

From: LeBleu, John B  
Sent: Tue May 04 18:29:49 2010  
To: Burns, Tim A  
Subject: FW: Macondo reports  
Importance: Normal  
Attachments: LeBleu annotated Macondo mud loss summary.xls; 18\_inch CSG section review.ppt;  
16\_inch CSG section review.ppt

<<...>>

**John LeBleu**

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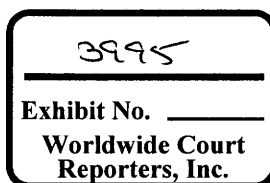
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From: Bodck, Robert  
Sent: Tuesday, May 04, 2010 8:36 AM  
To: LeBleu, John B  
Subject: Macondo reports

<<...>> <<...>>

***Bobby Bodek***

BP America Inc.  
*Geological Operations Coordinator*  
Gulf of Mexico Exploration - Tiger Team  
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Document Produced Natively



# DAILY AND TOTAL DRILLING FLUID DISCHARGES, LOSSES AND RECOVERING VOLUMES

Actual Days	Actual Depth	Date	Volume Data			O.O.C. % weight					
			MUD DISCHARGES ON SURFACE (Bbl)	DOWN HOLE MUD LOSSES (Bbl)	MUD RECOVERED (Bbl)	Daily Composite Average	O.O.C. BENCHMARK	WELL AVERAGE	Wt% Chlorides		
0	0	0					6.90		0	0	0
1	0	6-Oct-09					6.90		0	0	0
2	0	7-Oct-09					6.90		0	0	0
3	0	8-Oct-09					6.90		0	0	0
4	7,000	9-Oct-09					6.90		0	0	0
5	8,000	10-Oct-09					6.90		0	0	0
6	8,000	11-Oct-09					6.90		23	0	0
7	8,000	12-Oct-09	All of the mud loss data below comes from the Baroid and M-I SWACO mud reports.				6.90		24	0	0
8	8,000	13-Oct-09					6.90		0	0	0
9	8,000	14-Oct-09					6.90		0	0	0
10	8,000	15-Oct-09					6.90		0	0	0
11	8,000	16-Oct-09					6.90		23	0	0
12	8,000	17-Oct-09					6.90		24	0	0
13	8,000	18-Oct-09					6.90		24	0	0
14	8,000	19-Oct-09					6.90		24	0	0
15	8,000	20-Oct-09					6.90		23.00	0	0
16	8,011	21-Oct-09	Baroid losses in 22" hole section				6.90		20.00	0	0
17	8,050	22-Oct-09					6.90		19.00	0	0
18	8,050	23-Oct-09		68	Squeeze 22" shoe		6.90		19.00	68	0
19	8,050	24-Oct-09					6.90		0.00	68	0
20	8,901	25-Oct-09					6.90		0.00	68	0
21	8,970	26-Oct-09					6.90		0.00	68	0
22	9,063	27-Oct-09		23	Drilling		6.90		0.00	90	0
23	9,090	28-Oct-09					6.90		0.00	90	0
24	9,090	29-Oct-09		199	Running 18"		6.90		0.00	290	0
25	9,090	30-Oct-09		141	Cementing 18"		6.90		0.00	430	0
26	9,090	31-Oct-09							0.00	430	0
27	9,076	31-Jan-10					6.90		0.00	430	0
28	9,076	1-Feb-10					6.90		0.00	430	0
29	9,076	2-Feb-10					6.90		0.00	430	0
30	9,076	3-Feb-10					6.90		0.00	430	0
31	9,076	4-Feb-10					6.90		0.00	430	0
32	9,076	5-Feb-10					6.90		24.40	430	0
33	9,076	6-Feb-10					6.90		24.40	430	0
34	9,076	7-Feb-10					6.90		24.40	430	0
35	9,076	8-Feb-10					6.90		24.40	430	0
36	9,076	9-Feb-10					6.90		24.40	430	0
37	9,076	10-Feb-10					6.90		24.40	430	0
38	9,076	11-Feb-10					6.90		16.18	430	0
39	9,085	12-Feb-10					6.90		17.00	430	0
40	9,086	13-Feb-10					6.90		17.66	430	0

↑  
 Marianas Baroid  
 Horizon M-I SWACO  
 ↓



41	9,086	14-Feb-10			6.90	16.87	430	0
42	9,700	15-Feb-10		event near 18" shoe	6.90	16.57	430	0
43	11,605	16-Feb-10			6.90	15.30	430	0
44	12,350	17-Feb-10		121	6.90	15.55	551	0
45	12,350	18-Feb-10		3,498	6.90	17.71	4,049	0
46	12,350	19-Feb-10		1,370	6.90	18.58	5,419	0
47	12,350	20-Feb-10		699	6.90	18.15	6,118	0
48	12,350	21-Feb-10		710	6.90	18.15	6,828	0
49	12,350	22-Feb-10		169	6.90	17.71	6,997	0
50	12,350	23-Feb-10		237	6.90	16.81	7,234	0
51	12,350	24-Feb-10			6.90	16.81	7,234	0
52	12,350	25-Feb-10			6.90	16.25	7,234	0
53	12,350	26-Feb-10		running 16" Casing	6.90	15.81	7,234	0
54	12,350	27-Feb-10			6.90	16.25	7,234	0
55	12,350	28-Feb-10		45	6.90	15.98	7,279	0
56	12,350	1-Mar-10		2,714	6.90	16.53	9,993	0
57	12,350	2-Mar-10		1,007	6.90	16.25	11,000	0
58	12,350	3-Mar-10		337	6.90	15.90	11,337	0
59	12,350	4-Mar-10		338	6.90	15.90	11,675	0
60	12,350	5-Mar-10		255	6.90	15.90	11,930	0
61	12,350	6-Mar-10			6.90	15.24	11,930	0
62	12,350	7-Mar-10			6.90	16.11	11,930	0
63	13,305	8-Mar-10			6.90	14.02	11,930	0
64	13,305	9-Mar-10			6.90	14.50	11,930	0
65	13,305	10-Mar-10			6.90	14.50	11,930	0
66	13,305	11-Mar-10			6.90	14.97	11,930	0
67	13,305	12-Mar-10		Sidetrack left 411 in hole not counted as losses	6.90	15.44	11,930	0
68	13,305	13-Mar-10			6.90	15.44	11,930	0
69	13,305	14-Mar-10			6.90	16.00	11,930	0
70	13,305	15-Mar-10			6.90	15.17	11,930	0
71	13,305	16-Mar-10			6.90	16.08	11,930	0
72	11692	17-Mar-10			6.90	14.71	11,930	0
73	12906	18-Mar-10			6.90	15.44	11,930	0
74	13150	19-Mar-10			6.90	16.95	11,930	0
75	13150	20-Mar-10			6.90	16.95	11,930	0
76	13150	21-Mar-10		76	6.90	16.95	12,006	0
77	13509	22-Mar-10		Cementing 13.625"	6.90	16.19	12,006	0
78	14851	23-Mar-10			6.90	15.81	12,006	0
79	15113	24-Mar-10			6.90	16.61	12,006	0
80	15113	25-Mar-10		307	6.90	16.61	12,313	0
81	15113	26-Mar-10		Circulating and cementing 11.875"	6.90	17.10	12,313	0
82	15113	27-Mar-10			6.90	15.61	12,313	0
83	16194	28-Mar-10			6.90	17.10	12,313	0
84	17172	29-Mar-10			6.90	17.77	12,313	0
85	17173	30-Mar-10		Running circulating and cementing 9.875" liner	6.90	18.49	12,313	0
86	17173	31-Mar-10		342	6.90	18.49	12,655	0
87	17173	1-Apr-10			6.90	17.97	12,655	0
88	17647	2-Apr-10			6.90	17.44	12,655	0
89	17899	3-Apr-10		214	6.90	17.44	12,869	0
90	18260	4-Apr-10		639	6.90	17.44	13,508	0
91	18260	5-Apr-10		1,263	6.90	17.64	14,771	0
92	18260	6-Apr-10		1,104	6.90	16.91	15,875	0
93	18260	7-Apr-10			6.90	16.91	15,875	0
94	18260	8-Apr-10			6.90	16.36	15,875	Total mud lost according to

95	18360	9-Apr-10		51	Drilled last 100' to 18360'	6.90	16.91	15,926	Total mud lost according to Baroid and M-I SWACO mud reports.
96	18360	10-Apr-10				6.90	16.91	15,926	
97	18360	11-Apr-10				6.90	16.91	15,926	
98	18360	12-Apr-10	No mud lost running, circulating or cementing production casing.			6.90	16.91	15,926	
99	18360	13-Apr-10				6.90	16.91	15,926	0
100	18360	14-Apr-10				6.90	16.91	15,926	0
101	18360	15-Apr-10				6.90	16.36	15,926	0
102	18360	16-Apr-10				6.90	16.56	15,926	0
103	18360	17-Apr-10				6.90	16.56	15,926	0
104	18360	18-Apr-10				6.90	16.56	15,926	0
105	18360	19-Apr-10				6.90	17.09	15,926	0
106	18360	20-Apr-10				6.90	0.00	15,926	0





## MC 252 #1 (Macondo)

18 $\frac{1}{8}$ " x 22" hole-section review (18" CSG section)

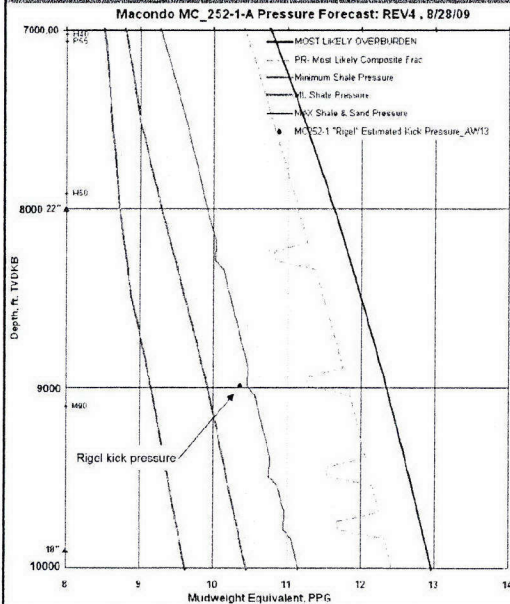
Drilling operations: 10/21/09 – 10/28/09

## Key topics:



- PP/FG forecast
- Low leak-off test at 22" casing shoe
- Drilling 18 $\frac{1}{8}$ " x 22" hole with narrow drilling window
- Well control event (kick) at 8,970' (MD/TVD)
- Decision to drill ahead past kick interval to TD hole section in shale

# PP/FG prospectus



Question: what is the most probabilistic trend of pore-pressure increase with depth in the 18 $\frac{1}{2}$  x 22" hole-section?

