Taking Well Control to a Whole New Level

Helio Santos
Safekick
Beyond Macondo, London, May 2011

SafeKick
Empowered Solutions


05/28/2007


05/28/2007


IS THE
IBOP/TIW
VALVE OPEN


05/28/2007

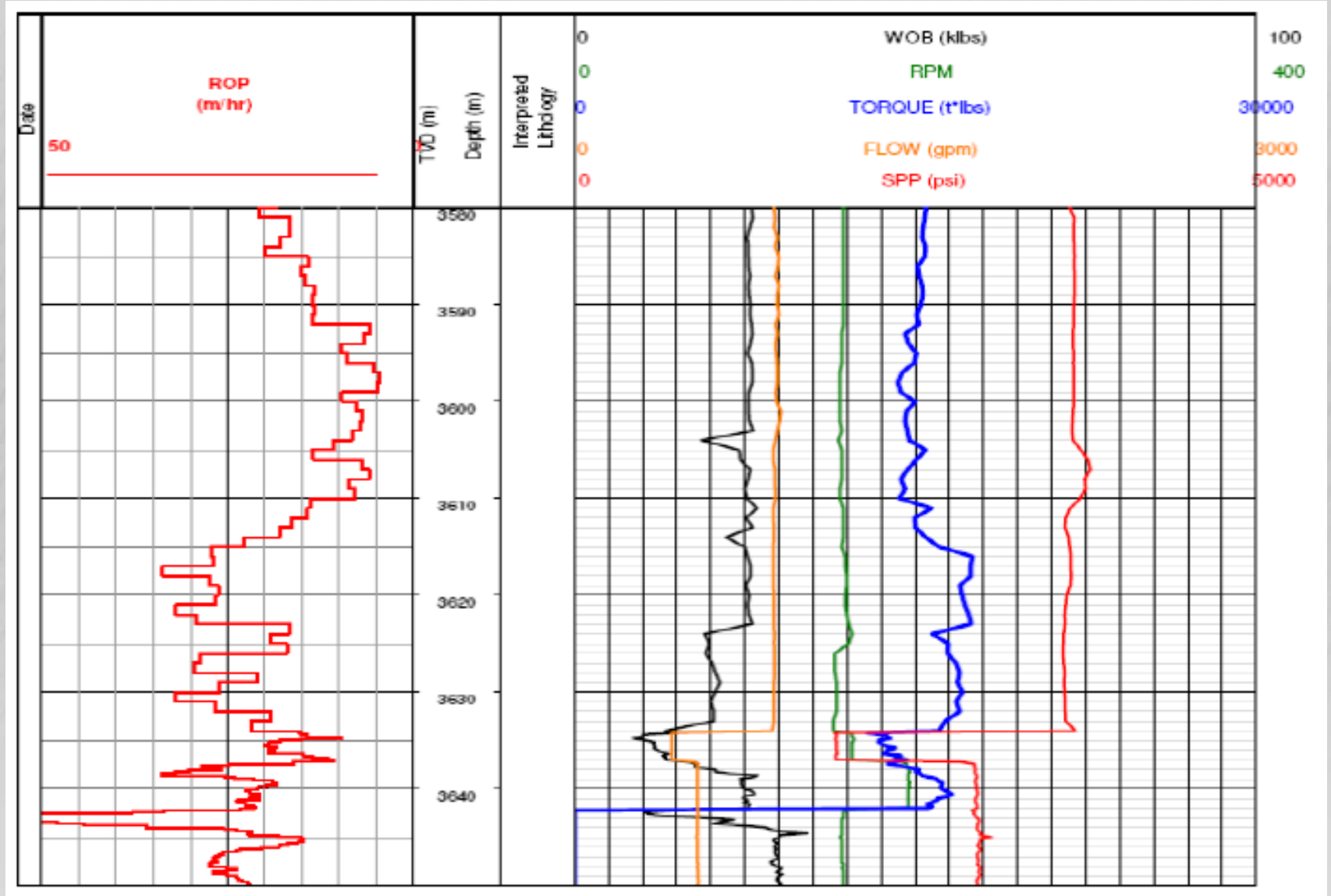

04/13/2008


05/28/2007

Top: Scene inside the control room of the gas treatment facility, BLNG Liquefaction plant at Lumut, Seria, Brunei
Bottom left: Shell employees in a meeting at the Real Time Operating Center RTOC which has the capacity to monitor real time data from 9 wells being drilled. USA
Bottom right: Employees operate computer equipment in the OP-2 ethylene plant control room at Deer Park. USA

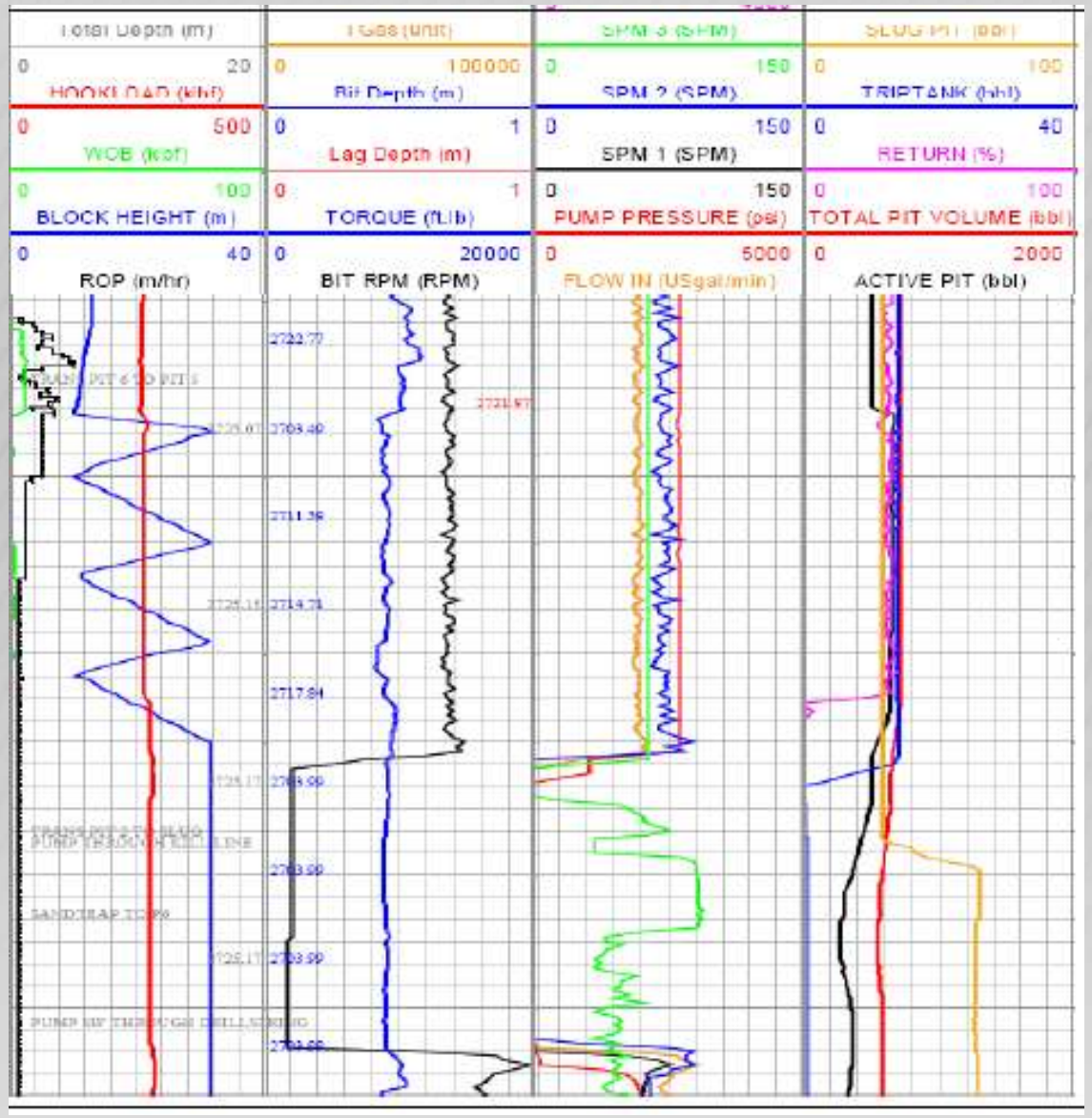
How we “see” things below the rig floor today…

