How Today's Production Logging & Analysis Can Deliver More Confidence

Calgary – September 2011

Cased Hole Special Service Division
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DIVISION FOUNDER

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HDD

AGENDA

- COMPANY OVERVIEW
- WHAT IS PRODUCTION LOGGING & THE MEASUREMENTS TO DELIVER CONFIDENT RESULTS?
- THE ELEMENTS OF SUCCESSFUL PRODUCTION LOGGING
- VERTICAL & HORIZONTAL WELL PRODUCTION LOG EXAMPLES
- MECHANICAL INTEGRITY LOG SOLUTIONS

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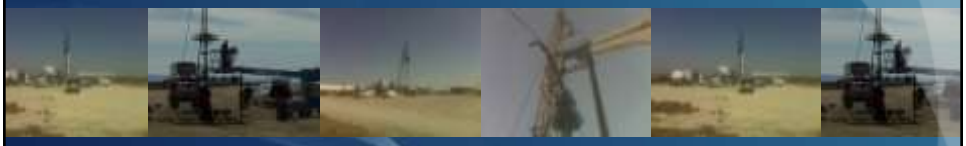
Company Overview



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RECON – CANADA & US LOCATIONS

- SPECIALTY CASED HOLE LOGGING
- CASED HOLE WIRELINE
- OPENHOLE LOGGING

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SPECIALTY PRODUCTION LOGGING

Team Background

- Field Personnel - Focused
  - Experienced in PLT with Well Testing background
  - Knowledgeable with down hole conditions & surface flow rates
- Log Analysis – Experienced
  - Global Experienced Champion at PL Analysis
  - Worked with PLT Log Analysis since 1997
  - Providing 'WL companies' with external PLT Analysis support
    - Wood Group, Baker, SLB & Energy Producers

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EXPERIENCE – HORIZONTAL & VERTICAL WELL EVALUATIONS

To date- Over 400 Horizontal Production Logging Deployments – Our Areas of Success

- Areas - All major unconventional plays
  - Barnett Shale, Haynesville, Eagleford, Oklahoma, Pan Handle, Fayetteville, Marcellus Shale
  - Major conventional plays;
    - Permian, East Texas, Oklahoma, Pan Handle, Rockies, Chengdu China
- Clients - All major & minor E&P operators in major producing basins

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EXPERIENCE – HORIZONTAL & VERTICAL WELL EVALUATIONS

Areas of Success

- Barnett Shale
  - Indentified water inflow zones on over 50 HZ wells
  - Production logs ran to verify and correlate to Micro-seismic measurements
- Eagleford / Haynesville / Marcellus / Pan Handle etc
  - High rate / High temp Gas
  - Identified flowing lateral profile, gas, oil & water inflows
- Marcellus Shale
  - High rate HZ Lateral producing profile logs

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EXPERIENCE – HORIZONTAL & VERTICAL WELL EVALUATIONS

Areas of Success

- Permian Basin
  - Gas & Oil Horizontal production logs
- Texas & Oklahoma Pan Handle
  - High Rate wells
  - East OK Shale Arkoma
- North Dakota - Bakken
  - Completion evaluation logs

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What Is Production Logging?
&
The Measurements To Deliver Confident Results?

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PRODUCTION LOGS – WHAT FOR?

- MONITOR / SURVEILLANCE
  - Identify hydrocarbon & water inflows – Profile Log
- DIAGNOSTICS
  - Discover unknown faults or natural fractures
  - Compare or contrasts micro– seismic results
  - Evaluation frac / completion efficiency

CHALLENGES - Acquire Data that is Representative of Actual Flow

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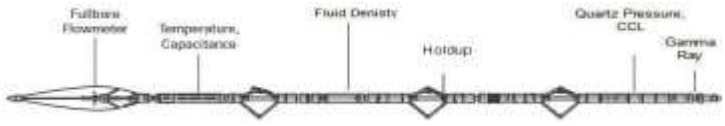
PRODUCTION LOGGING SENSORS

Gamma Ray / CCL	– depth correlation
Pressure	– downhole pressure, PVT determination
Temperature	– identifies fluid or gas inflow
Flowmeter	– measures the rate of change of flow
Fluid Capacitance	– measures dielectric property between water & oil
Fluid Density	– measures electron mass of fluids & gas in wellbore
Holdup (YG)	– a direct measurement of Holdup in wellbore
	- the phase fraction occupying the wellbore



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HDPLT – HIGH DEFINITION PRODUCTION LOGGING

A High Confident Production Logging Solution

3 Fluid ID Sensors

- Fluid Capacitance , Fluid Density & High Definition Holdup
- High Definition HOLDUP – directly measures of wellbore phase fraction
- Temperature, Pressure, Flow

- Additional Data will support Higher Confidence in Log Analysis
  - More sensors adds more pieces of the puzzle
  - Delivers a clearer understanding of flow - Accuracy

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HDPLT – HIGH DEFINITION PRODUCTION LOGGING

'Most' Production Logging Vendors Platform;

- Limited Fluid ID measurement
- A Single Point measurement – Middle of Tool
- Can not directly measure a full bore Holdup
- Results will lead to Lower Confidence in Inflow Anlaysis

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OPERATIONAL VERSATILITY

FEATURES	BENEFITS
Short Compact 1 3/8" OD – 15 ft Vert / 20 ft Hz	Deploys thru small tubing & nipples
Can Deploy in Memory or SRO Mode	SRO > quality verification of data Memory > Lower cost of deployment
Platform with using of 3 Fluid Sensors Fluid Capacitance Fluid Density Fullbore Holdup	Highest confidence of fluids & gas inflows
Deployed in Horizontal & Vertical Wells	Versatile & Available
Fast Delivery of High Confidence Results Representative / Actual Well Flow	Client can make decisions The same or next day

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What Is Holdup?

