Application of Classical Reservoir Engineering Toolkit to Track and Predict the Water Breakthrough Timing in a Dry-Gas Reservoir Located in East Nile Delta Basin

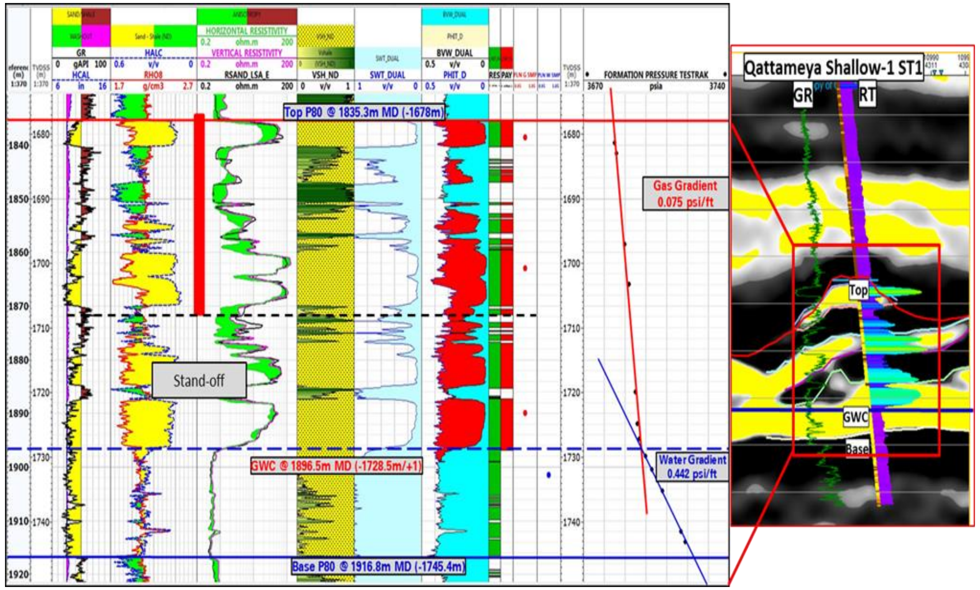
RMT PhPc

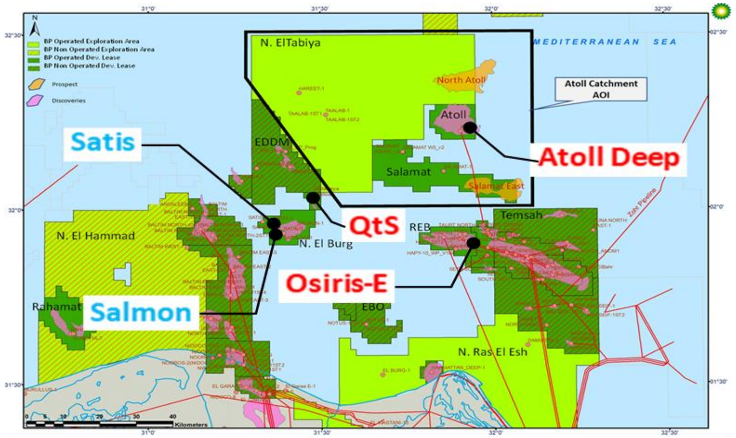
Roadmap

- Quick familiarization for QTS field
  - Main static and dynamic features
  - Early Water breakthrough risk
- Classical Reservoir Engineering toolkit
- Main takeaways

Main static features

- QTS was discovered in 2016 in the North Damietta offshore (NDO) concession in East Nile Delta region (END) and developed in a form of a single subseawell development that started up in October 2020
- QTS P80 is an amalgamated submarine slope channel complex reservoir system within P80 (late Pliocene section) which is equivalent to Kafr El-Sheikh formation.
- The reservoir is slightly over pressurized relative to its stratigraphic and depth level with high quality reservoir properties in terms of grain size, N/G and porosity
- The field is in approximately 108m water depth within North Damietta concession