Strongly attune to seismic velocities as exhibited in the Isabella well? (most-likely scenario) \_\_\_\_\_

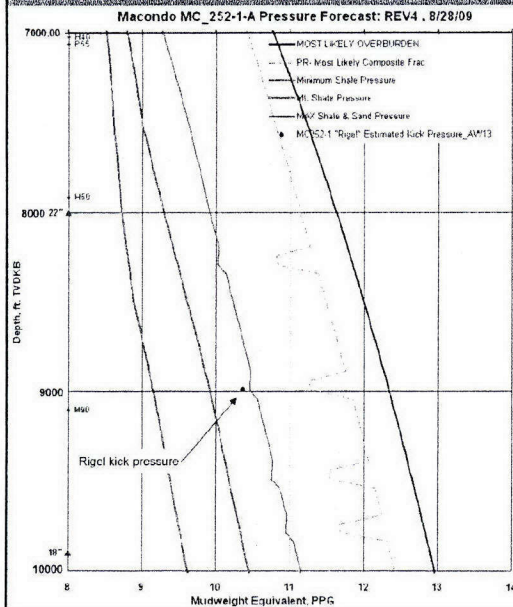
-or-

Similar to the maximum predicted pore-pressure as modeled from the Yumuri well, and corroborated by the kick pressure in the offset Rigel well? (maximum pore-pressure scenario) \_\_\_\_\_

-or-

Something intermediate to these two suggested end members

# PP/FC prospectus



A stuck pipe incident in the offset Rigel exploratory well (also in MC block #252) was determined to have been the result of a kick:

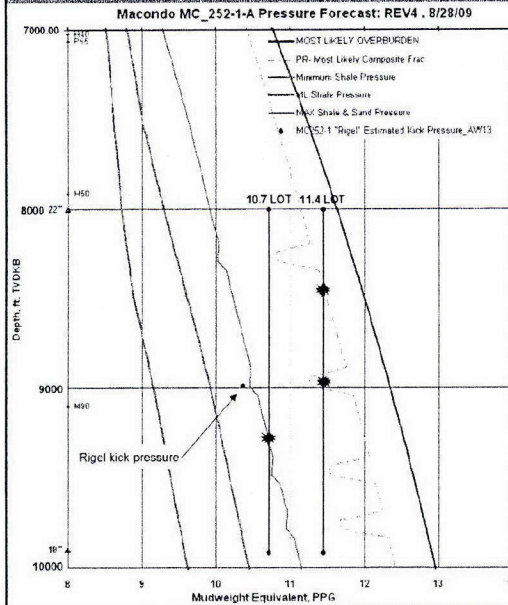
The kick event took place in the Rigel well in a sand at 9,038' (MD) / 9,018' (TVD).

Subsequent MDT pressure tests in this sand suggest sand pore-pressure at 9,018' (TVD) to be 10.26ppg MW equiv.

Structurally adjusted from Rigel, the estimated pore-pressure at ~8,970' TVD at the Macondo location was estimated to be approximately 10.20ppg.

This figure closely corresponds to the maximum sand/shale pore-pressure pre-drill estimate.

**Desired leak-off test value:  
(Downhole mudweight equivalent)**



Assuming the well will follow the most-likely pressure forecast, the estimated pore-pressure at the targeted 9,900' hole-section TD will be approximately 10.4ppg.

A 10.7 ppg LOT value would provide for 0.3ppg margin at 9,900'

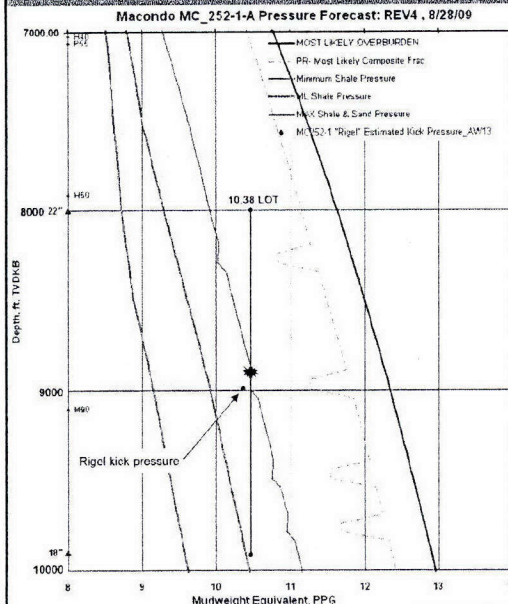
Honoring the kick pressure point from the Rigel well, however, would suggest that the well could closely follow the maximum sand/shale pressure forecast.

Under this circumstance, the pore-pressure at the 18" casing point would be approximately 11.1ppg.

A 0.3ppg margin at projected TD (11.4ppg total) would exceed the composite fracture gradient at the 22" casing shoe, and the sand fracture envelope of any potential shallow sand intervals.



## Leak-off test(s)



An undesirably low leak-off test severely hindered efforts towards achieving a 18" casing point depth near 9,900' (TVD). Weak formation/sand at 22" CSG shoe?

Performed 8 leak-off tests at 22" CSG shoe:

- 5 tests pumping down various combinations of choke/kill lines/drillpipe against annulars/pipe rams
- 1 after spotting an LCM pill on bottom
- 1 after reducing surface mudweight
- 1 after a cement/LCM slurry squeeze

### Results – (reported in downhole MW equivalent):

Minimum LOT: 10.33ppg

Maximum LOT: 10.47ppg

Mean LOT: 10.38ppg

### Scenarios:

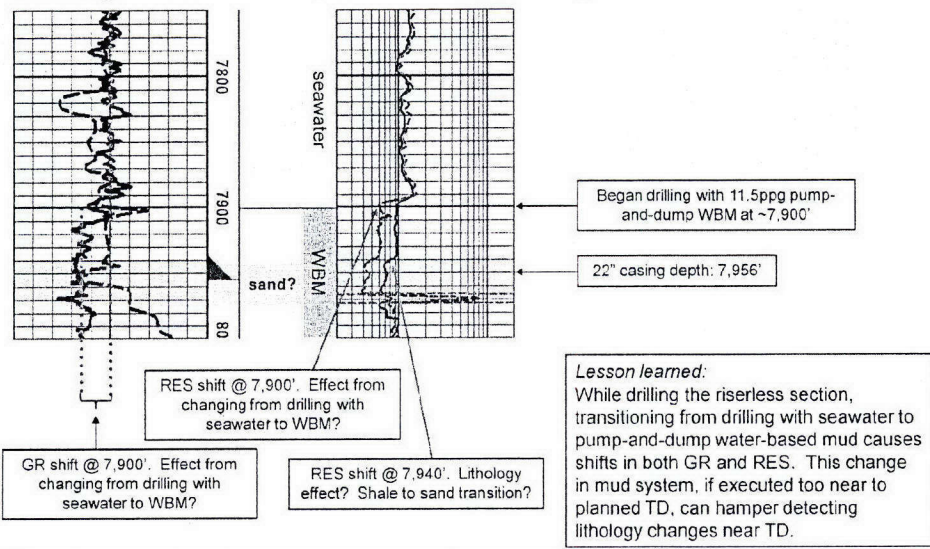
If well trended along the most likely pore-pressure gradient: Make it to projected 18" CSG section TD with little, if any, margin.

If well trended along the maximum sand/shale pressure gradient: Could become underbalanced around 9,000' (TVD). Potential wellbore influx or wellbore stability issues

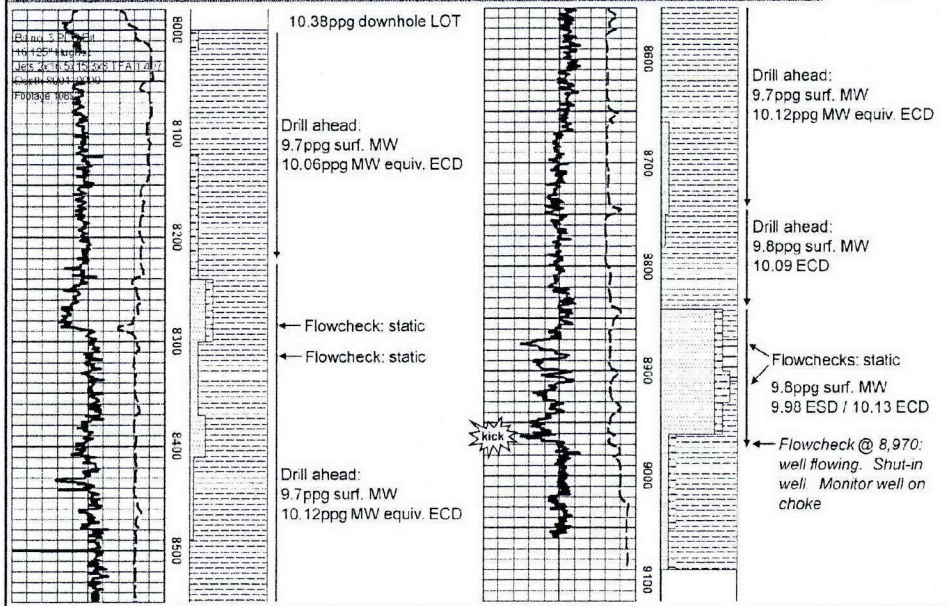
## Low leak-off test @ 22" shoe



It is thought that a sand is exposed near the 22" casing shoe.

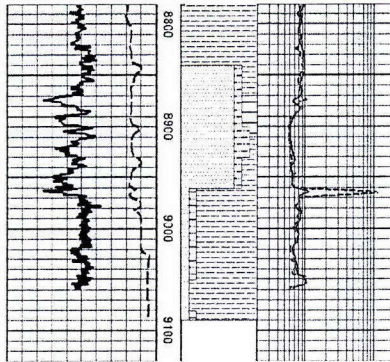


# Drilling 18 1/8" x 22" hole with narrow drilling window





## Well control event (kick) at 8,970' (MD/TVD)

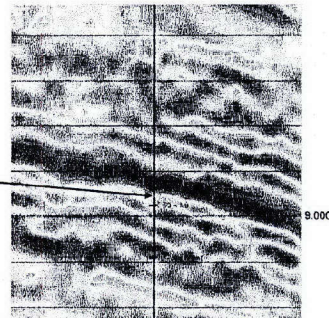


### Parameters:

Surface mudweight:	9.8ppg
ESD:	9.90ppg MW equiv.
Hydrostatic:	4651psi
ECD:	10.13 ppg MW equiv.
Dynamic:	4720psi
Shut-in DP pressure:	120psi
Casing pressure:	90psi
Kick pressure:	4729psi
Kick pressure:	10.15 ppg MW equiv.
Underbalance (static):	78psi
Underbalance (dyn):	9psi
Kick volume:	11bbls

### Well control operations:

- Shut-in and monitor well on the choke
  - 120psi drill pipe / 90psi casing pressure
  - Worked pipe every 15 minutes
- Increased surface MW to 9.9ppg and circulate 9.9ppg
- MW around on choke
  - Still detected drill pipe and casing pressure
- Displaced choke lines to 10.2ppg MW and open well
  - well static
- Displace riser to 10.1ppg MW; displace well to 10.0+ppg MW
  - well static

