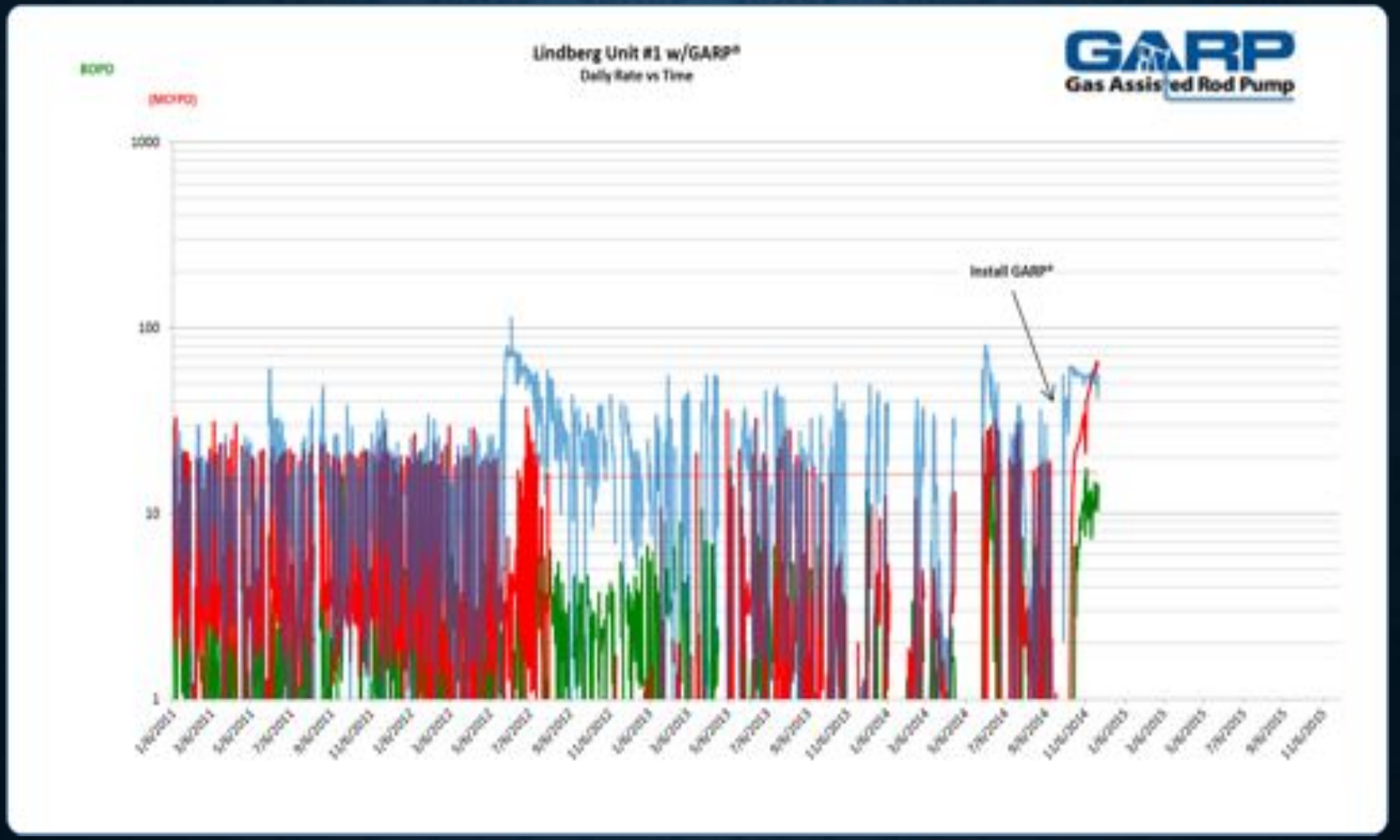