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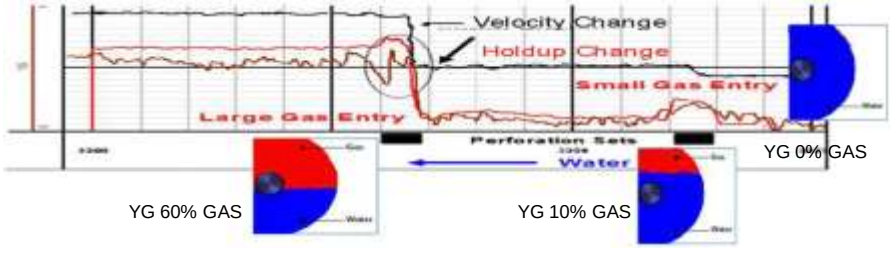
WHAT IS HOLDUP?

- The phase fraction (g/l ratio) that occupies cross section of the wellbore
- A Better method is to directly measure HOLDUP
  - Holdup was derived from Capacitance or Density Fluid ID measurements
- Low energy gamma rays bombard the wellbore cross section in a fixed pipe size
- A straight-line count rate of g/l volume in a fixed pipe size determines the g/l ratio



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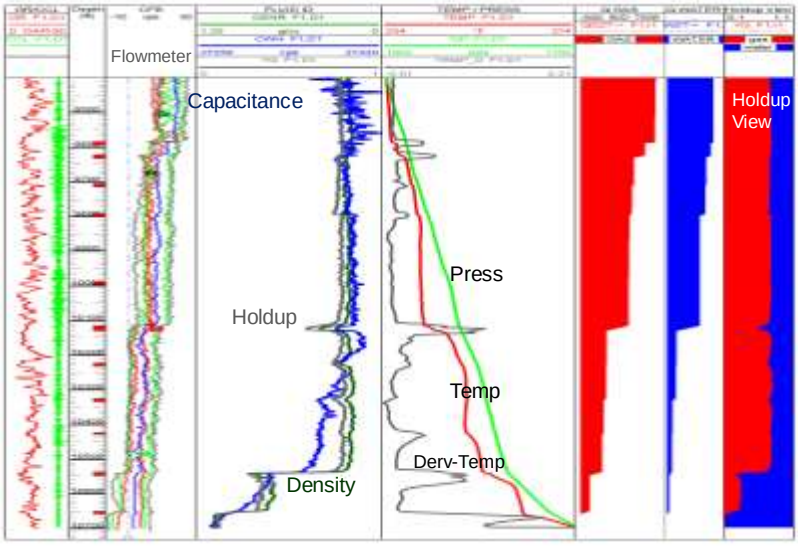
RATE DERIVED FROM - HOLDUP & VELOCITY



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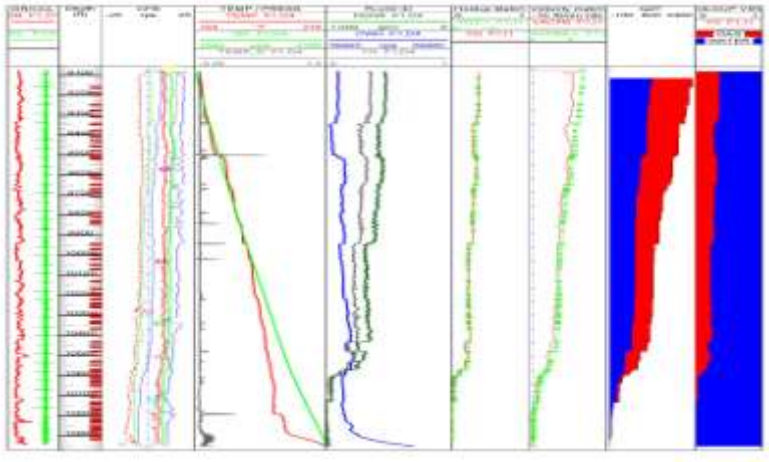
RATE DERIVED FROM - HOLDUP & VELOCITY

- Rate Calculation relies on how accurate Holdup can be measured or derived



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The Elements of Successful Production Logs

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THE PRODUCTION LOG SOLUTION

Required – The Path for Successful Results

- Specialty Production Logging Group
- Experience & Understanding
- Fullbore (cross sectional) flow measurements
  - High Confidence Log Solution

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THE PRODUCTION LOG SOLUTION

The 4 Quadrants of a Successful Production Log

- Logging Job preparation / Project Manage
- Onsite experience & execution
- Downhole Measurements
- Experienced HZ Shale well Production Log Analysis