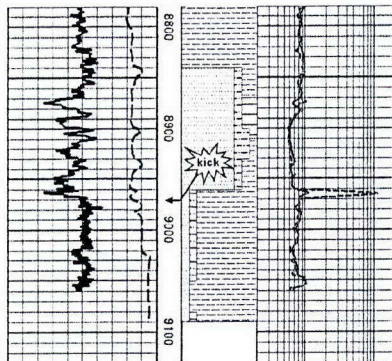


## Decision to drill ahead



- \* The team was faced with the decision on whether to drill ahead past the interval that caused the well control event.
  - *Stop and set casing at current depth:*
    - Risks: likely get a poor leak-off test at 18" shoe. Bring into play the 11 3/4" contingency liner, and perhaps an expandable liner. Potentially sacrifice hole-diameter in the reservoir interval
    - Reward: Avoid another, potentially uncontrollable, well control event. Stick BHA – sidetrack. Lose well.
  - *Drill ahead approximately 100' in order to set 18" casing shoe below problematic sand interval:*
    - Risks: drill into another overpressured sand package that would initiate a potentially uncontrollable well control event. Stick BHA. Lose well.
    - Reward: Drill ahead past problematic interval making it possible to isolate this interval behind 18" casing. Achieve adequate leak-off test pending hole-section TD is in a shale, and get "back on track" regarding planned casing point depths.
- \* Team decision: drill ahead approximately 100' to get 18" CSG shoe in a shale

## Drill ahead past kick interval:



- Drilled ahead with 10.1ppg MW.
- Flowcheck at 9,064 – static
  - ESD: 10.26ppg equiv. MW
  - ECD: 10.34ppg equiv. MW
- Minimum leak-off observed was 10.33
  - Reduce MW to 10.0+ppg
  - ECD: 10.30ppg equiv. MW
- Drill ahead 9,064' to 9,090' (MD/TVD)
- TD

- Decision was made to drill ahead approximately 100'.
- 22" underreamer was approximately 100' behind the bit.
- Drilling 100'+ would ensure that the underreamer is sufficiently past the kick interval at 8,970'.
- This would enable the 18" casing shoe to be set below the problematic interval at 8,970'.
- The 18" casing section was drilled to a TD of 9,090' (MD/TVD) without further incident.
  - Increased MW to 10.1+ppg for trip out
  - Spot 16.0ppg pad mud in pilot hole.
  - POOH for casing
- 18" casing shoe was set at 8,983' (MD/TVD)

GR/RES and cuttings suggest that 18" casing shoe and hole-section TD are both in shale. Noted to be slightly marly at TD





## MC 252 #1 (Macondo):

18 $\frac{1}{8}$ " x 22" hole-section review (18" CSG section)

Drilling operations: 10/21/09 – 10/28/09

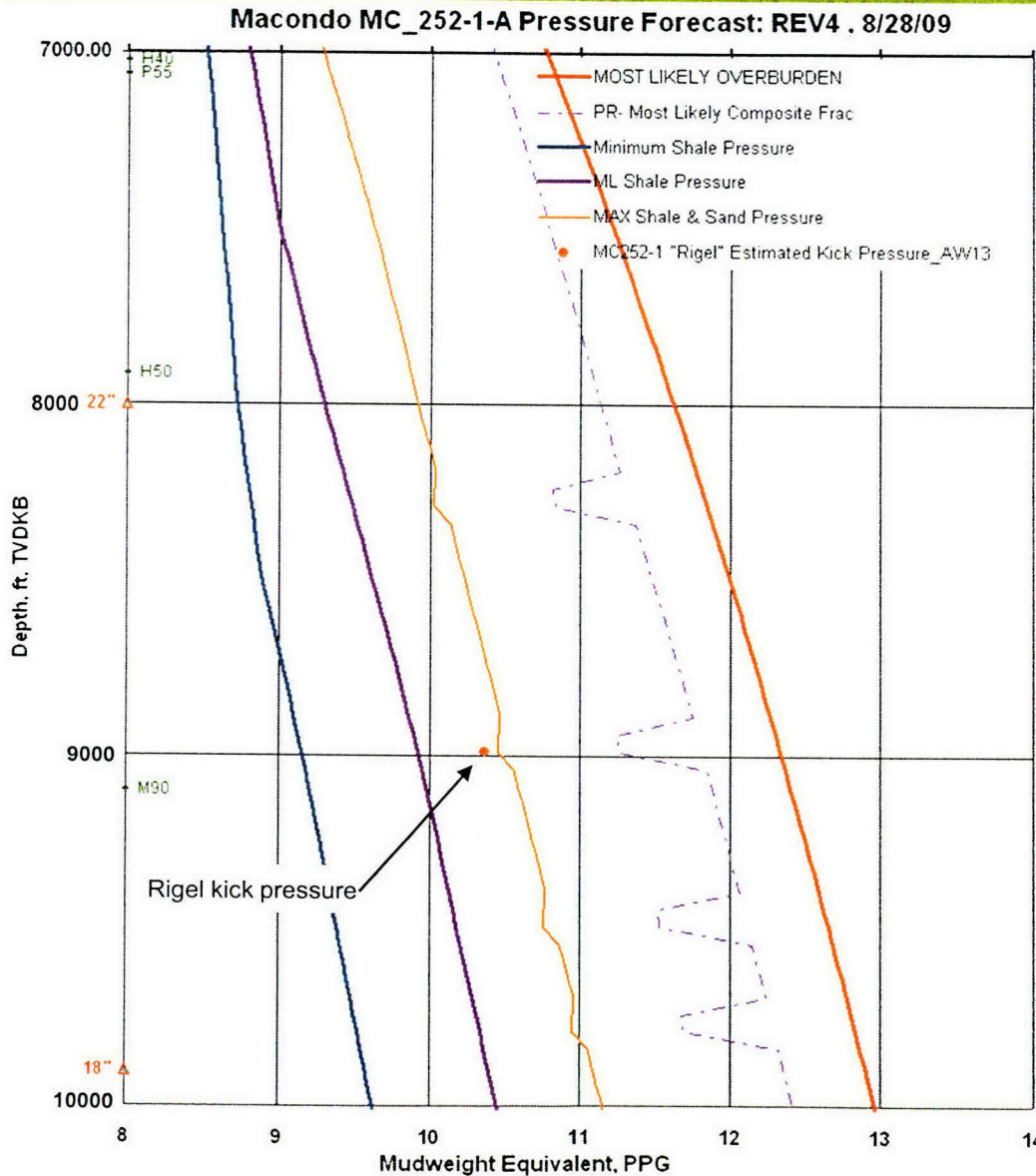
## Key topics:



- PP/FG forecast
- Low leak-off test at 22" casing shoe
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# PP/FG prospectus:



*Question: what is the most probabilistic trend of pore-pressure increase with depth in the 18 $\frac{1}{8}$  x 22" hole-section?*

Strongly attune to seismic velocities as exhibited in the Isabella well? (most-likely scenario) \_\_\_\_\_

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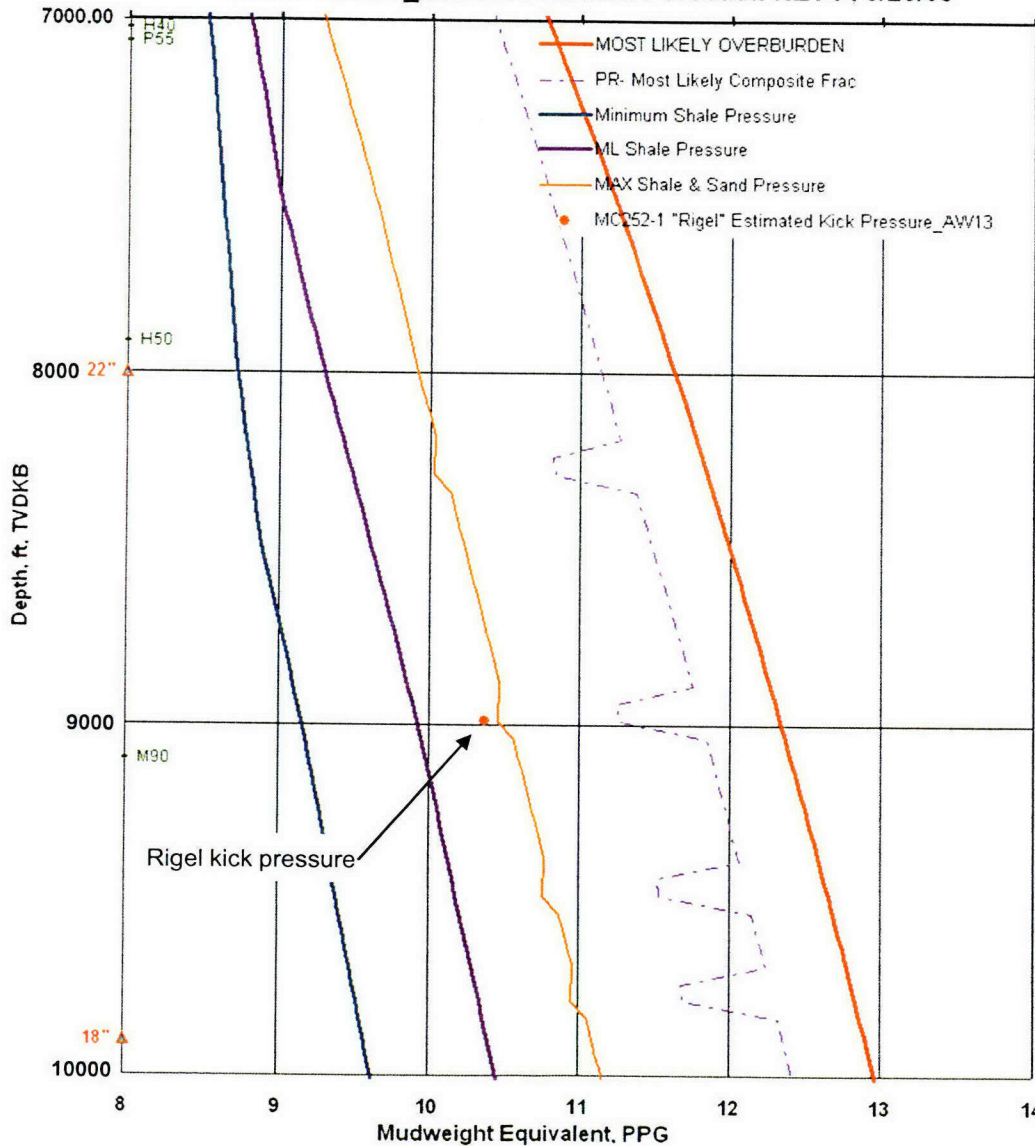
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# PP/FG prospectus:



Macondo MC\_252-1-A Pressure Forecast: REV4 . 8/28/09



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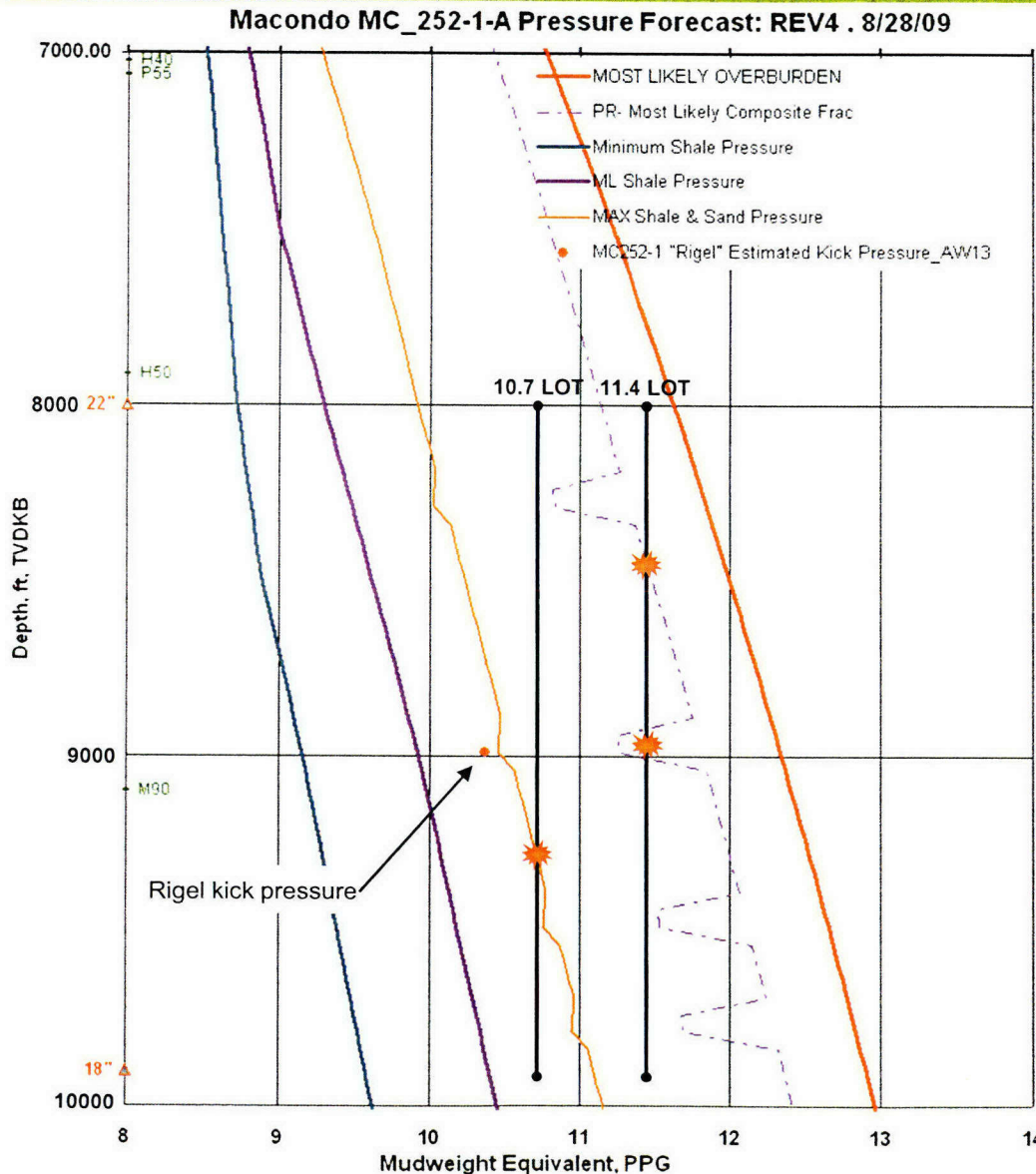
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This figure closely corresponds to the maximum sand/shale pore-pressure pre-drill estimate.



# Desired leak-off test value: (Downhole mudweight equivalent)



Assuming the well will follow the most-likely pressure forecast, the estimated pore-pressure at the targeted 9,900' hole-section TD will be approximately 10.4ppg.

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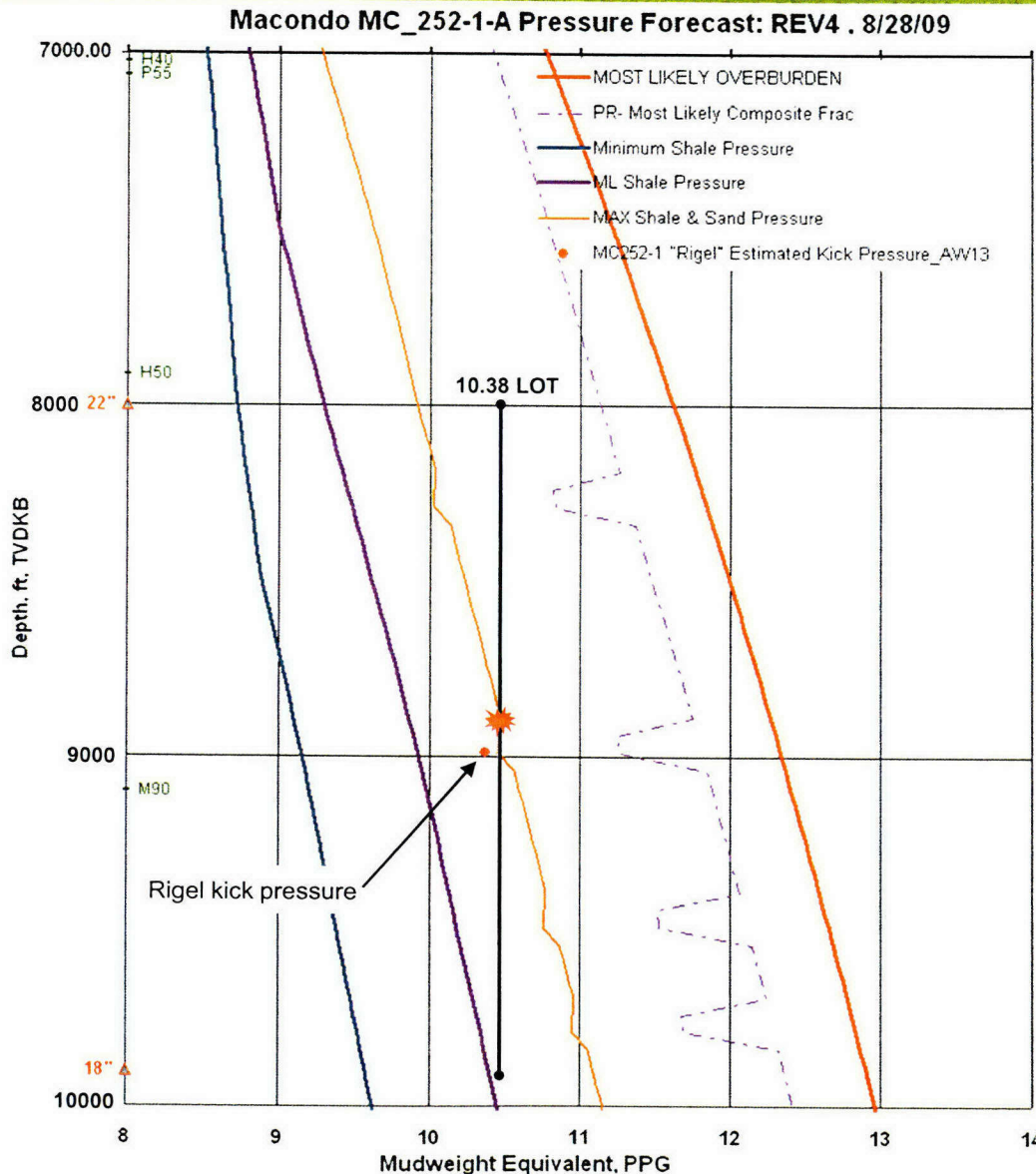
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Under this circumstance, the pore-pressure at the 18" casing point would be approximately 11.1ppg.

A 0.3ppg margin at projected TD (11.4ppg total) would exceed the composite fracture gradient at the 22" casing shoe, and the sand fracture envelope of any potential shallow sand intervals.



# Leak-off test(s):



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Performed 8 leak-off tests at 22" CSG shoe:

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If well trended along the most likely pore-pressure gradient: Make it to projected 18" CSG section TD with little, if any, margin.

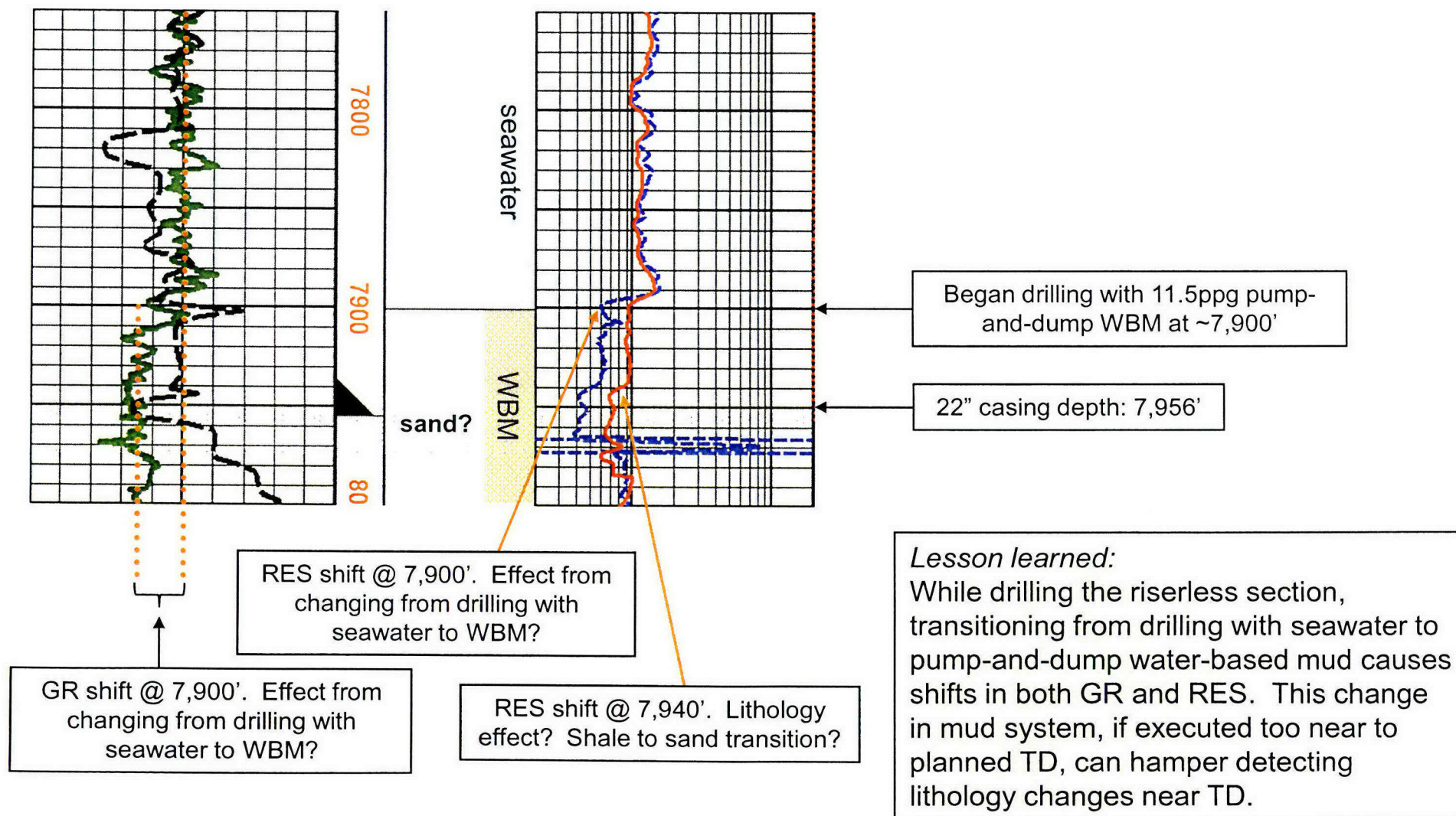
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# Low leak-off test @ 22" shoe

