Automated Real-Time Reservoir and Production Engineering Analysis and Surveillance

February 2024

Questions & Outline

Potential Areas of Interest for you:

1. Do you want to Improve your Production?
2. Do you want to Know your EUR?
3. Do you want Real Solutions, not just Models?

Summarized in this introductory presentation:

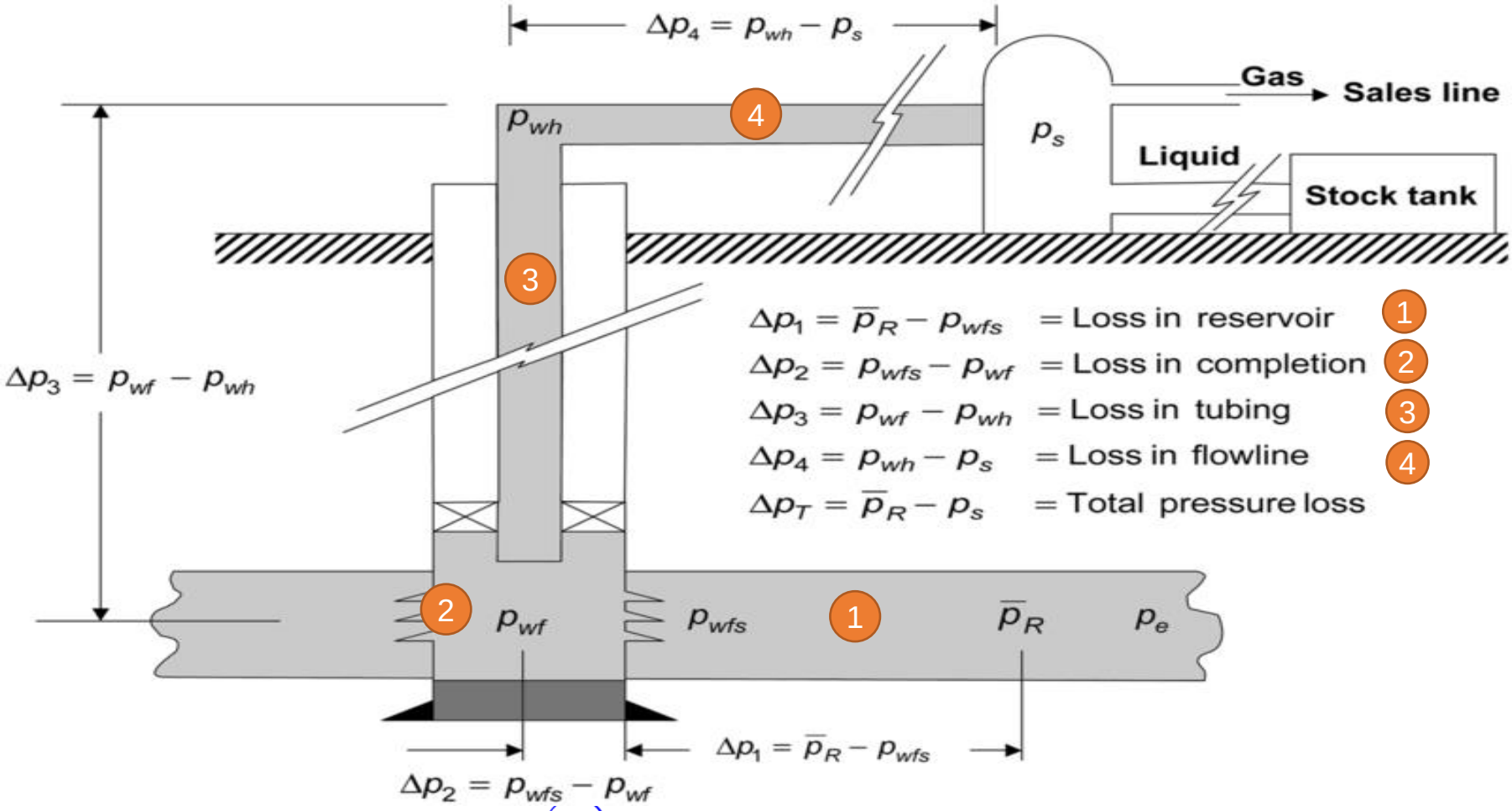
- ODSI's Complete Wellbore Solution
- Dashboard: Time-Lapse PTA Graphs
- Well Spare Capacity Spreadsheet
- Well/Reservoir Threat Array