Will Guarantee Successful Results

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Production Logging Vertical Well Example Diagnostic

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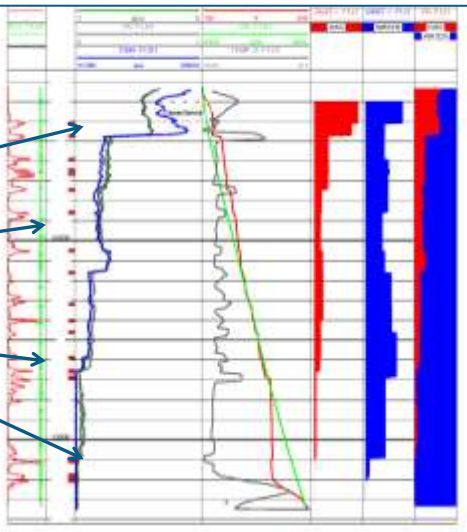
DIAGNOSTIC – TECHNIQUES & MEASUREMENTS

~ 3 MM Gas & 600 BD water

- Production Log Verified
  - Gas Inflows
  - Cross Flow
  - Water Inflows



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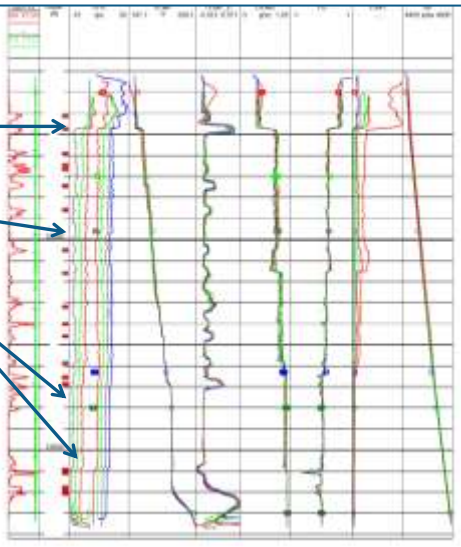
DIAGNOSTIC – TECHNIQUES & MEASUREMENTS

~ 3 MM Gas & 600 BD water

- Production Logging Verification
  - Gas Inflows
    - Spinner / Temperature / Holdup
  - Cross Flow - Spinner
  - Water Inflows
    - Spinner (Station Stops) / Holdup
  - Identified ~ 200 b/d flowing from lower intervals



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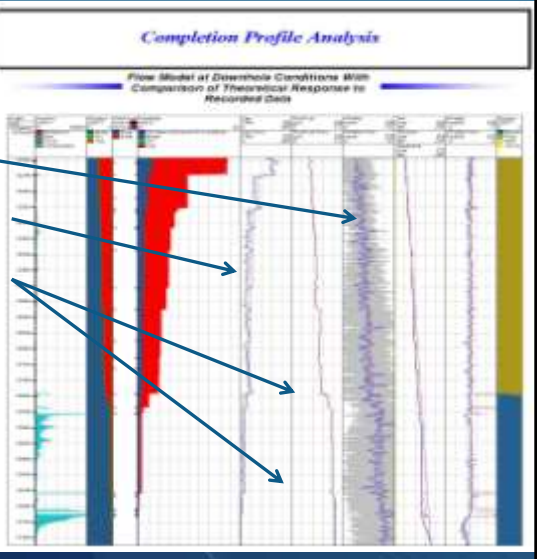
DIAGNOSTIC – COMPETITOR RESULTS (SAME WELL)

~ 3 MM Gas & 600 BD water

- Production Logging Verification
  - Single Fluid ID sensor
    - No Fullbore Holdup measurement
  - Cross Flow
    - Spinner response ignored
  - Water Inflows
    - Under Estimated Spinner Response
  - Log Analyst Identified < 50 b/d flowing from lower intervals
    - Plug was set above lower intervals
    - Remediation shut off ~ 190 B/D Water
    - RECON identified ~ 200 B/D Inflow



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Production Logging Vertical Well Example 3 Phase Flow

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VERTICAL PLT EXAMPLE

Permian area well produces ~ 200 Mscfd, 200 bbl oil & 50 bbl water

- Operator wanted to locate Water, Oil & Gas inflows
- The used 3 Fluid ID sensors
  - Fullbore Holdup / Fluid Density / Fluid Capacitance
  - Aids in Accurately identify 3 phase entries
- Most Competitors provide
  - Gradiomanometer (pressure converted to density)
  - As a Fluid ID measurement
  - Cannot identify oil or gas entries with confidence