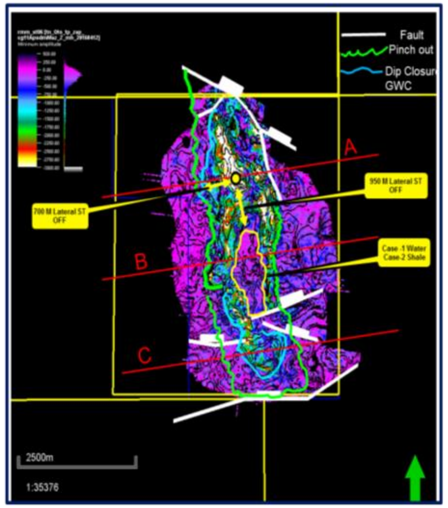


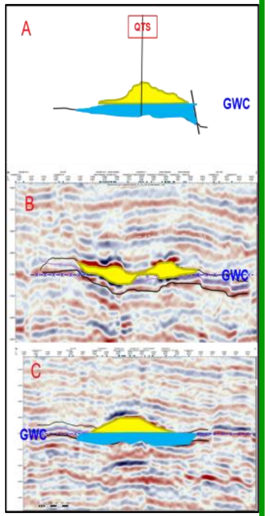


- P80 Reservoir shows good reservoir quality by QTS penetration, complete WL acquired across the pay zone " triple combo-OBMI, MSIP pressure point plus MDT samples".
- Perforated the first three bodies of QTS well and left the last 2 bodies as stand off (21.87 mTVD SS thickness from bottom perf to GWC).

WD	108.8
KB	33.31
WL tops	mTVDSS (m MD)
Top	1678 (1835.5)
GWC	1729 (1897.3)
Base	1745.4 (1816.8)
Gross Reservoir	67.4 (81.5)
Net Reservoir P80	52.9 (63.8)
Net Reservoir above GWC	38.3 (63.8)
CH till contact	51 (62)
Net pay	37.4 (45.1)
Net Gross/ whole P80	78%
Netpay/ above contact	73%
Porosity	35%
SG	82%
Reservoir Pressure Psi	3680
GEF	240
Gas gradient (psi/ft)	0.07

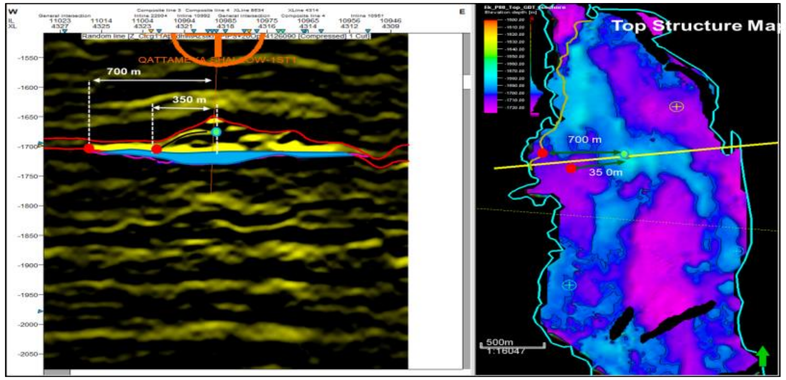
- A wide range of static GIIP was captured to pinpoint all high weighted possibilities (66-117-136) bcf with different aquifer scenarios





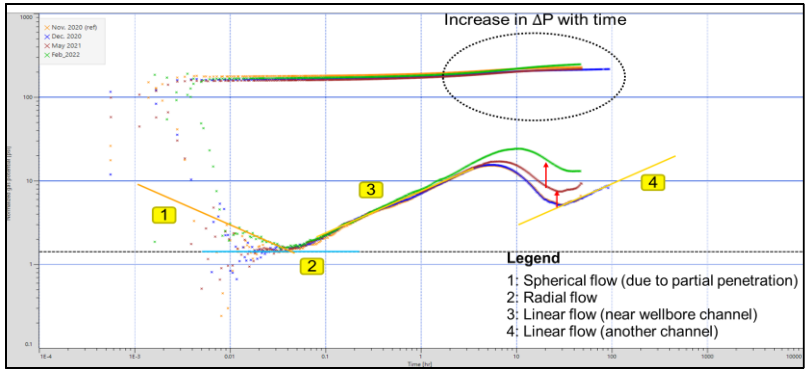
	LS Case	MID Case	HS Case
Area	6.73E+06	6.73E+06	6.30E+06
AVG Thick	18	18	19.05
BRV	1.22E+08	1.22E+08	1.20E+08
N:G	0.4	0.52	0.57
NET ROCK Vol	4.88E+07	6.60E+07	6.84E+07
PHIT	0.28	0.3	0.3
Sg	0.57	0.7	0.78
Conv.	35.3146	35.3146	35.3146
GEF	240	240	240
GIIP (scf)	66,011,293,394	117,470,485,440	135,672,483,763
GIIP (bcf)	66	117	136

