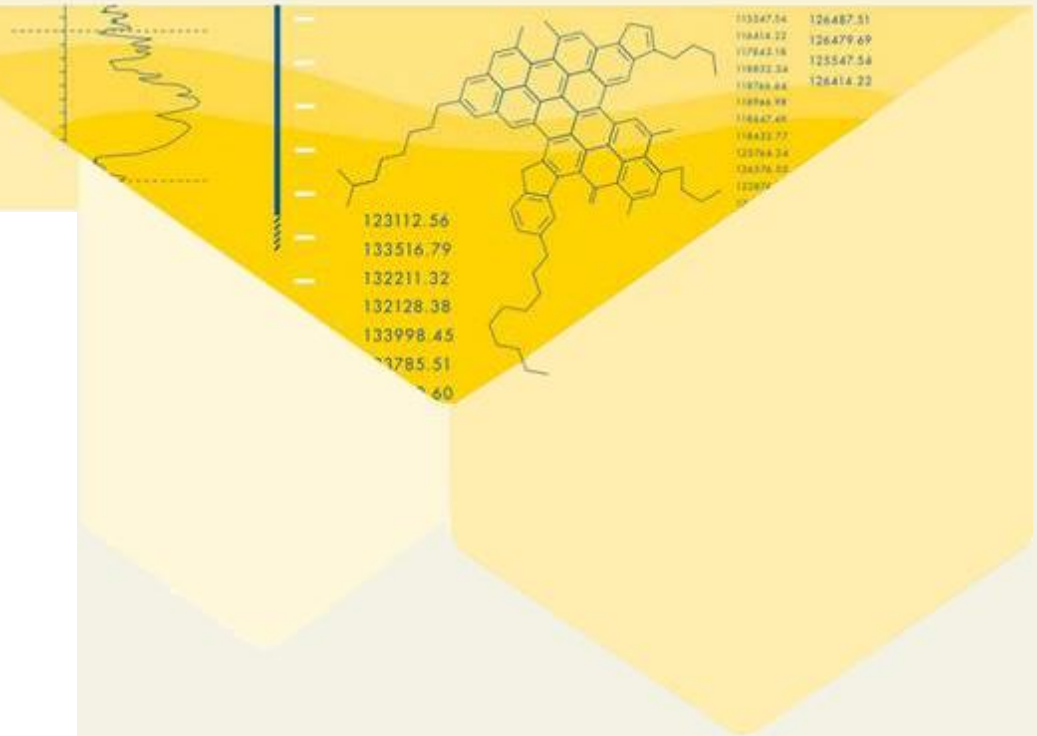

Unlock Production From a Highly-Challenging Well in a Deep-water Mature Gas Field

EGPC Workshop – Oct 2023

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Modather Mohamed
Omar Awad
Sherif Omar

Agenda

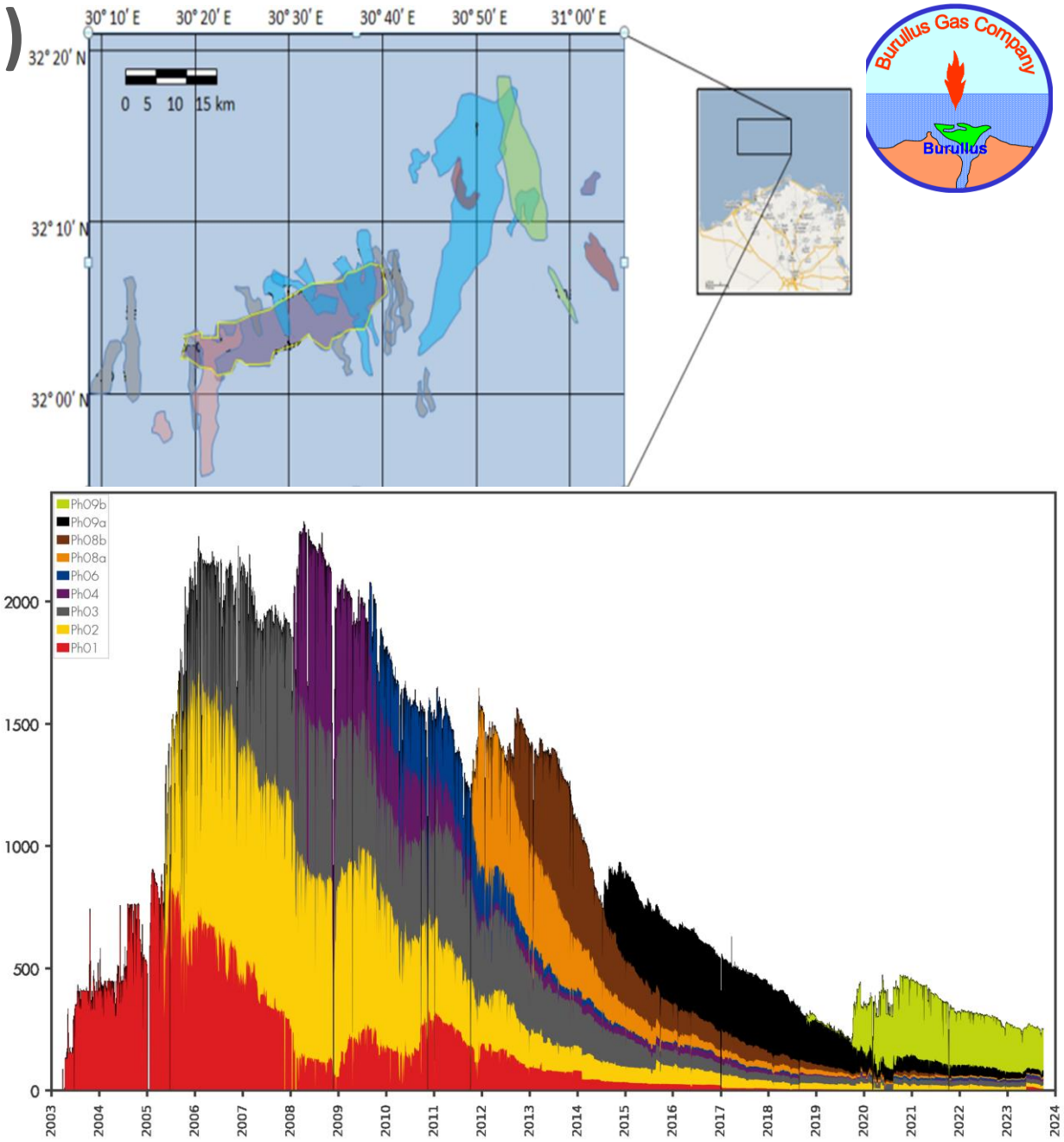
- Introduction
- Drilling & Completion Challenges
- WOE Uncertainties & Workflow
- Production Performance
- Accessed Volume Assessment
- Conclusion

West Delta Deep Marine (WDDM) Concession

- WDDM is a gas development producing entirely from deep water subsea wells, located in water depths of 300m up to 1200 m below sea level, located of the north coast of the Nile Delta, approximately 90 km offshore Egypt.

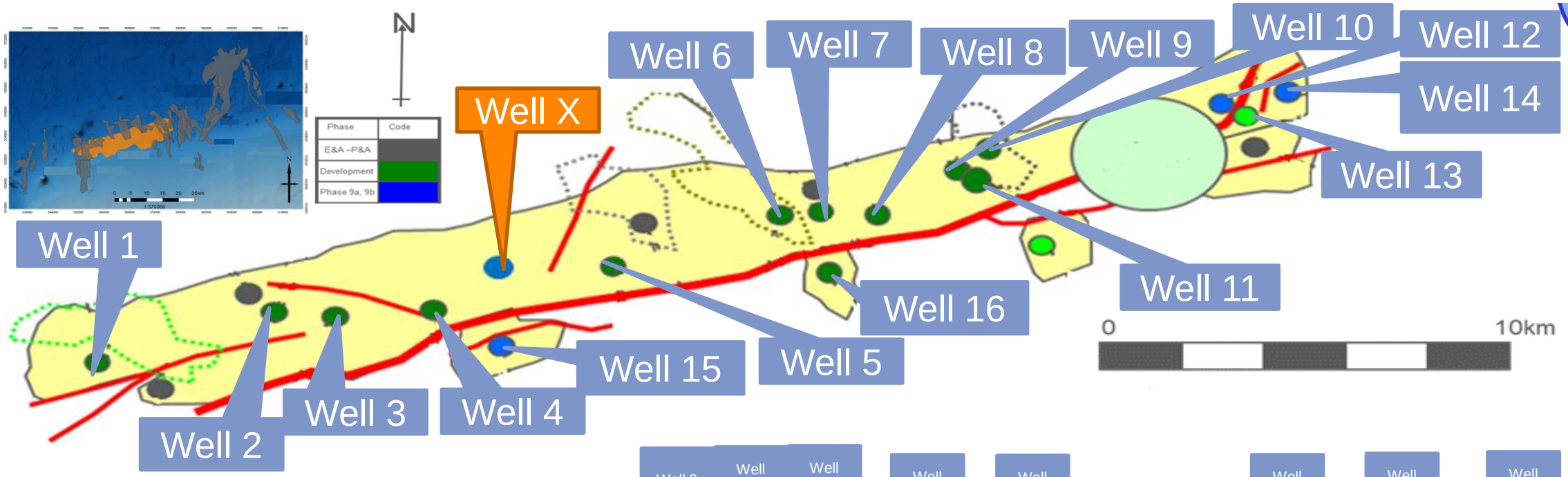
- WDDM Contains 19 producing gas field, its cumulative production until now around 7.35 TCF gas and 56 MMSTB condensate.