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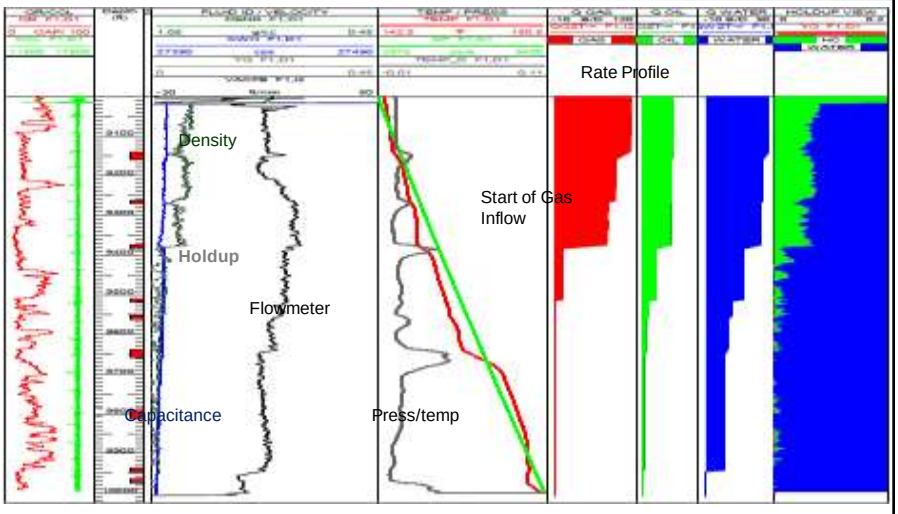
THE BENEFIT OF 3 FLUID ID SENSORS



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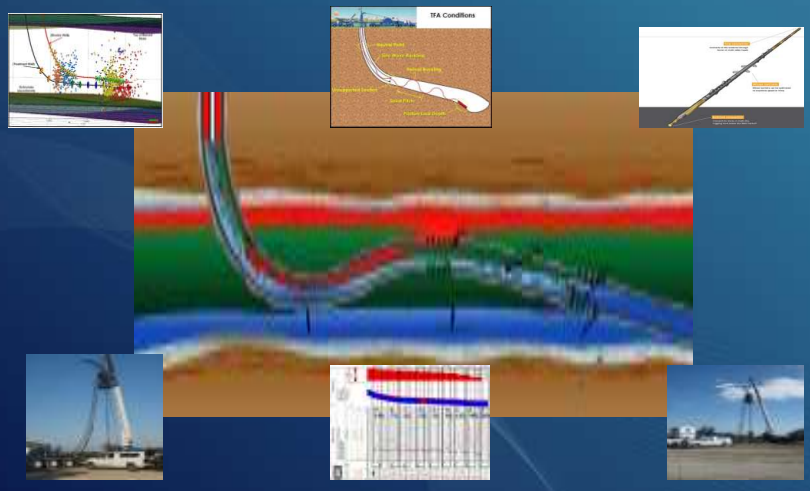
Horizontal Production Logging



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BASED ON INFORMATION PRESENTED

SPE 120591 - Horizontal Well Production Logging Deployment and Measurements Techniques for US Land Shale Hydrocarbon Plays

Presented at the SPE Production and Operation Symposium held in Oklahoma City, Oklahoma, April 4th, 2009 & North East SPE October 2009

SPE 133134 – Shale Gas Horizontal Production Logging Measurements and Challenges

Presented at the SPE Tight Gas Completion Conference held in San Antonio, Texas November 3rd, 2010

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Horizontal Production Log Example
Well Tractor Deployed

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HZ PRODUCTION LOG - EXAMPLE 1

Example well was producing ~ 5-6 MMscfd & high water rate

- The well operator required a production log for diagnostic purposes
  - The well broke through with higher water rate ~ 800 – 1000 bpd
  - The well operator twice tried 2 separate PLT vendors with a Coil tubing supplier & could not receive usable data to help remediate the well
- RECONs solution
  - Deploy via well tractor
- RECON delivered results on 1st attempt in the well
  - Well was remediated & water shut off

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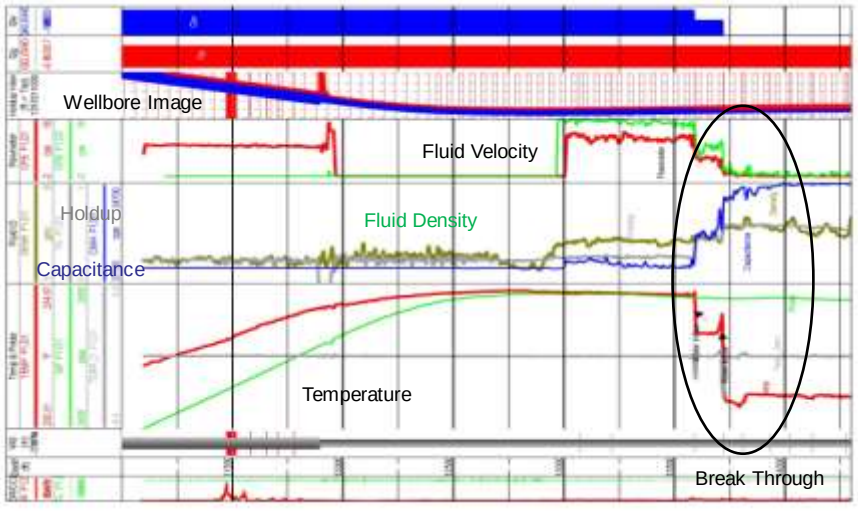
HZ PRODUCTION LOG – WATER BREAK THROUGH