Main dynamic features



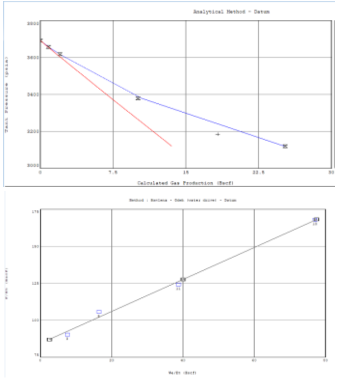
- The well encountered 3-amlgmated layers and a clear GWC within the third layer hence, the decision was to perforate the first two layers and leaving the third one untapped to act as a standoff as a trial to delay the WBT
- However, the main concern here was having a high-perm streak that may cause an edge water encroachment so, we tried to keep an open eye on the water encroachment from day 1 and to do so, we applied the idea of time-lapse PBUs

- To apply the idea or the concept of time lapse PBUs, a baseline should be established at first then chronological PBUS should be conducted and evaluated against the baseline to capture any deflection or differences from the base moreover, as long as the concern was related to water encroachment, the focus was totally on the changes of the late time region

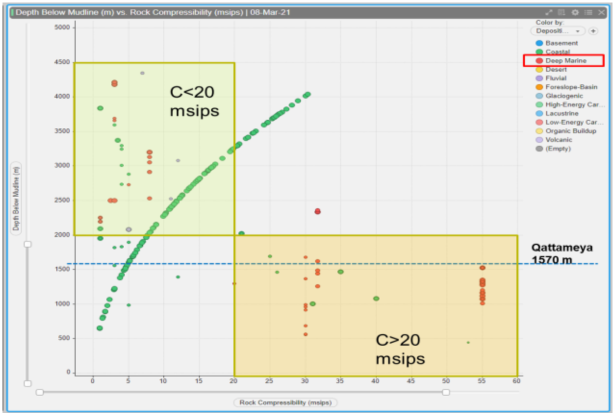


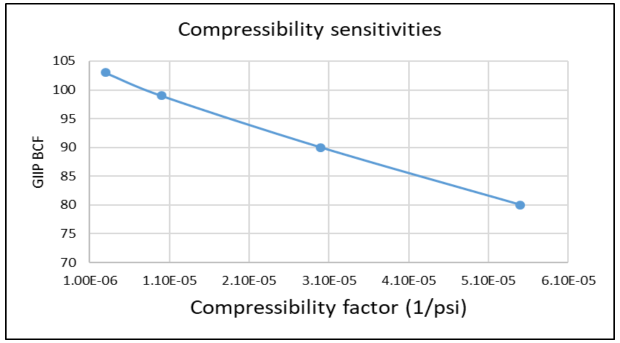
- To fine the range of static GIIP a detailed surveillance program was established to acquire pressure points and PBUs to calculate the dynamic GIIP with different techniques including (static material balance, deconvolution, RTA)

date m/d/y	psia	Bscf	BSTB
10/15/2020	3691.81	0	0
11/01/2020		0.444	0
11/10/2020	3656.3	0.8186	0
12/01/2020		1.523	0
12/18/2020	3617.6	2	0
01/01/2021		2.257	0
02/01/2021		3.519	0
03/01/2021		5.214	0
04/01/2021		7.108	0
05/01/2021		8.875	0
05/24/2021	3378.7	10.065	0
06/01/2021		10.512	0
08/01/2021		14.2044	0
09/01/2021		16.0786	0
10/01/2021		17.8745	0
10/12/2021	3185	18.35	0