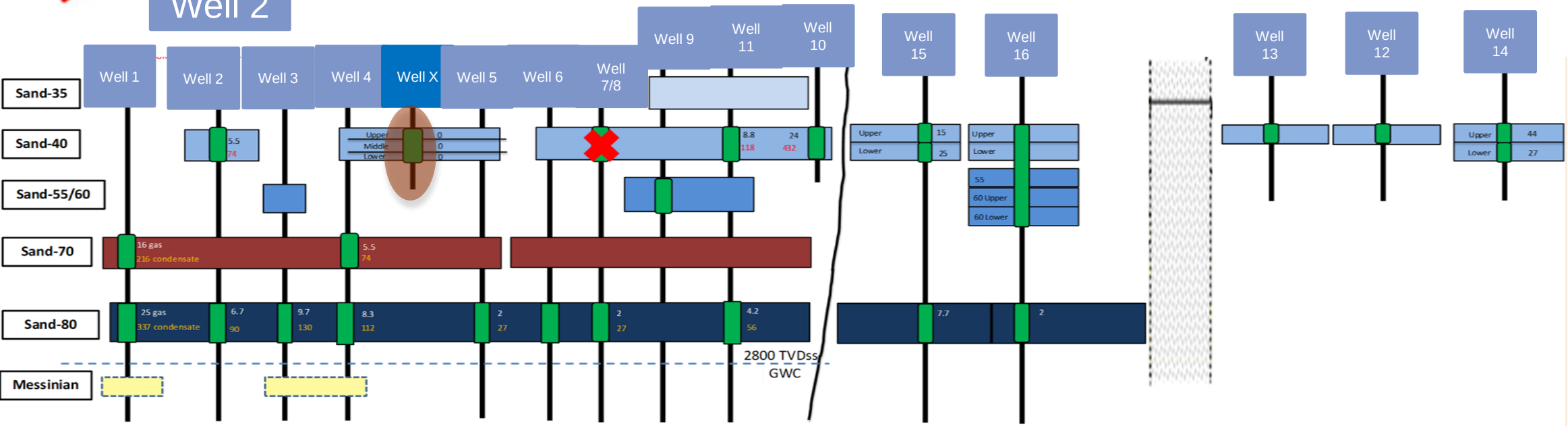
- Started Production in 2003, 10 development phases, 68 development wells.



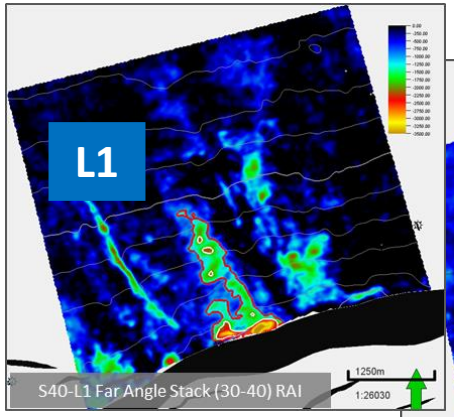
Field Overview

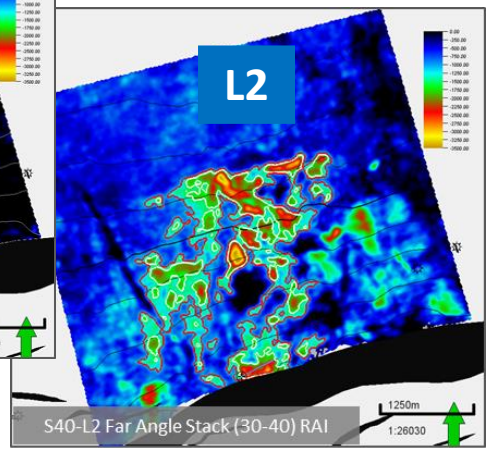
- 1st Gas Sep.2005, CGR= 18-22 bbl/MMscf, 6 E&A, 17 Dev, 11 currently online (G_p = 2.01 TCF)

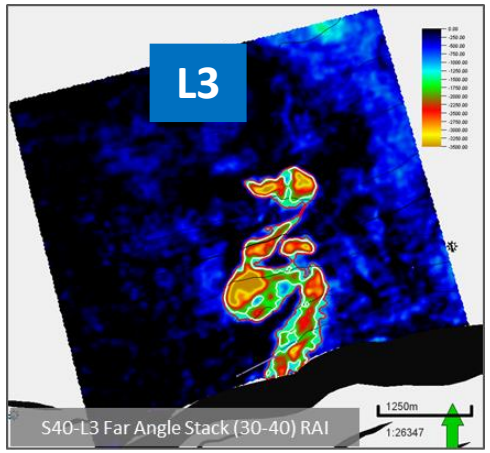


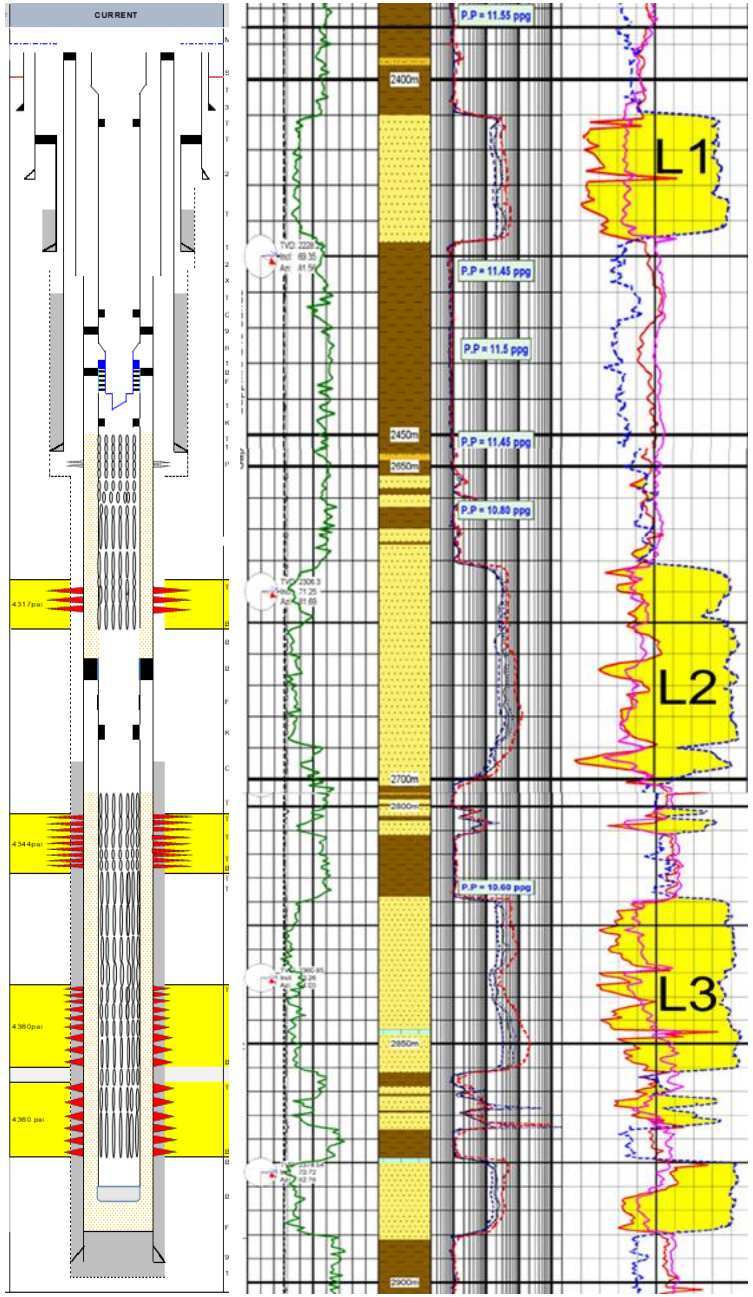


Well Overview









Completion Type	Net Pay, TVD	Water Depth	Rt-MSL	PBTD	TBG Size
CHGP	39.5	370.5	25.6	2,943	5.5

Zone / Interval Data		Net Reservoir Data			
Zone Name	Gross Thickness	Net Thickness	NTG	Average ϕ	Average Sw
L1	11	7	0.64	0.27	0.18
L2	16.2	13.1	0.64	0.22	0.23
L3	23.8	19.4	0.75	0.27	0.24

