BHP Conversion from Surface Data PTA

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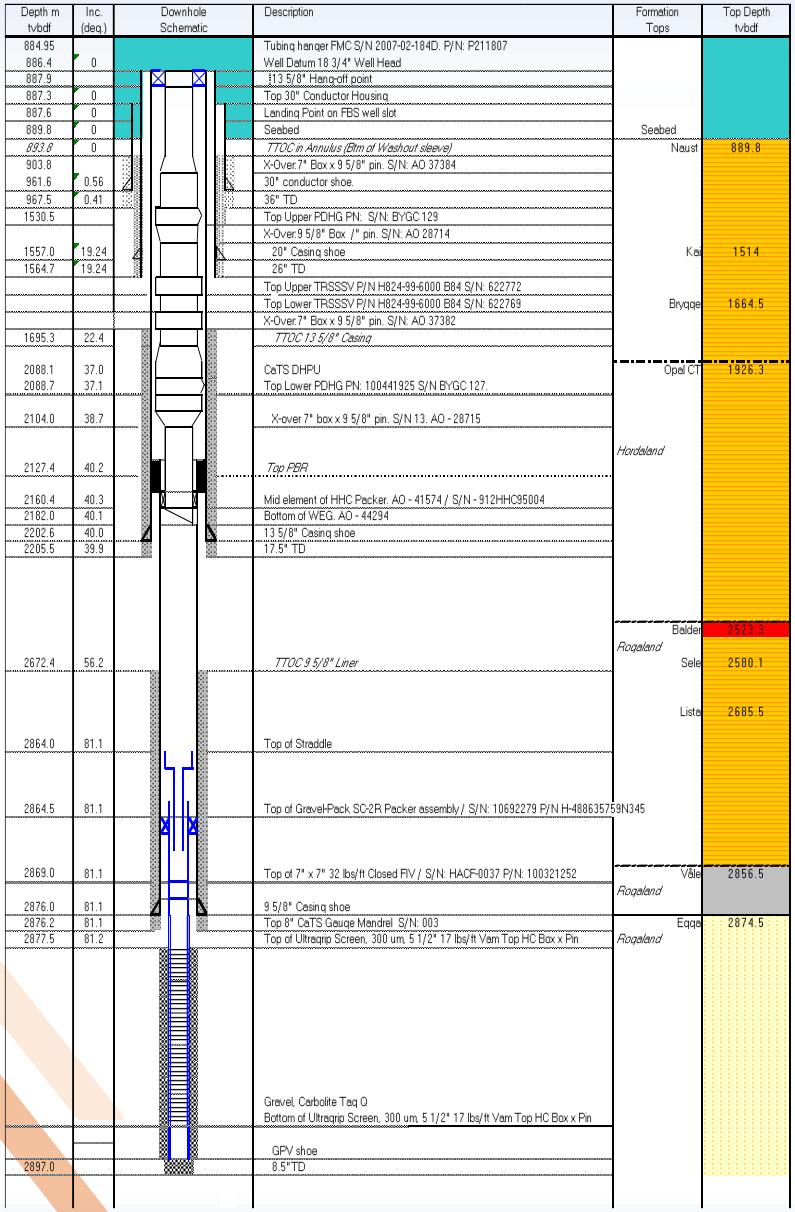
Outline

- Well Background Information
- Objective
- Data Processing
- Trial Results
  - Rate Comparison
  - BHP Conversion
  - PTA Summary
- Conclusions and Recommendations

Well Background Information

Completion Schematics



Upper DHGP @ 1531' mTVBDF

558 mTVD

Lower DHGP @ 2089' mTVDBDF

800 mTVD

MOC @ 2889' mTVDBDF

(Failed)
Calculated by ODSI and compared to historic data

(Failed)
Calculated by ODSI and compared to historic data

Calculated by ODSI for PTA purposes

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Well Background & Objectives

- The well was equipped with multiple gauges
  - Tree gauges
  - Upper downhole gauge *(failed, historic data only)*
  - Lower dowhole gauge *(failed, historic data only)*
- The rates were being measured
- Both downhole gauges failed; ODSI performed BHP conversion from the surface data at the Upper and Lower downhole gauge depths & compared the results to historic data when both gauges were functional **(Proof of Concept)**
- ODSI to calculate BHP at the mid-completion depth
- ODSI to perform PTA and evaluate if the well's a stimulation candidate