ODSI Automated & Manual Deliverables

- **AutoPTA (Buildups and Drawdowns) Analysis & Reporting**
  - Skin
  - Permeability
  - Productivity Index
  - Pressure drop due to skin
  - Completion Efficiency
  - Reservoir pressure
- **Virtual Metering/Multiphase Rates**
  - Oil, Water and Gas (Producers & Injectors)
  - MPFM calibration
  - Backup if MPFM fails
  - Flow Regime Recognition and Gas Lift Optimization
- **PVT Tuning & Calibration (including automatically detecting changes in PVT)**
  - Gas Wells: Gas Composition/Gravity, Oil Yield, Water Yield
  - Oil Wells: Oil Density, Water Cut & GOR
- **BHP Conversion (at Datum/mid-completion depth)**
- Observed **Apparent HC Volumes** and how they change with time:
  - In-place (Static MBAL, Boundary Volumetric)
  - Hydraulically Connected (Decline)
  - Mobile Volume (TTA Decline)
- Distances to boundaries/**Blind Reservoir Mapping (Manual)**
- **Performance and Production Optimization Strategies (Manual)**

Which Parts of the System Can You Evaluate?

Find the pressure drop that shouldn't be there (and get rid of it)!



ODSI's Wellbore Model

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

- Does not rely on vertical lift correlations and provides **more reliable results** for single-phase or multi-phase flow (with and without gas lift)

The wellbore model

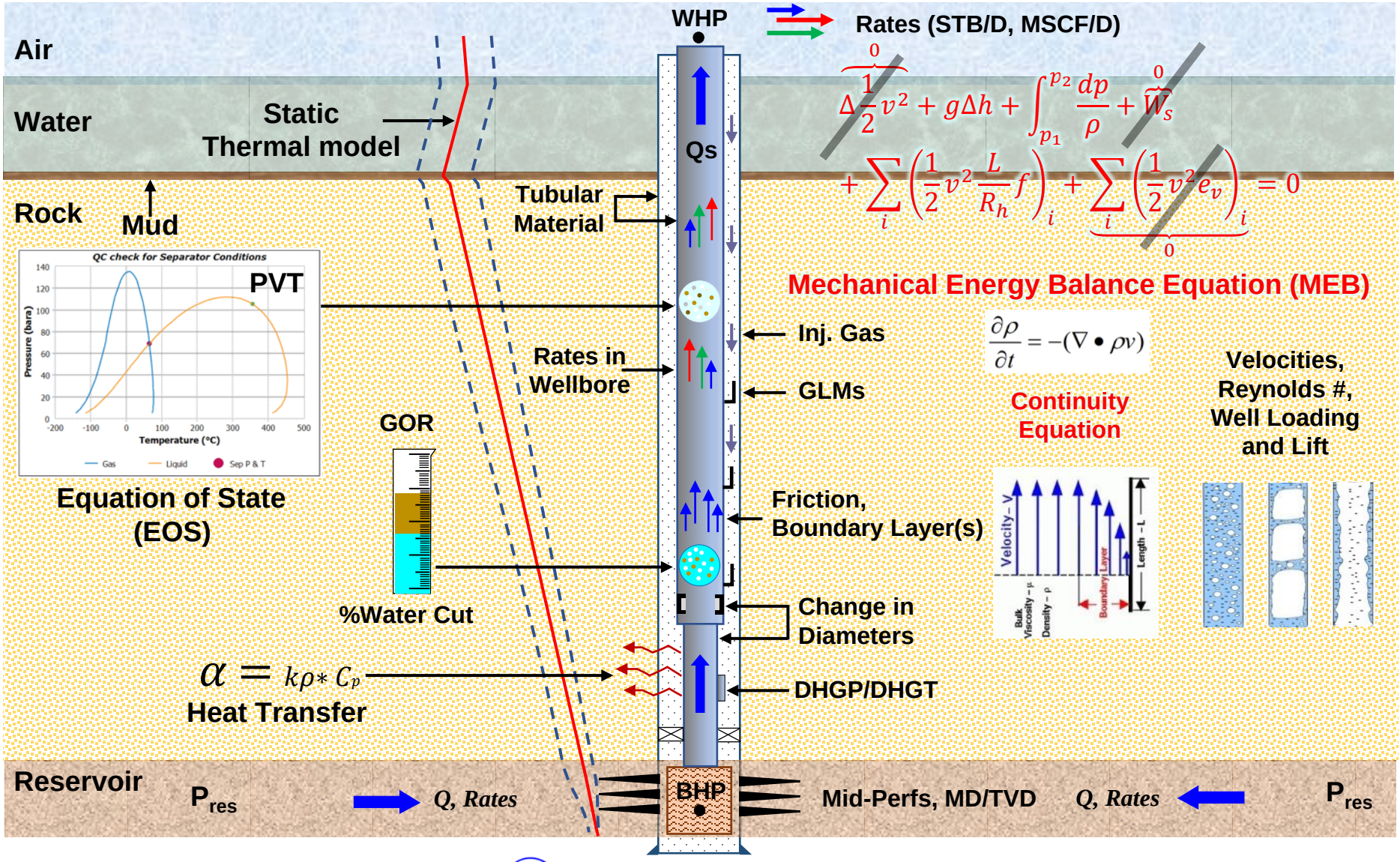
- Performs wellbore flash calculations to determine the composition of the fluid in the well bore during build-ups & Adjusts the fluid properties accordingly
- Accounts for dynamic temperature and phase behavior (coupled)
- Recognizes the wellbore flow regime & whether the well is lifting efficiently
- Automatic Gas Lift Optimization