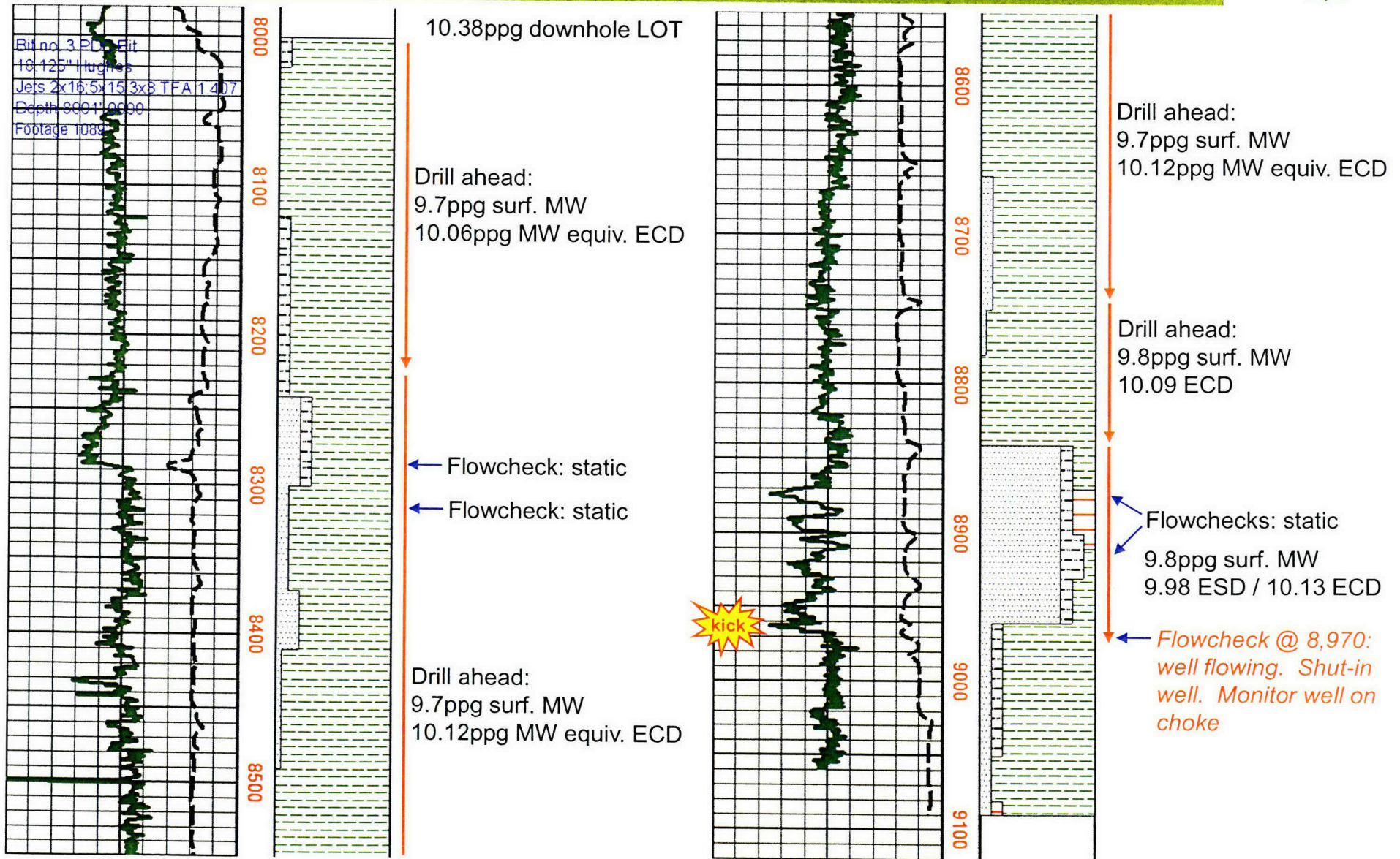


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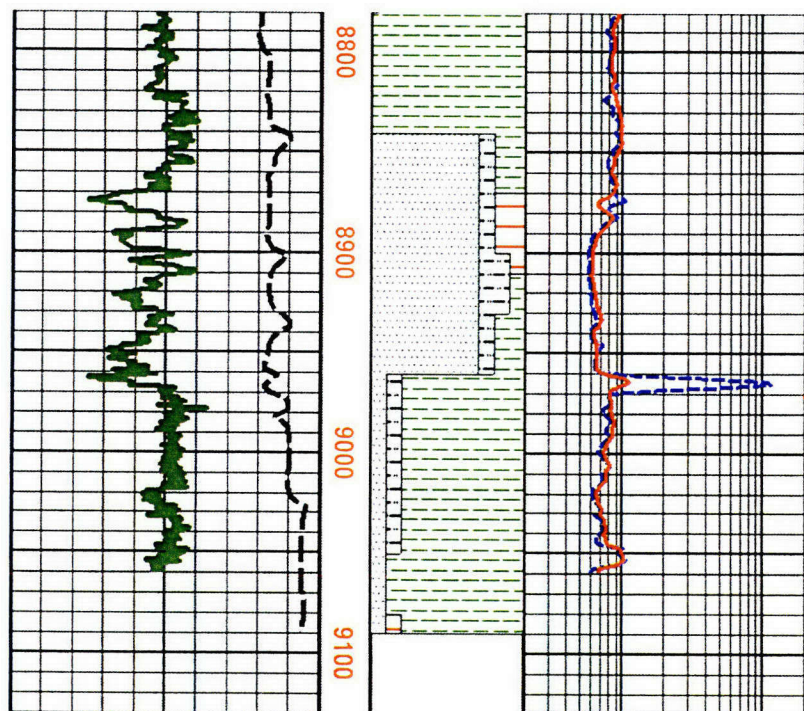


# Drilling 18 $\frac{1}{8}$ " x 22" hole with narrow drilling window





# Well control event (kick) at 8,970' (MD/TVD)

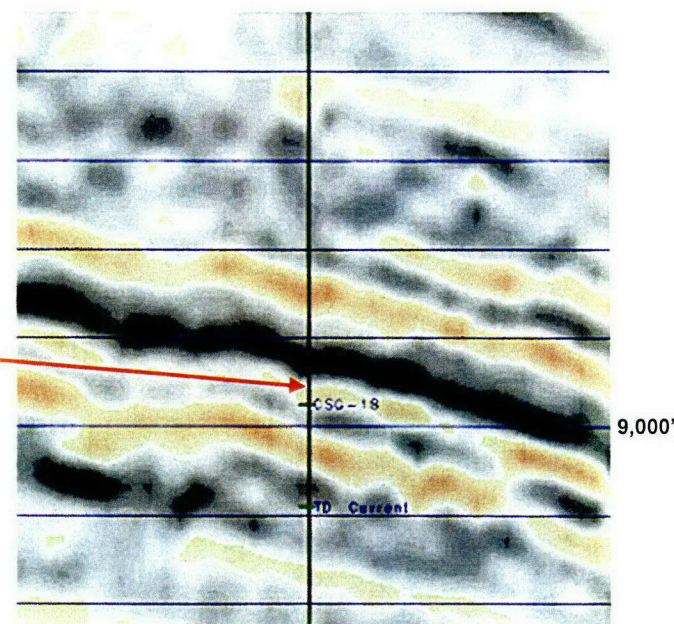


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Kick volume:	11bbls

## Well control operations:

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  - 120psi drill pipe / 90psi casing pressure
  - Worked pipe every 15 minutes
- Increased surface MW to 9.9ppg and circulate 9.9ppg
- MW around on choke
  - Still detected drill pipe and casing pressure
- Displaced choke lines to 10.2ppg MW and open well
  - well static
- Displace riser to 10.1ppg MW; displace well to 10.0+ppg MW
  - well static





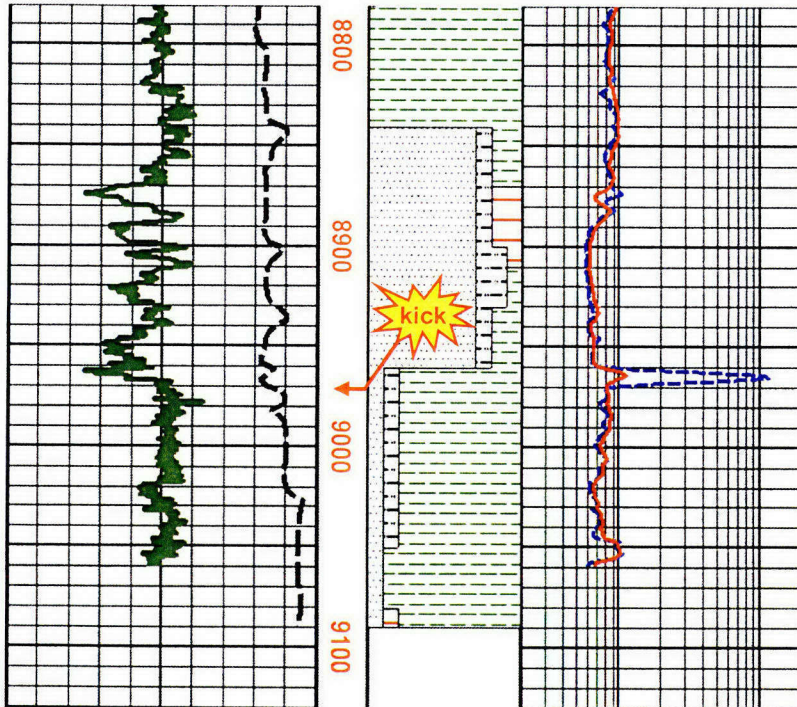


## Decision to drill ahead:

- The team was faced with the decision on whether to drill ahead past the interval that caused the well control event.
  - *Stop and set casing at current depth:*
    - Risks: likely get a poor leak-off test at 18" shoe. Bring into play the 11 ¾" contingency liner, and perhaps an expandable liner. Potentially sacrifice hole-diameter in the reservoir interval
    - Reward: Avoid another, potentially uncontrollable, well control event. Stick BHA – sidetrack. Lose well.
  - *Drill ahead approximately 100' in order to set 18" casing shoe below problematic sand interval:*
    - Risks: drill into another overpressured sand package that would initiate a potentially uncontrollable well control event. Stick BHA. Lose well.
    - Reward: Drill ahead past problematic interval making it possible to isolate this interval behind 18" casing. Achieve adequate leak-off test pending hole-section TD is in a shale, and get "back on track" regarding planned casing point depths.
- Team decision: drill ahead approximately 100' to get 18" CSG shoe in a shale