Data Processing & Results

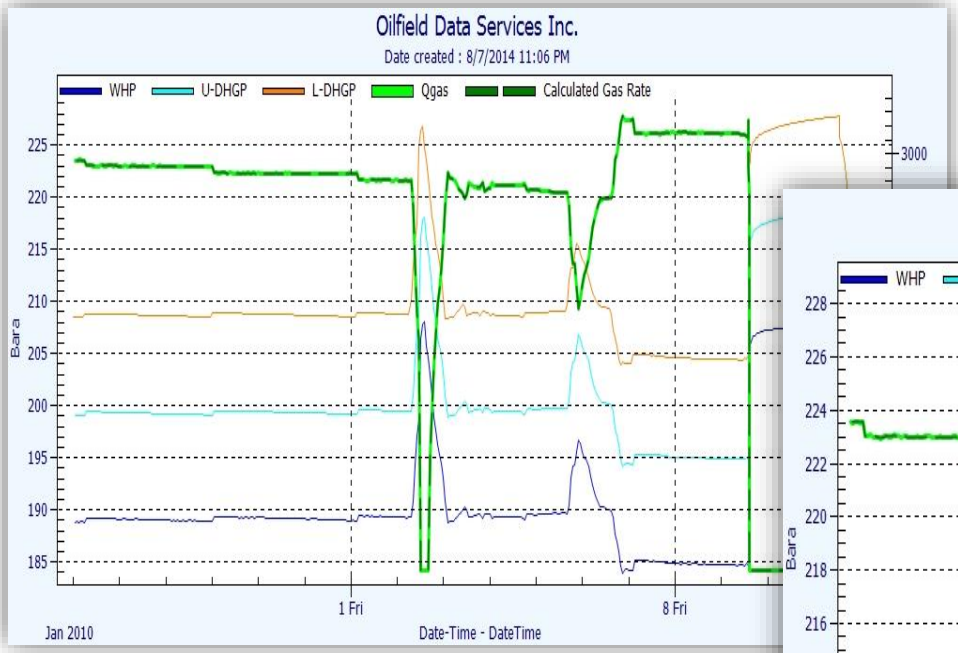
Data Processing

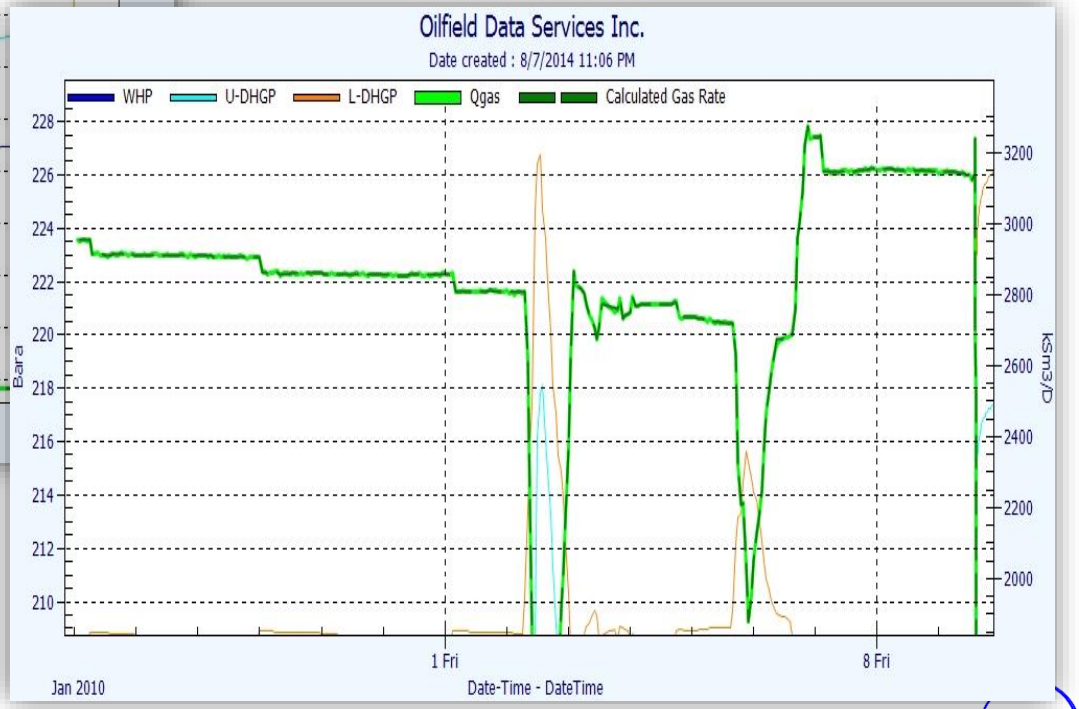
- PVT and frictional component were calibrated using shut-in data and flowing pressure data (DP wellbore)
- Tree gauge and lower DHGP data used to calculate/validate production rates
- Good MPFM measurements (less than 1% deviation)
- Tree gauge data and calculated rates used to perform BHP conversion at the following depths for proof of concept & PTA purposes:
  - Upper Downhole Gauge
  - Lower Downhole Gauge
  - Mid-completion BHP

- **Note:** All calculations were based on ODSI's direct solution to Mechanical Energy Balance Equation