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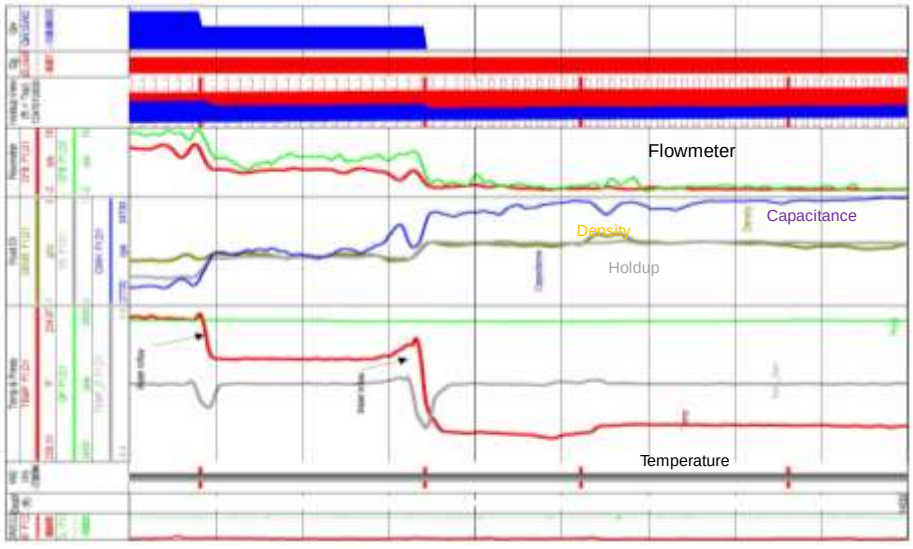
HZ PRODUCTION LOG – 4 MMSCFD & ~ 800 BPD WATER



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Horizontal Production Log Example
Coiled Tubing Deployed

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HZ PRODUCTION LOG - EXAMPLE 2

Example well produces ~ 3 MMscfd & low water rate

- The well operator required a production log for Surveillance purposes
  - Completion team monitoring the effects when changing frac techniques per stage across the lateral
- RECON Results show
  - RECONs spinner passes repeat & showcase the inflow profile
  - Temperature correlates to the spinner responses
  - Fullbore Holdup identifies water entries

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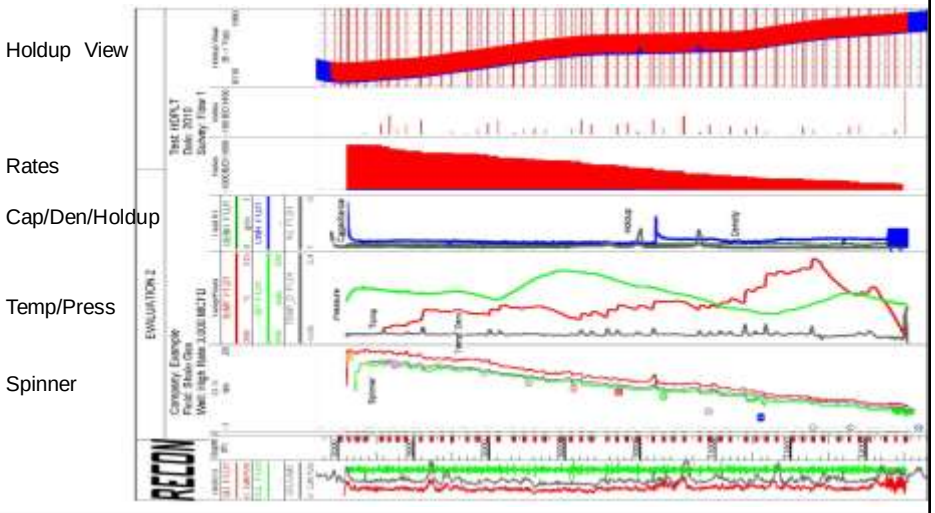
HZ PRODUCTION LOG – PROFILE MONITORING

~ Well 200 bbld & 3 MMSCFD



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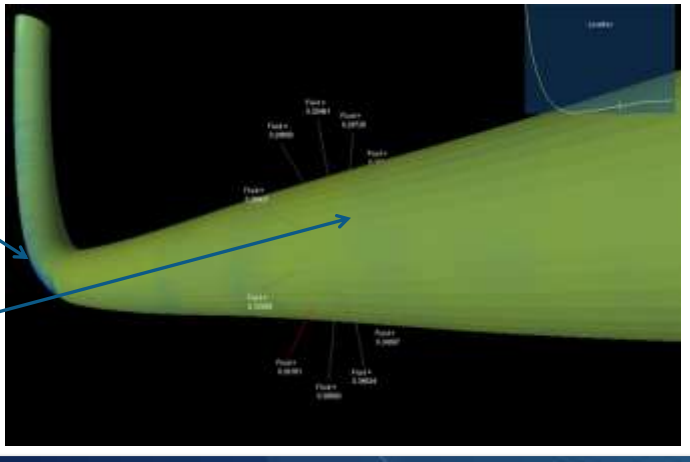
HORIZONTAL WELL PRODUCTION IMAGE

Illustration of a flowing lateral ~ 2-4 MM Gas & < 200 bpd water



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Horizontal Production Log Example
Port & Packer Completion