ODSI Deliverables

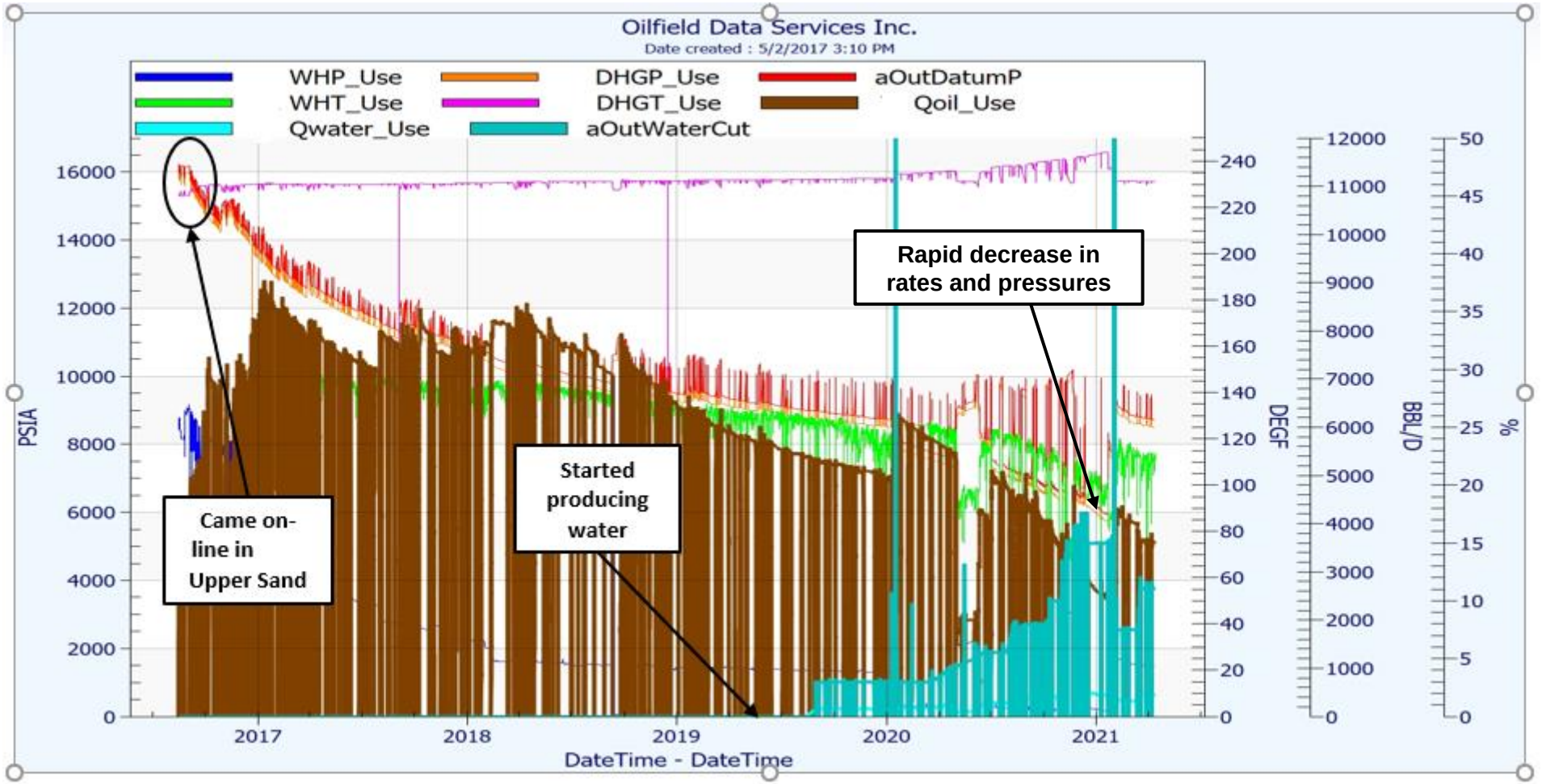
Accurate PVT (with automated Tuning)
Accurate Production Rates
Accurate Datum/Mid-completion BHP
Automatic Pressure Transient Analysis
Automatic Static MBAL
Automatic Decline Analysis