# Drill ahead past kick interval:



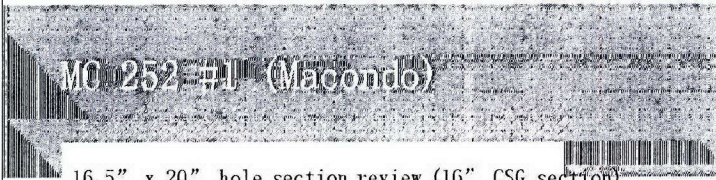
- Drilled ahead with 10.1ppg MW.
- Flowcheck at 9,064 – static
  - ESD: 10.26ppg equiv. MW
  - ECD: 10.34ppg equiv. MW
- *Minimum* leak-off observed was 10.33
  - Reduce MW to 10.0+ppg
  - ECD: 10.30ppg equiv. MW
- Drill ahead 9,064' to 9,090' (MD/TVD)
  - TD

- Decision was made to drill ahead approximately 100'.
  - 22" underreamer was approximately 100' behind the bit.
- Drilling 100'+ would ensure that the underreamer is sufficiently past the kick interval at 8,970'.
  - This would enable the 18" casing shoe to be set below the problematic interval at 8,970'
- The 18" casing section was drilled to a TD of 9,090' (MD/TVD) without further incident.
  - Increased MW to 10.1+ppg for trip out
  - Spot 16.0ppg pad mud in pilot hole.
  - POOH for casing
- 18" casing shoe was set at 8,983' (MD/TVD)

GR/RES and cuttings suggest that 18" casing shoe and hole-section TD are both in shale. Noted to be slightly marly at TD



**Macondo**  
MC 252 #1



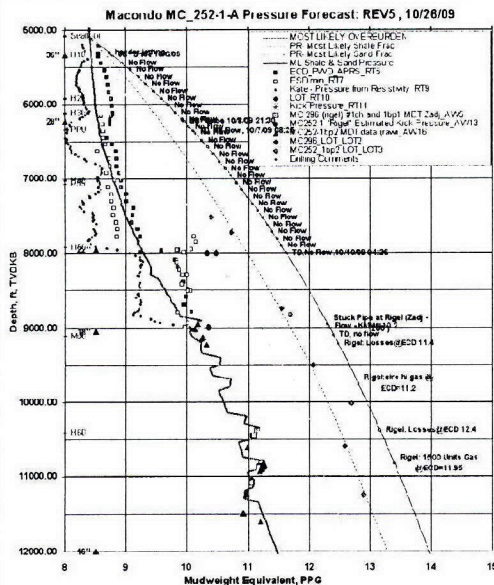
16.5" x 20" hole section review (16" CSG section)

## Outline



- Pre-drill PP/FG model
- Leak-off test at 18" casing shoe
- While drilling
- 16" casing point decision
- Lost circulation event
- Lesson learned





Over 70 bcf gas production from a completed "Rigel" interval. Possible depletion around 10,700' - 10,800' in the Macondo well.

## Leak-off test attempts 1-4



- Attempting a leak-off test at the 18" casing shoe was met with some difficulty.
  - The first two leak off attempts were performed against the upper annular. While pressuring up the system, observed returns to the trip tank
  - The third attempt packed-off
  - The fourth attempt was performed against the pipe rams. Similar to the first two attempts, gains were noted in the trip tank
- It was concluded that a hole or washout must be present in the drill pipe. Mud was being expelled to the annulus from the drill string, and displaced to the trip tank via the return line.
- Tripped to inspect drill pipe.

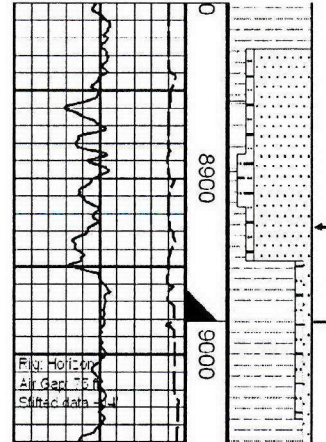
4



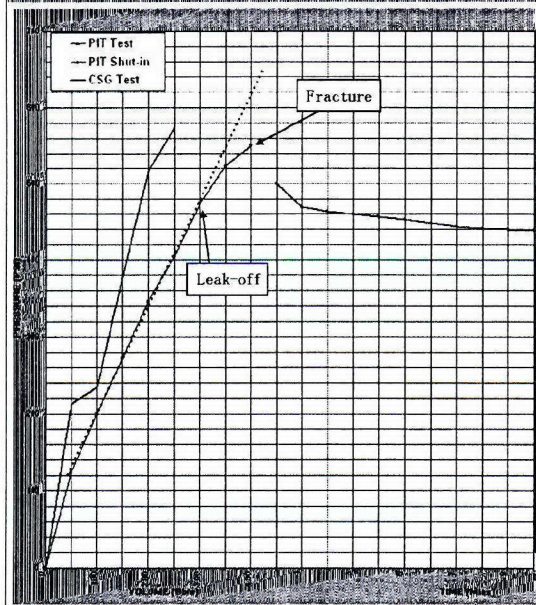
\* After tripping to inspect/re-make the BHA, a 5<sup>th</sup> leak off test was attempted.

- Pumped up a 10.84ppg ESD
- Maximum observed pressure during leak-off test: 317psi (11.2ppg MW equiv.)
- It was thought that we were pumping into the overlying sand interval from 8,860' - 8,950' via a leaky 18" casing shoe. Estimated FG in this sand (11.2 - 11.3ppg downhole equiv.) closely corresponds to the maximum pressure observed in LOT #5.

\* Decision was made to perform a cement squeeze on the 18" casing shoe.



# 18" Leak-off test #6



Subsequent to a cement squeeze. A desirable leak-off value was achieved on the 6<sup>th</sup> attempt:

Mud weight (surface): 10.6ppg SOBM  
Mud weight (downhole) [FWD]: 10.70ppg  
18" Casing shoe depth: 8,972' (TVD)

## Pre-drill estimated fracture:

Sand: 11.3ppg downhole  
Shale: 11.8ppg downhole

## LOT:

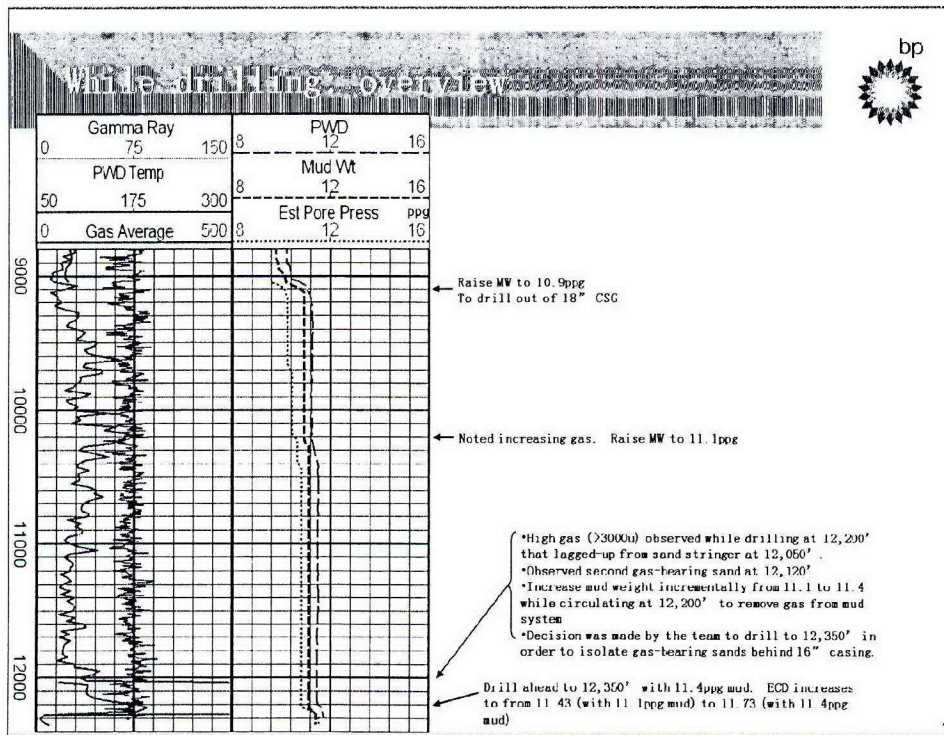
Surface pressure (leak off): 475psi  
Maximum surface pressure (fracture): 550psi

Surface leak off - 11.62ppg  
Downhole leak off - 11.72ppg MW equiv.

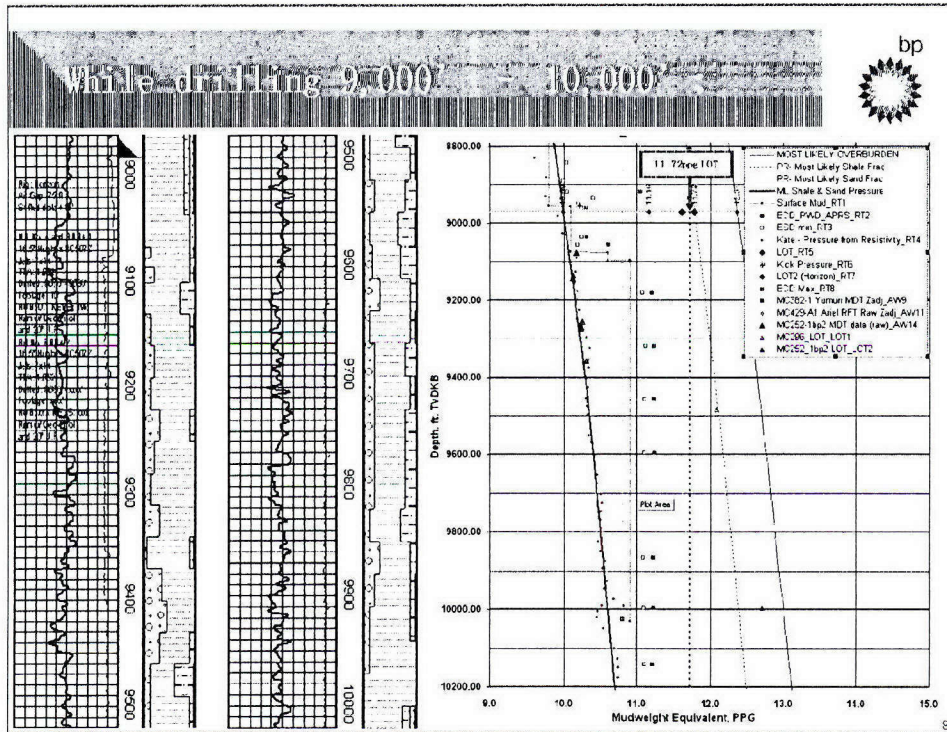
Surface fracture - 11.78ppg (Report to MMS)