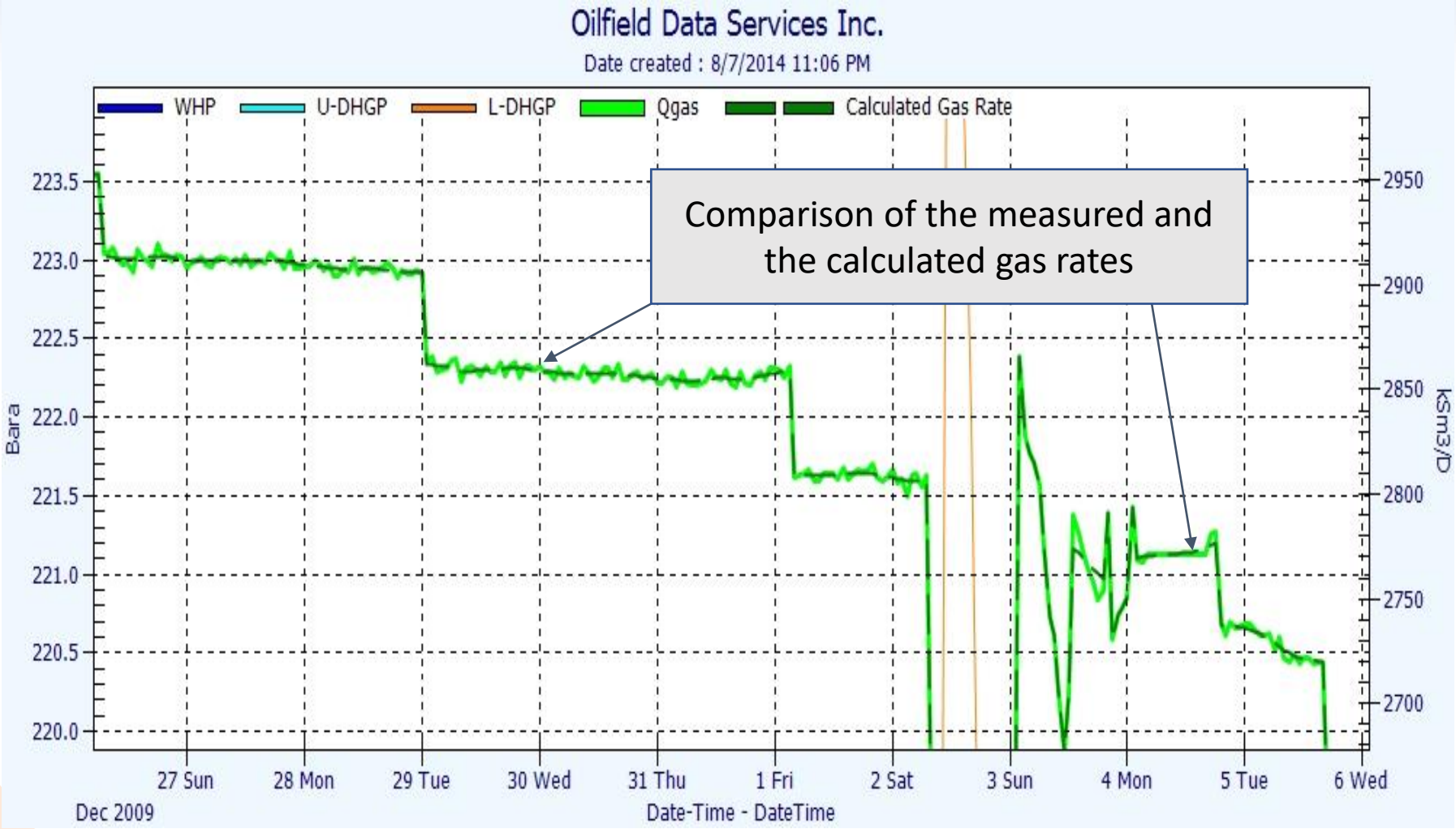
Results – Rate Comparison

- The gas rate was calculated to demonstrate the accuracy of ODSI's rate calculation method and as a proof of concept
  - Using the DP Wellbore (DP between the Lower DHGP and tree gauge)
  - **Less than 1 % error**





Results – Rate Comparison Zoom



The calculated rates were within 1 % when compared to the metered rates

Rate Comparison

- The gas rates were calculated using the pressure drop in the wellbore
- When compared to the metered gas rate, the measured rate was within 1 %

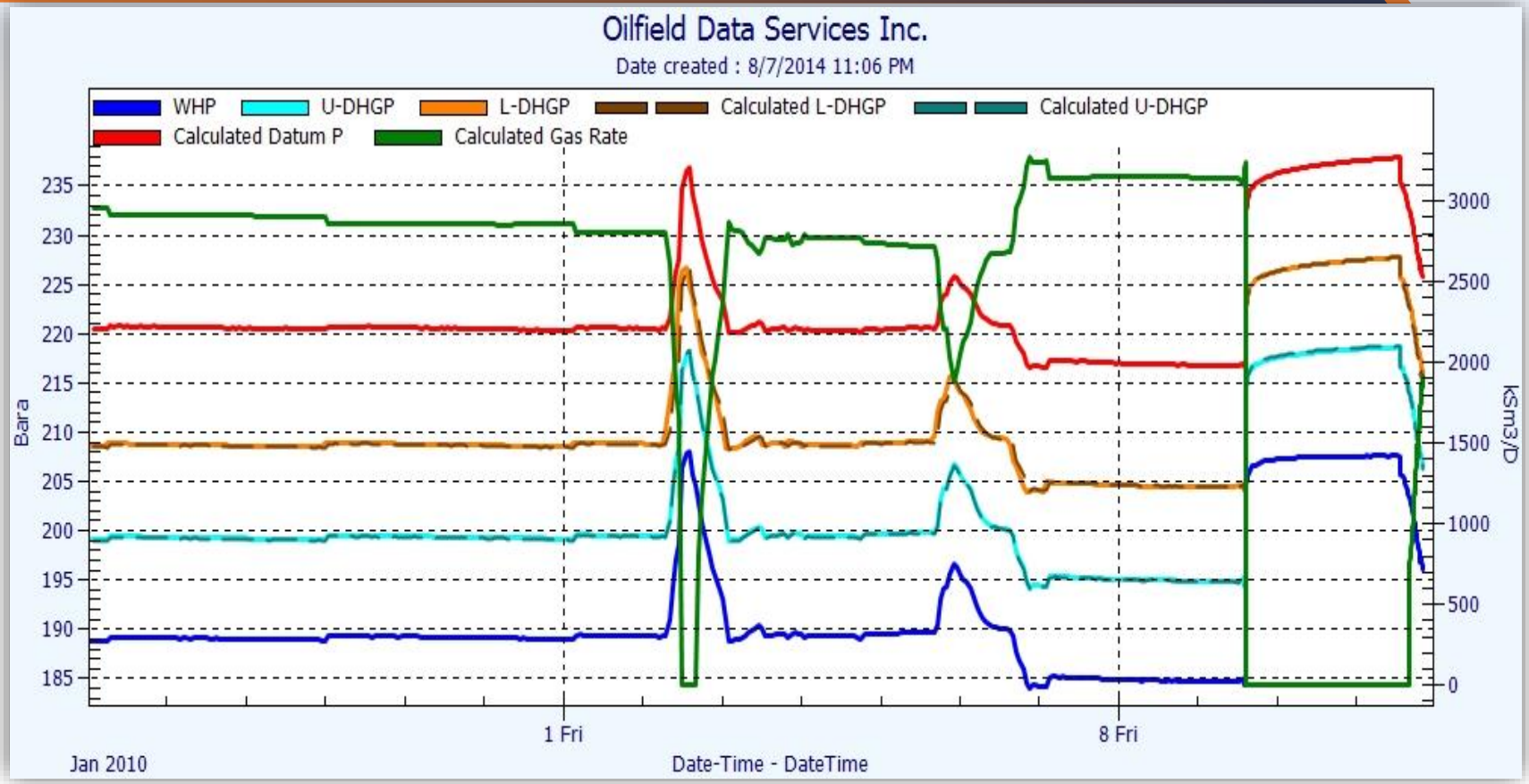
- **<u>The method can be used independently:</u>**
  - To validate allocations/MPFM accuracy
  - To determine the onset of the water production
  - PVT tuning
  - Alternative solution if flow meter fails
    - Low-cost investment
    - Does not require additional instrumentation