A) Simple mud logging display

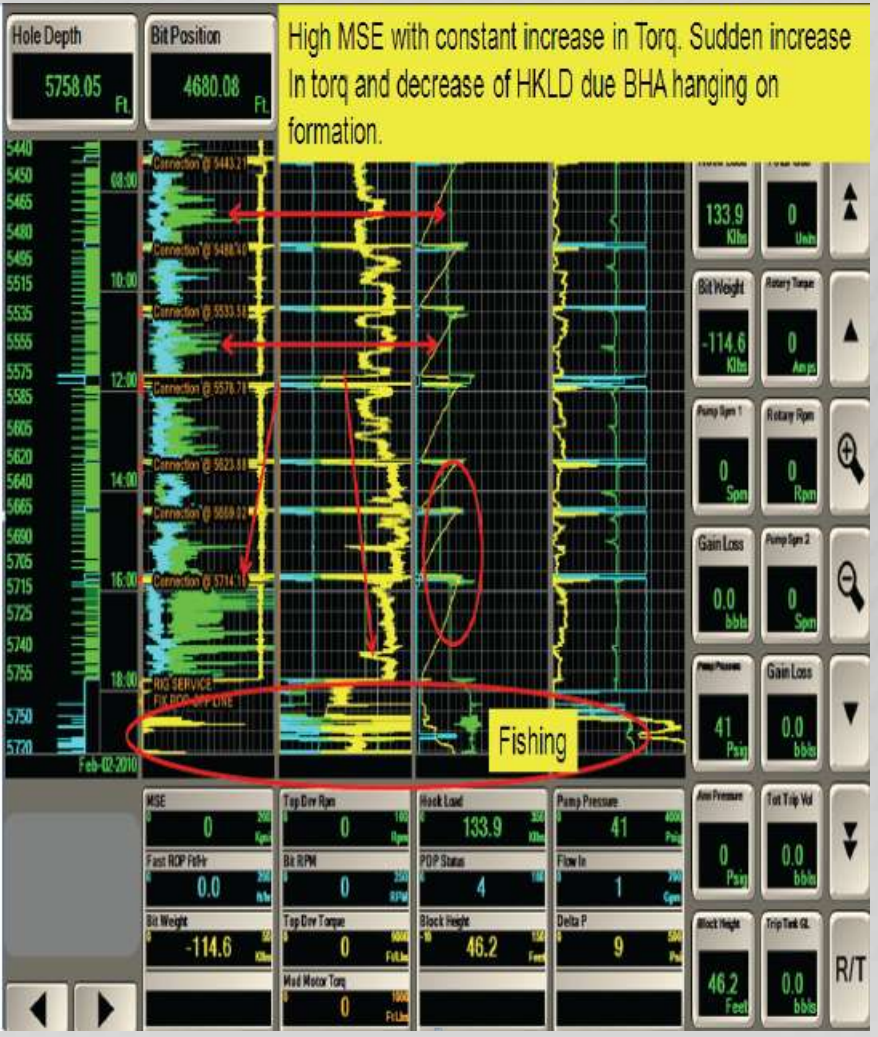


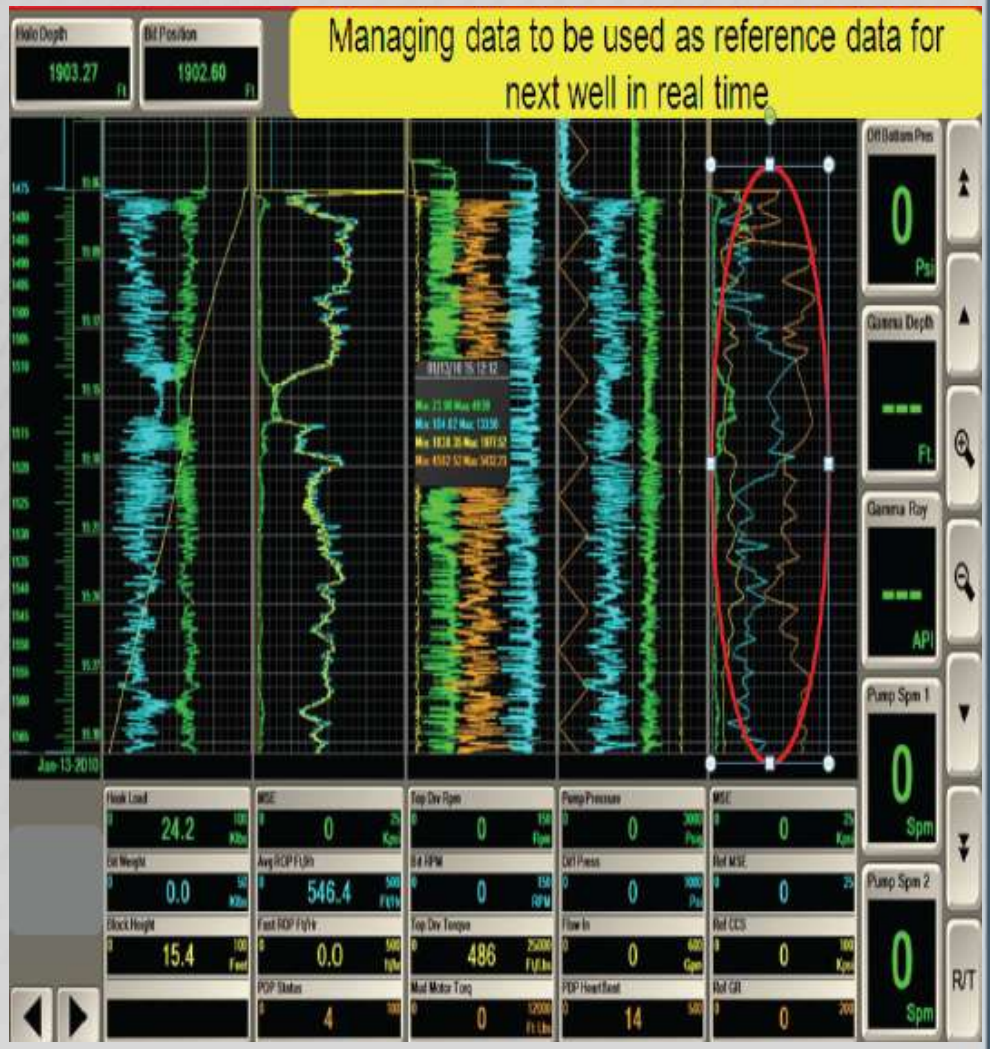
How we “see” things below the rig floor today…