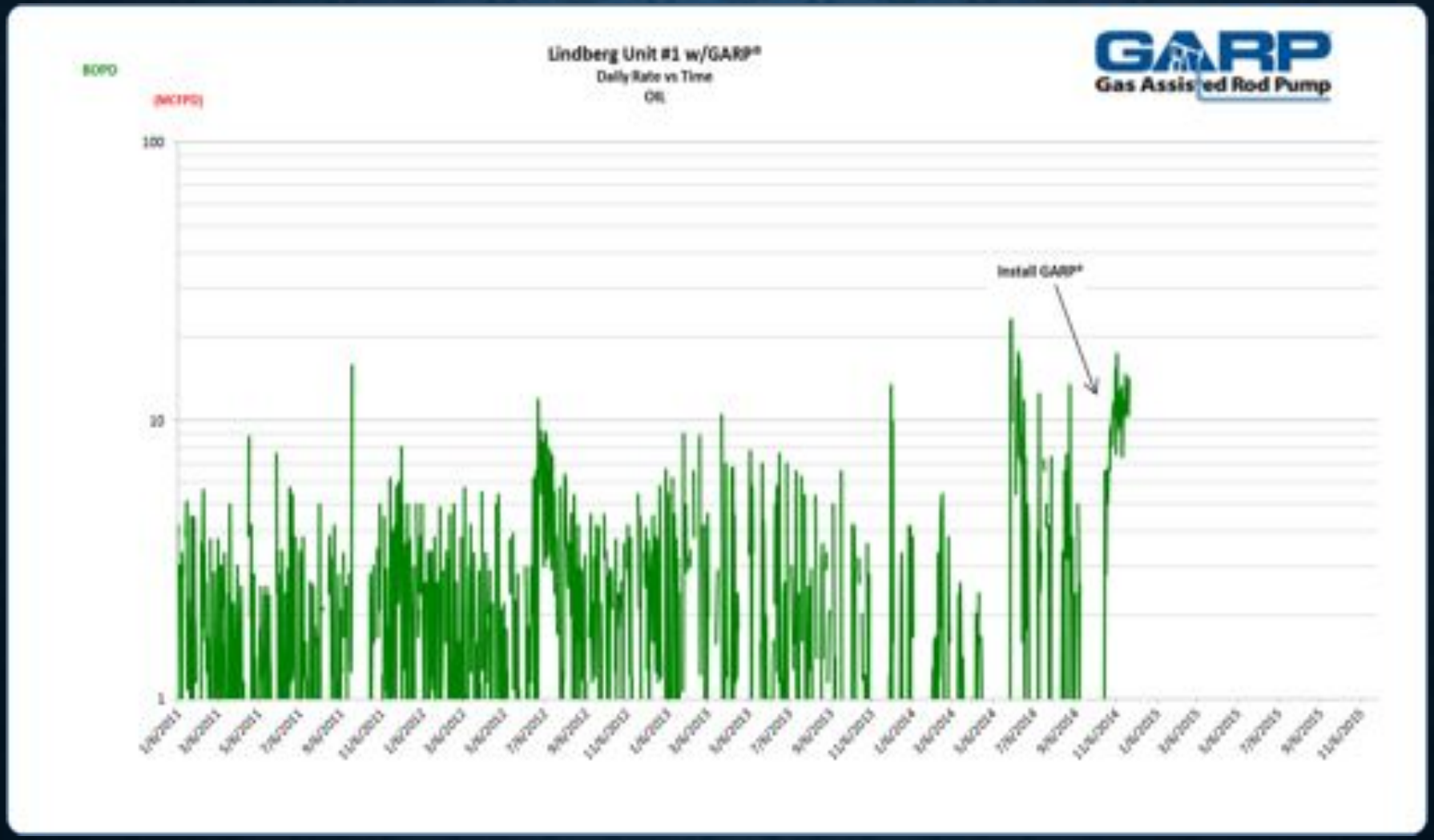
RATE VS CUM

