Well Analyzer

for

Producing Oil & Gas Wells

Pro-Active

Automated Real-Time Surveillance (ARTS)

Well/Reservoir Evaluation Software Package

- ✓ Oil & Gas Reservoir Testing and Evaluation
- ✓ Real-Time Pressure Transient Analysis
- ✓ Hydrocarbon Volume Determination
- ✓ Well(s) Performance Tracking
- ✓ Multiphase Rate & BHP Calculations
- ✓ Optimize Gas Lift / Oil Production Rates
- ✓ Life Of Well Surveillance/Analysis
- ✓ Automated PVT Calibration

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The Well Analyzer ARTS Concept:

Experienced Surveillance Engineers

+

Automation

Spend your time thinking about what the results mean, not digging for data!

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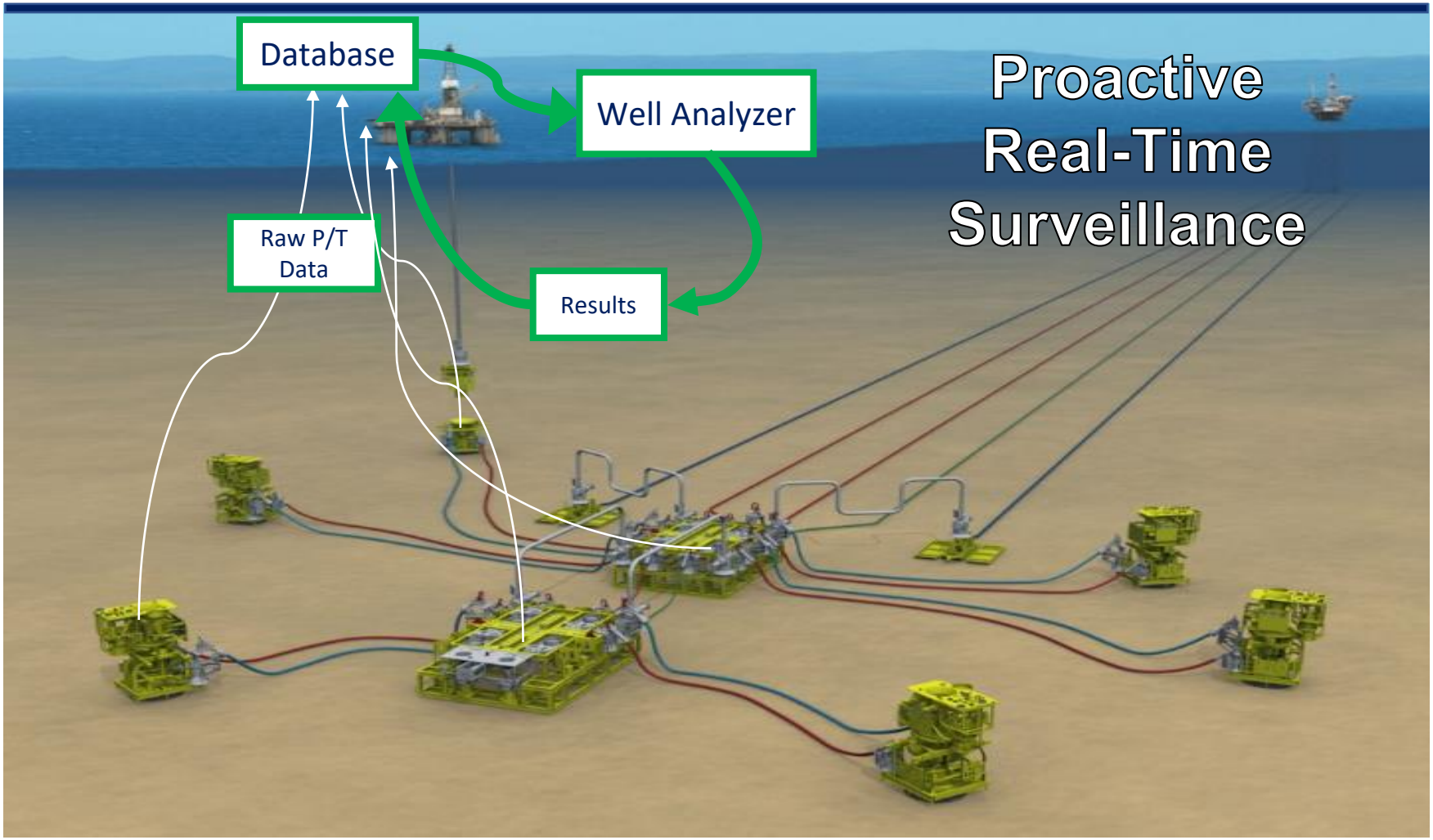
The Well Analyzer ARTS Solution

Presentation Outline

1. ODSI's Well Analyzer Introduction & Setup
2. ODSI's Well Analyzer Features
3. ODSI's Well Analyzer Wellbore Solution
4. ODSI's Automated Pressure Transient Analysis
5. ODSI's Time-Lapse PTA Results (Skin, Permeability, …)
6. ODSI's Horizontal Well Evaluation
7. ODSI's Case Study
8. ODSI's Well Analyzer Benefits Summary