B) More complex mud logging display



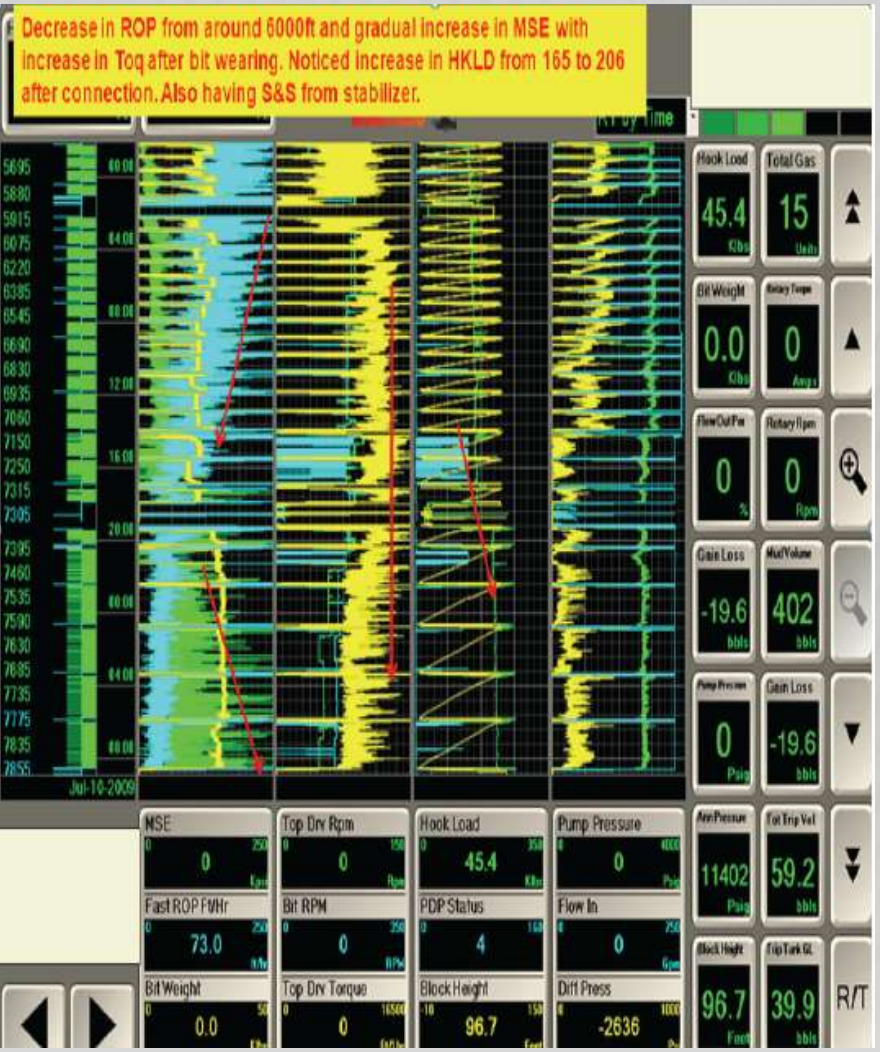
Another “sophisticated” system

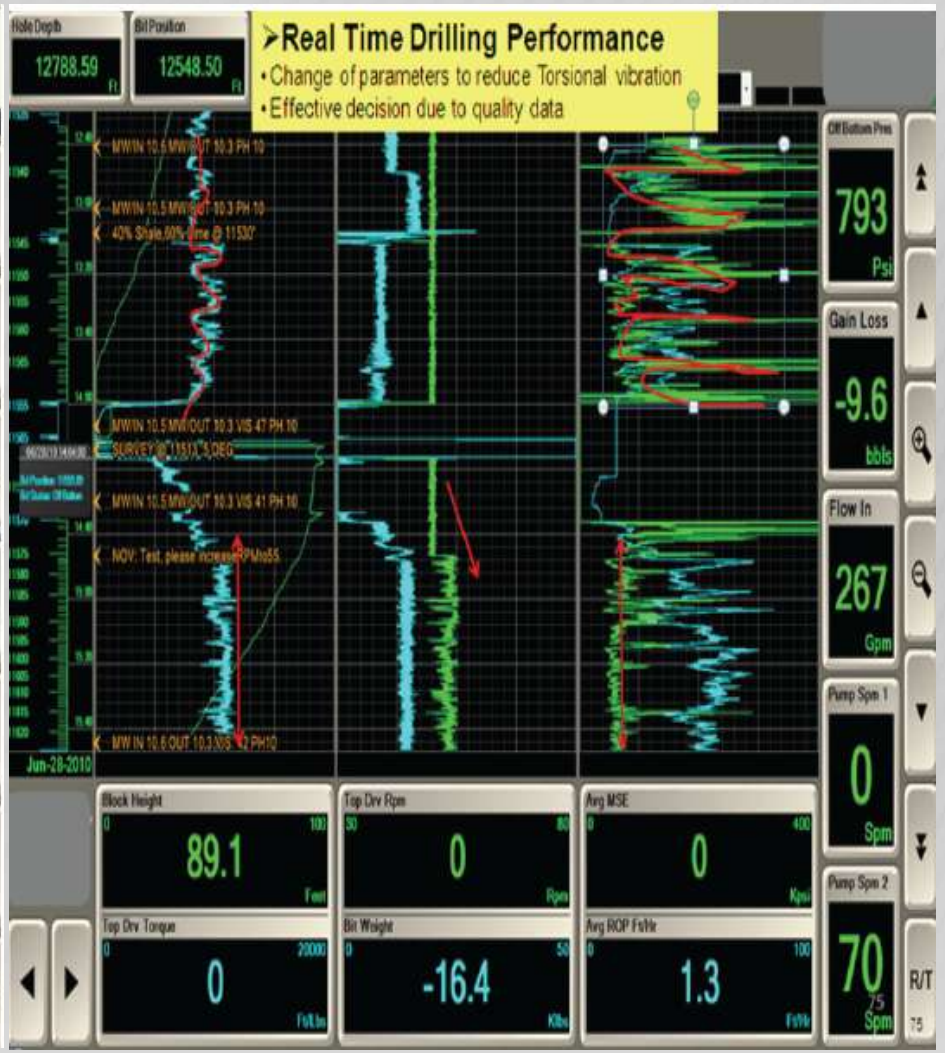




Same concept as usual

Any better or more confusion?





Understanding what is going on below the rig floor

- Where is the bit? Inside the casing, open hole or riser?
- What is the well configuration? Casings, liners, shoe depths, diameters, top of cement?
- Is the BOP open or closed? Is the choke/kill line open or closed? Are they aligned to take returns from the well or to inject into the well?
- Where are and what are the fluids inside the drill string and annulus?
- What is the operation being conducted?
- What is the pore/frac pressure and pressure along the wellbore?
- Are we likely to be under or overbalanced? By how much?
- Is the well likely to be cleaned (without cuttings)?
- What are the expected conditions (pressures) in the next 3 hours?

Directions Taken

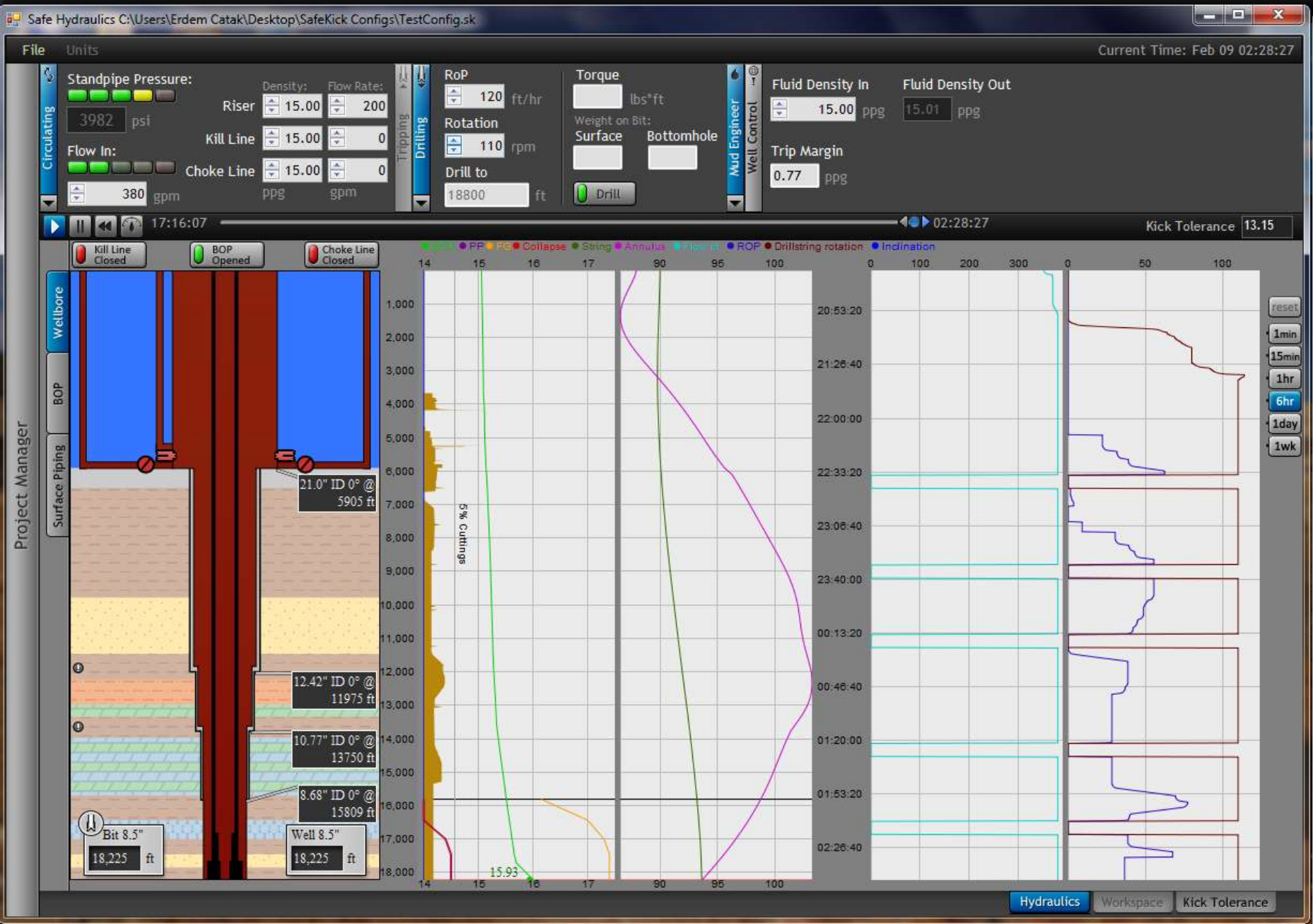
- Display valuable information instead of just raw data
- Raw data => Simulation => Intelligent Processing => Valuable Information
- Display needed information avoiding overloading
- Integrate all the operations – BOP open or closed
- User friendly and straightforward display
- Same system to be used before, during and after the operations, as well as for training
- Same information available to all involved, on and off the rig

Current Modules

- Well Visualization
- Fluid Tracking
- Integrated Hydraulics
  - Temp and pressure effects on mud properties
  - Effect of pipe rotation
  - Effect of pipe movement – surge/swab
  - Effect of cuttings load
- Solids Transport
- Kick Tolerance
- Trip Margin