Accurate PTA (Skin, Permeability, Productivity, Reservoir Pressure)
Accurate Volumes: In-place, Hydraulically Connected and Mobile
Current EUR Evaluation and Strategies to Maximize EUR
Distance to and Type (Strat, Fault, Water Contact) of Boundaries
Current well's performance and strategies to optimize production
Field Development Strategies

ODSI's Complete Wellbore Solution



Time-Lapse Auto PTA – Production History



PTA Dashboard – Accreting Skin Example

Compaction

Significant & Unexpected Decrease in Perm Asphaltenes?

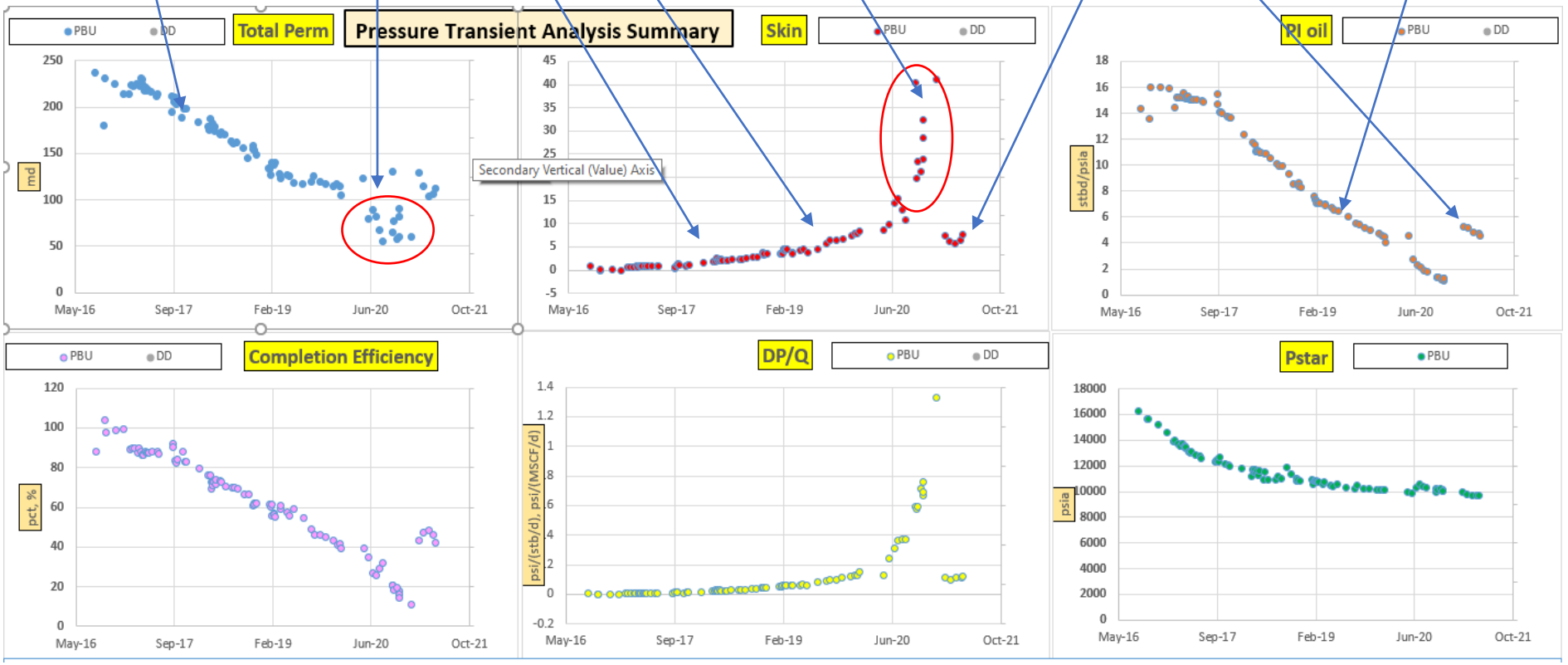
Scale & Fines

Fines (skin)

Significant Skin Increase – Need to Plan for Xylene Treatment

Post-stim job – Back to Normal (Still dealing with compaction)

PI Reduction due to compaction and skin accretion (fines)