BHP Conversion

- BHP was calculated at the Lower & Upper downhole gauge depths to demonstrate the ability to perform accurate pressure conversions at any point along the wellbore
  - Can be used as an alternative solution if DHGP fails
  - Using tree gauge data and the calculated gas rates
- Similarly, Datum P was calculated at the mid-perforation depth

Note: All rate and wellbore calculations were based on ODSI's proprietary solution to *Bernoulli equation*

Results – BHP Conversion Overview



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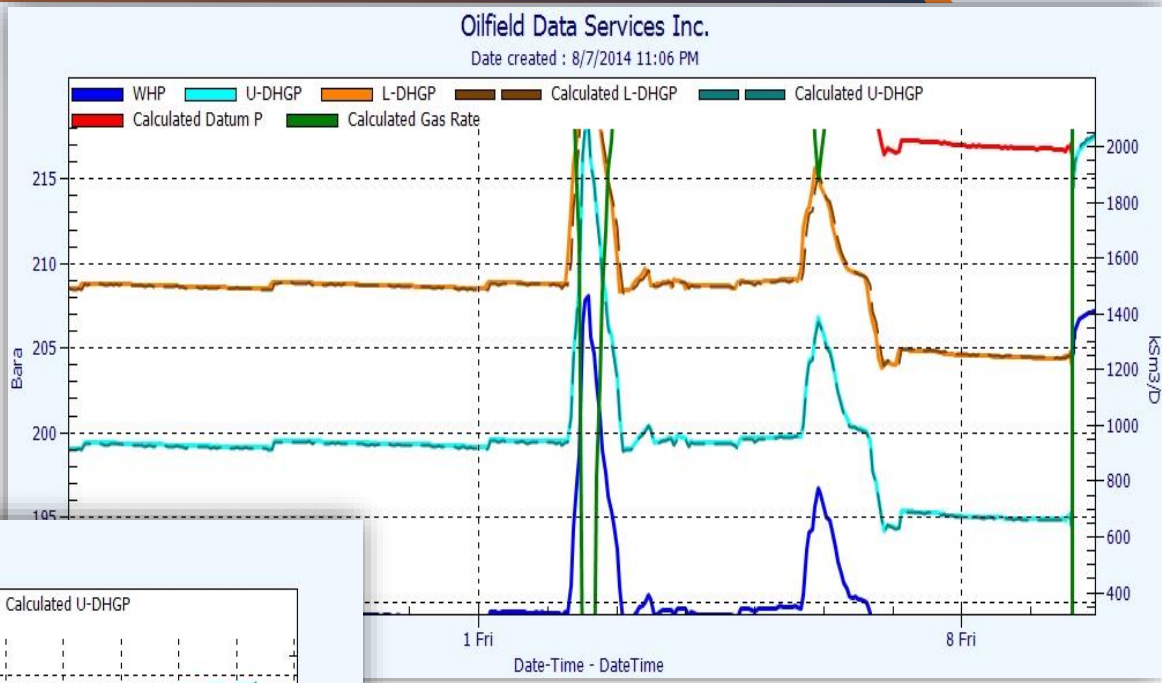
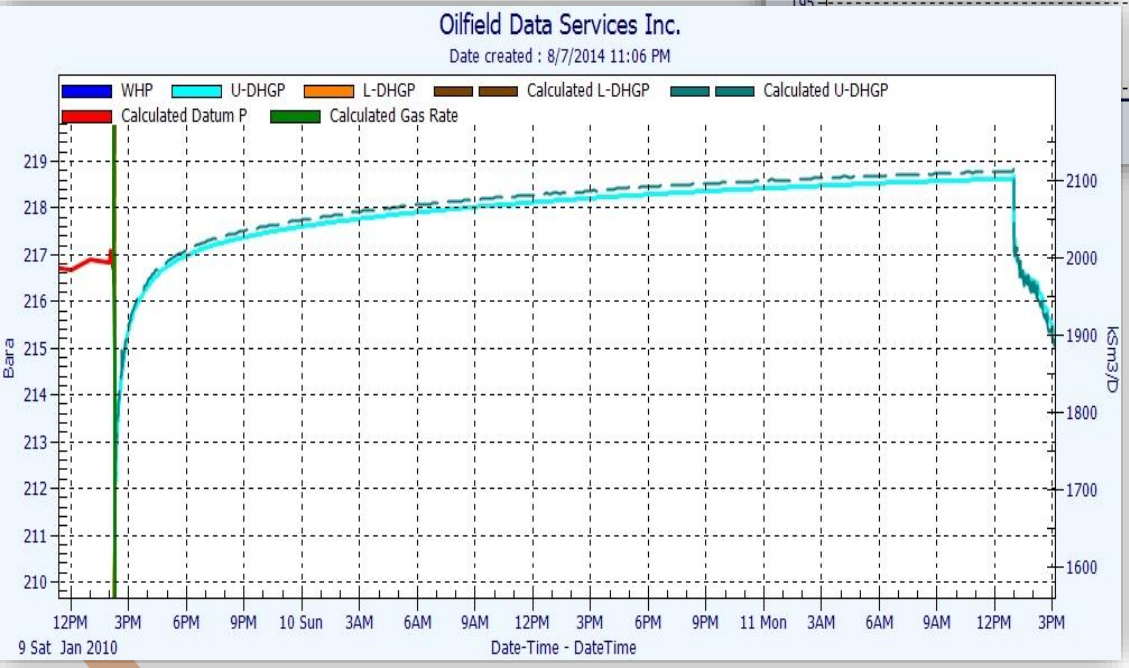
Results: BHP Conversion at Upper Downhole Gauge Depth