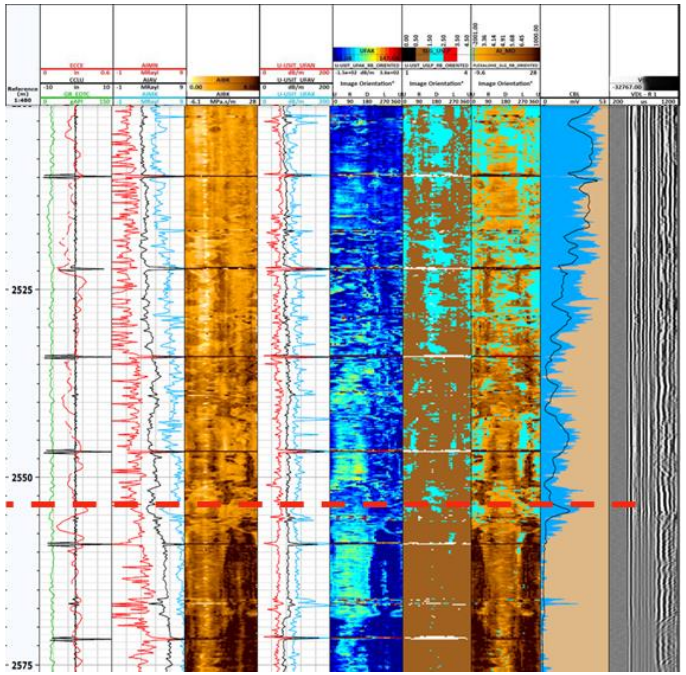
Drilling and Completion Challenges – Formation Damage in well