SafeKick
Empowered Solutions

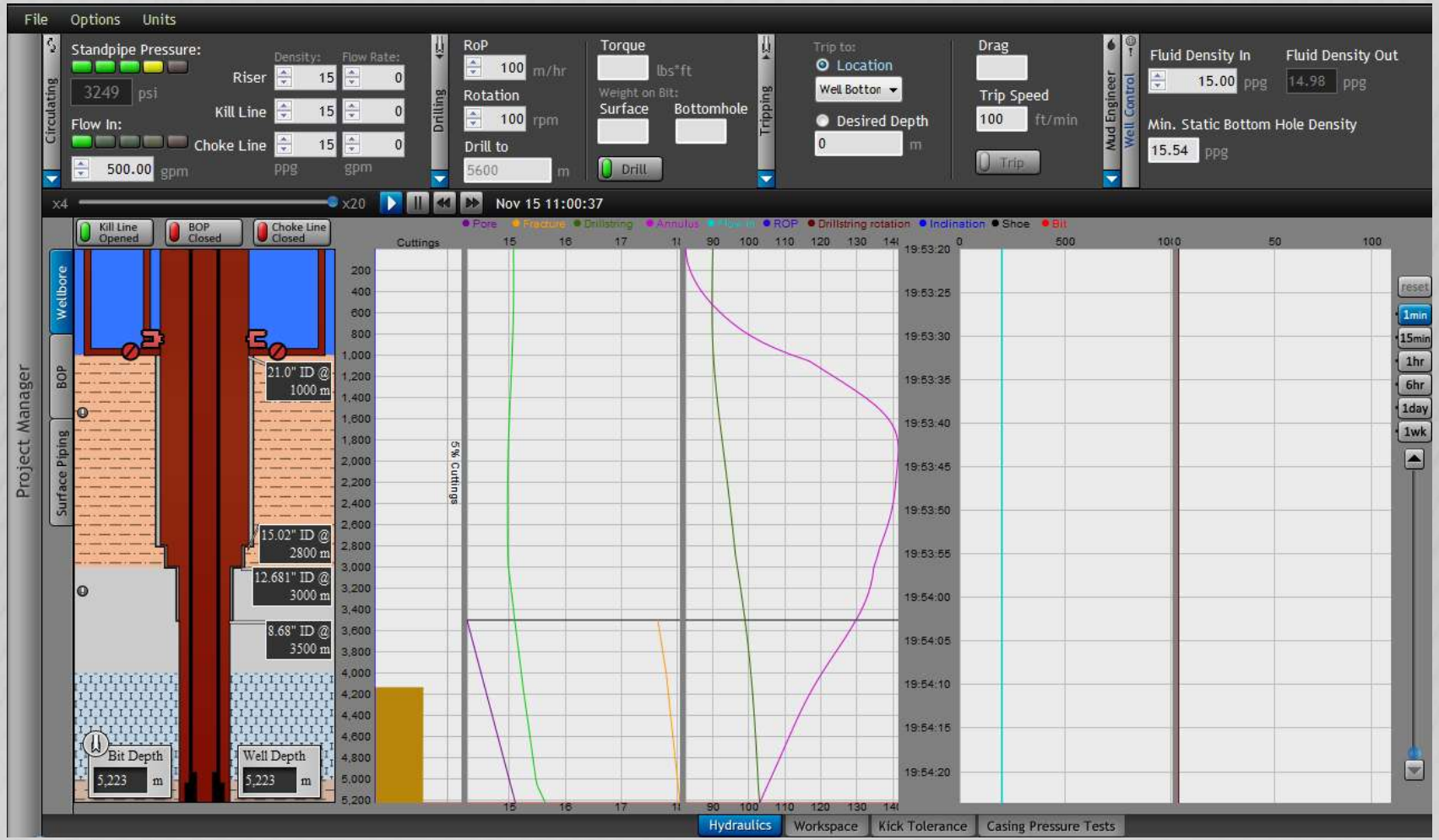
SafeVision - Main Screen



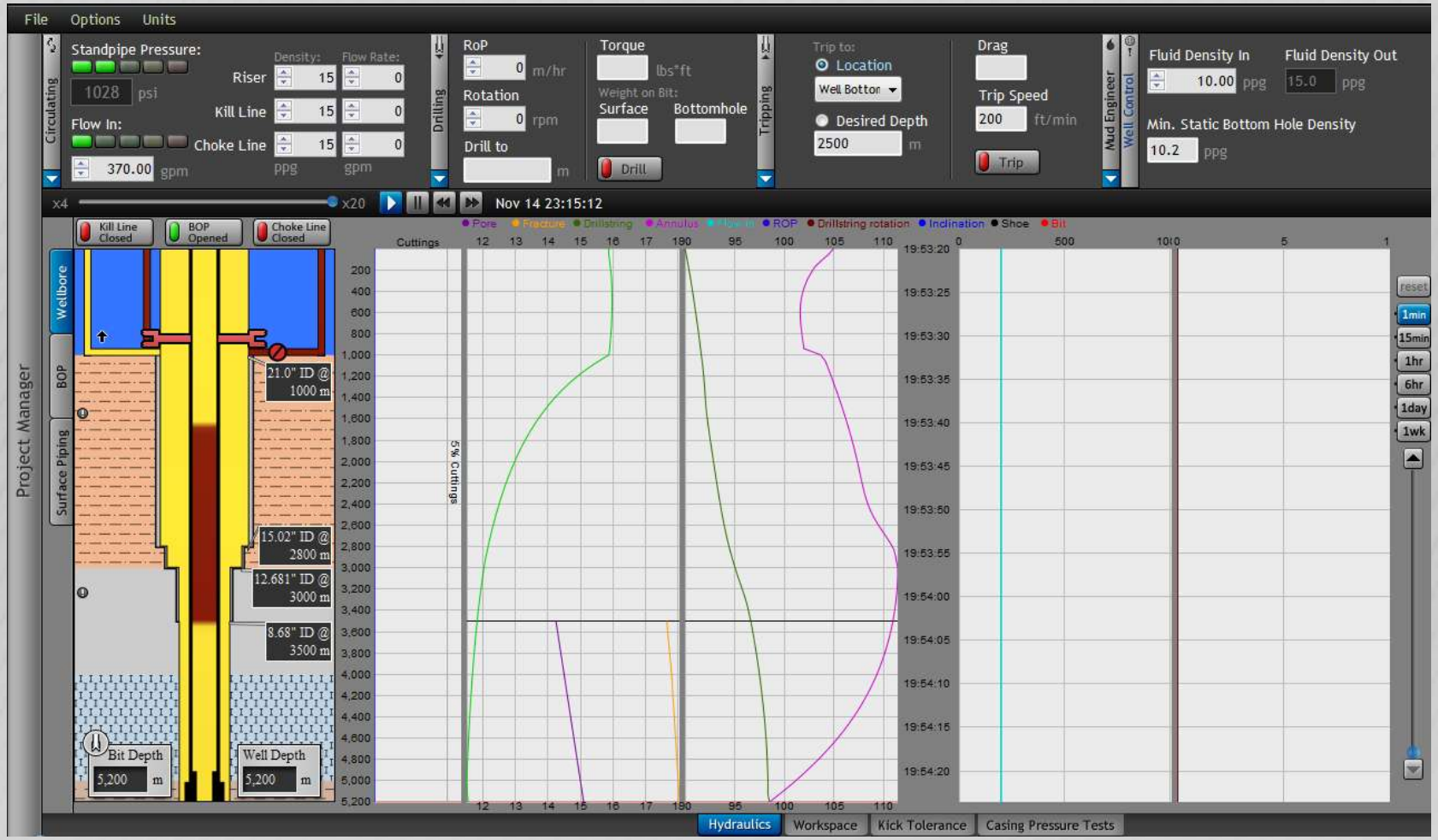
Cuttings load, ECD, and all relevant drilling data