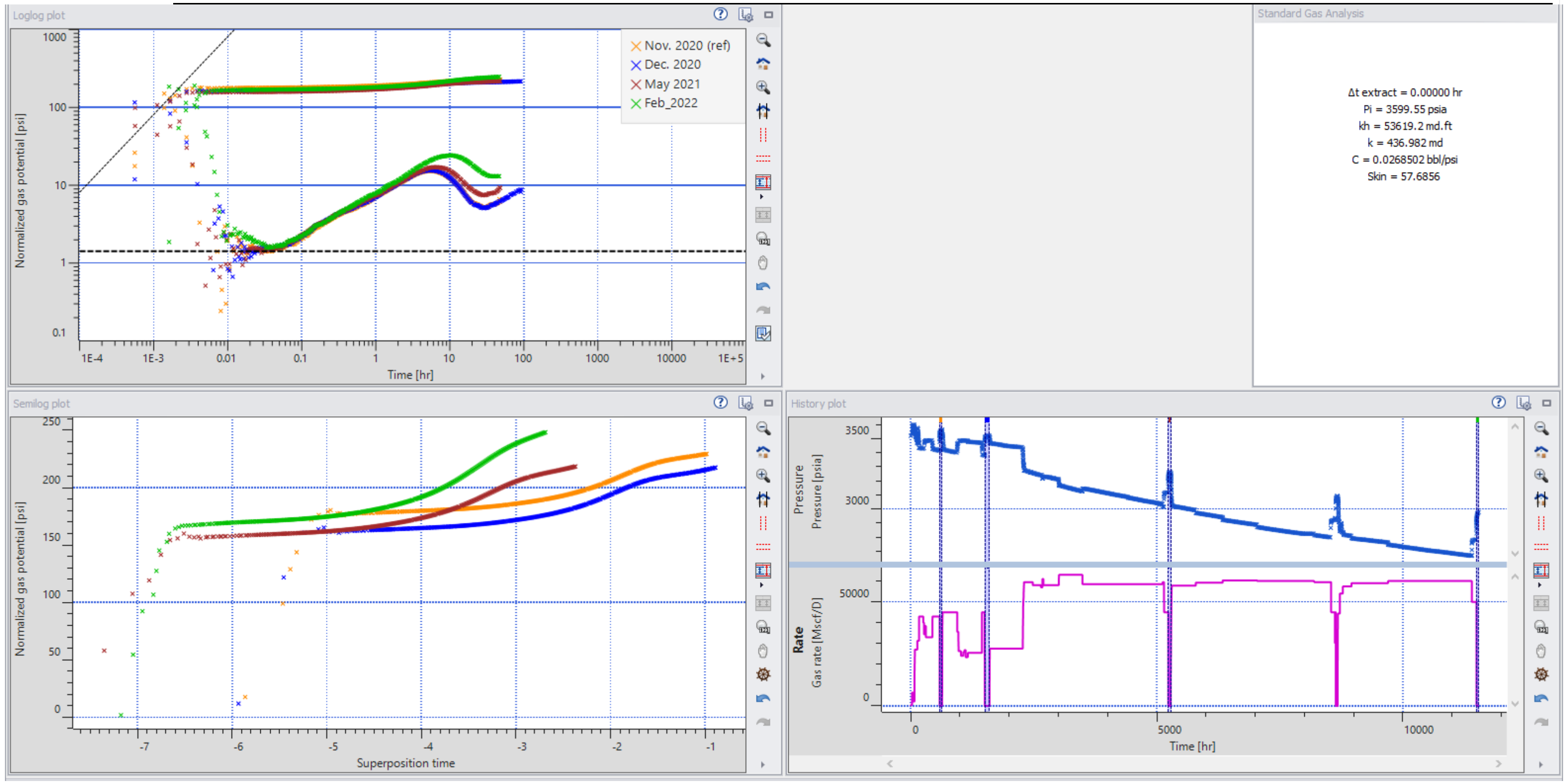


- As no cores were collected, the rock compressibility was an unknown besides, we are talking about a Pliocene reservoir in which the compressibility has a real impact on the energy stored within the reservoir, therefore, we benchmarked the compressibility of QTS formation against some local and global data gathered from similar depositional environment.





QTS Time-lapse PBUs coupled with static MB



Nov 2020: 1st PBU @ 0.8 bcf cum & 35 psi depletion from initial pressure

Dec 2020: 2nd PBU @ 2 bcf cum & 73 psi depletion from initial pressure

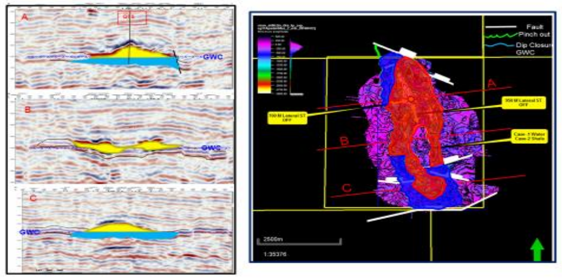
May 2021 3rd PBU @ 10 bcf cum & 307 psi depletion from initial pressure