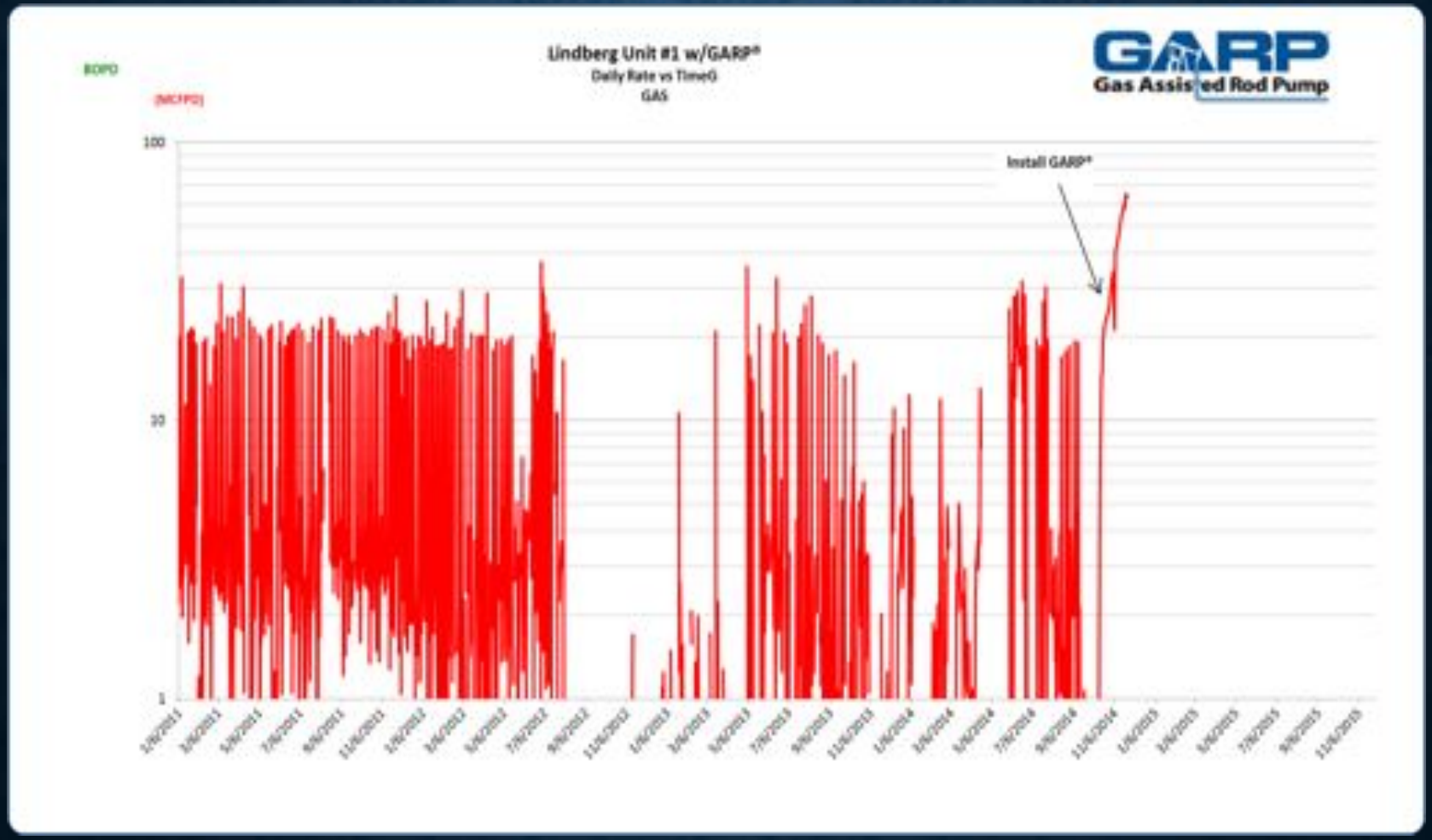


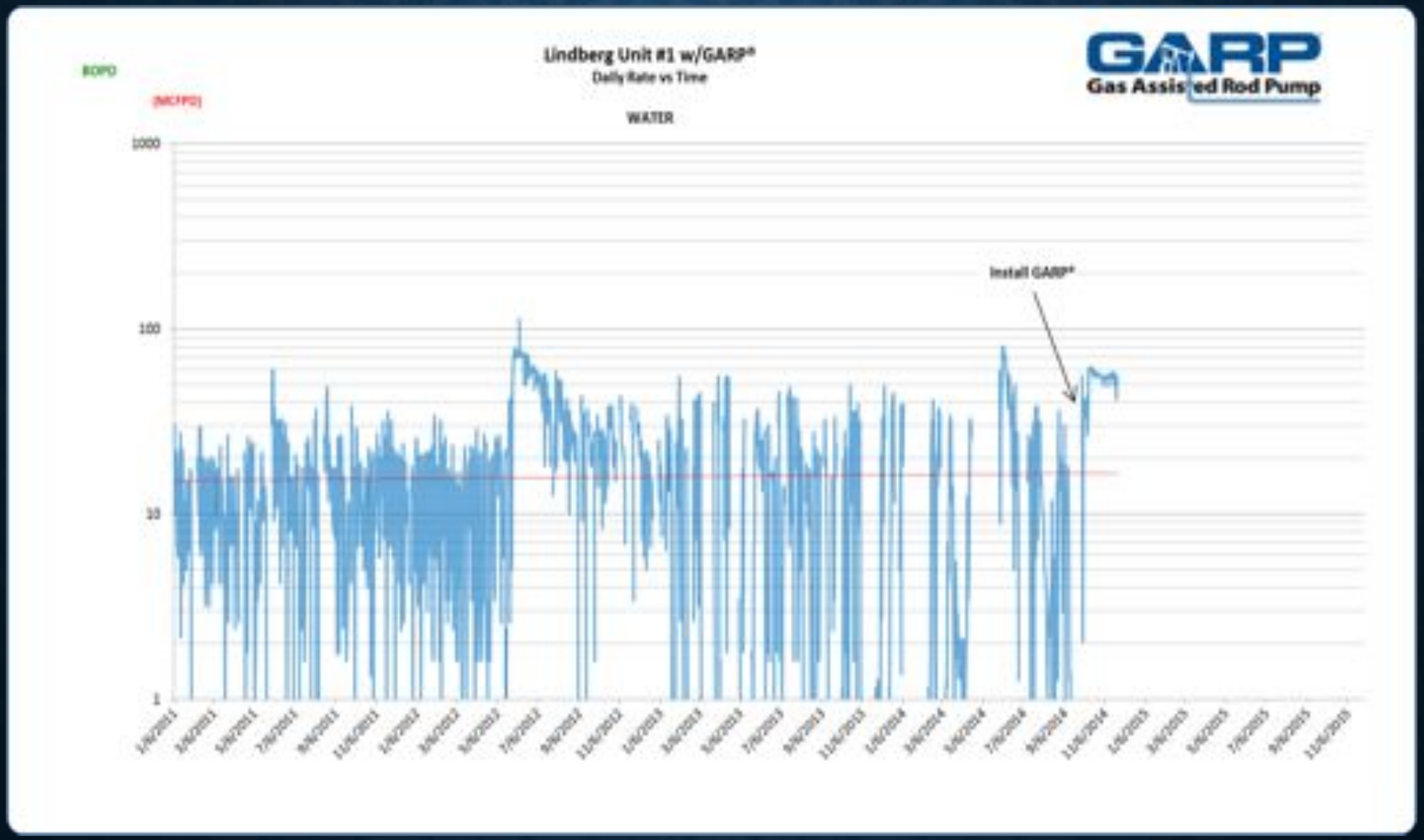
PHILIP DL #1 DYNO




Lindberg Unit #1 w/GARP®
Daily Rate vs Time
GARP
Gas Assisted Rod Pump
BOPD
(MCFPD)
1000
100
10
1
Install GARP®