- Standalone version expected Jan/2011

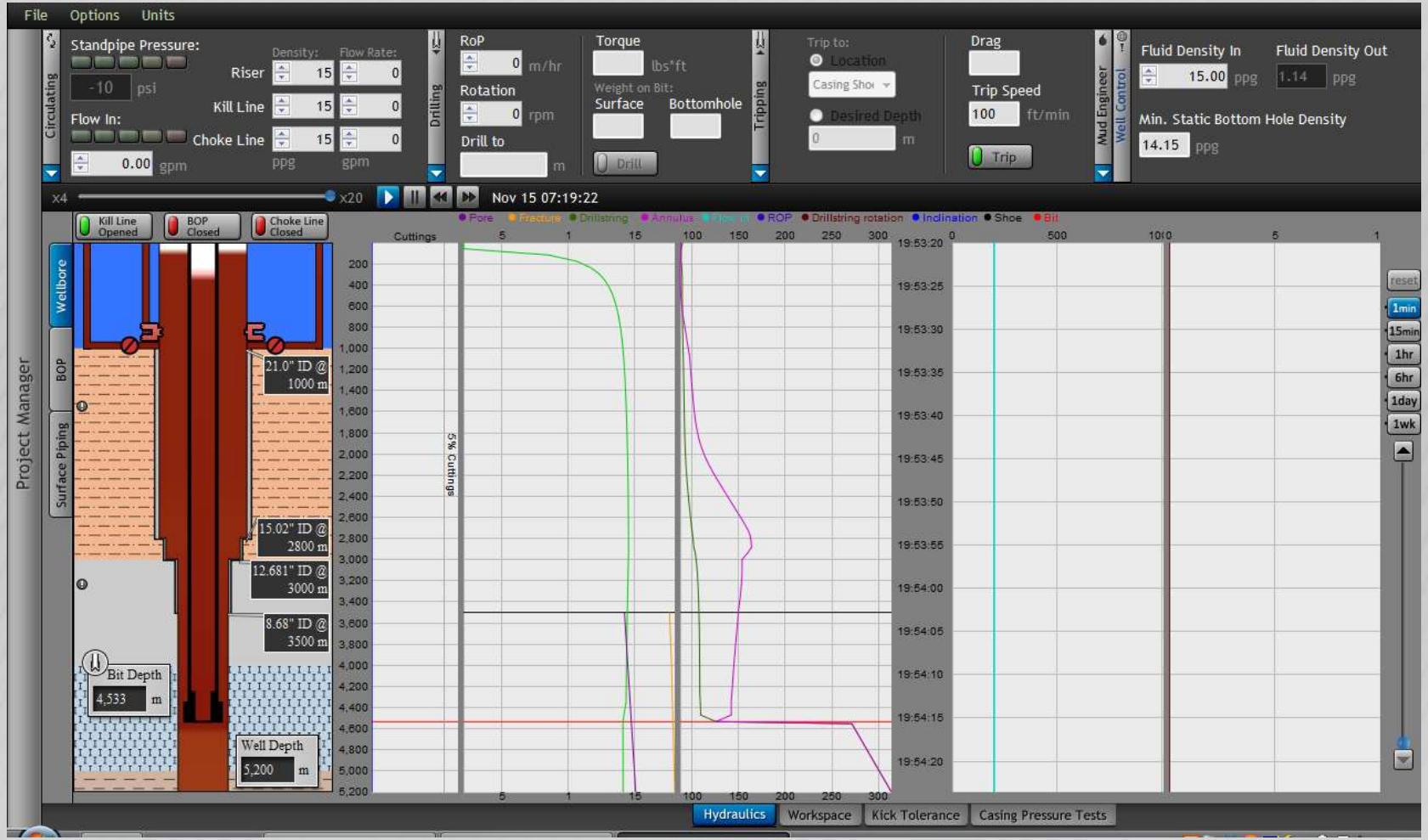
Main Screen



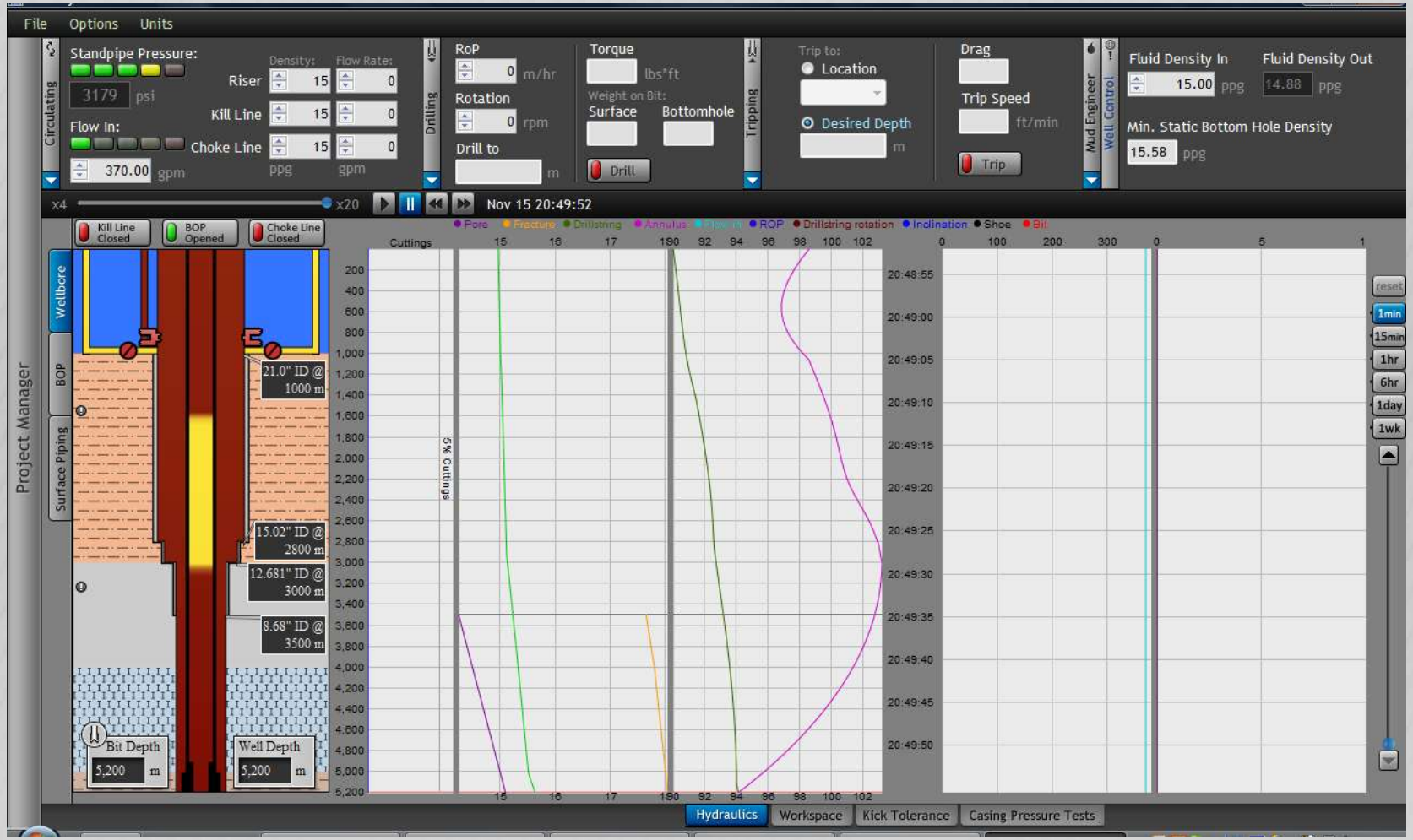
BOP closed, kill line open, choke line closed, and different fluids clearly seen on all lines including kill, choke and booster line



Bit position, mud level inside drill string and in the annulus due to u-tube effect, surge and swab effect on ECD and all relevant tripping data

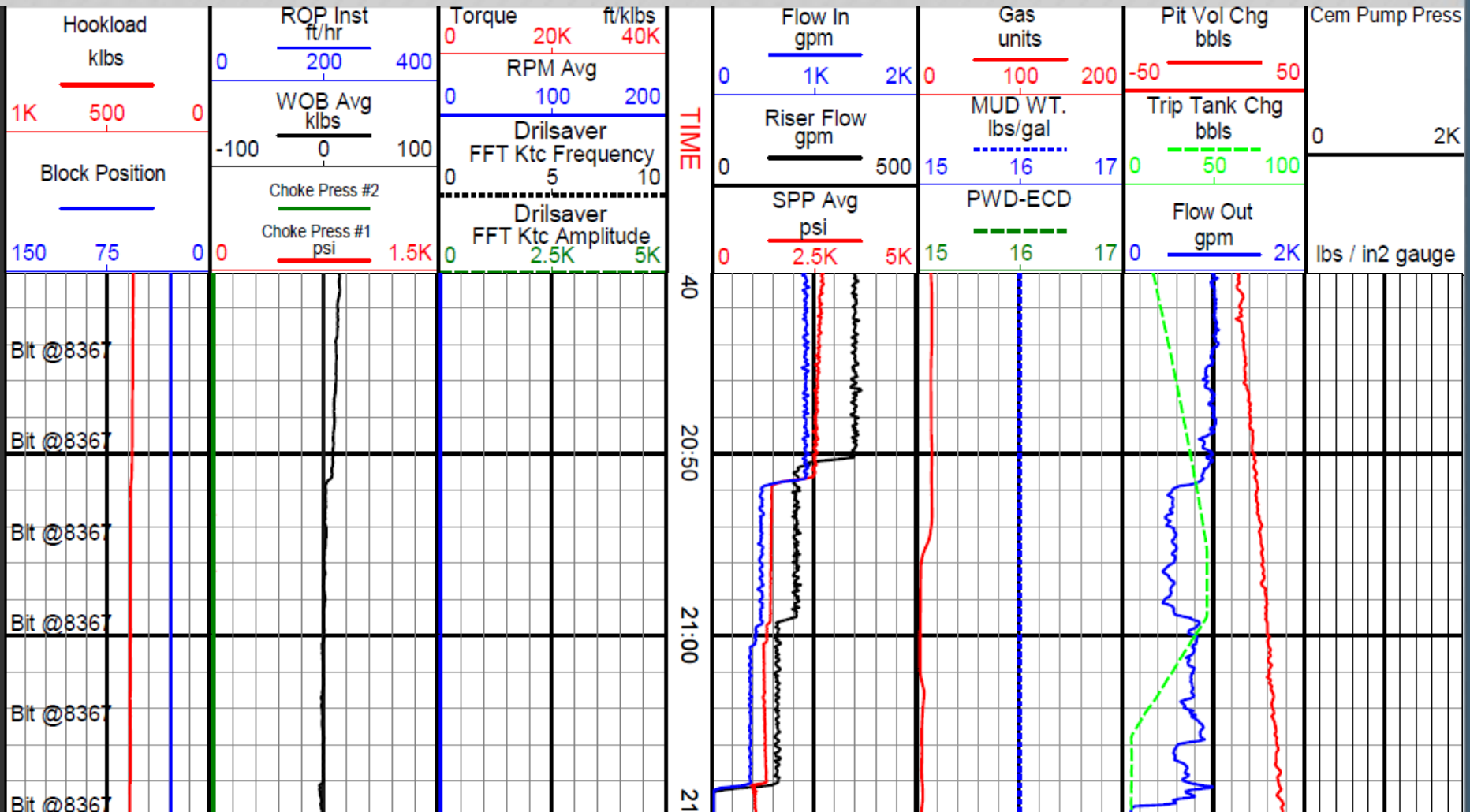


Relative position of all different fluids clearly seen – light pill (yellow color) being pumped. Light fluid in the choke and kill lines. Alarming levels for SPP (equipment) and Flow in (wellbore)