Feb 2022 4th PBU @ 25 bcf cum & 559 psi depletion from initial pressure

CRE Workflow

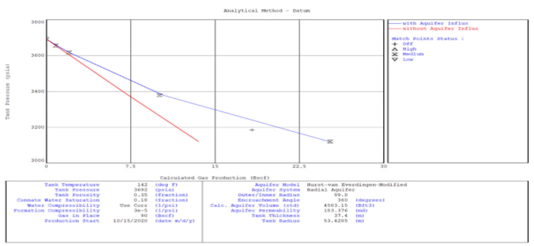
1- Range of Static GIP and aquifer description

Qattameiya Aquifer Scenarios



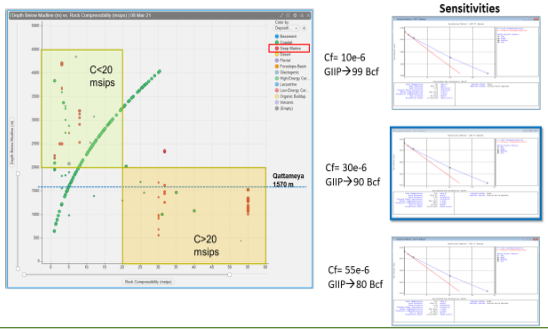
2- Early Time Material Balance, Dynamic GIP range

Material Balance Calculations (Analytical)



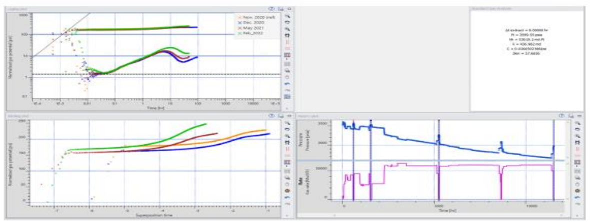
3- Impact of rock compressibility on dynamic GIP range

Analogue Rock Compressibility



4- PTA derivative time-lapse technique

Time-lapse PBUs



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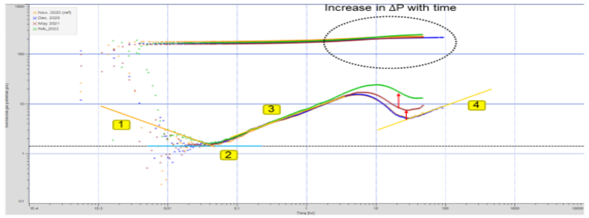
5- PBU Quick look Analysis

PBU Quick look analysis

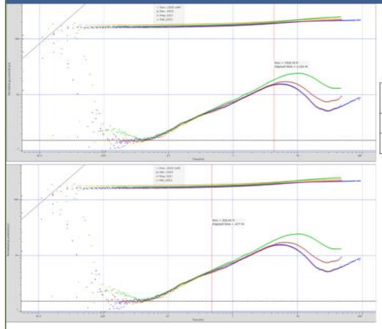


Legend

1: Spherical flow (due to partial penetration)
2: Radial flow
3: Linear flow (near wellbore channel)
4: Linear flow (another channel)

6- WBT timing estimate using ROE technique

Estimation of WBT Timing using Radius of investigation



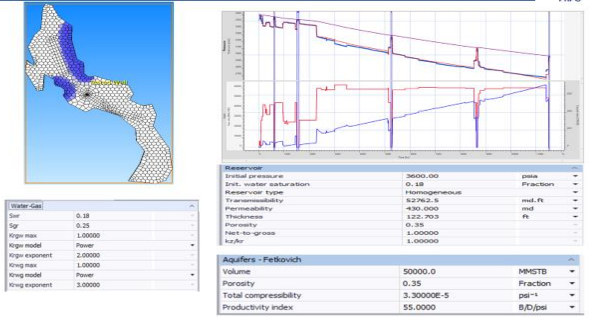
PBU	Cum. Prod. (bcf)	Radius Of deflection (ft)	Elapsed time of deflection (hr)
24 May. 2021	10	1055	4.326
8 Feb. 2022	25	350	0.477

Assuming the same production conditions (60 MMSCF/day):

so, the estimated WBT time might occur by Jun. 2022 after producing around **8 bcf** (total recovery=25+8 = **33 bcf** & **RF=** 33/90= **37%)**