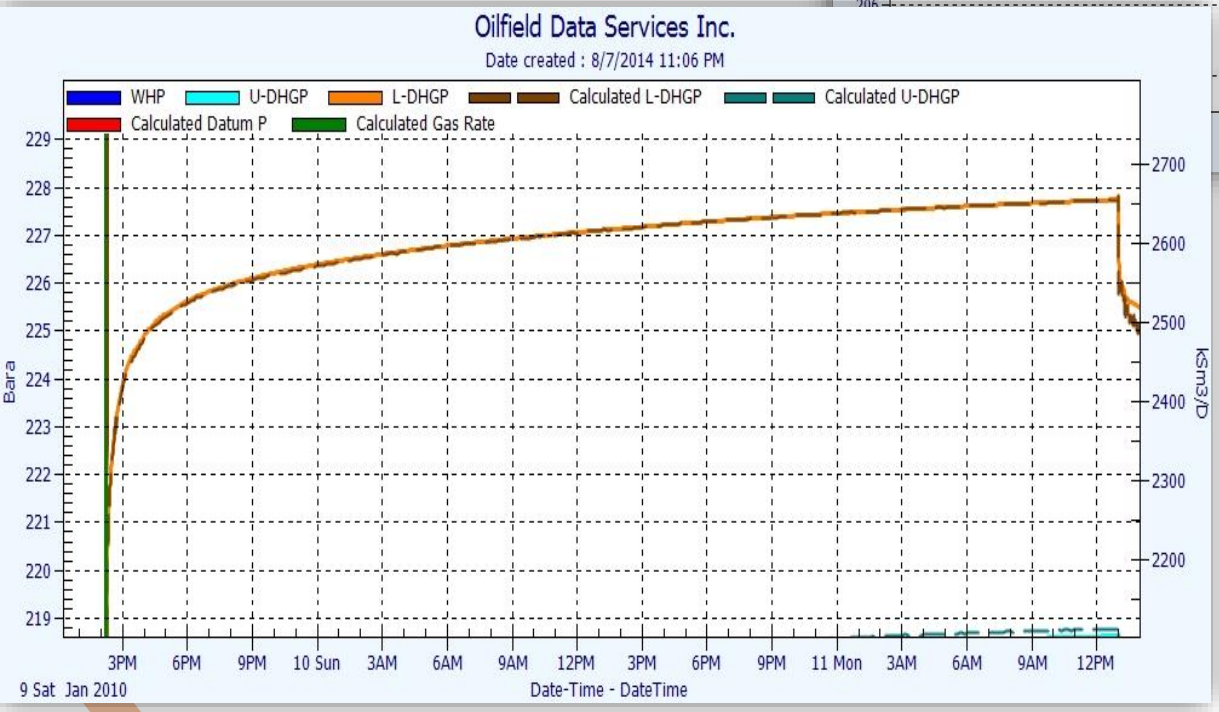
- Comparison of the measured vs calculated pressure at the Upper DHGP depth
  - **~ 0.15 bar (0.07 % error)**