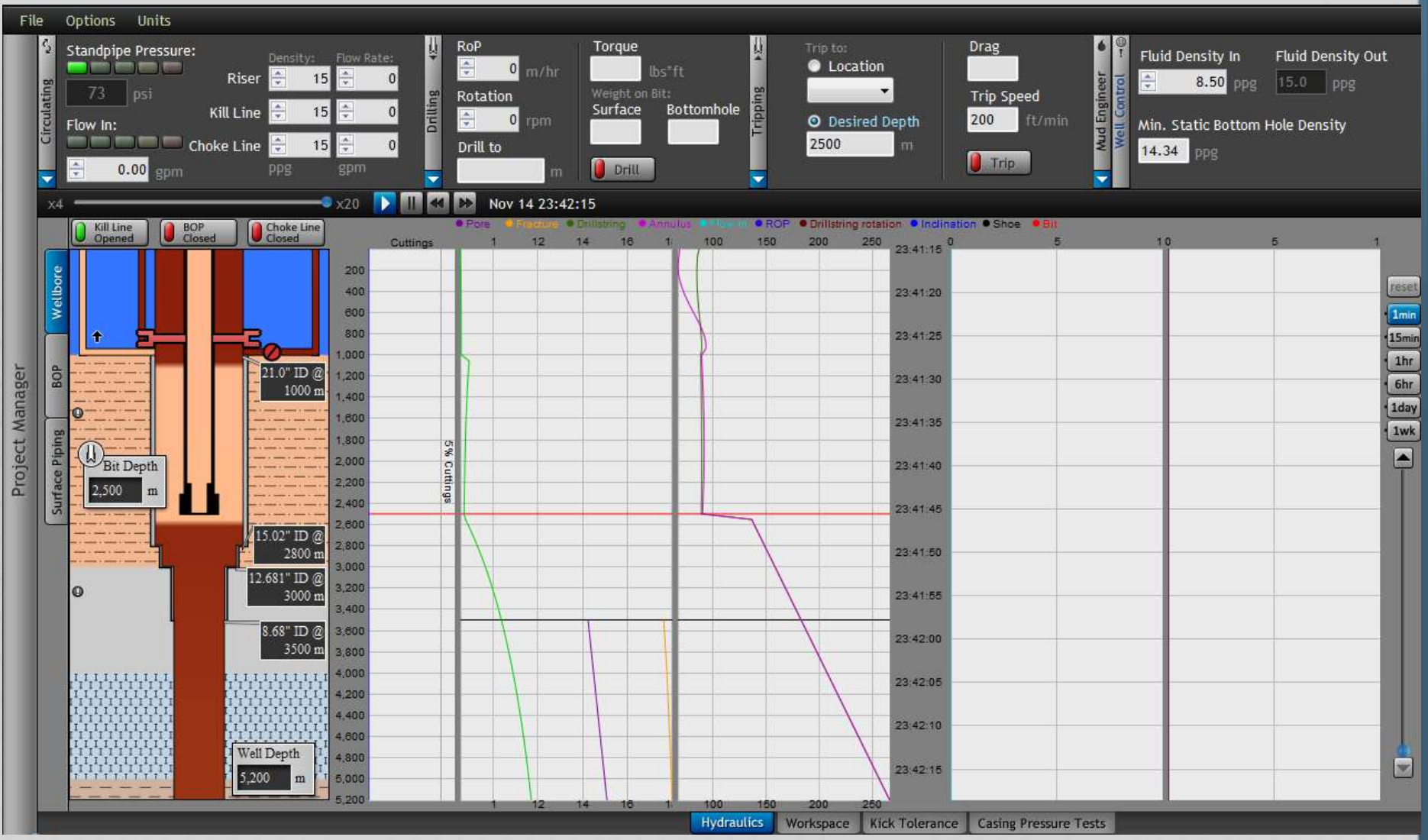
Macondo Display Before the Explosion

Can we answer those questions? Do we understand what is happening below the rig floor?



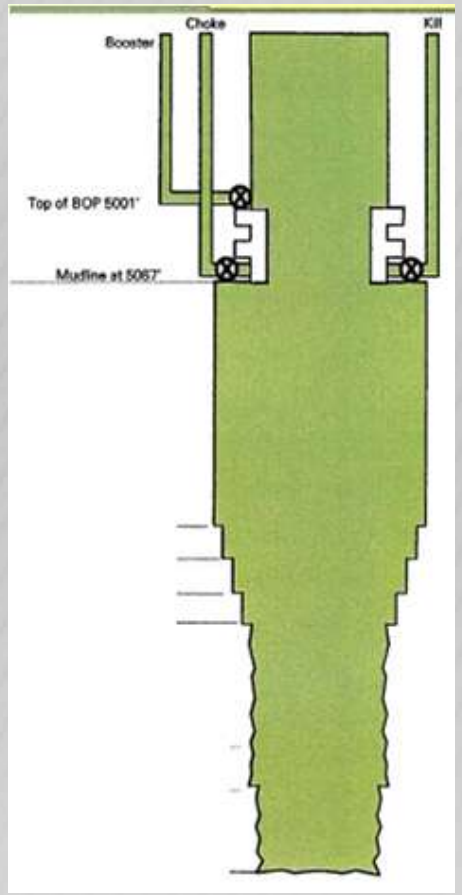
Understanding what is going on below the rig floor

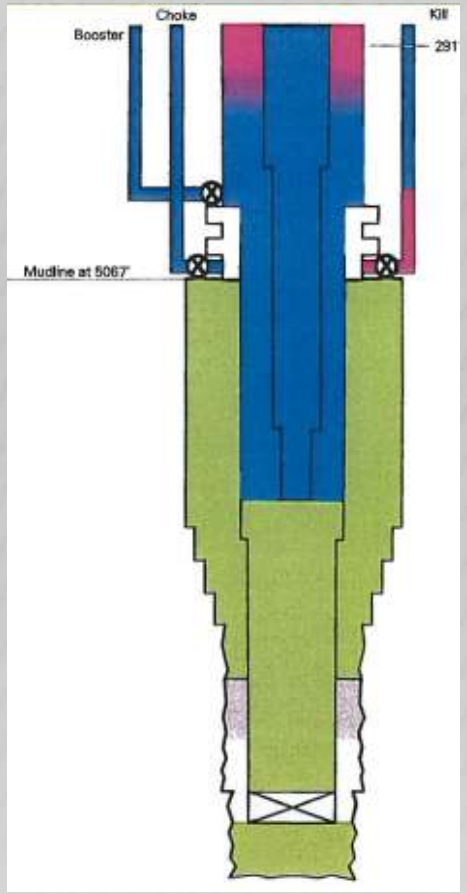
- Where is the bit? Inside the casing, open hole or riser?
- What is the well configuration? Casings, liners, shoe depths, diameters, top of cement?
- Is the BOP open or closed? Is the choke/kill line open or closed? Are they aligned to take returns from the well or to inject into the well?
- Where are and what are the fluids inside the drill string and annulus?
- What is the operation being conducted?
- What is the pore/frac pressure and pressure along the wellbore?
- Are we likely to be under or overbalanced? By how much?
- Is the well likely to be cleaned (without cuttings)?
- What are the expected conditions (pressures) in the next 3 hours?