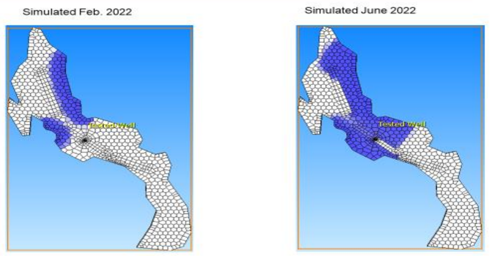
7- Build Saphir Numerical model to HM PTA response technique

Numerical Model



8- WBT Timing estimate using Saphire Numerical model

Estimation of WBT Timing using the numerical model forecast

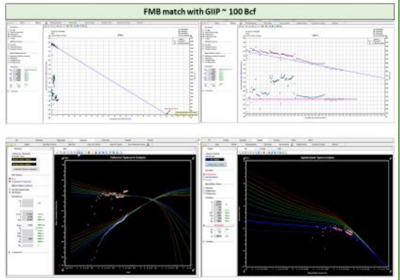


9- Integrate RTA technique to refine GIP range

FLOWING MATERIAL BALANCE

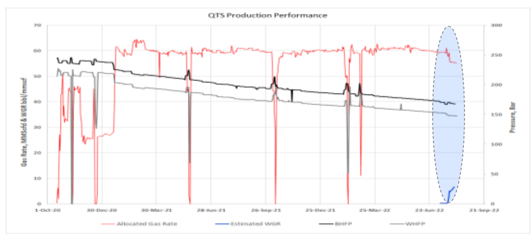
FMB history matching (giving more weight to latest flowing period)

- Flowing material balance is independent from P* estimates, but is influenced by Pres init
- **FMB suggests some uncertainty, typically ~100-110 Bcf GIIP in current analysis**
- Not all data can be matched with single trend
- Suggests that PSS conditions have not been achieved and method is not fully applicable
- **Analysis is possibly biased by BHFP corrections to datum ignoring here friction losses that are rate dependent**



10- Well Performance monitoring, for WBT signs

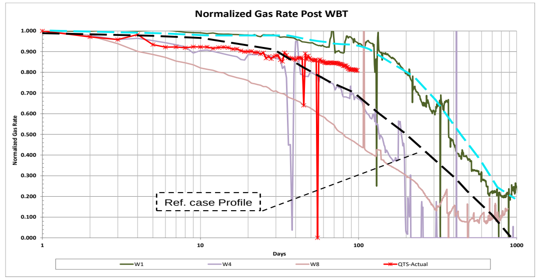
QTS-1 Production Performance Aug-2022



Highlighted WBT event in July 22nd 2022

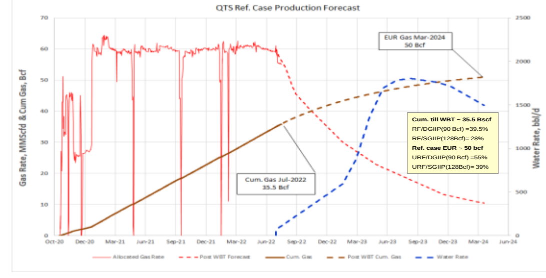
11- Benchmarking Well performance Post WBT

Performance Post WBT



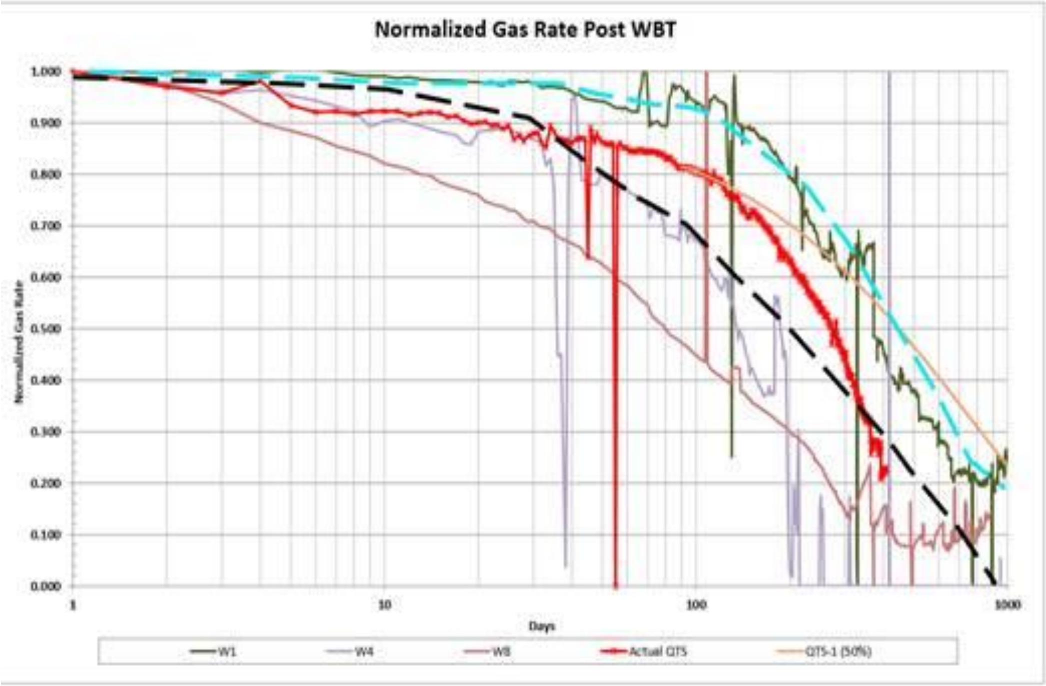
12- Provide production forecasting Post WBT