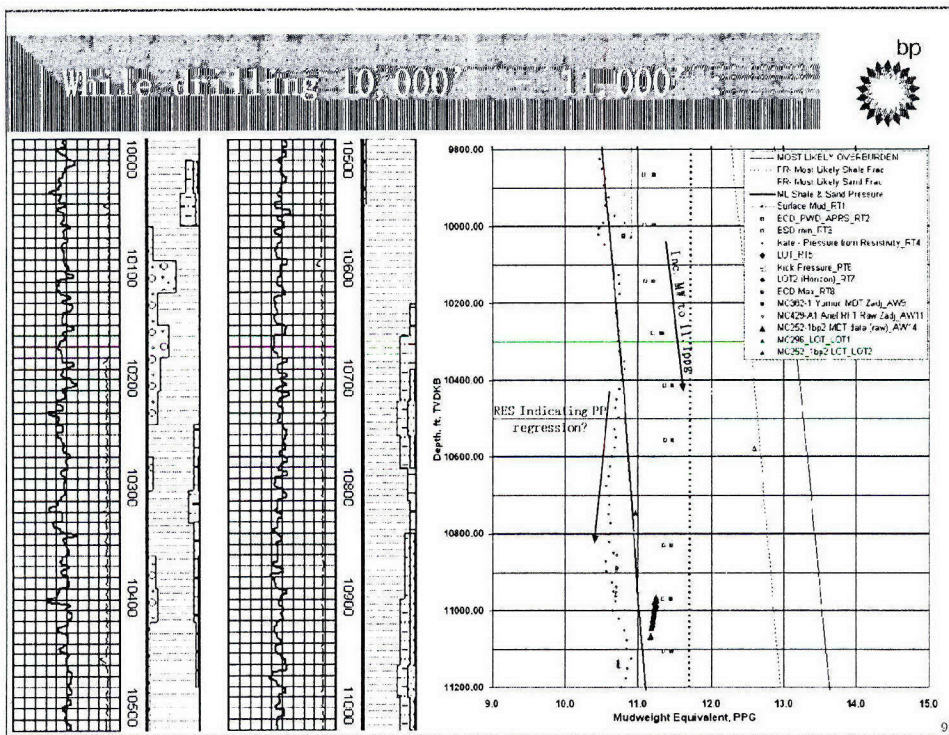
After leak off test, displaced well to 10.9ppg SOBM, drilled ahead.

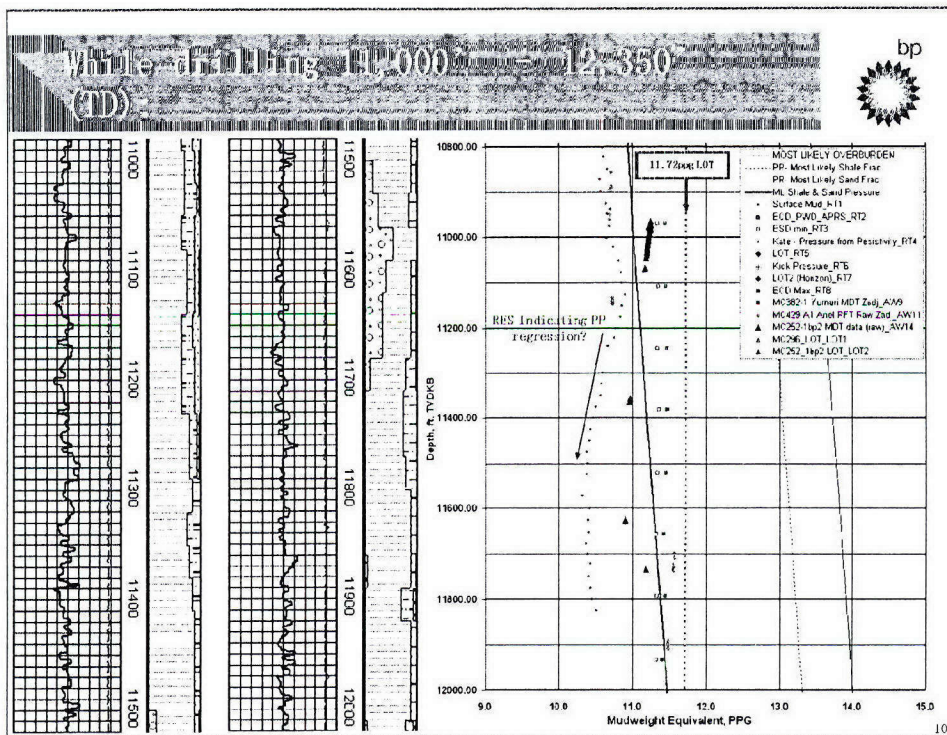




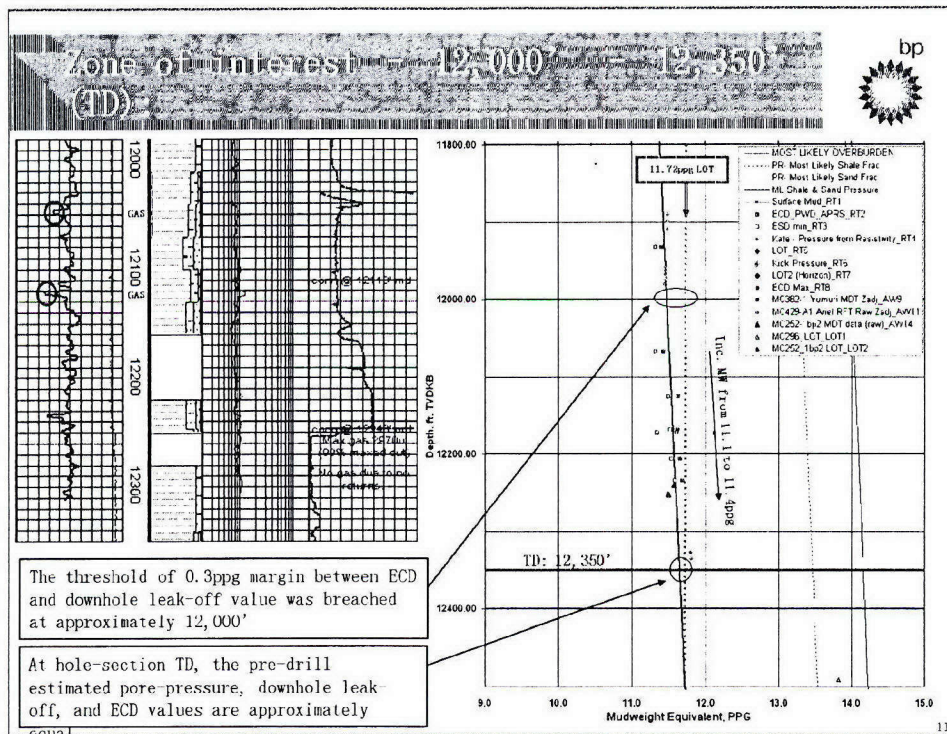












## 16.7 casing point decision



- \* While drilling at 12,000' , the team convened to discuss casing point.
  - Geophysicist indicated, from seismic data, that a sand-prone interval was likely present below 12,500' . Thin sands observed from log data in the offset Rigel wells corroborated this assertion.
  - It was accepted amongst the team to call casing point before 12,500'
  - The exact depth was the subject of further discussion.

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## 16 casing point decision



- \* Observations while drilling ahead at 12,000' :
  - The leak-off test value at the 18" casing shoe was 11.72ppg
  - Pre-drill predicted pore-pressure at 12,000' , from seismic velocities, and Rigel MDT pressure data, was 11.5ppg downhole equivalent.
  - ECD values while drilling with 11.1ppg mud to 12,000' were 11.43ppg
  - ECD values were below predicted pore-pressure
  - Drilling indicators suggested pore-pressure was lower than predicted.
    - No connection gas, no cavings or splintered shale in cuttings, and resistivity was modeling a pore-pressure regression.
  - Sand intervals observed in the Rigel wells were not encountered while drilling at Macondo

\* Decision:

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## 16" casing cement decision



### \* Outcome:

- Drilled ahead past 12,000' with an 11.1ppg MW.
- While drilling at ~12,200' , circulated up excessive gas (greater than 3,000u) from a thin sand at 12,050' , and a connection at 12,110' .
- Stopped drilling at ~12,200' and incrementally increased mud weight to 11.4 circulate out, and squelch gas.
- Decision was made to drill ahead with an 11.4ppg mud to 12,350' . This depth would ensure the reamer was sufficiently past the gaseous sand stringers, and that they could be isolated behind the 16" casing.
- Drilled to 12,350' with 11.4ppg mud. Maximum ECD values observed were 11.73ppg mud weight equivalent.
- Reached a drill depth of 12,350' . Picked-up off bottom, and lost full returns.

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## Lost Circulation Log Event



- Finished drilling to hole-section TD at 12,350' . Circulated, and lost full returns after pulling off bottom.
  - Pumped LCM pill and circulated to spot pill at 18" casing shoe.
  - Lost 2300bbls while circulating LCM pill to shoe.
  - POOH into 18" casing shoe
- Pumped various LCM applications to attempt to curtail losses
  - Calcium carbonate of variable size and concentration, form-a-squeeze, form-a-set, swell LCM, and EZ-squeeze were utilized.
  - An application of 200bbls of form-a-squeeze followed by a spacer and 200bbls of form-a-set ceased losses brought the well to static. A plug of form-a-set was left in the bottom of the 18" casing.
- Mud weight was cut from 11.4ppg to 11.2 ppg. Well was static.
- POOH for a clean-out BHA

15



# ***Macondo***

***MC 252 #1***



MC 252 #1 (Macondo)

16.5" x 20" hole section review (16" CSG section)