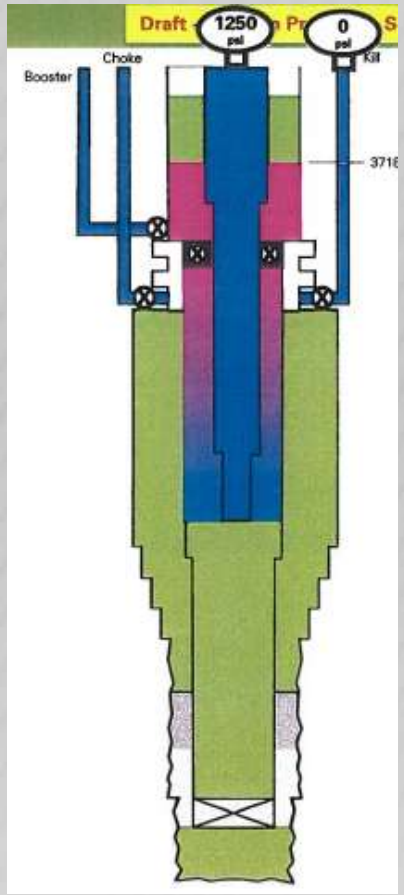

File
Options
Units
Circulating
Standpipe Pressure:
73 psi
Flow In:
0.00 gpm
Density:
Flow Rate:
Riser 15 0
Kill Line 15 0
Choke Line 15 0
ppg
gpm
Drilling
RoP
0 m/hr
Rotation
0 rpm
Drill to
m
Torque
lbs*ft
Weight on Bit:
Surface
Bottomhole
Drill
Tripping
Trip to:
Location
Desired Depth
2500 m
Drag
Trip Speed
200 ft/min
Trip
Mud Engineer
Well Control
Fluid Density In
8.50 ppg
Fluid Density Out
15.0 ppg
Min. Static Bottom Hole Density
14.34 ppg
x4
x20
Nov 14 23:42:15
Kill Line Opened
BOP Closed
Choke Line Closed
Pore
Fracture
Drillstring
Annulus
ROP
Drillstring rotation
Inclination
Shoe
Bit
Cuttings
5% Cuttings
Wellbore
BOP
Surface Piping
Project Manager
21.0" ID @ 1000 m
Bit Depth 2,500 m
15.02" ID @ 2800 m
12.681" ID @ 3000 m
8.68" ID @ 3500 m
Well Depth 5,200 m
reset
1min
15min
1hr
6hr
1day
1wk
Hydraulics
Workspace
Kick Tolerance
Casing Pressure Tests

Example of actual situation- Macondo Well

- A picture is worth thousands of words
- And an animation is worth thousands of pictures







Simulate Next Ops Steps

- To confirm feasibility
- Know in advance expected values for critical variables such as pressures
- Use “Drill the well on the simulator” capability on the rig

Quick ops note for the next few days:

1. Test casing per APD to 250 / 2500 psi
2. RIH to 8367’
3. Displace to seawater from there to above the wellhead
4. With seawater in the kill close annular and do a negative test ~2350 psi differential
5. Open annular and continue displacement
6. Set a 300’ balanced cement plug w/ 5 bbls in DP
7. POOH ~100-200’ above top of cement and drop neft ball / circulate DS volume
8. Spot corrosion inhibitor in the open hole
9. POOH to just below the wellhead or above with the 3-1/2” stinger (if desired wash with the 3-1/2” / do not rotate / a separate run will not be made to wash as the displacement will clean up the wellhead)
10. POOH and make LIT / LDS runs
11. Test casing to 1000 psi with seawater (non MMS test / BP DWOP) – surface plug
    a. Confirm bbls to pressure up on original casing test vs bbls to test surface plug (should be less due to volume differences and fluid compressibility –seawater vs sobm)
    b. Plot on chart / send to Houston for confirmation

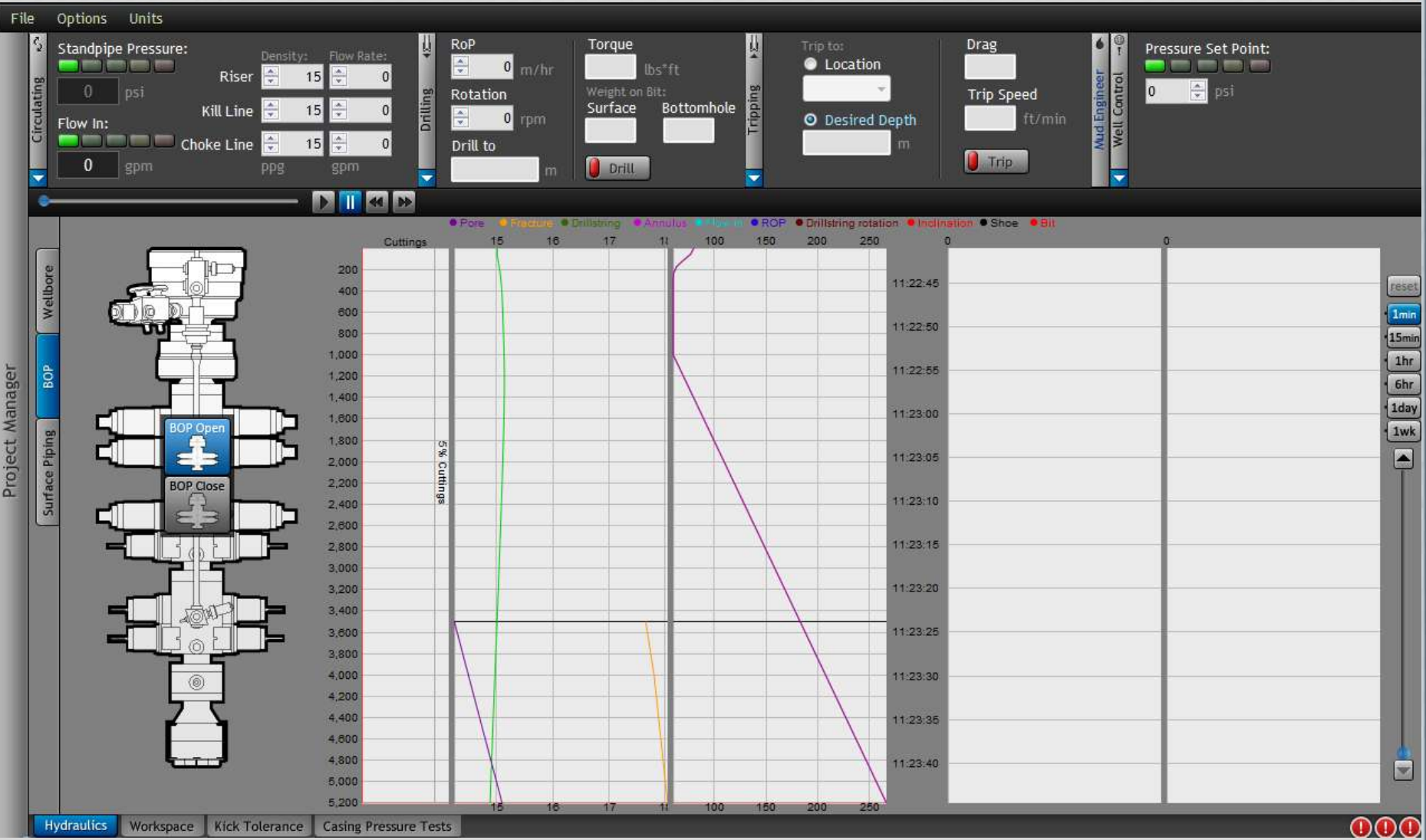
What Happens Today When an Influx is Detected?

- The BOP is closed and all sophisticated drilling data is bypassed – MWD, LWD, PWD, return flow
- Rig crew is left with pressure gauges (standpipe and casing), pit volume measurements (as accurate as they can be), manual choke, MGS without instrumentation and a BIG PROBLEM to solve
- Information is usually scattered around the rig and not easily accessible and in one place
- Rig crew does not have quick visualization of all conditions – surface and downhole – for full understanding to make correct and fast decisions