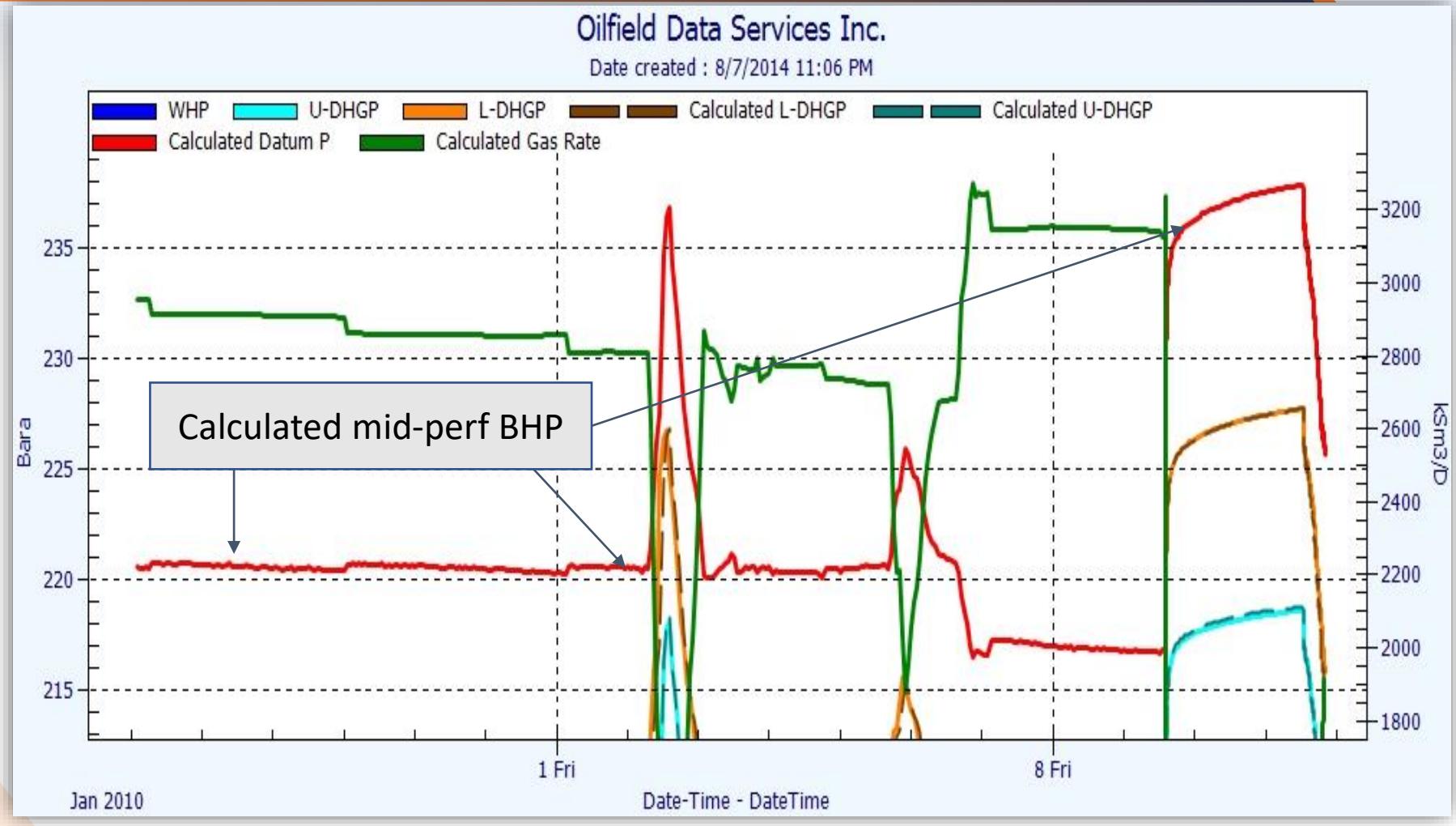


Results: BHP Conversion at Lower Downhole Gauge Depth

- Comparison of the measured vs calculated pressure at the Lower DHGP depth
  - **~ 0.02 bar (0.009 % error)**



Results: BHP at Datum (mid-perf) Depth



Datum Pressure was calculated at the mid-perforation depth

BHP Conversion Results

- Pressure was calculated at the Upper and the Lower DHGP depths to show ODSI's ability to accurately calculate pressure at any point along the wellbore
  - **Within ~ 0.07 % accuracy for the Upper – DHGP**
  - **Within ~ 0.009 % accuracy for the Lower – DHGP**
- Datum P was calculated at the mid-perforation depth

Alternative solution if no downhole gauges are present or downhole gauge fails

PTA Results

BHP Conversion Results

- The main objective was to determine if the well was a stimulation candidate
- It was thought that the well had high skin/damage
- Therefore, PTA was performed on
  - WHP
  - Upper DHGP
  - Lower DHGP
  - Datum P/mid-perf BHP

Importance of mid-completion BHP

- It is important to use a valid mid-perforation BHP for the PTA purposes

- **<u>Failure to do so leads to:</u>**
  - Overestimation of Skin
  - Overestimation of Permeability
  - Underestimation of Reservoir pressure

(Due to additional friction and fluid density changes below the gauge)

- ODSI's solution accounts for both frictional and phase-thermal changes in the wellbore