Well Analyzer ARTS – Introduction



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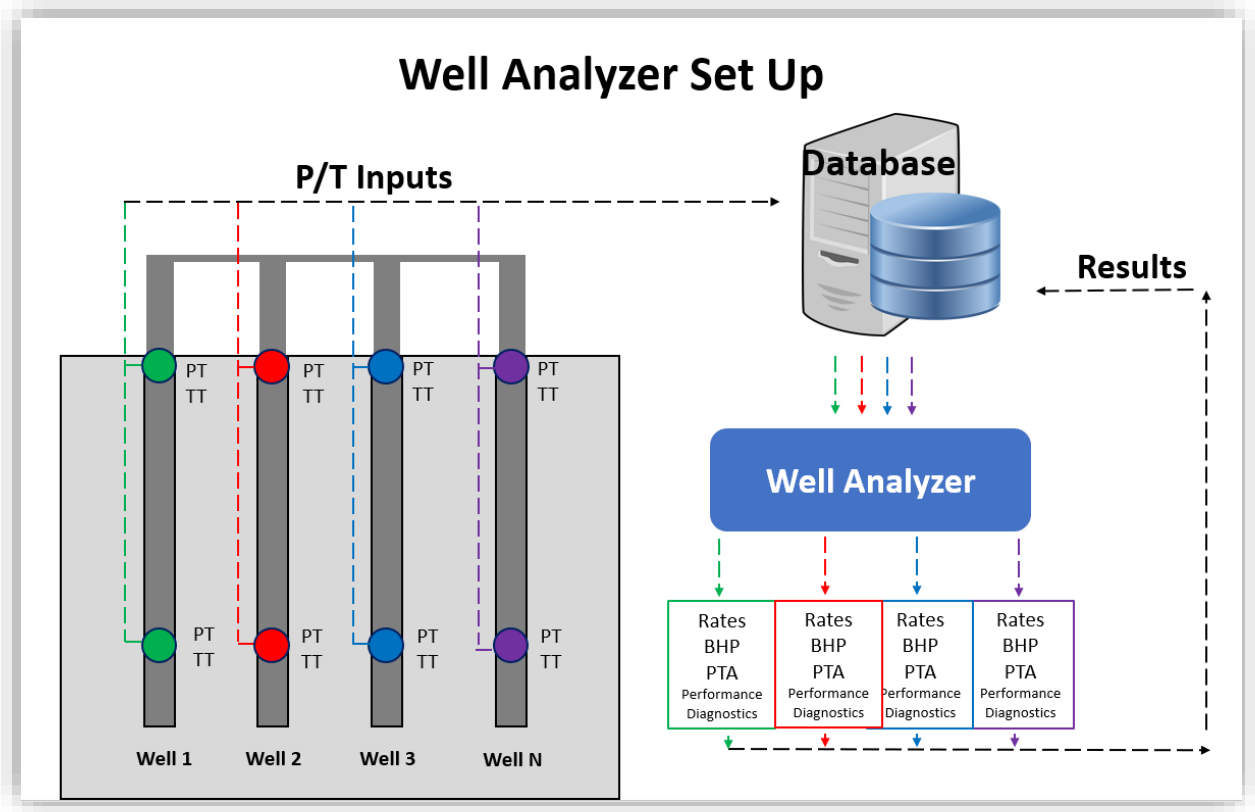
Well Analyzer - Real-Time Set Up

Well Analyzer works both in Real-Time and on Historic data

It polls the required data tags from the client's database/historian, performs the calculations, validates the results and writes them back to the database



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About Well Analyzer (Wellbore Model)

The only existing software based on a direct numerical solution to the Mechanical Energy Balance (MEB) equation

- Does not rely on vertical lift correlations and, hence, it provides more accurate and reliable results (or fails when the well is loading)

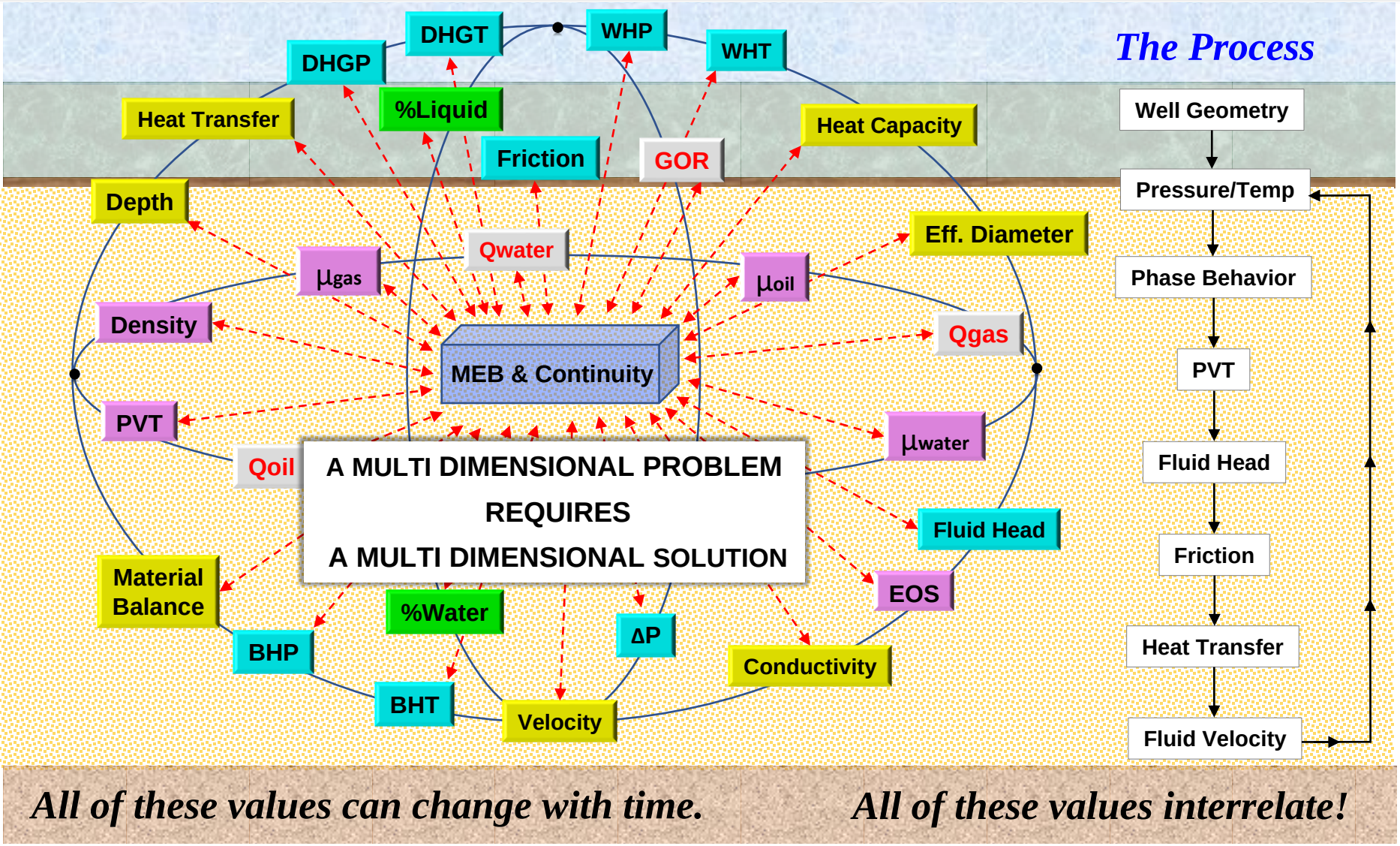
The wellbore model

- Accounts for dynamic temperature behavior
- Adjusts the fluid properties/PVT accordingly
- Performs wellbore flash calculations (See Case Study 1) to determine the composition of the fluid in the wellbore