Fluids loss in the hole

- 2700 bbl OBM
- 70-80 bbl Cement

Limited Cement above MZ

- Isolation Scanner imaging



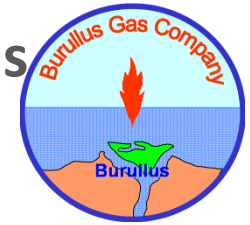
Cement Squeeze Job

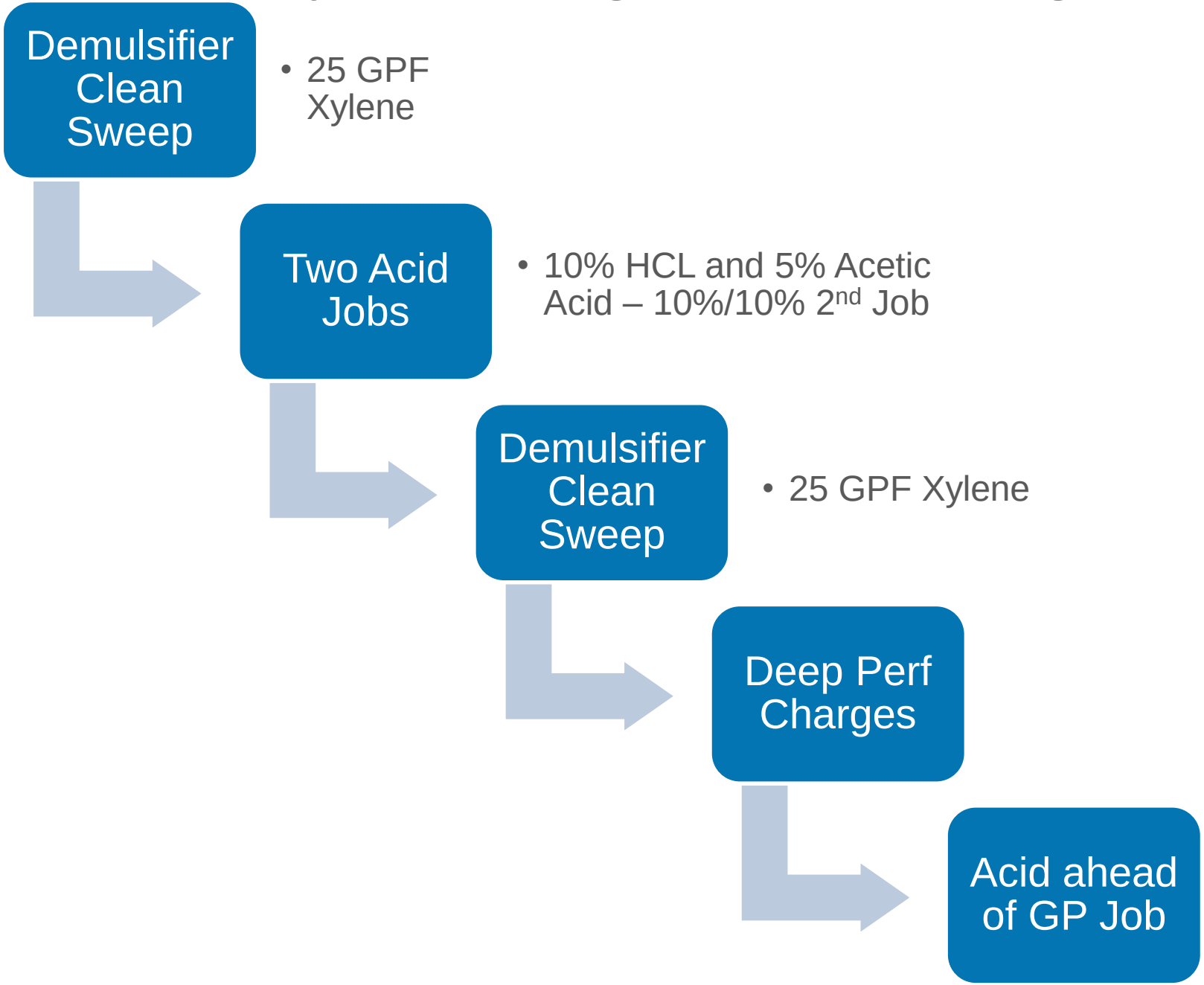
- Cement set and hold 1500 psi

Minimal losses during MZ Perf

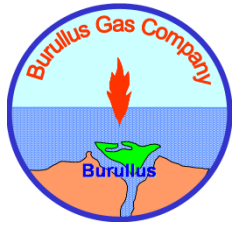
- Assume at least 10% of big perfs

Drilling & Completion Challenges – Formation Damage Remedial Trials





Drilling & Completion Challenges – Gravel Pack (GP) Job



Pre-Acid for LZ/MZ

- 360 BPH losses

DHT support MZ injectivity → Deep Perfs Connectivity in MZ

GP Job pumped

- No Screen-out

Top-up Job

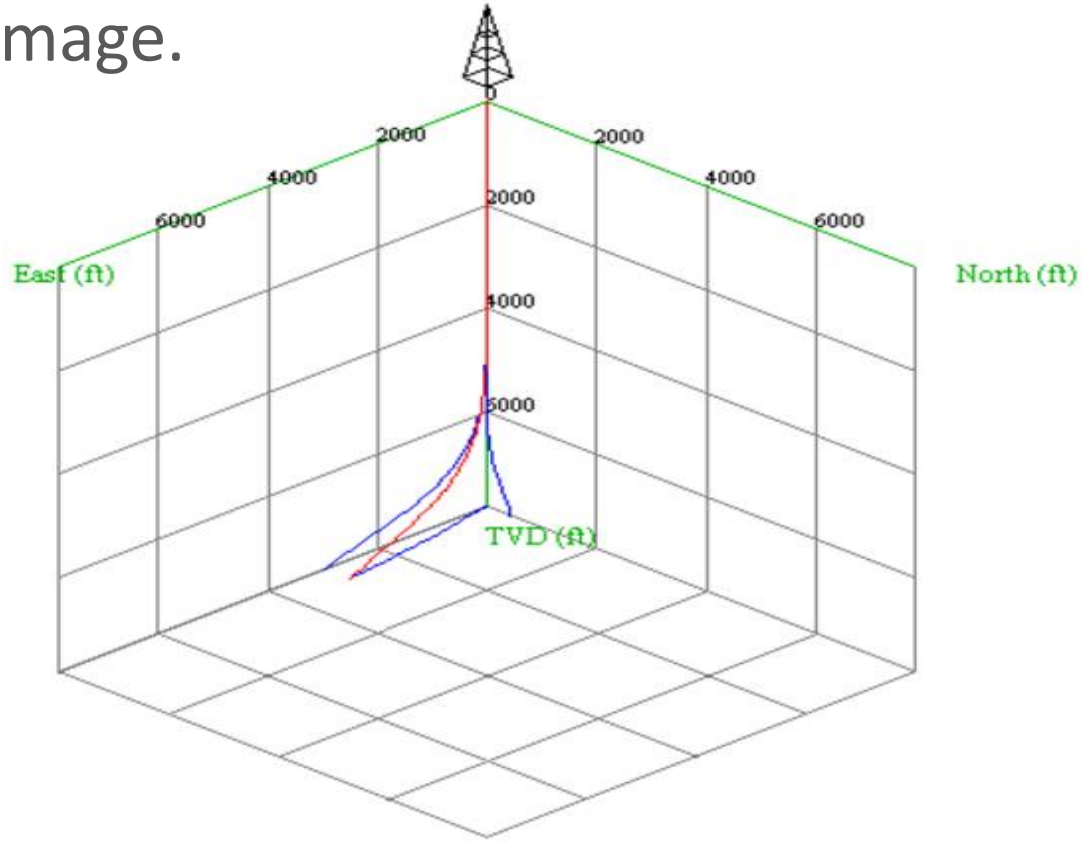
- Screen-out & good annular packing

UZ GP went as planned

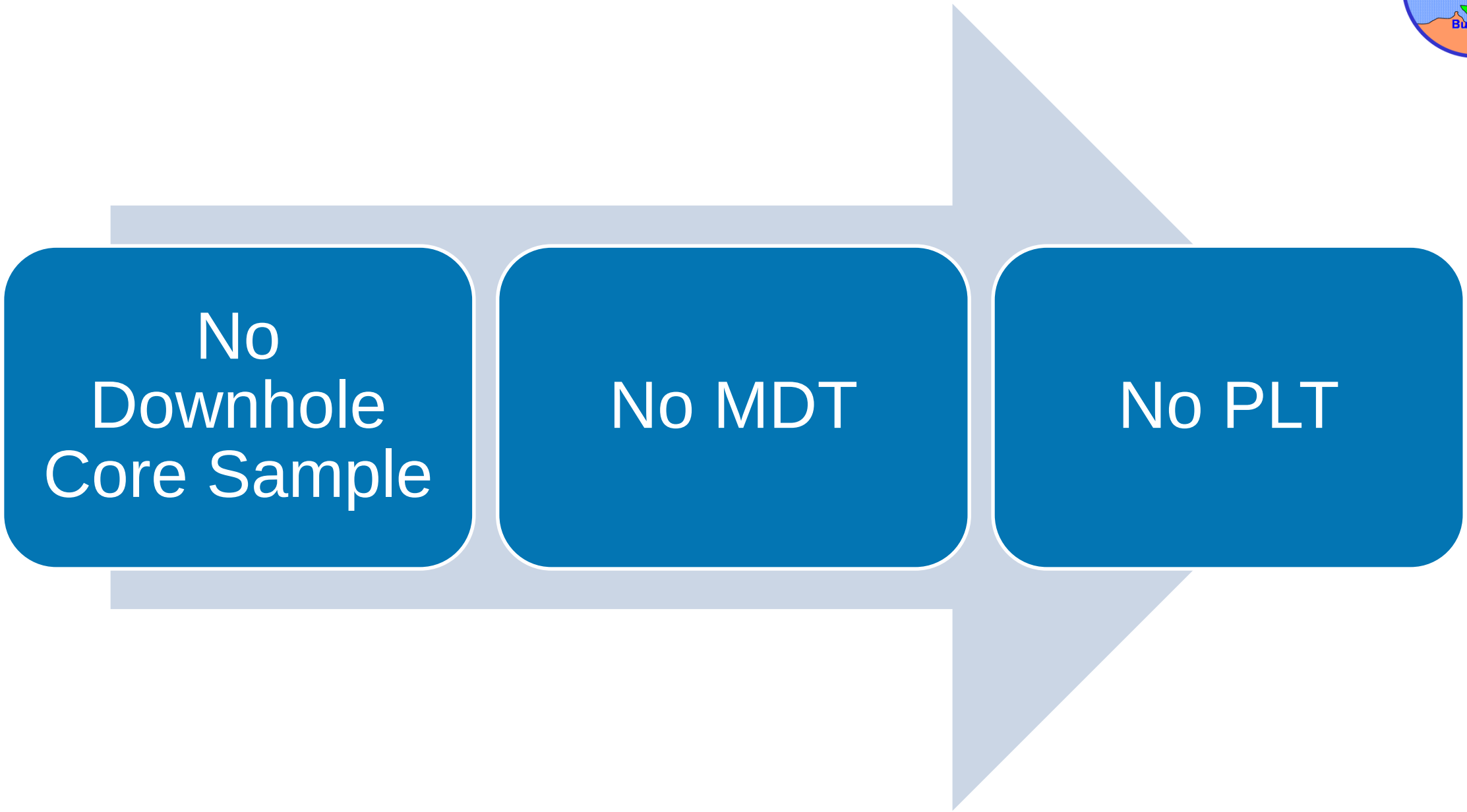
- KOIV milled

Drilling & Completion Challenges – PLT Job Key Challenges

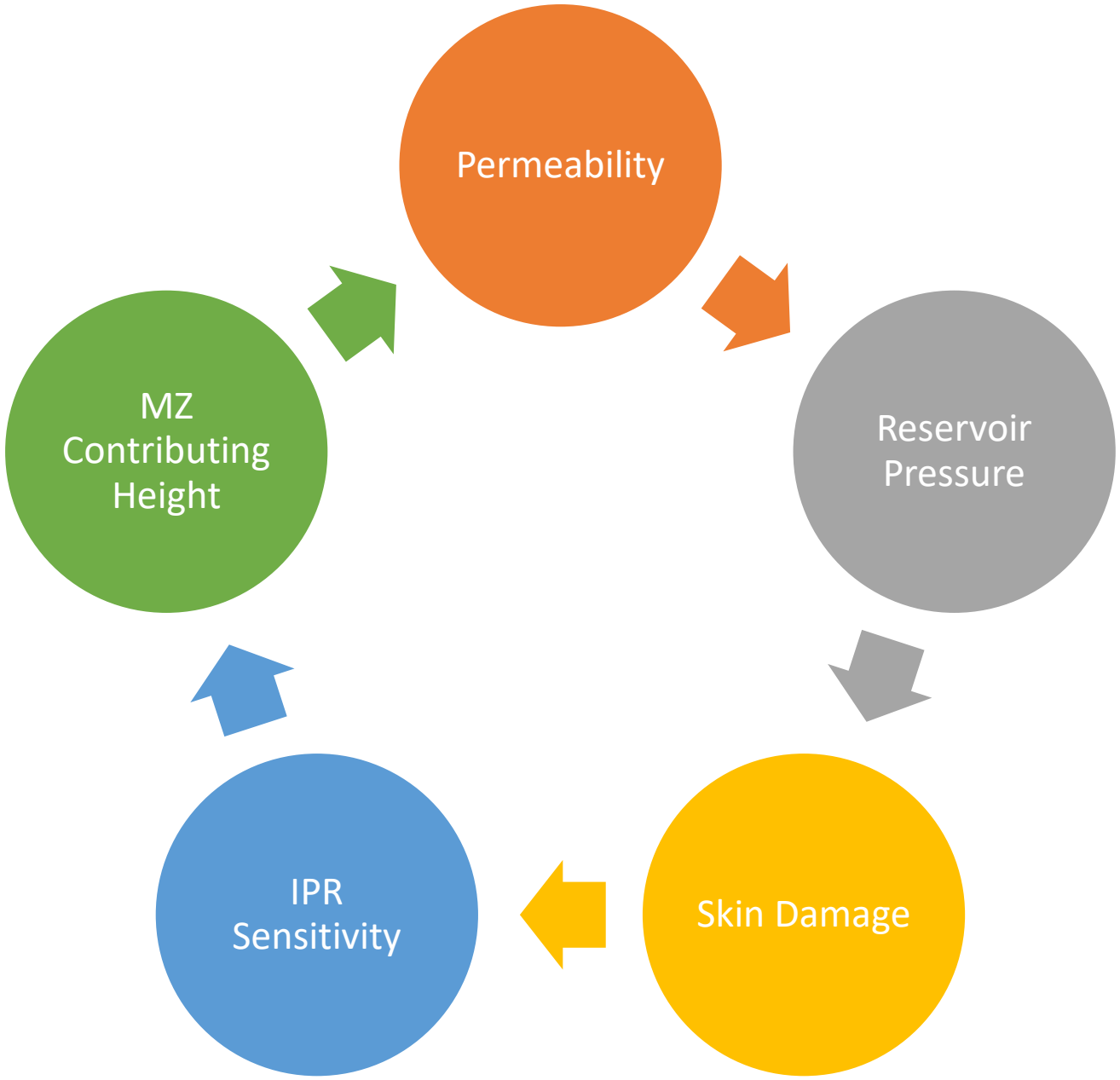
- The Well Trajectory Maximum Inclination is 72° with a long payzone ~200 ft MD.
- KOIV Condition after milling
- Maximum rate limitation to avoid cable damage.
- As a result, the PLT was canceled.