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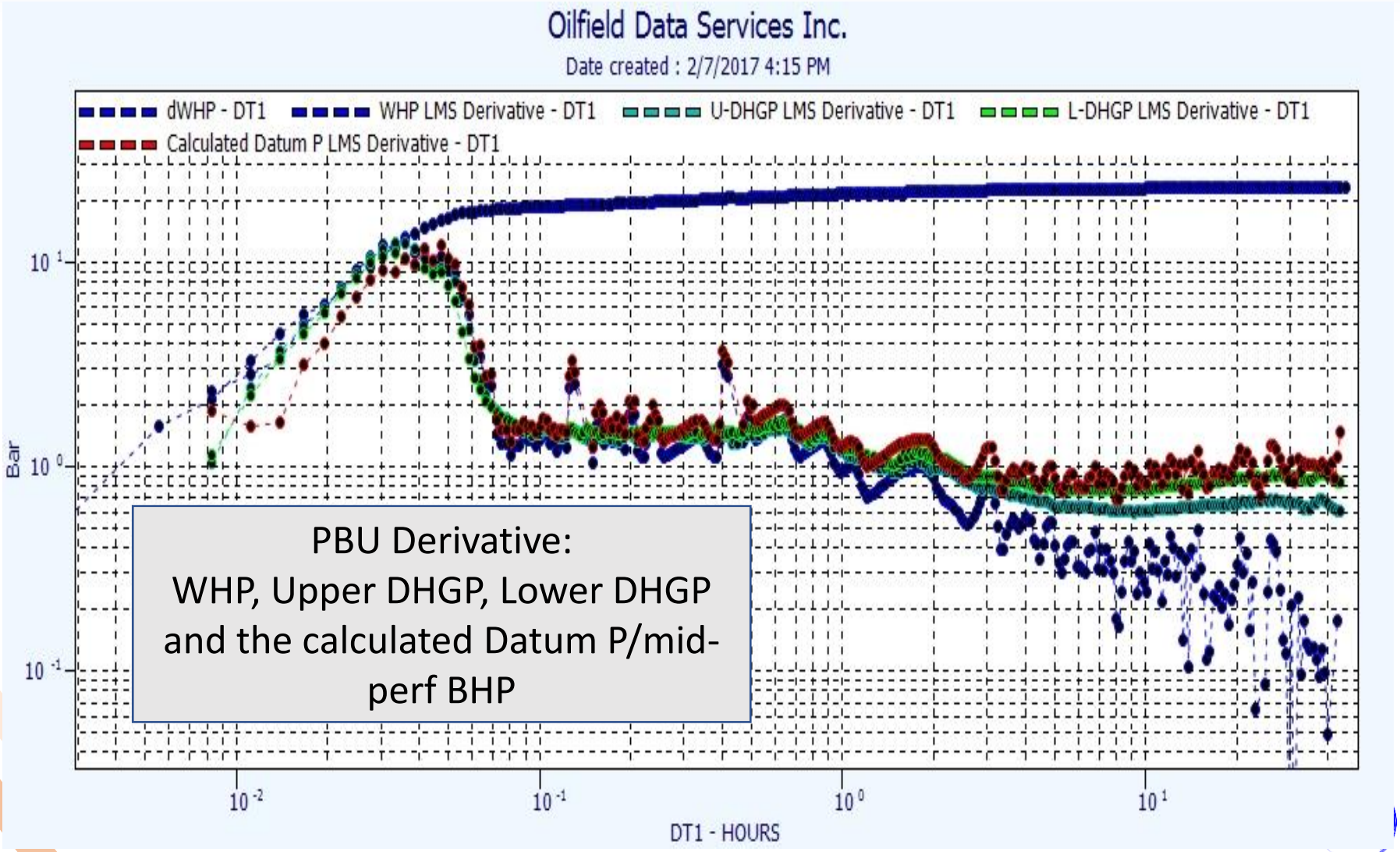
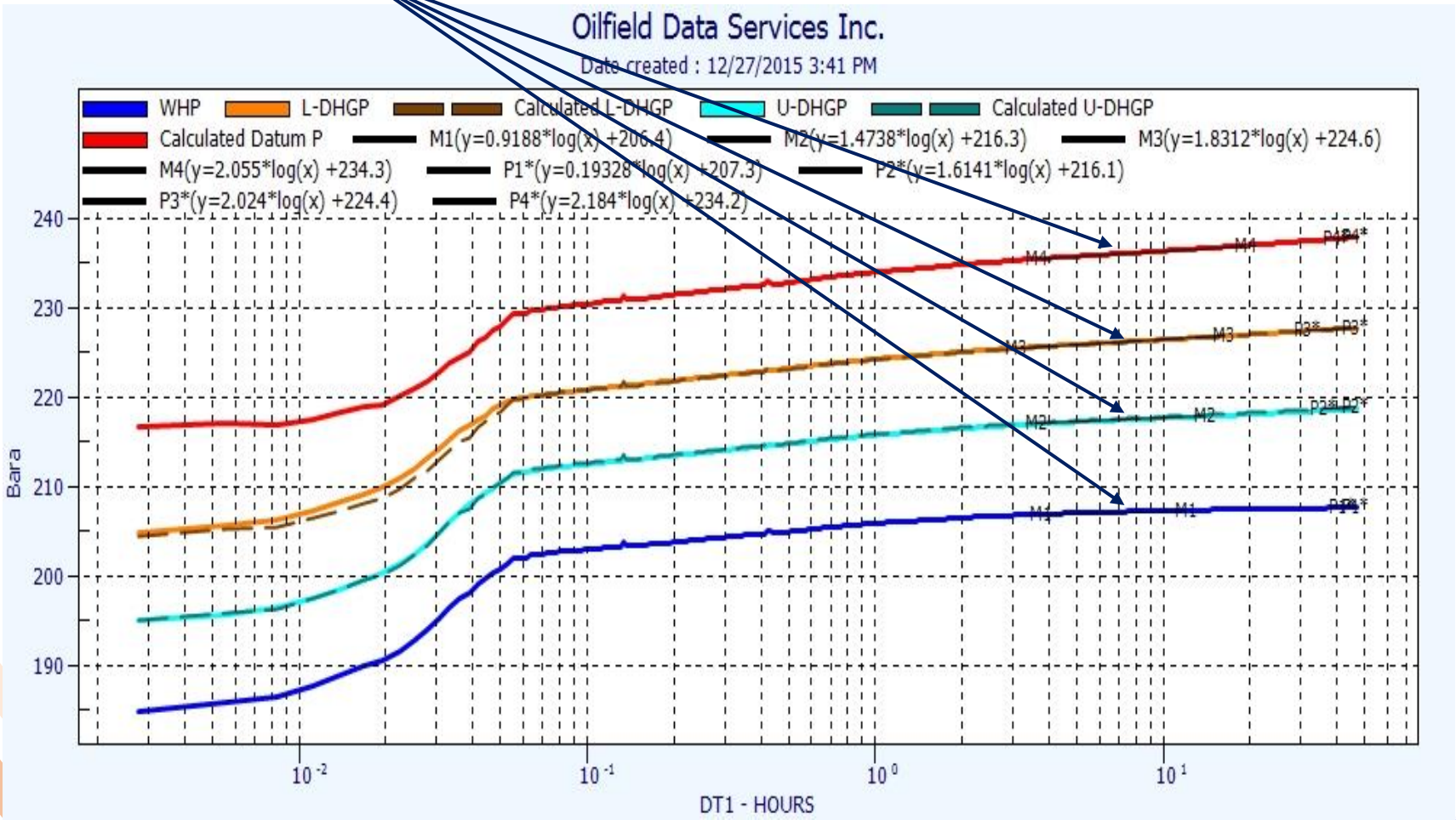
PBU – Derivative Plot