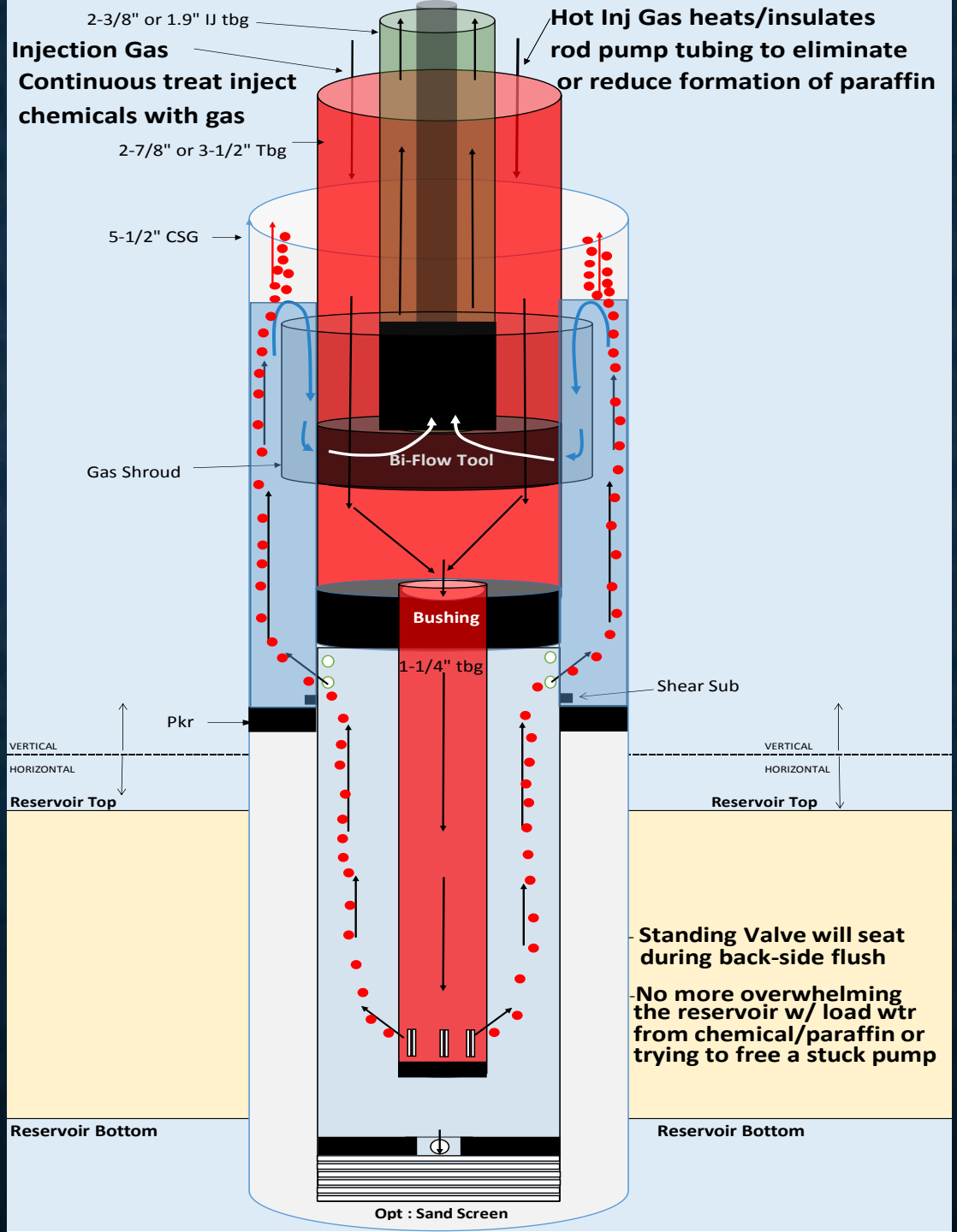

Lindberg Unit #1 w/GARP®
Daily Rate vs Time
OIL
BOPD
GARP
Gas Assisted Rod Pump
100
10
1
Install GARP®