The wellbore flash calculations can be used to determine the water cut for oil wells and the condensate/water yield for gas wells

- Our accuracy on the flash calculations is normally within 2 BBL/MMcf for gas wells and within 2% for water cuts (percent relative to total well volume)

ODSI's Wellbore Solution, a Brief Overview



All of these values can change with time.

All of these values interrelate!

Well Analyzer Real-Time Features

- Automated Rate Calculations and PVT Adjustments
- Conversion to BHP/Datum Depth
- Automated Pressure Transient Interpretation of Build-ups (PBUs) and Drawdowns (DDs)
- Static MBAL
- Flowing MBAL
- Conventional Decline
- TTA Decline (Thermodynamic Transient Analysis)
- Time-Lapse Skin, Perm, Mobility-Thickness, P* and P.I. or I.I.

ODSI's Workflow

- Build Well Model (Flow Path, Petrophysics, PVT)
- Tune Well Model with Dynamic Data
- Begin Running Auto-Analysis Features as soon as they are valid
  - Rate Calcs, BHPs, Auto-PTA, Static MBAL, Decline Analysis, etc.
- Determine Initial Condition of the Well/Reservoir
  - PTA Parameters, KPIs, Well Potential
  - Location (Time & Distance) and Types of Reservoir Boundaries (OWC)
  - Work with Subsurface Team to fine tune reservoir size/drainage volume
- Use Decline Analysis to Determine Drive Mechanism components and how they may be changing with time
- How are things changing? What does it mean?

General Issues with Horizontal Well Evaluation

How much of the lateral is open to flow

Where along the lateral is the flow coming into the well?

How 'standard' is the flow regime response

- First Radial
- Horizontal Radial
- Second Radial (Circular or Ellipsoidal?)
- Boundary Dominated Radial Flow
- Linear/Channel Flow
- PSS/SS Flow
- Response to Injection

Is there a way to evaluate the well performance with short-term data?

Case Study 1
Gulf of Mexico – Wet Gas Well

- ✓ Oil & Gas Reservoir Testing and Evaluation
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Case Study 1: Background

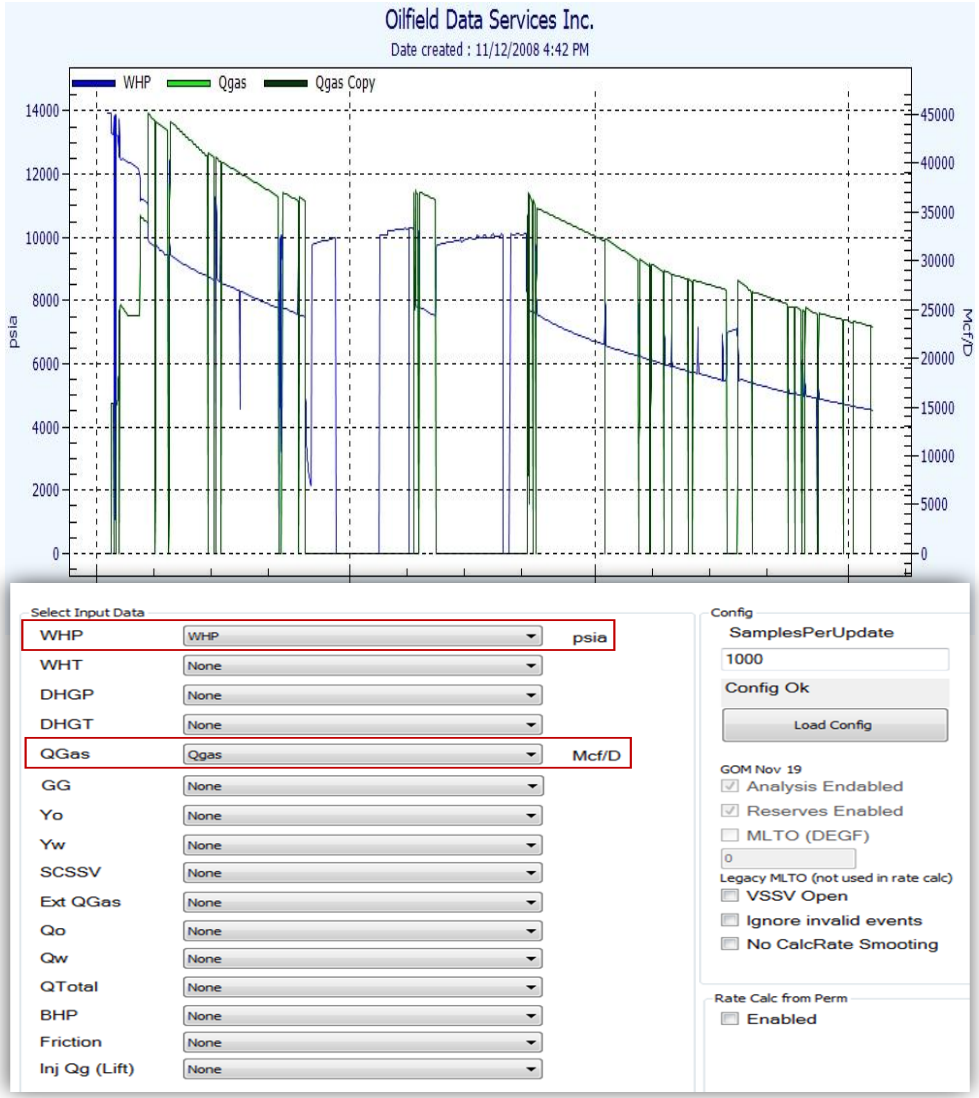
- Gulf of Mexico
- Wet Gas Well (~ 15 BBL/MMcf)
  - Well head gauge
  - Rates were continuously measured at a dedicated test separator (1-well platform)