Drilling & Completion Challenges – Data Impact

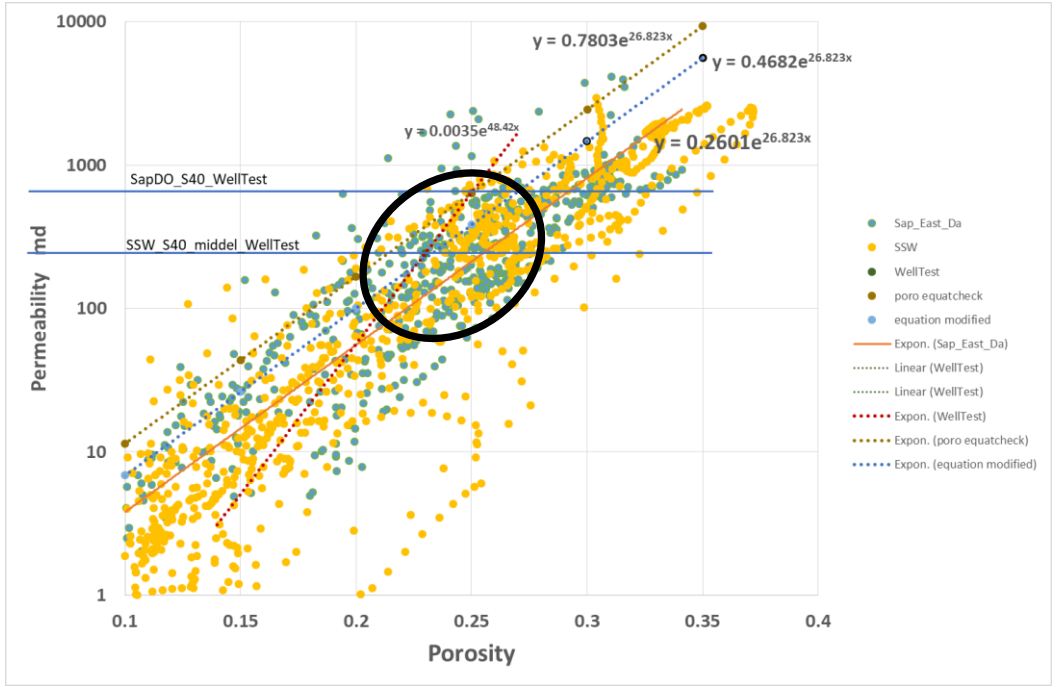


WOE Uncertainties Loop



Permeability Estimation

- Calculated permeability for three layers from field CMR and analogs correlations



Layer	Porosity	CMR Perm, mD	Analogues Perm, mD
UZ	0.27	620	490
MZ	0.22	480	430
LZ	0.24	570	470

Formation Pressure and Skin Estimation

- Assumed reservoir pressure based on rig testing 4059.07 psi (280 bar) and reflected this pressure by field global pressure gradient 0.1 psi/ft to the three layers to be:

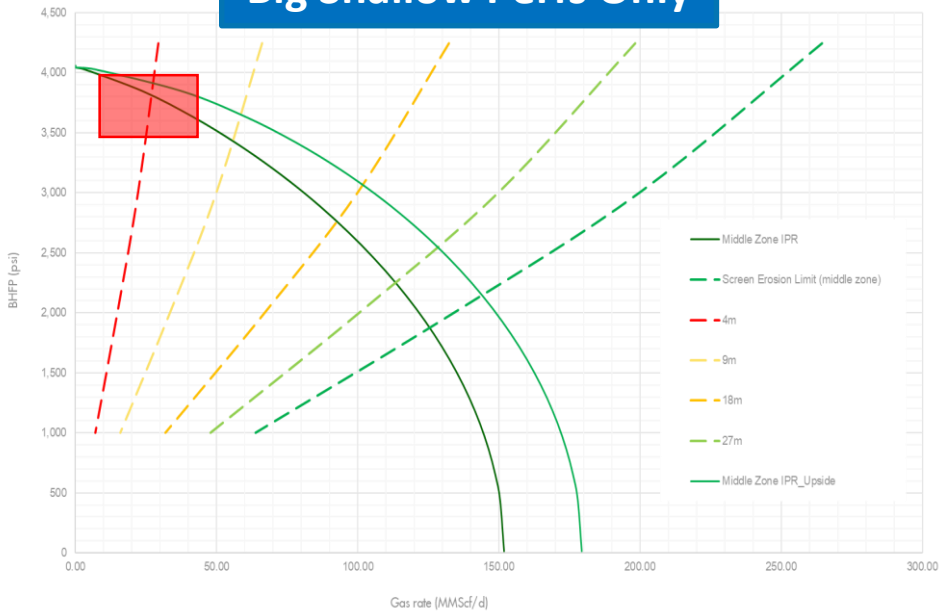
Layer	Reservoir Pressure, psia
UZ	4092.6
MZ	4120.9
LZ	4139.4

Level	TVT, m	K, mD	Skin
UZ	7	620	0 – 10
MZ	15	480	0 – 10
LZ	18	570	0 – 10

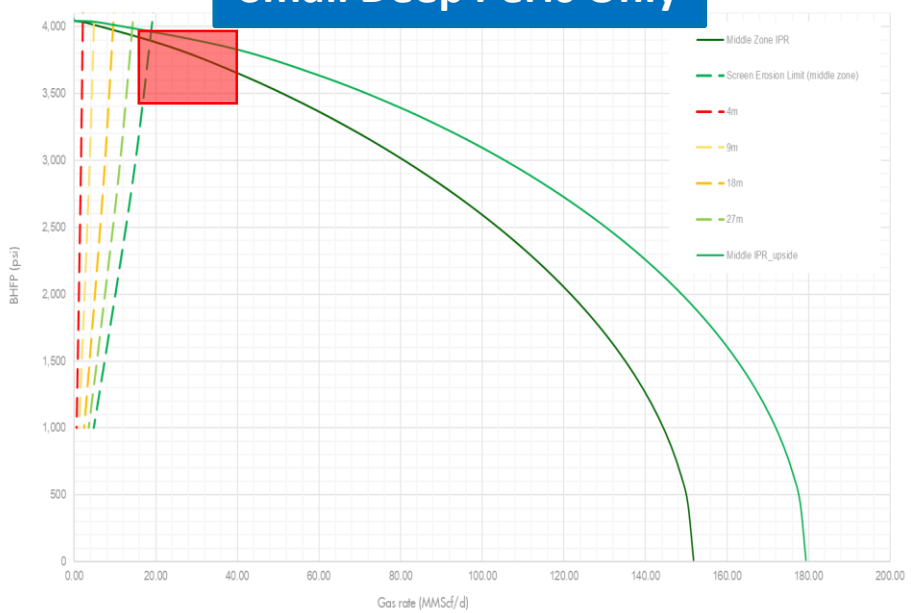
- Utilized these permeability (K) values in three layers model with corresponding reservoir pressure to make sensitivities for a range of geometrical skin (assume DFAC is 0.1 $MMscfd^{-1}$)

Workflow Assumptions – MZ Perfs Contribution

Big Shallow Perfs Only



Small Deep Perfs Only



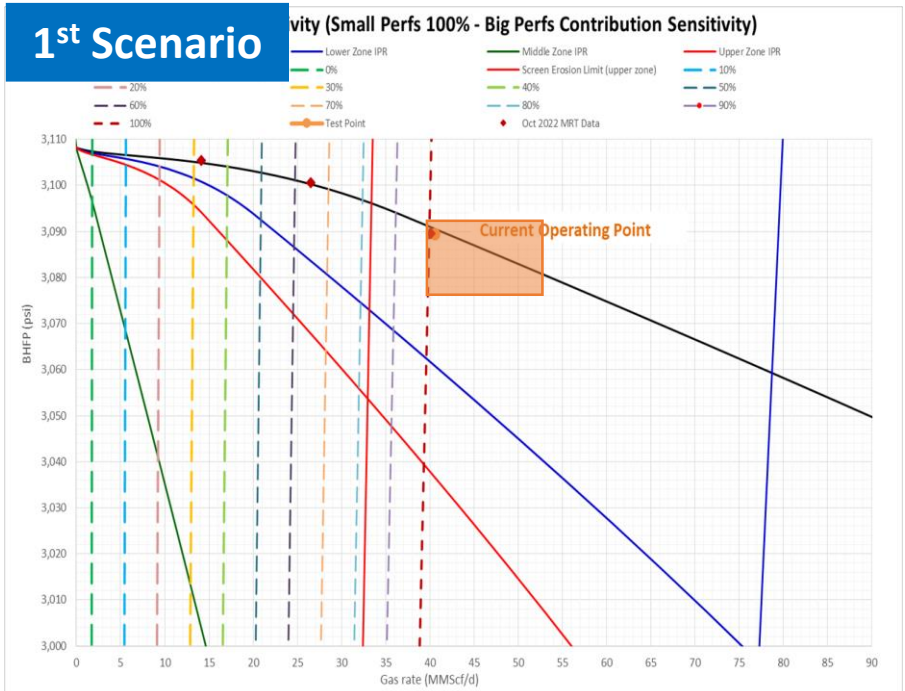
Perforation Type	Shot Density, SPF	EHD, inch	Penetration Length, inch	Area Open to Flow, $in^2/ft.$
Big Shallow Holes	18	1.15	7	18.7
Small Deep Holes	5	0.37	46.4	0.87

- The log shows fairly uniform sand (uniform production), and all perforations fired.
- The stimulation jobs and acid jobs were all pumped below fracturing conditions, likely all perforations have seen acid.
- It is considered that all 100% deep small perfs with at least 10% of shallow big perfs contribute