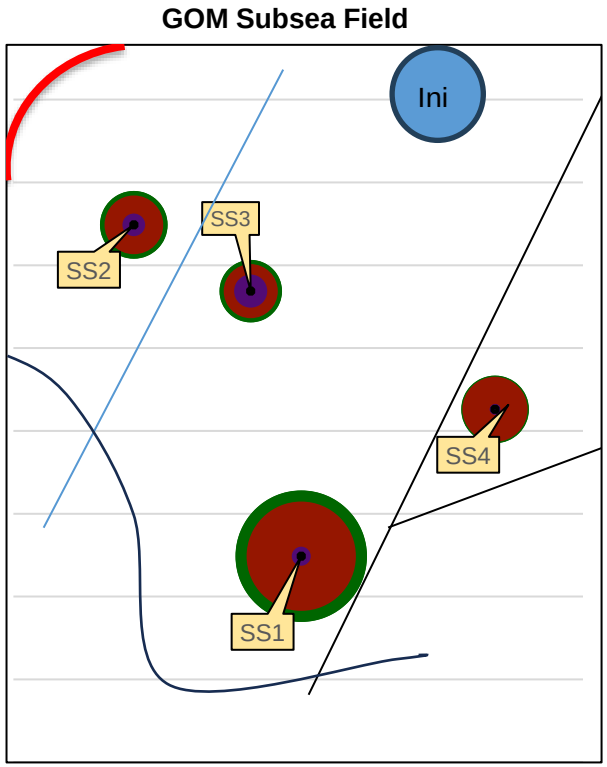


Spare Capacity Spreadsheet

Operator Spare Capacity Table											
Well	ODSI Current Rate (Oil) [stb/d]	ODSI Current WC [%]	Operator Current WC (%)	Operator DPR Oil [stb/d]	ODSI-Operator ΔOil [stb/d]	Excess Capacity (Oil) [stb/d]	FDHGP [psia]	Minimum DHGP [psia]	Min DHGP Rationale	FBHP/Compaction Flag?	Screen Velocity Issues
SS01	10,630	16	15	10,807	-177	2,800	9,953	**8,500**	**Bad Ju-Ju Asphaltenes**	No	No
SS02	2,475	18	26	2,356	119	550	9,500	8,500	Asphaltenes	No	No
SS03	5,194	53	56	4,851	343	0	10,100	8,500	Asphaltenes	No	yes, at higher rates
SS04	5,396	12	14	5,294	102	550	8,650	6,200	Compaction / Sand Failure	Some, not critical yet	No
Sum =	23,695			23,308	387	3,900	**<--Excess Potential Oil Rate**			Date:	5-Jan-2017