Objective:

- Validate/model separator rates
- BHP conversion from the WHP data
- Demonstrate auto-PTA
- Determine the Producible Gas Volumes

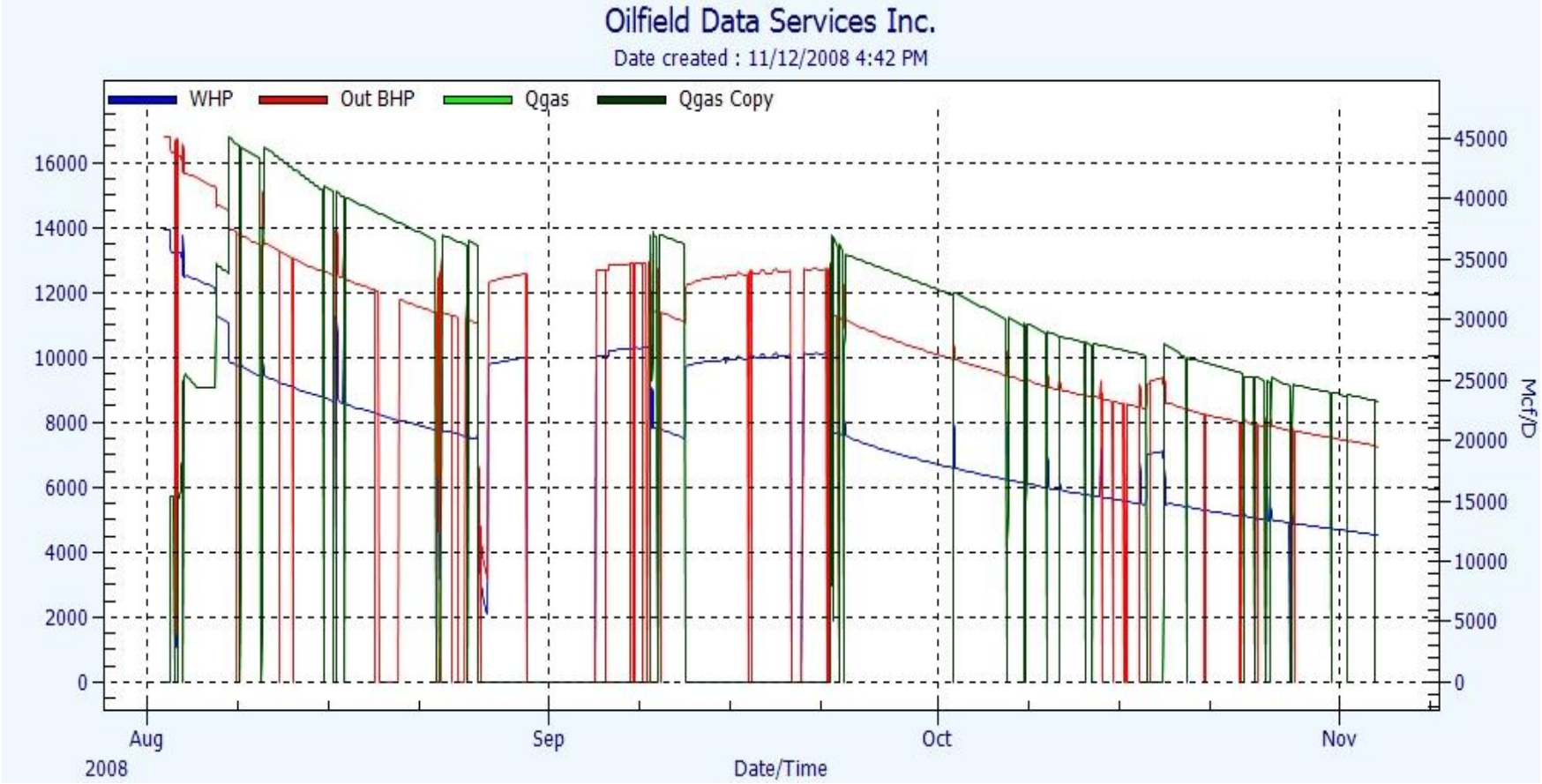
Case Study 1: System's Inputs

- The following inputs were used:
  - Tree gauge pressure
  - Occasionally measured gas rates from a test separator
- To calculate the following:
  - BHP at the mid-completion depth
  - Auto-PTA
  - Evaluate the In-place, hydraulically connected and mobile reservoir volumes