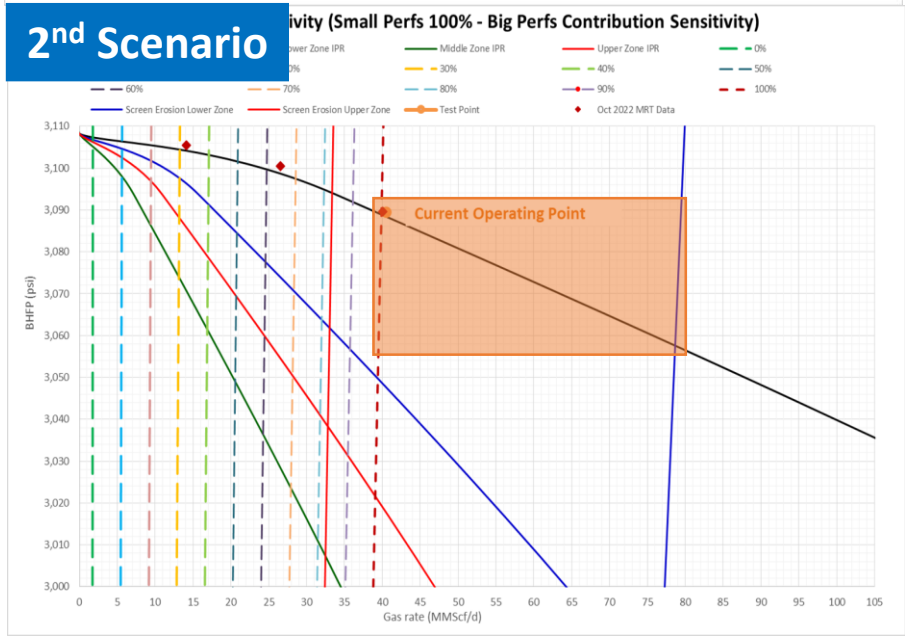
WOE Sensitivities

- The current reservoir pressure based on last calculated BHSIP in Oct 2022 and reflected for the three layers using field gas gradient.
- Calculated new permeability from well test, current gas production is 40 MMscfd.
- Well erosion limit is subjective to MZ perfs contribution
- Big Perfs contribution is questionable, gas rate didn't exceed 40 MMscfd since start-up; at least 10% of big perfs contribute.
- Gas rate max limit is UZ screen erosion (up to 50 & 80 MMscfd; 20% & 60% of big perfs contribution assumption in place for both scenarios respectively)

1st Scenario

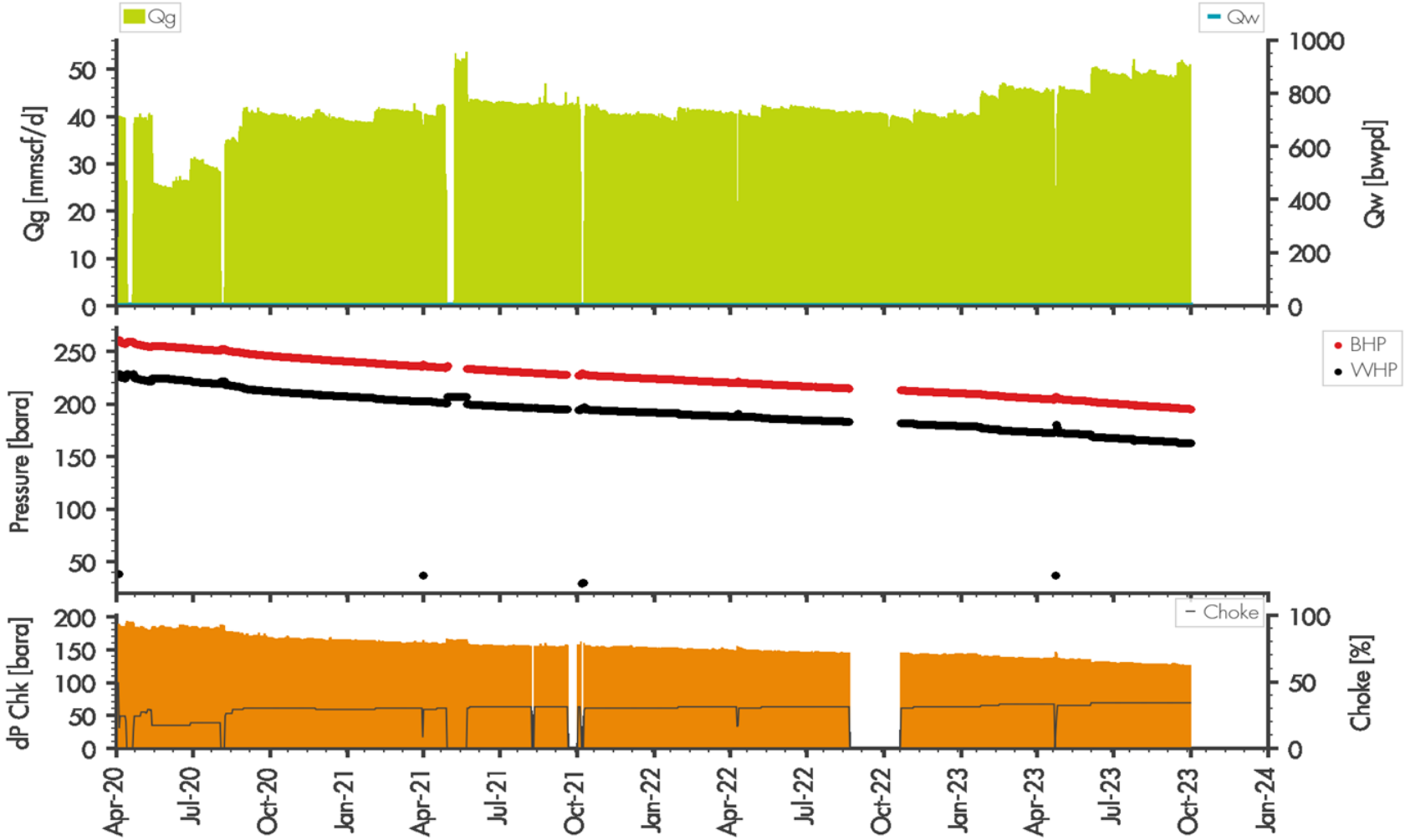


2nd Scenario

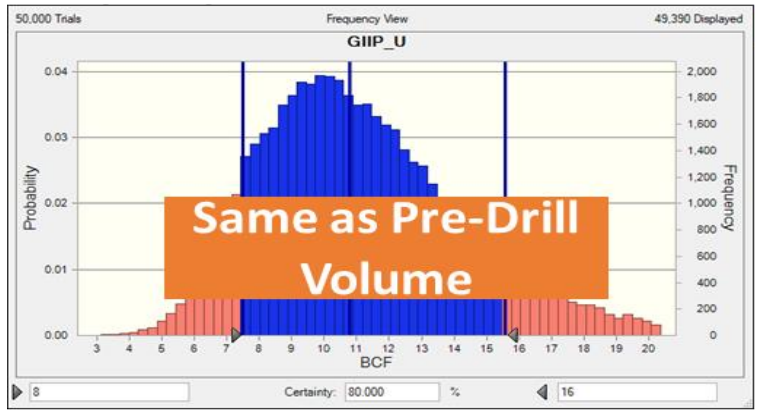


Production Performance

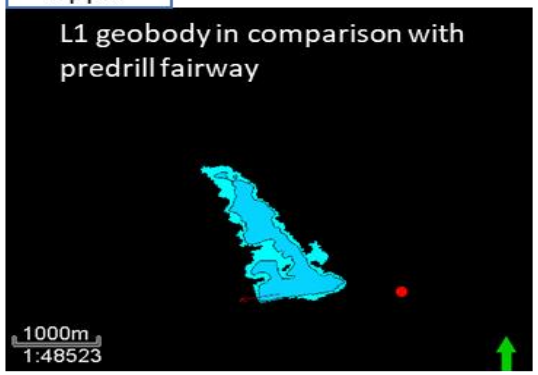
- Started up the well in April 2020, with rate of 40 MMscfd, beaned-up production to 45 MMscfd in Jan 2023, and again to 50 MMscfd in June 2023; after well operating envelope new workflow.
- Cum Production 51.2 BCF gas and 358 MSTB condensate till the 1st of Oct 2023.