Lindberg Unit #1 w/GARP®
Daily Rate vs TimeG
GAS
BOPD
(MCFPD)
GARP
Gas Assisted Rod Pump
Install GARP®
100
20
1


Lindberg Unit #1 w/GARP®
Daily Rate vs Time
BOPD
(MCFPD)
WATER
GARP
Gas Assisted Rod Pump
1000
100
10
1
Install GARP®

ADVANTAGES

- Manpower friendly technologies – not a lot of tweaking
- Achieves lower BHP w/o placing pump in undesirable places
- Very High Efficiency Gas Separation (< 6 in/sec velocities)
  7"+ csg up to ~**1200 BFPD** (MORE THAN PUMP CAPACITY)
  5-1/2" csg – ~**1000 BFPD** (MORE THAN PUMP CAPACITY)
  4-1/2" csg – ~**120 BFPD** (~= CAPACITY OF PUMP)
- MORE EFFICIENT BEAM PUMP SELECTION- No need to over design equipment to place beam pump deeper for initial higher volumes. Pump can be placed shallower and gas lift can raise liquids to the pump
- Offers very efficient continuous chem treating w/ inj gas
  Reduces or eliminates paraffin (depends on cloud point)
  SV prevents load water from overwhelming reservoir &
  Backside injection can free stuck pumps


2-3/8" or 1.9" IJ tbg
Injection Gas
Continuous treat inject chemicals with gas
Hot Inj Gas heats/insulates rod pump tubing to eliminate or reduce formation of paraffin
2-7/8" or 3-1/2" Tbg
5-1/2" CSG
Gas Shroud
Bi-Flow Tool
Bushing
1-1/4" tbg
Shear Sub
Pkr
VERTICAL
HORIZONTAL
Reservoir Top
VERTICAL
HORIZONTAL
Reservoir Top
Standing Valve will seat during back-side flush
No more overwhelming the reservoir w/ load wtr from chemical/paraffin or trying to free a stuck pump
Reservoir Bottom
Reservoir Bottom
Opt : Sand Screen

DISADVANTAGES

- No Obstructions - Desired artificial lift point must be open to the bottom hole assembly
- Does not overcome inherent limitations of SRP's - liquid production rate range, fines plugging, maintenance/workover costs
- Costs more than a conventional SRP installation depending on depth & desired BBLS/D (incr costs – 2 days rig time, tbg string (s), wellhead, compressor install, pkr, may be as low as ~$100K (depth dependent) ~75% of $$ re-useable equip
- A pressured gas source is necessary. Rental compressors ~$1700/mo or build for ~$40,000

FUTURE APPLICATIONS FOR GARP

- Rate acceleration tests
- Vertical wells with long perforated intervals
- Future Designs

  -Use down-hole pumps w/ NO rods for pad wells w/ near surface deviations

  - Incorporate a solids handling system

  -Replace gas lift w/ different lift for wells that don't have an adequate gas supply

WELL CRITERIA

- Wells that have pumps set high above the reservoir
- Wells that are currently on other forms of artificial lift and not meeting expectations
- 4-1/2" casing size or larger
- 4" + liners…No obstructions in the well
- Horizontal/deviated wells
- High gas-liquid ratios or gas slugging
- Deep reservoirs – conv lift not economic/practical
- Vertical wells w/ long perforated intervals
- Line pressures 15 psig or higher & capable of delivering ~ 50 -100 MCFD. Depends on depth lifted, desired rate & existing GLR

CONTACT INFORMATION

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