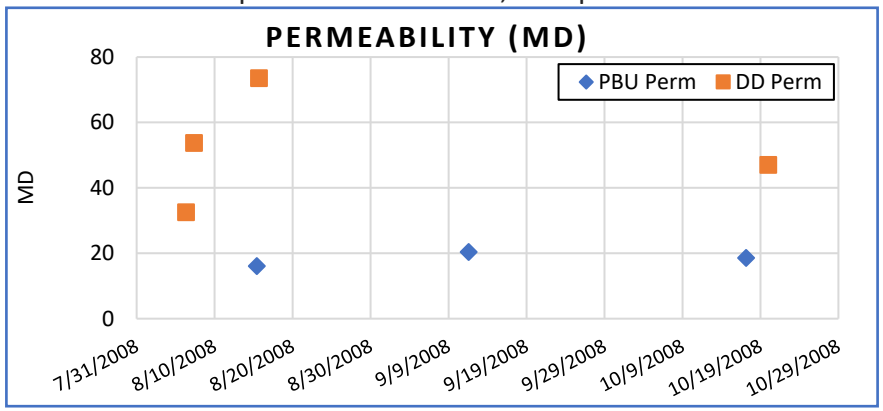
Case Study 1: BHP Results

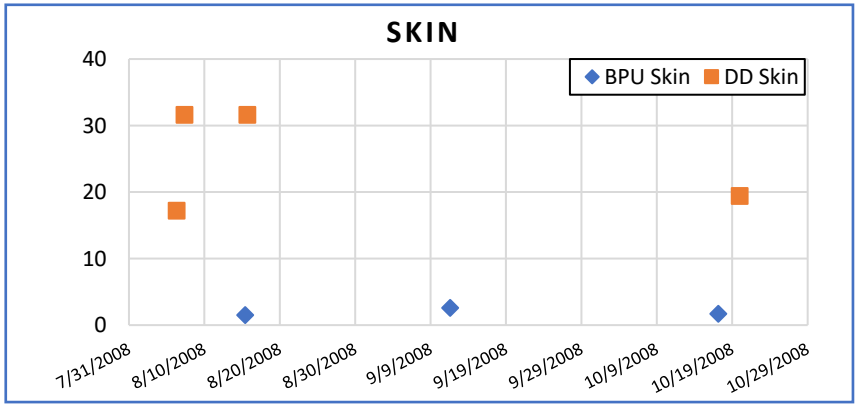
BHP conversion was performed at the mid-completion depth using the surface pressure and the measured gas rate

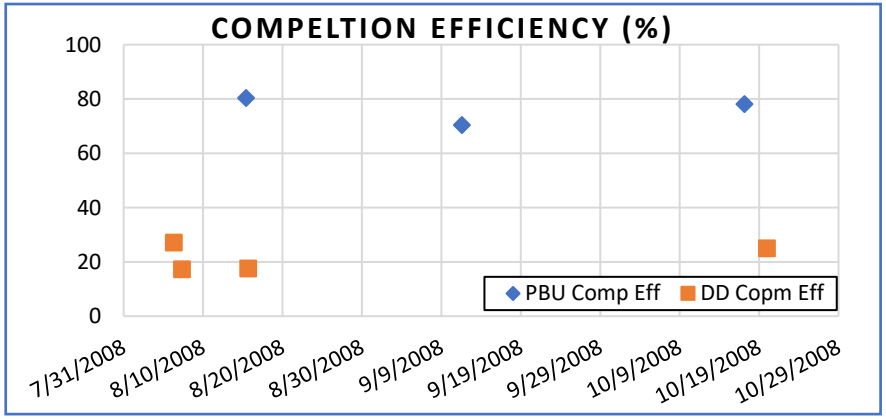


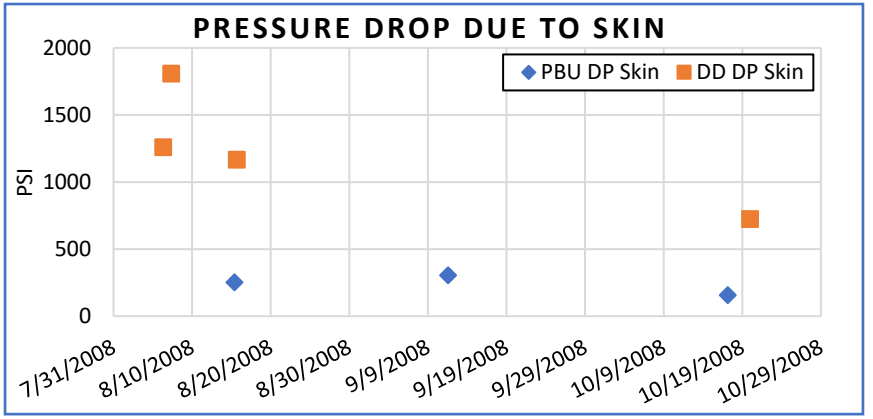
Case Study 1: Auto PTA Results

- Well was producing from 2 different zones; PBU was seeing a lot of cross-flow, but was consistent; DD was seeing a high-perm zone for the most part, but was variable
  - High permeability zone ~ 50 mD
  - Low perm zone ~ 10 mD ; PBU perm 15 - 20 mD