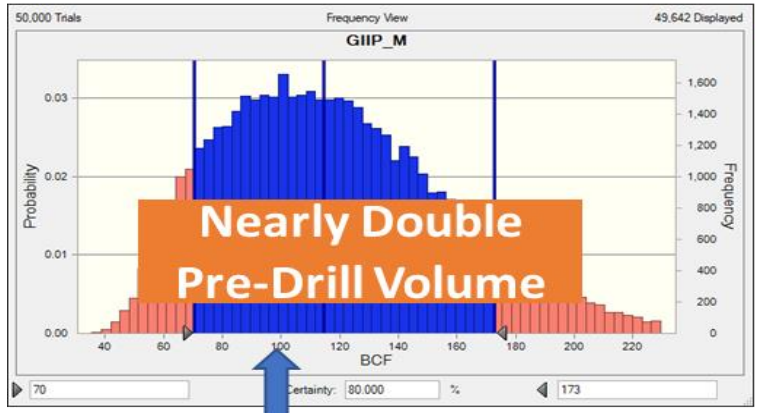


Volume Assessment – Monte-Carlo

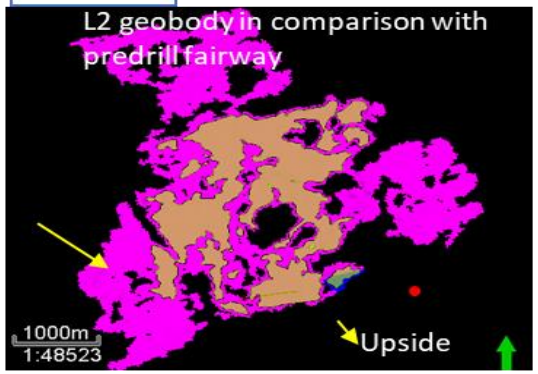


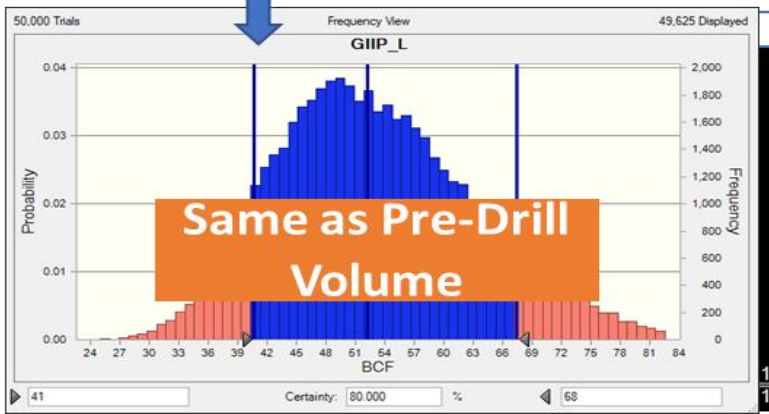
Upper



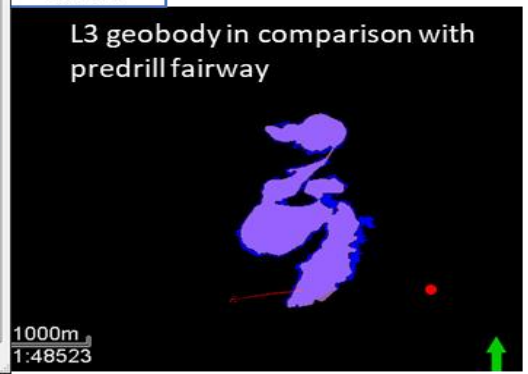


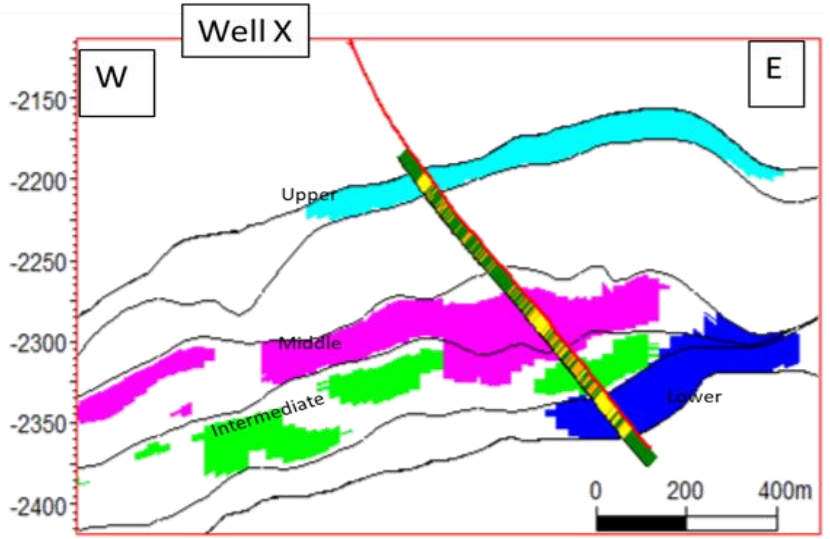
Middle

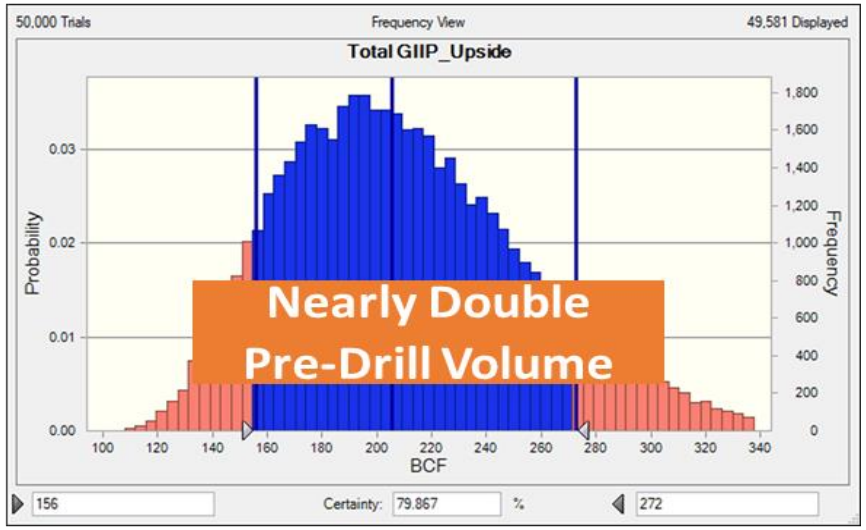




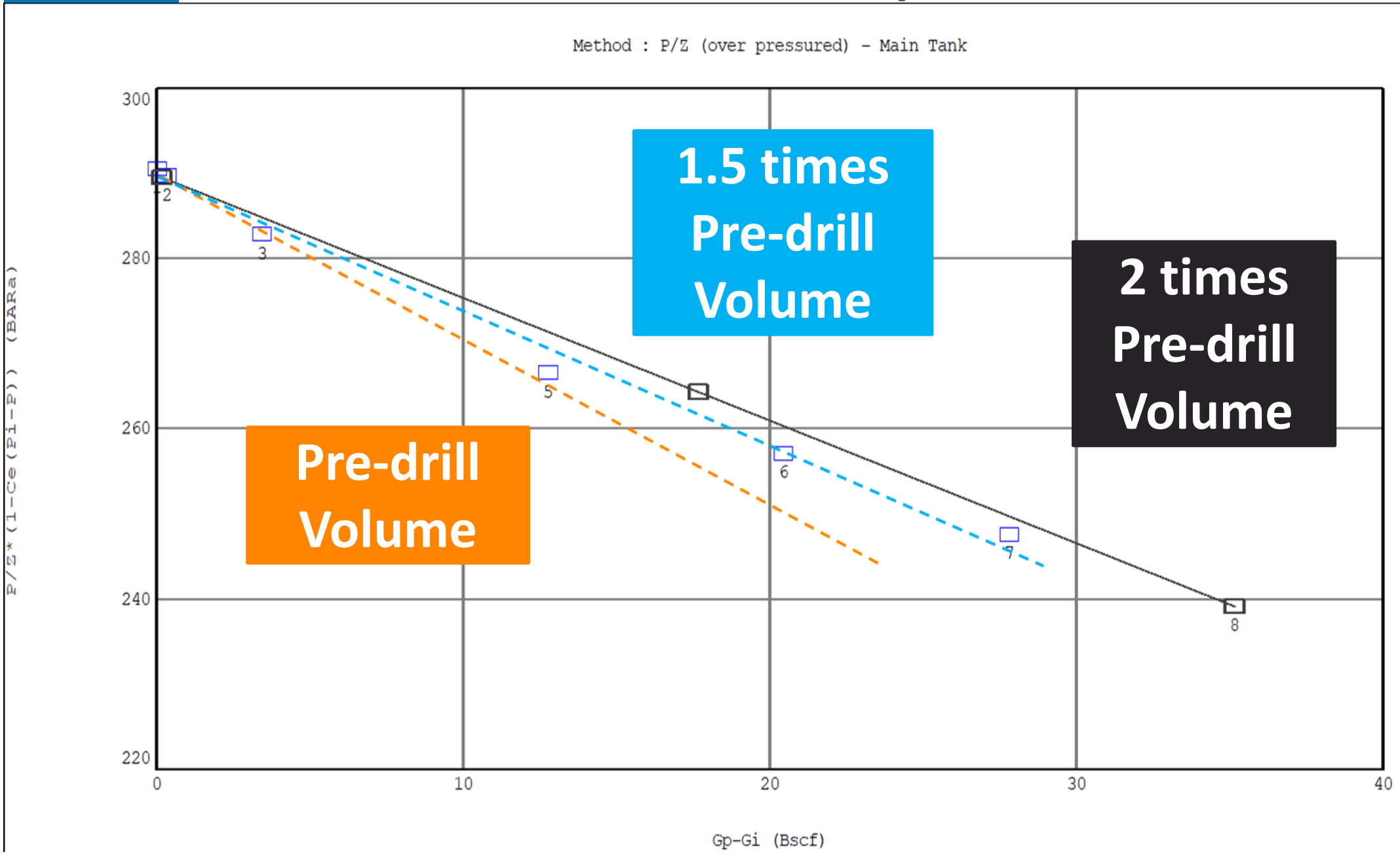
Lower



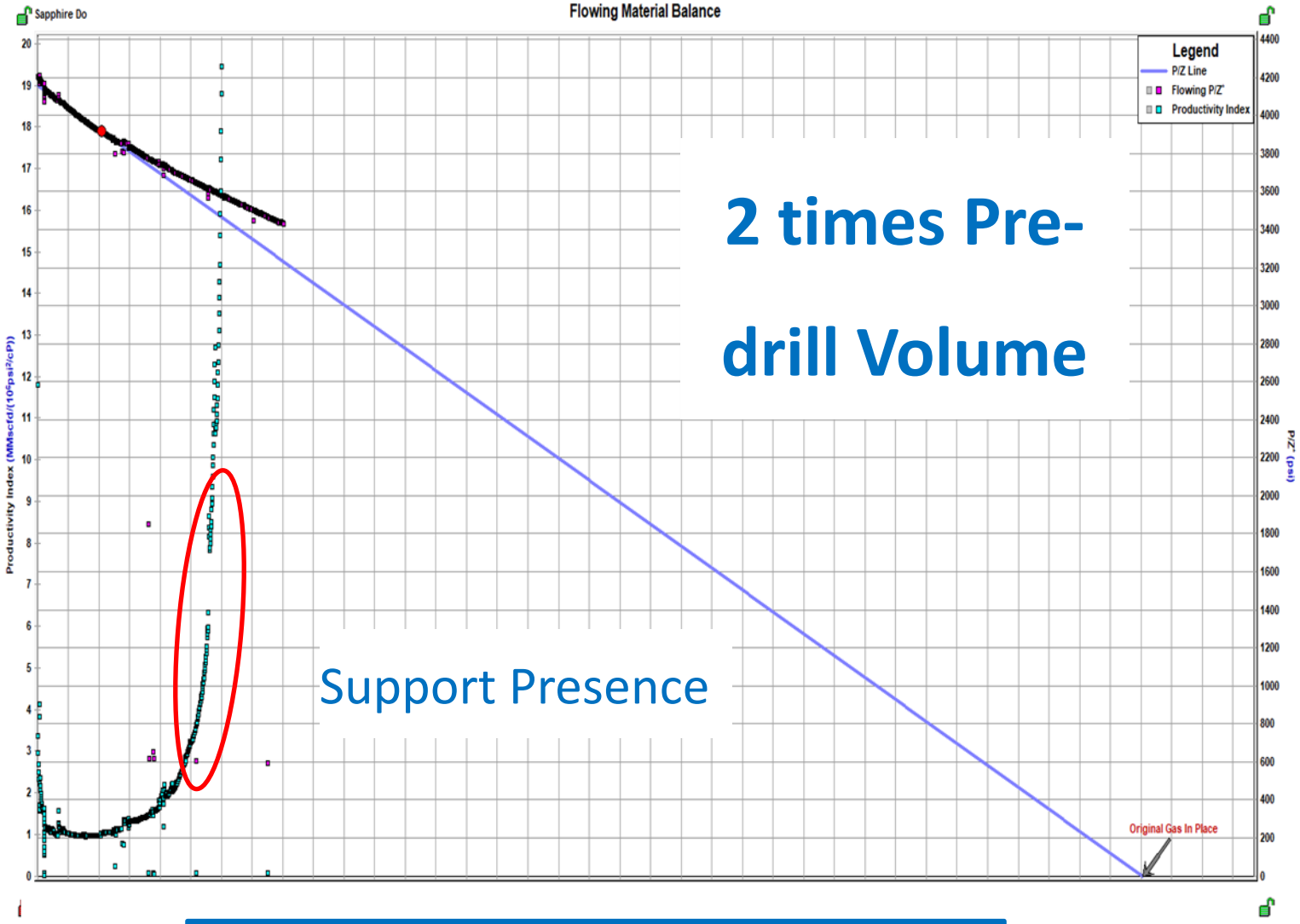




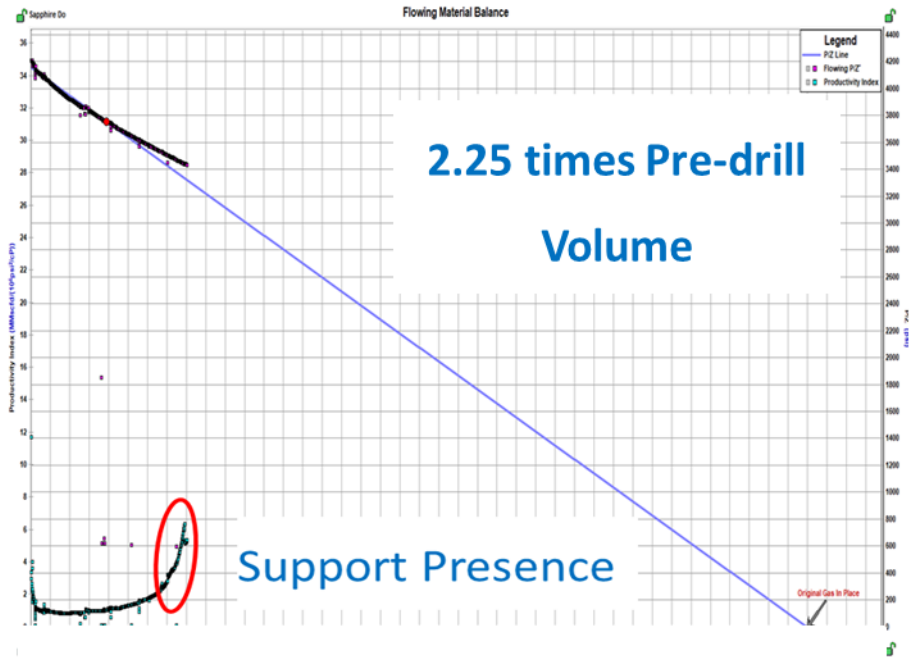
Volume Assessment – Static MBAL Graphical Method



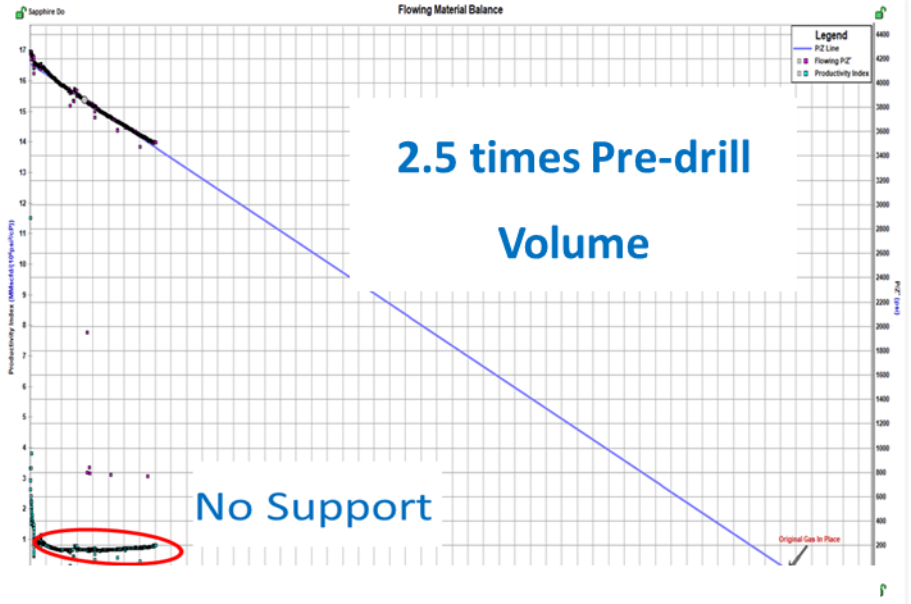
Volume Assessment – Dynamic MBAL



Taking 10 BCF Cum. Prod. as basis

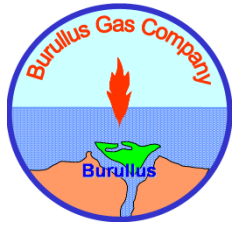


Taking 20 BCF Cum. Prod. as basis



Taking 40 BCF Cum. Prod. as basis

Conclusion



- Integrated workflow has been used to overcome drilling challenges in this well; from productivity improvement & safe operating the well without possible screen failure and asset loss.

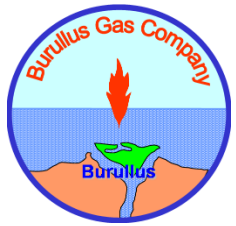
- Produced 51 BCF gas and 358 MSTB condensate from a considered dead-well, without plug back and side-track.

- The assessment of the production data unlocked unseen volume from the initial geological static model that promote drilling another infill well.

Acknowledgement

Rashid Petroleum Company (RASHPETCO)

acknowledged for granting permission to publish this work



Q & A

Back-up

Well Test Interpretation

- Signature
  - Clear IARF Regime (Possible Two regions)
  - Channelized behavior ½ slope
  - Channel width 200 m or near fault/barrier at 100 m
- Interpretation
  - KH 78,627 md.ft, delivers average K 600 mD with using reservoir average vertical H 40 m
  - Current Average Skin 8
  - Liquid segregation effect
- Analysis
  - Accessed volume double sanctioned volume