PBU Derivative:
WHP, Upper DHGP, Lower DHGP and the calculated Datum P/mid-perf BHP

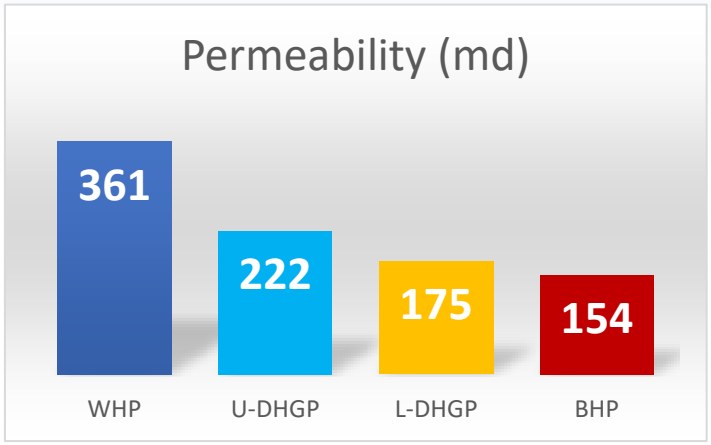
PBU – Semi-log Analysis

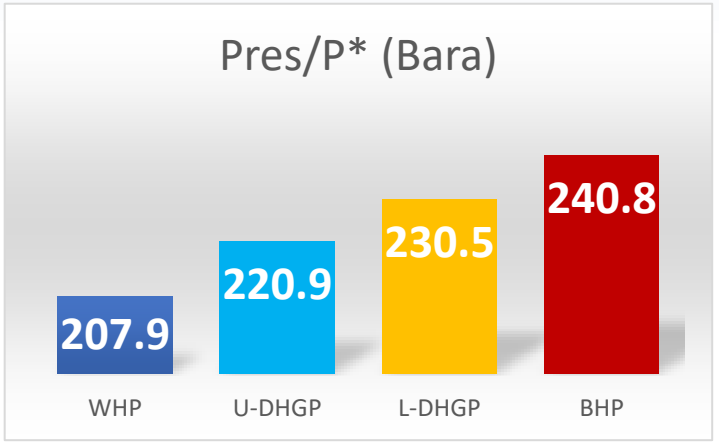
Note: The mid-time slope value differences were caused by the wellbore cooling effect during S/I

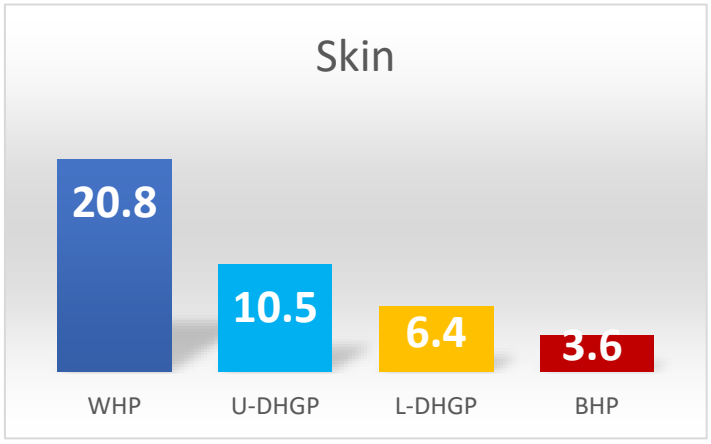


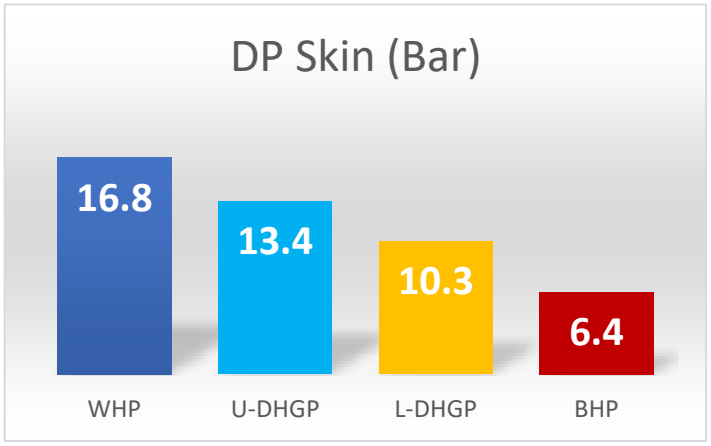
PBU Analysis Results

PTA was performed on the WHP, Upper DHGP, Lower DHGP and the Calculated mid-perf BHP









Failure to use valid BHP leads to overestimation of skin & perm and underestimation of reservoir pressure!

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PTA Summary

- When the PTA was performed on WHP, the well appeared to have a high skin/damage
- In reality, the well did not have skin
  - Low skin ~ 3.6
  - High permeability ~ 154 md

- **Stimulation of that well would not lead to an improved performance**

Well Analyzer – Rate Calculation Feature

- Accurate rate calculations
  - Matched the metered rate with less than 0.04 % error
- Metered rate validation/MPFM Calibration
- Detects errors in allocations
- Detects changes in fluid composition
- Detects onset of the water production
- Alternative and cost-effective solution if flow meter fails

Well Analyzer – BHP Calculation Feature

- ODSI was able to successfully calculate pressure at the Upper & Lower DHGP depths and match accurately the gauge response
  - Less than 0.07 % error
- Allows accurate BHP conversions from the surface data
- Alternative and cost-effective solution if downhole gauge fails