Case Study 1: Auto PTA Report Example

Below are screenshots of an automatically generated buildup report

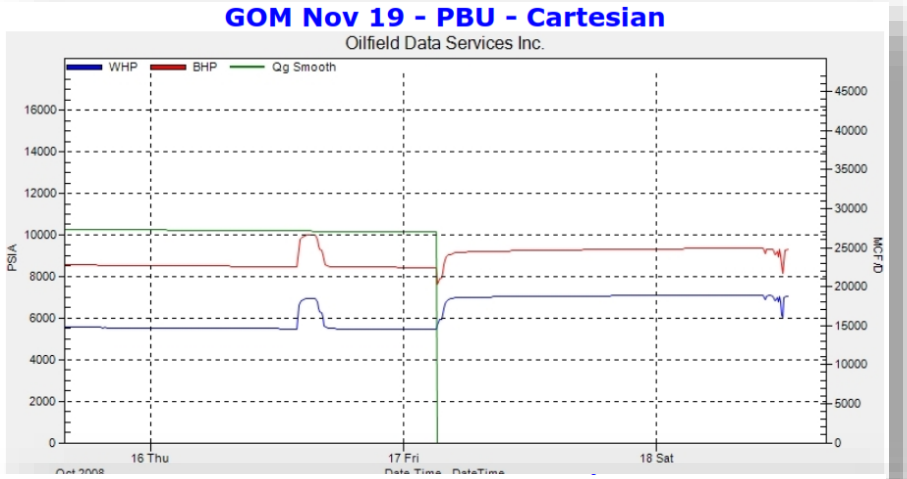
Report Link

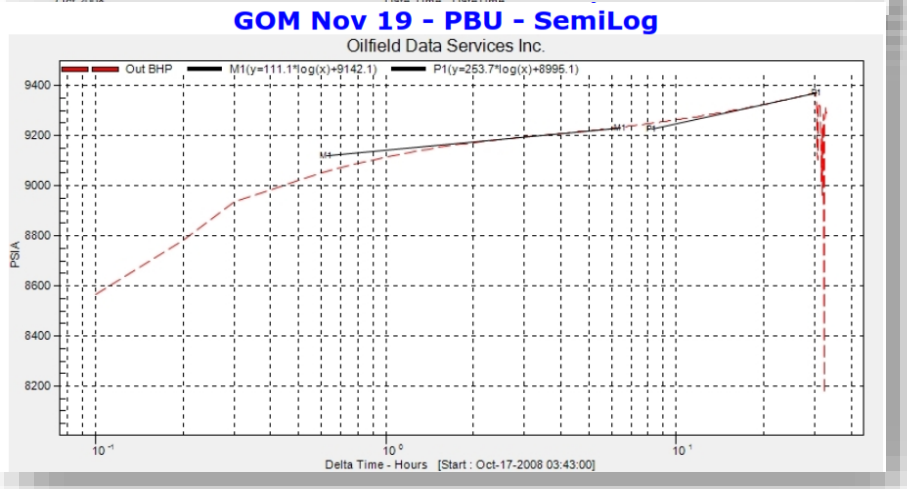
ANALYSIS RESULTS

PBU
Oct/17 - 18/2008

Calculated Reservoir & Completion Properties

SKIN	1.7	
PRESSURE DROP DUE TO SKIN	158	PSI
COMPLETION EFFICIENCY	78	%
PERMEABILITY	19	md
RADIAL FLOW PI	37.5	MCF/PSI
SKINLESS RADIAL FLOW PI	48.0	MCF/PSI
PERMEABILITY THICKNESS	817	md-ft
MOBILITY THICKNESS	23,740	md-ft/cp