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HZ PRODUCTION LOG - EXAMPLE 3

Example well produces ~ 700 Mscfd & low water rate

- The well operator required a production log for diagnostic purposes
  - The well operator wanted to determine if a section of the lateral was unproductive
  - Geologic information showed the last stages was a non-core section
- RECON Results show
  - Excellent spinner results at low rates down to 1 mcfd
  - The last sections of the lateral has very low production
- Data is representative of everyday flow

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HZ PRODUCTION LOG – PROFILE MONITORING

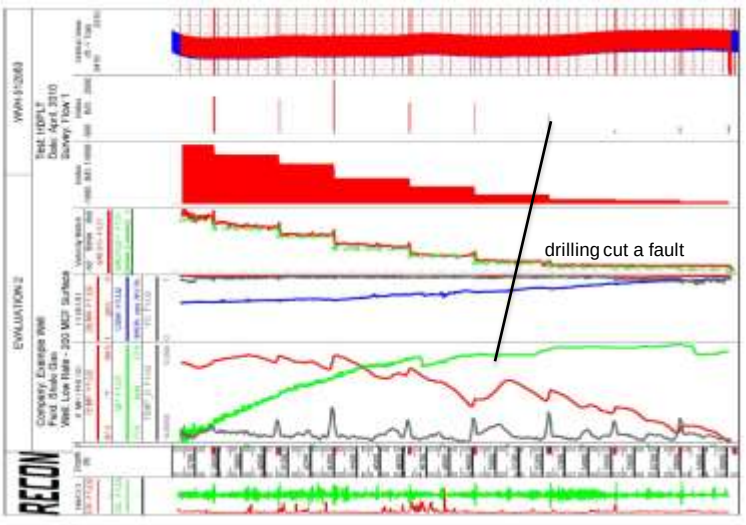
Holdup View

Rates

Spinner

Cap/Den/Holdup

Temp/Press



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HZ PLT EXAMPLE 4 – OIL & WATER

Example well produces ~ 100 Mscfd , 125 bopd, 630 bwdp

- The well operator required a production log for surveillance purposes
  - The well operator wanted to verify completion efficiency
- RECON Results shows
  - Water starting to enter the wellbore from mid point of the lateral to the heel.
- Data is representative of everyday flow

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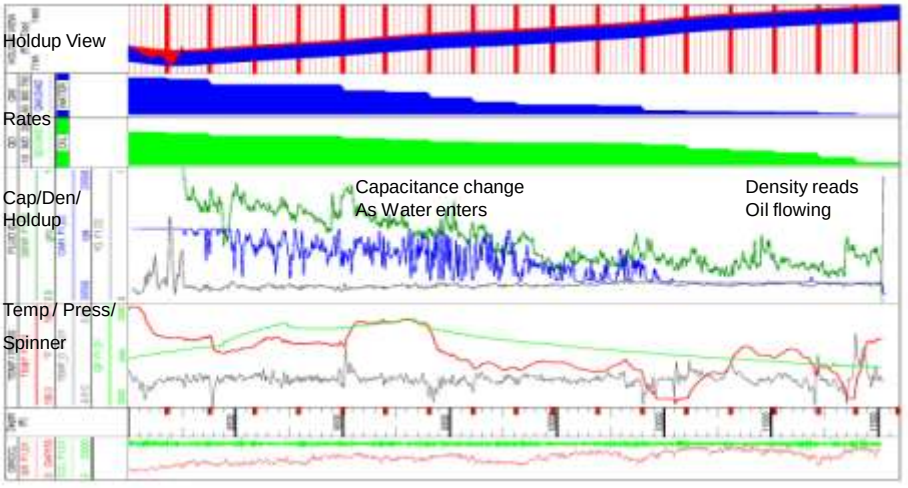
HZ PRODUCTION LOG – PROFILE MONITORING



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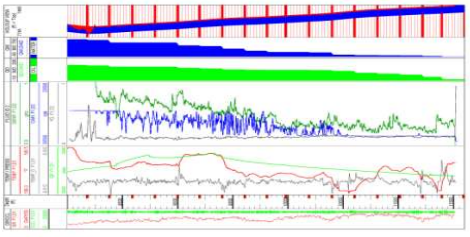
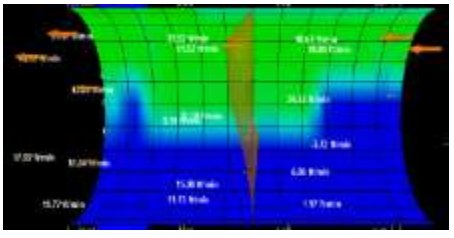
HZ PRODUCTION LOG – PROFILE MONITORING

- Capacitance change as Water enters
- Density in tow reads Oil



- Oil / Water flowing in the lateral



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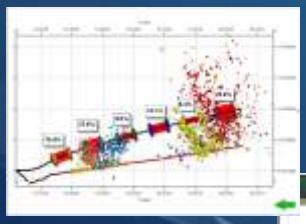
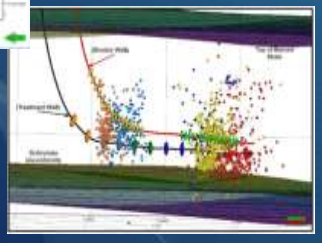
Horizontal Production Log Verifies Micro-Seismic Data