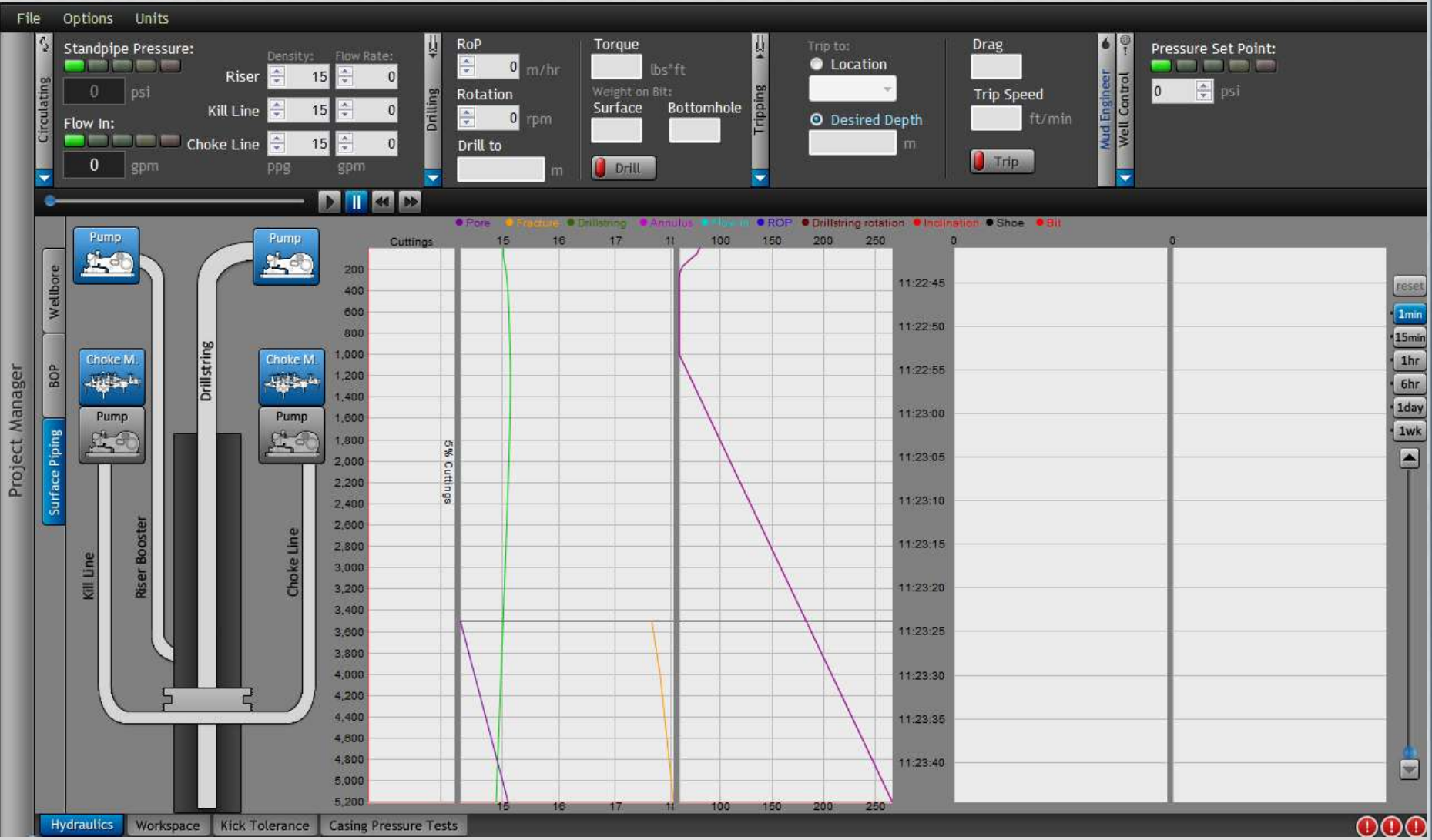
Well Control Module

- Incorporation of procedures required by Well Control Manual
  - Calculation of kick tolerance before the well is drilled to confirm acceptable values
  - Real-time kick tolerance calculation to define whether it is safe to continue drilling or dispensation is needed
- Assist rig crew with kill operation, automatic fill up of kill sheets, step by step procedures for selected kill method
- Equipment and formation testing
  - BOP, casing and leak-off test
- All information available to all, on the rig and remotely
- Reduction of potential human errors during well control
- Hands-on training and competence assessment – kick drills using rig equipment

Visualization of Well Control Equipment and Specific Data



Visualization of all surface piping in detail, including valves and choke status on lines and manifold and flow path all the way to MGS, which will have instrumentation to allow proper monitoring



BOP and Casing Test Module

- Everything recorded
  - Pressures
  - Valves and RAMS position
  - Sequence

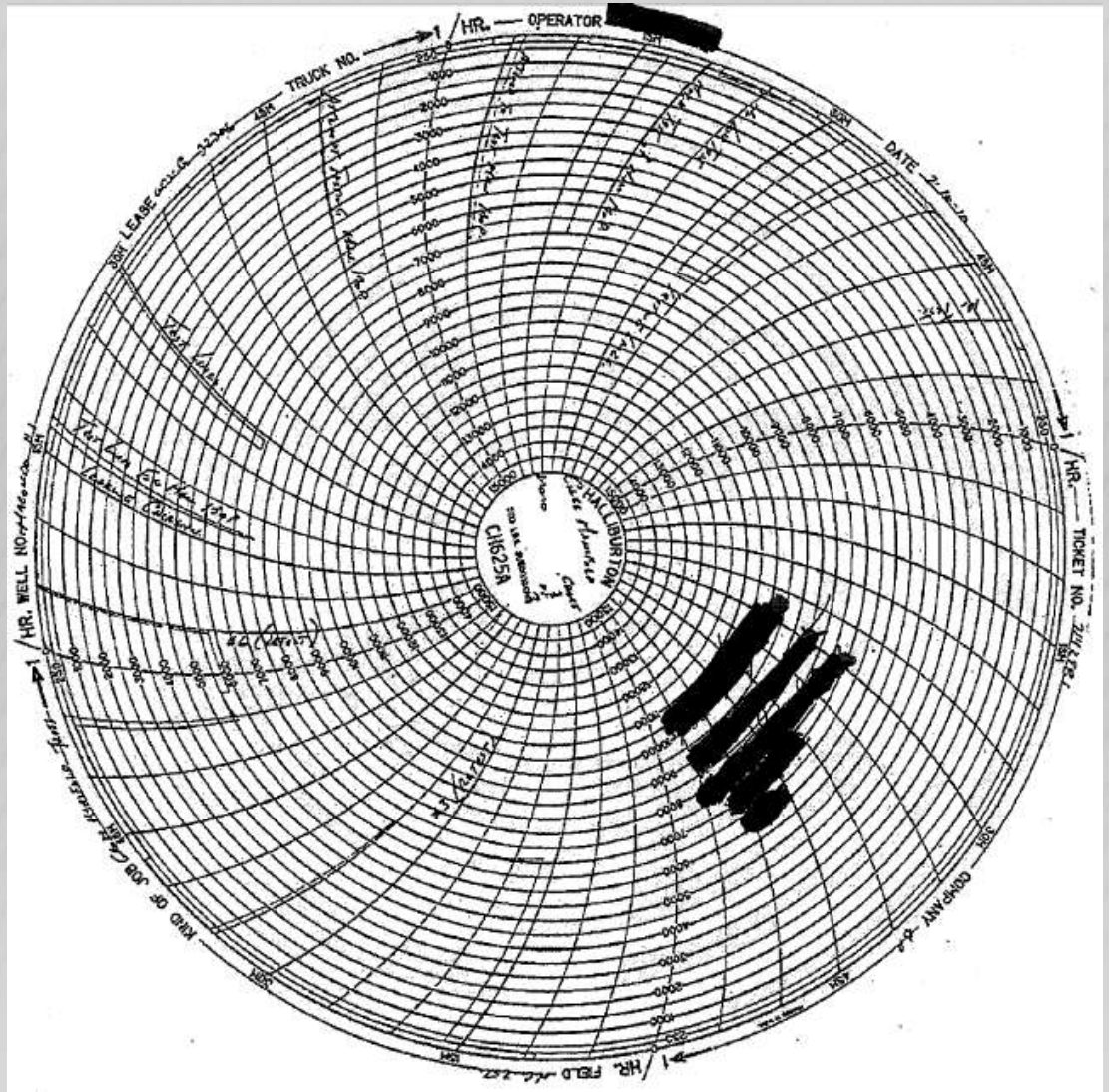
- Recommended practices and observations displayed to be followed –> standardization

Done today on paper – Again from Macondo

Pod Used Blue Panel Used **DCP**

	Time	Gallons		Low Press		High Press	
			close				
6-5/8" DP Down Kill Line							
Test 1 SEE EXPLANATION SHEET.							
Lower Annular & Inner Bleed	25	46.5	close	250	psi	3,950	psi
	20	44.5	open	5	min.	5	min.
Test 2							
Upper Annular & Outer Bleed	25	47.1	close	260	psi	5,200	psi
Kelly Hose & Standpipe V/V #11	21	42.4	open	5	min.	5	min.
Test 3 SEE EXPLANATION SHEET.							
Middle Pipe Rams, & Manifold Valve # 4	16	23.7	close	250	psi	7,150	psi
(2) 65/8" TIW				5	min.	5	min.
Test 4							
Middle Pipe Rams & Manifold Valve # 9	15	20.5	open	250	psi	7,100	psi
(1) Gray Valve				5	min.	5	min.
Test 5							
Upper Pipe Rams, UIC, LIC	16	23.6	close	270	psi.	7,100	psi.
Auto IBOP				5	min.	5	min.
Test 6							
Upper Pipe Rams, UOC, LOC	15	20.2	open	280	psi	7,150	psi
				5	min.	5	min.
			open				
6-5/8" DP Down Choke Line							
			close				
Test 7 SEE EXPLANATION SHEET.							
Lower Annular & UIK	26	46.7	close	270	psi	3,750	psi
	24	43.9	open	5	min.	5	min.
Test 8							
Upper Annular & UOK	26	47.7	close	270	psi	3,700	psi
	23	41.6	open	5	min.	5	min.
Test 9							
Middle Pipe Rams & LIK	16	22.4	close	250	psi	6,800	psi.
				5	min.	5	min

Same chart for more than 25 years



Summary – Features and Objectives of the System

- Provide quick and objective sub-surface awareness to all on the rig and remotely
- Clear visualization of the wellbore “Below the Rig Floor”
- Useful tools to help the rig crew and company man with routine operations
- Unique alarms based on equipment and wellbore limitations and discrepancies between expected and actual
- Useful interpretation and visualization of the wellbore conditions, helping to identify potential problems in the early stages
- Information easily available for everybody – on the rig (those directly involved) and remotely (when help and assistance is needed)
- For use before, during and after the operations, as well as for training

Thank You for Your Attention

Questions?

SafeKick
Empowered Solutions