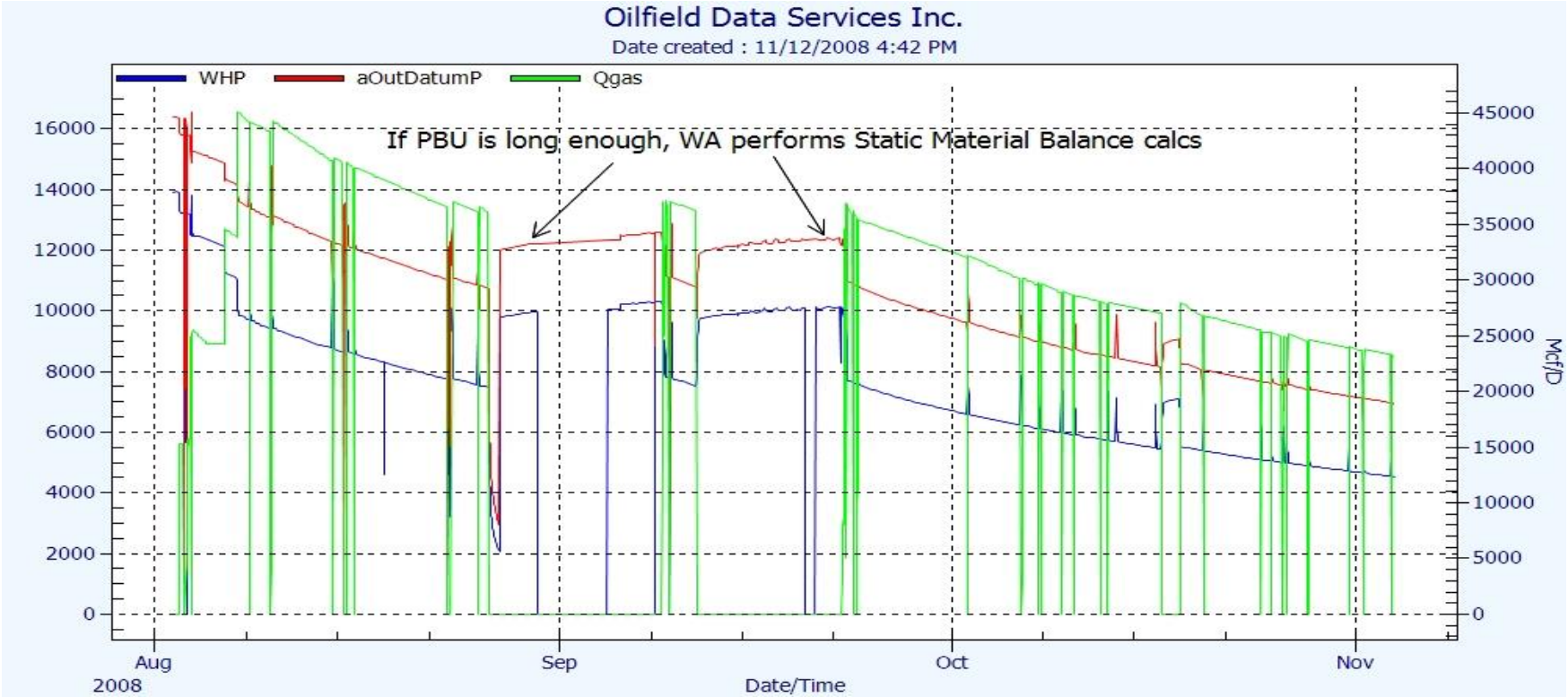




Case Study 1: Reservoir Volume

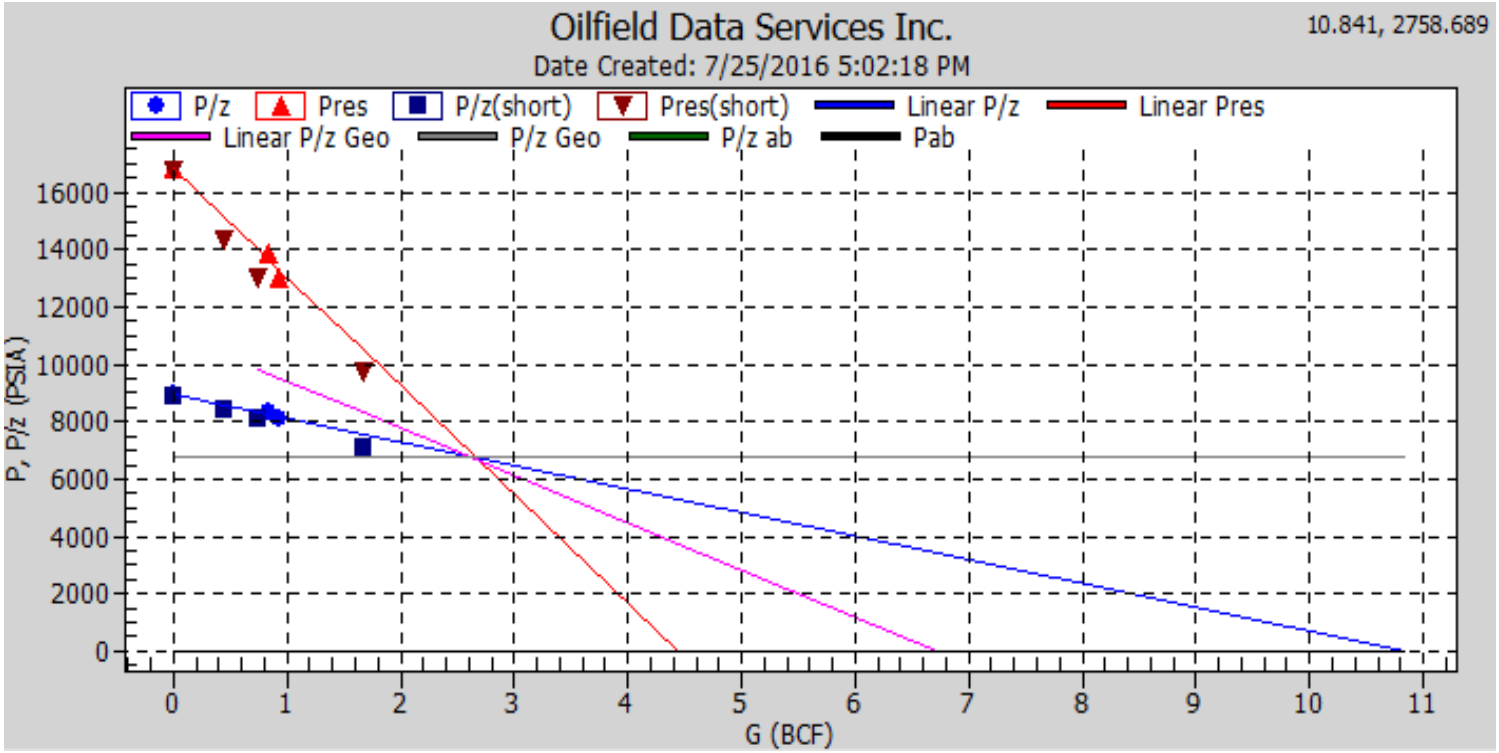
Static Material Balance (P/z plots)

- If a buildup test is sufficiently long to provide a valid P^*/P_{res}, WA is going to perform Static Material Balance calculations for the total in-place volume
- The MBAL results/plots are part of the PTA (buildup) reports



Case Study 1: Reservoir Volume

Static Material Balance (P/z plots)



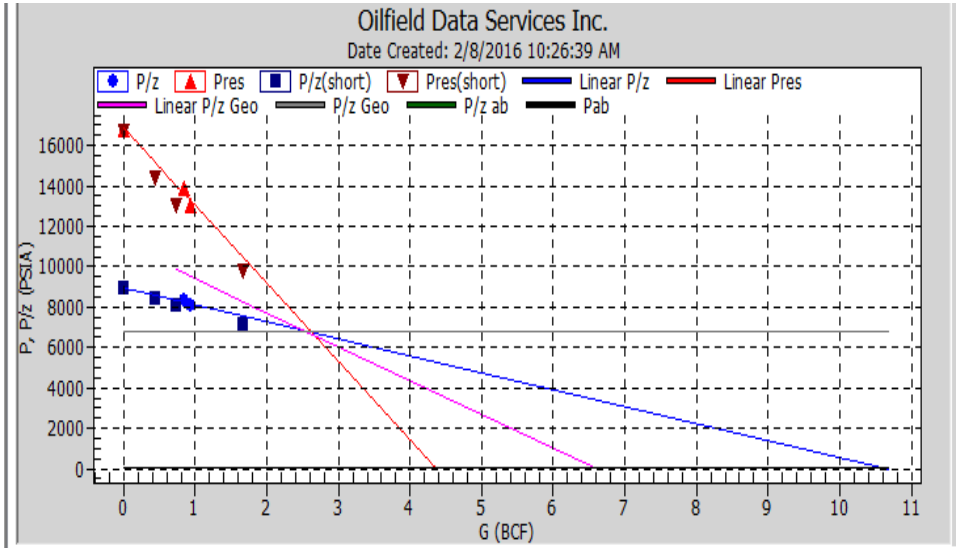
WA keeps track produced HC volumes and every time there is shut-in long enough to have a valid P*/Pres, WA performs auto Static MBAL (P/z) calculations:

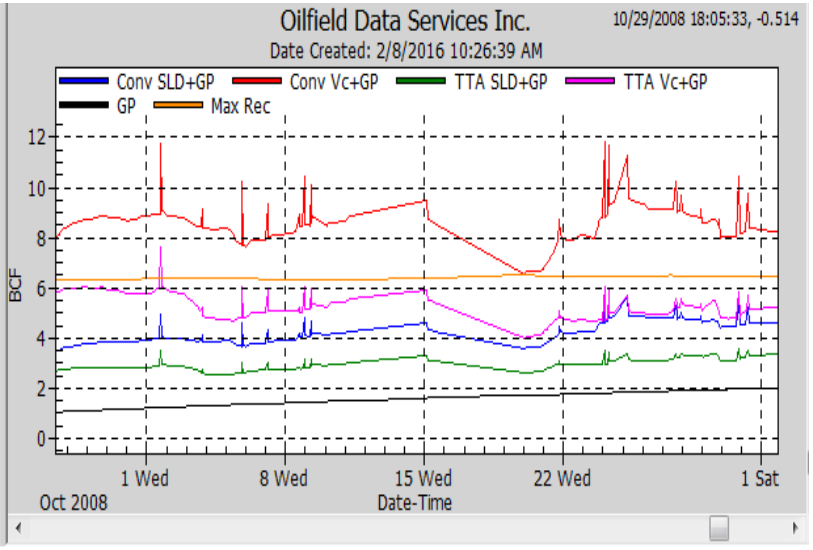
- The min total in-place HC volume ~ **4.5 BCF** (assuming infinite water drive)
- The max total in-place HC volume ~ **10.5 BCF** (assuming expansion drive)