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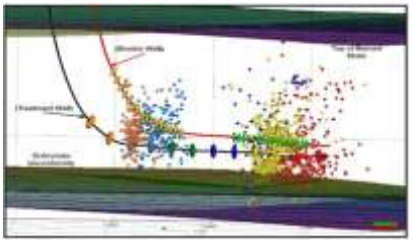
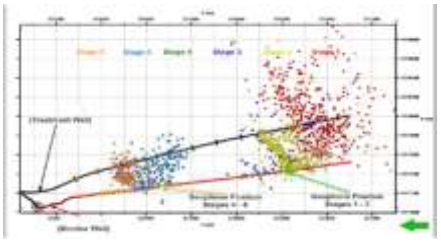
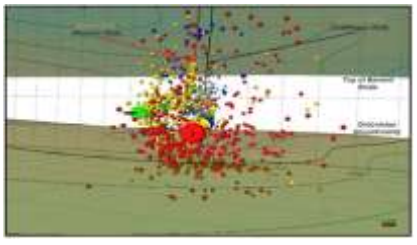
HZ PRODUCTION LOG – MATCHING MICRO-SEISMIC

Measurement Scope

- 2 Wells Side by side
- Well 1 – Monitor well (Micro-Seismic) is uncompleted
- Well 2 is frac'd & later production logged
- Well 1 is completed & production logged







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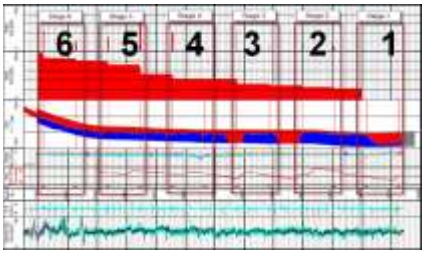
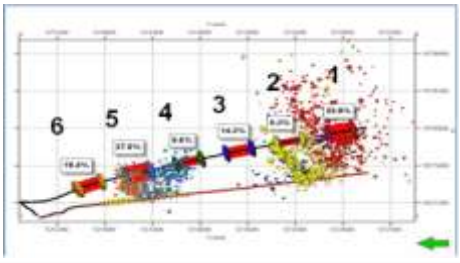
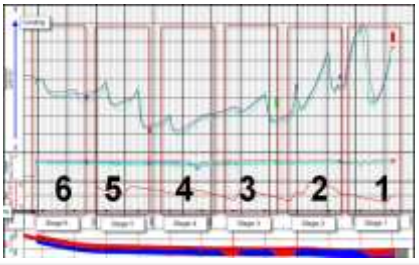
HZ PRODUCTION LOG – MATCHING MICRO-SEISMIC WELL 2

Gas production rates fractional flow

- Heel Section (44%) - Enters at Stage 5 & 6
  - Anistropic
- Mid Section (24%) - Enters at Stage 3 & 4
  - Isotropic
- Toe Section (32%) - Enters at Stage 1 & 2
  - Anistropic







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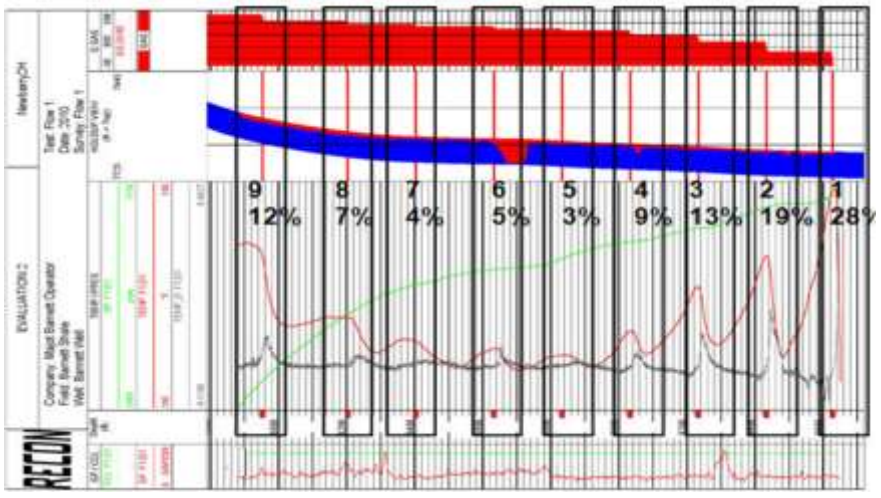
HZ PRODUCTION LOG – MATCHING MICRO-SEISMIC WELL 1



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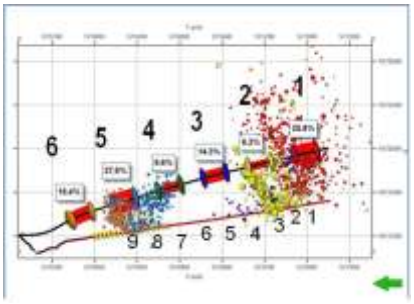
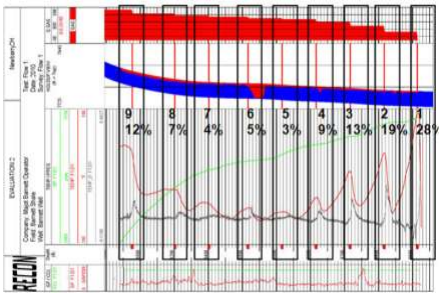
HZ PRODUCTION LOG – MATCHING MICRO-SEISMIC WELL 1