Field Level – How Much is Left?
Which Wells are Worth Fixing if Something Bad Happens?

Proactive Surveillance keeps you well informed of your current EUR & NPV



Well				Remaining EUR, MMSTBo			Comments / Recommendations
	Cum Oil Prod, MMSTB	Cum Gas Prod, BSCF	Cum Water Prod, MMSTB	P90	P50	P10	
SS01	23.5	16.3	1.8	6.80	9.97	14.45	Maintain current Ck setting, plan stim job if skin exceeds 20
SS02	6.2	4.7	0.7	1.60	2.62	3.12	Maintain current Ck setting
SS03	5.3	4.0	1.5	3.00	5.40	6.10	Flow the well as hard as possible for as long as possible to keep water away from the SS1
SS04	6.2	5.8	0.4	0.80	1.60	2.20	Ok to increase choke but monitor closely

Well Capacity Determination

Understand as much as you can about your well/reservoir:

- Formation Strength & Stress
- Sanding Potential & Shear Failure
- Skin (scale, fines, asphaltenes?), Perm, P*
- Coning Potential
- Compaction
- Screen and Wellbore Velocities
- Moving Fluid Contacts (OWC)

Turn that Knowledge into a Dashboard that Everyone Can Understand (and Use to Make More Money!)

Real-Life Surveillance Example: Deepwater Oil Well

SS01 Oil Example: Big Problem Checklist

Potential Issue	Good/Bad/Ugly?	Comment
Compaction/Shear	Manageable	The well shouldn't get below 5500 psia unless it develops a large skin
Completion Velocity/ Screen Cutting	Possible Issues	Screen Cutting is possible if we try to flow the well at high rates with a high skin
Scale	Treatable	Drop Acetic/HCl if the skin gets above 20
Fines	Manageable	Normal Fines accretion…any stimulation/solvent treatment will push them back
Asphaltenes	**Severe!!!**	**Stay above 8500 psia!!!** **Potential Asphaltene Death Spiral!** 
Flow Behind Pipe	Possible	That Water Sand about 100' up the hole looks ornery…if it breaks through, the reserves justify a R/C Squeeze
Early Water Front Arrival	Possible	Trying to balance withdrawal rate from SS03 and SS01 decay to shape the water front/Maximize EUR & Stay Above AOP

Automated Real-Time Service (ARTS)

Real-Time Reporting on Wells / Field KPI's

The ARTS Concept: Physics + Automation + Experienced Surveillance Engineers

Rates & PVT	Production & Reservoir Performance Optimization		Flow Assurance	Topsides/Facilities
3-Phase Rate and BHP Calculations	Auto Real-Time PTA & Reporting	In-place, Connected and Recoverable Volumes	Wax, Hydrates, Asphaltenes, Scale, Corrosion, Emulsion Detection & Mitigation	Automated Facilities Debottlenecking & Optimization
Flow meter Validations	Scale and/or Asphaltene detection in reservoir, completion & well bore	Producer-Injector Interaction		Recognition of Inefficiently Operating Equipment
Automated PVT Tuning & Calibration	Recognize Wellbore Lift Issues & Gas Lift Optimization	Tracking on Moving Oil-Water, Gas-Oil, Gas-Water Contacts with time		
Water Cut and GOR or Yield Calculations	Recognize Completion & Reservoir Performance Issues (Skin, Scale, Compaction, Velocities)	Know the Maximum Safe Flow Potential of the Well (Spare Capacity)		

Reservoir & Production Engineering Surveillance

Asset Modeling, Monitoring & Diagnostics

Photo credit: www.energyglobalnews.com