Case Study 1: Flowing Material Balance & Decline Analysis

- Well analyzer tracks apparent HC volumes and a well's performance/productivity with time
- It analyzes the data for PSS flow periods and performs Flowing Material Balances to evaluate:
  - Hydraulically Connected HC Volume
  - Mobile HC Volume
  - Likely Producible Hydrocarbons
- It is also possible to split the apparent Energy in to it's constituent components (Oil, Gas, Water & Rock Compaction)

Case Study 1: Reservoir Volumes – Apparent Volume Splits





WA 'splits' the total in-place volume into <u>what reservoir is made of</u>:

- Total in-place volume ~ **<u>10.5 BCF</u>**
- Hydraulically Connected Volume ~ **<u>9 BCF</u>**
- Mobile (producible) Volume ~ **<u>5.5 BCF</u>**
- Water (dead-leg) ~ **<u>3 BCF</u>** (equivalent)
- Rock Compaction ~ **<u>1 BCF</u>** (equivalent)
- Tight gas ~ **<u>1 BCF</u>**

Case Study 1: Summary

- BHP conversion was performed using the surface data
  - Useful for wells without DHGP or in case DHGP fails
- PTA and Reservoir Volume calculations were performed then
  - Static MBAL calcs for long PBU's with valid P*/Pres
- WA is the only software package that is able to split the in-place volume into what is the connected, mobile HC evaluate EUR
  - Locks into solution from first months of production data

If you know how much 'money' you have left in the ground and how much is going to be produced – You Make Better Decisions!

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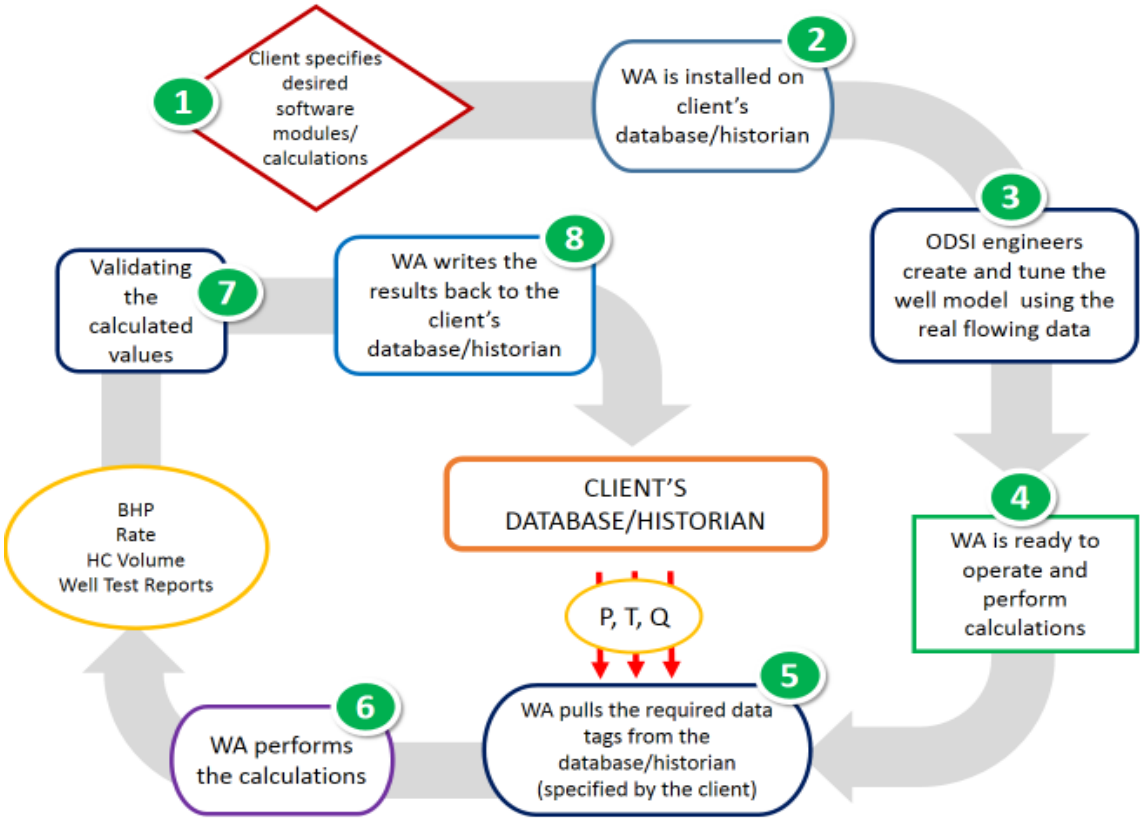

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Well Analyzer Real-Time Features

- Virtual metering
  - More accurate than MPFM for 3-phase flow
  - Metered rate validation
  - Detects errors in allocation/meter calibration
  - Backup if MPFM fails
- BHP conversion
  - From the surface data
  - Can replace downhole pressure gauge if it fails
- Automated Pressure Transient Interpretation of buildups and drawdowns
  - Skin
  - Permeability
  - Avg.Pres/P*
  - Productivity (PI)
- Continuous HC volumes and Mobile HC updates
  - Static and Flowing Material Balance calculations

Well Analyzer Benefits - Summary

- Reduce Planned Downtime
- Analyze ALL of the data, not just the data you have time to look at
- Optimize Production at Every Opportunity
- Understand how much Money you have left in the ground
- Train Your Team in Proactive Surveillance
- Spend Your Time Thinking about What to Do to Make More Money!