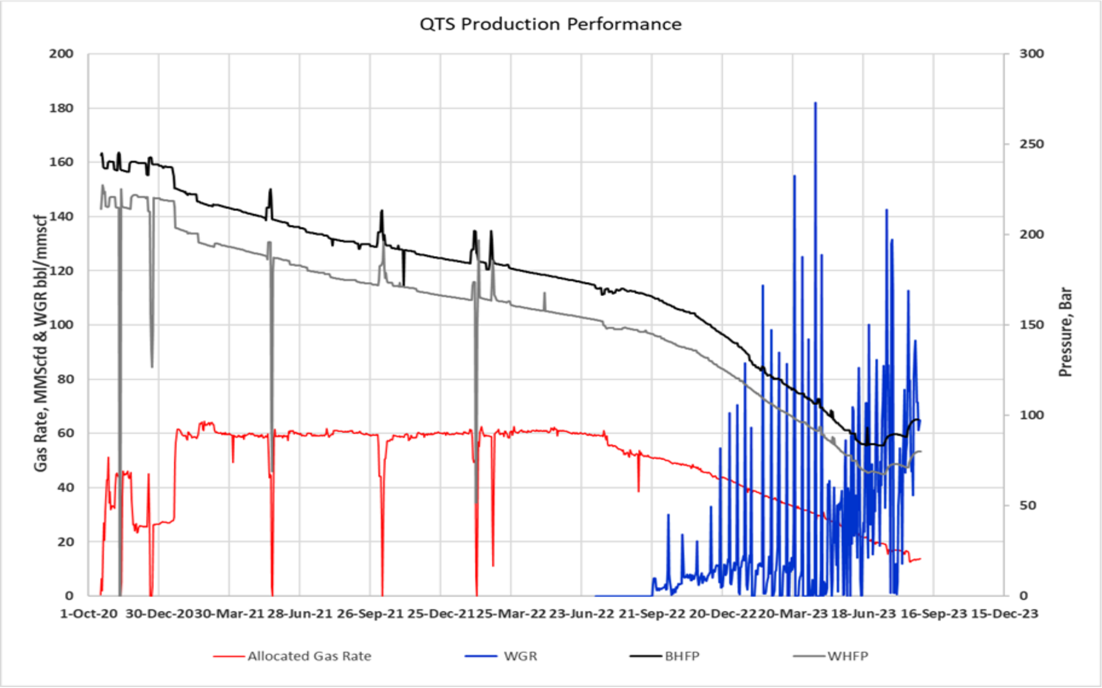
QTS-1 Updated Production Forecast



Recovered volumes after WBT subject to the mitigation of buckling risk in QTS 14" P/L, corrosion risk and liquid holdup in the 30" trunk line in addition to water handling capacity in WH.

Latest Well performance





Main takeaways

- **Investigate and integrate different tools, Material Balance, Flowing MB, RTA, PTA, and Benchmarks can help reliably predict WBT**
- **Capture the uncertainty range** specially in the rock compressibility and aquifer description and its impact on dynamic GIIP.
- **Use of Analogues to benchmark RF at WBT** and to develop post WBT gas and water profiles.
- Caution should be considered in FMB technique when defining energy source attributes, integration with other techniques is key for robust interpretation