RECON HDPLT - Gas production rates fractional flow

- Heel Section (23%) - Enters at Stage 7, 8 & 9
- Mid Section (17%) - Enters at Stage 4, 5 & 6
- Toe Section (50%) - Enters at Stage 1, 2 & 3





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Mechanical Integrity Solution

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MECHANICAL INTEGRITY SOLUTION

- Measurements
  - Utilizes Casing calipers -24 /40 / 60 finger versions
  - Radial Bond Log Measurement
  - Production Logging Measurements
- Deployment Options
  - Surface Read Out or Memory options
  - Can run all tools combined in 1 run
  - Suitable for all well deviations
  - Extended finger lengths available for all tools (optional)
- 3D data analysis using WIVA software
  - Statistical analysis using WIPER software

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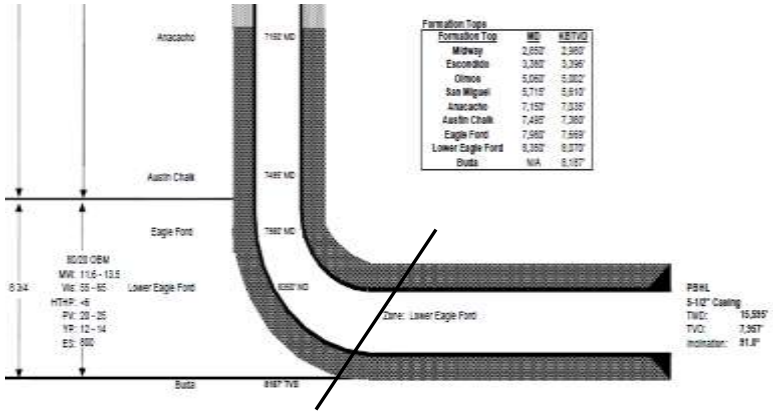
MECHANICAL INTEGRITY SOLUTION

- A Clients Horizontal well with integrity issues & couldn't pump down guns to complete



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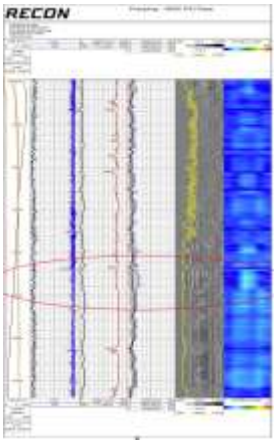
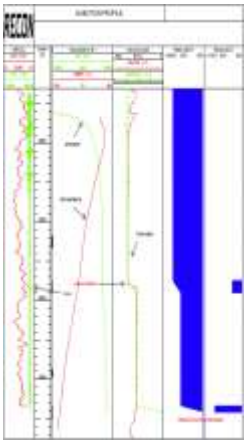
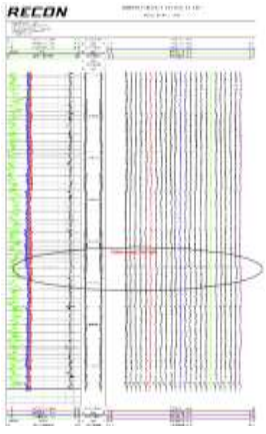
MECHANICAL INTEGRITY SOLUTION

- RBL / Casing Caliper / Injection Survey all showed a collar leak & cement channel







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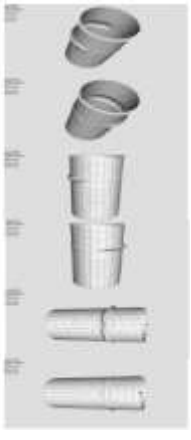
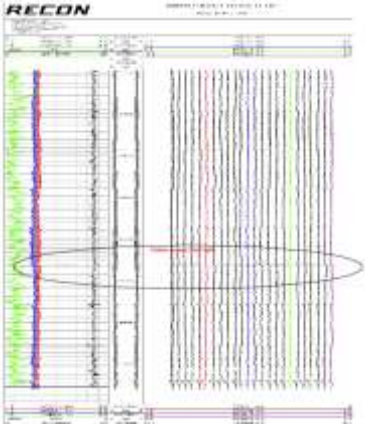
MECHANICAL INTEGRITY SOLUTION

- Casing Caliper - Casing imager highlights the failed area





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SUMMARY

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SUMMARY

- Production Logs will assist to;
  - Understanding Reservoirs
  - Diagnostics – Well Issues
- Production Log Confidence
  - Focus Specialty Teams
  - Fullbore Holdup Measurements
  - All Peripheral Measurements
  - Production Logging is the Proof of Flow
- Mechanical Integrity Solutions
  - Calipers, Radial bond log & PLT Injection Survey

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THANK YOU FOR YOUR TIME

ANY QUESTIONS ?

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