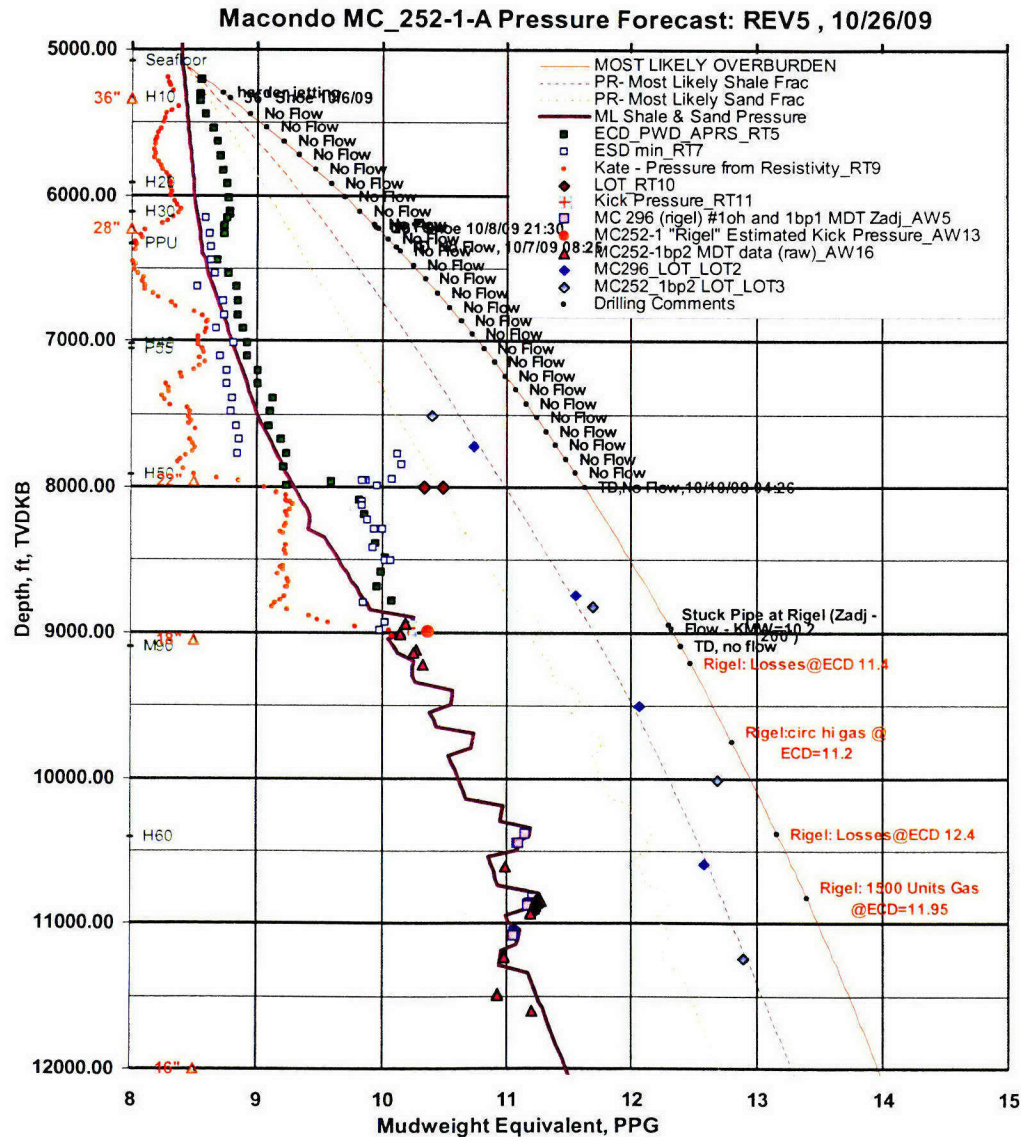


## Outline:



- Pre-drill PP/FG model
- Leak-off test at 18" casing shoe
- While drilling
- 16" casing point decision
- Lost circulation event
- Lesson learned

# Pre-drill PP/FG model:



*Target depth for 16" hole-section:*

12,000'

*Estimated FG at 18" shoe:*

Sand – 11.3ppg downhole

Shale – 11.8ppg downhole

*Estimated PP at 16" hole-section TD:*

11.5ppg downhole

*Other considerations:*

Potential connectivity to both charged and depleted "Rigel" sands

Slightly updip from Rigel. Potential for over-pressured gas sands

Over 70bcf gas production from a completed "Rigel" interval.

Possible depletion around 10,700' – 10,800' in the Macondo well.



## Leak-off test attempts 1-4:



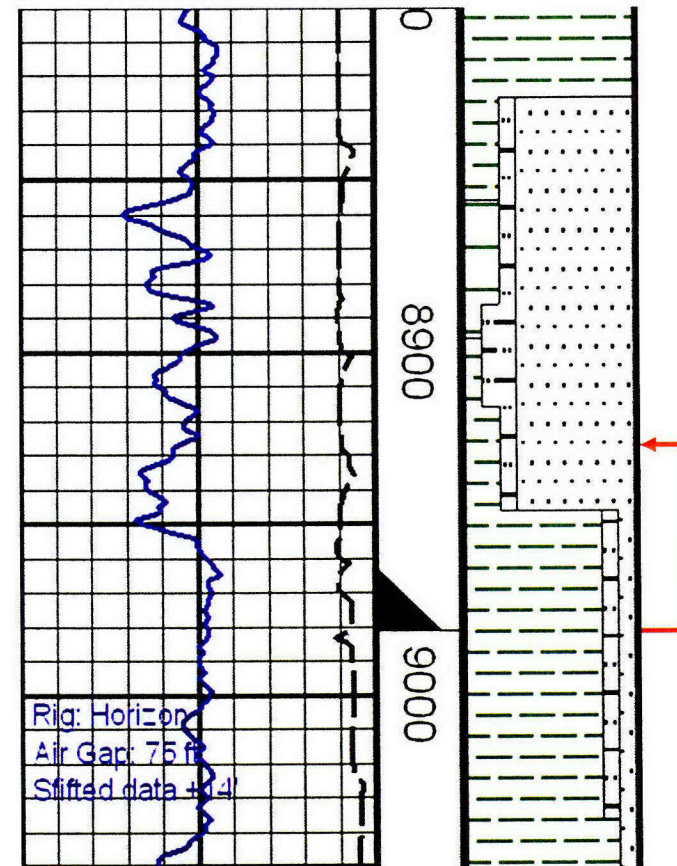
- Attempting a leak-off test at the 18" casing shoe was met with some difficulty.
  - The first two leak-off attempts were performed against the upper annular. While pressuring up the system, observed returns to the trip tank
  - The third attempt packed-off
  - The fourth attempt was performed against the pipe rams. Similar to the first two attempts, gains were noted in the trip tank
- It was concluded that a hole or washout must be present in the drill pipe. Mud was being expelled to the annulus from the drill string, and displaced to the trip tank via the return line.
- Tripped to inspect drill pipe.



## Leak-off test attempt 5:

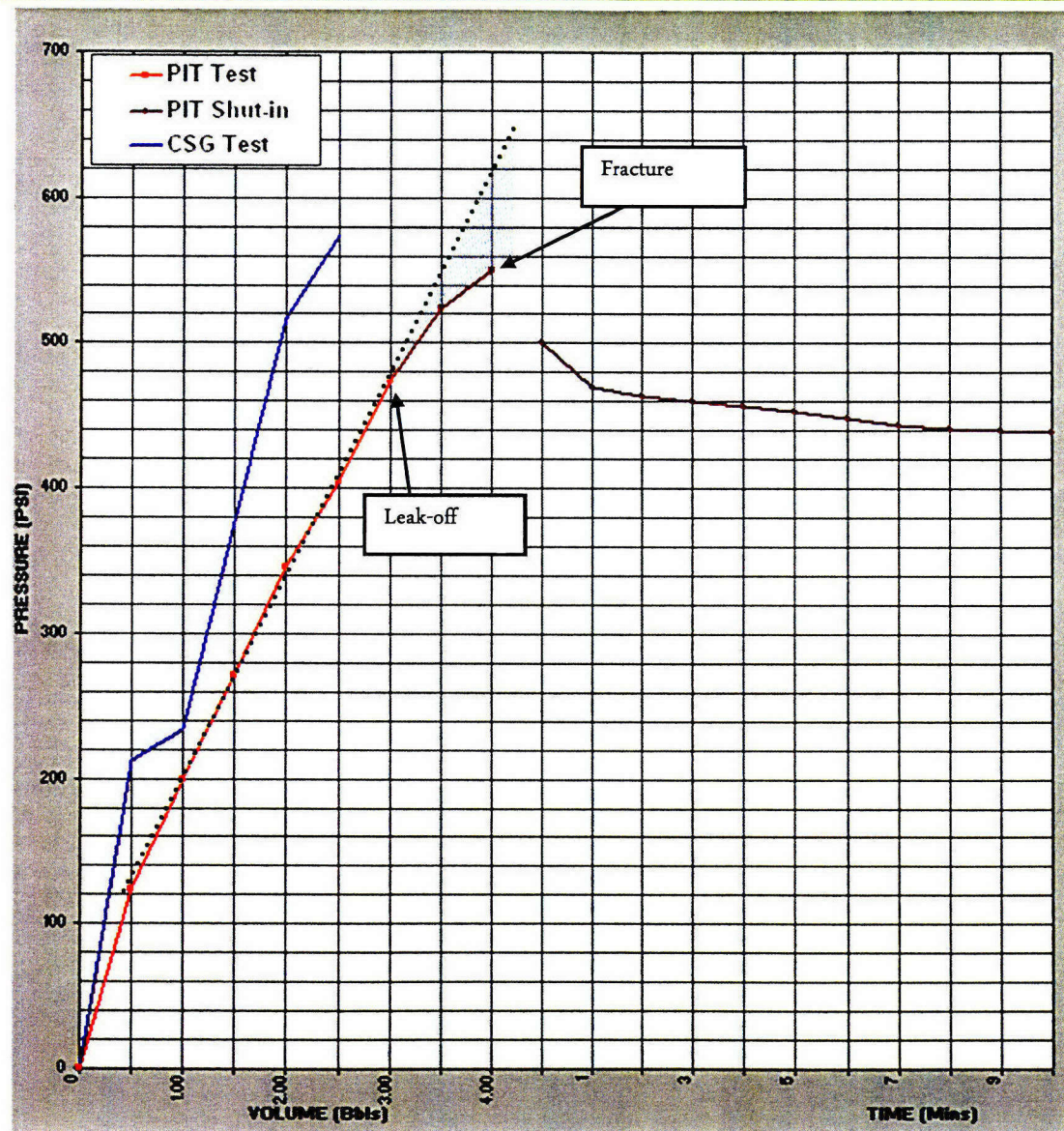


- After tripping to inspect/re-make the BHA, a 5<sup>th</sup> leak-off test was attempted.
  - Pumped up a 10.84ppg ESD
  - Maximum observed pressure during leak-off test: 317psi (11.2ppg MW equiv.)
  - It was thought that we were pumping into the overlying sand interval from 8,860' – 8,950' via a leaky 18" casing shoe. Estimated FG in this sand (11.2 – 11.3ppg downhole equiv.) closely corresponds to the maximum pressure observed in LOT #5.
- Decision was made to perform a cement squeeze on the 18" casing shoe.





## 18" leak-off test #6:



- Subsequent to a cement squeeze. A desirable leak-off value was achieved on the 6<sup>th</sup> attempt:

*Mud weight (surface): 10.6ppg SOBM*

*Mud weight (downhole) [PWD]: 10.70ppg*

*18" Casing shoe depth: 8,972' (TVD)*

### Pre-drill estimated fracture:

Sand: 11.3ppg downhole

Shale: 11.8ppg downhole

### LOT:

*Surface pressure (leak off): 475psi*

*Maximum surface pressure (fracture): 550psi*

Surface leak off – 11.62ppg

Downhole leak off – 11.72ppg MW equiv.

Surface fracture – 11.78ppg (Report to MMS)

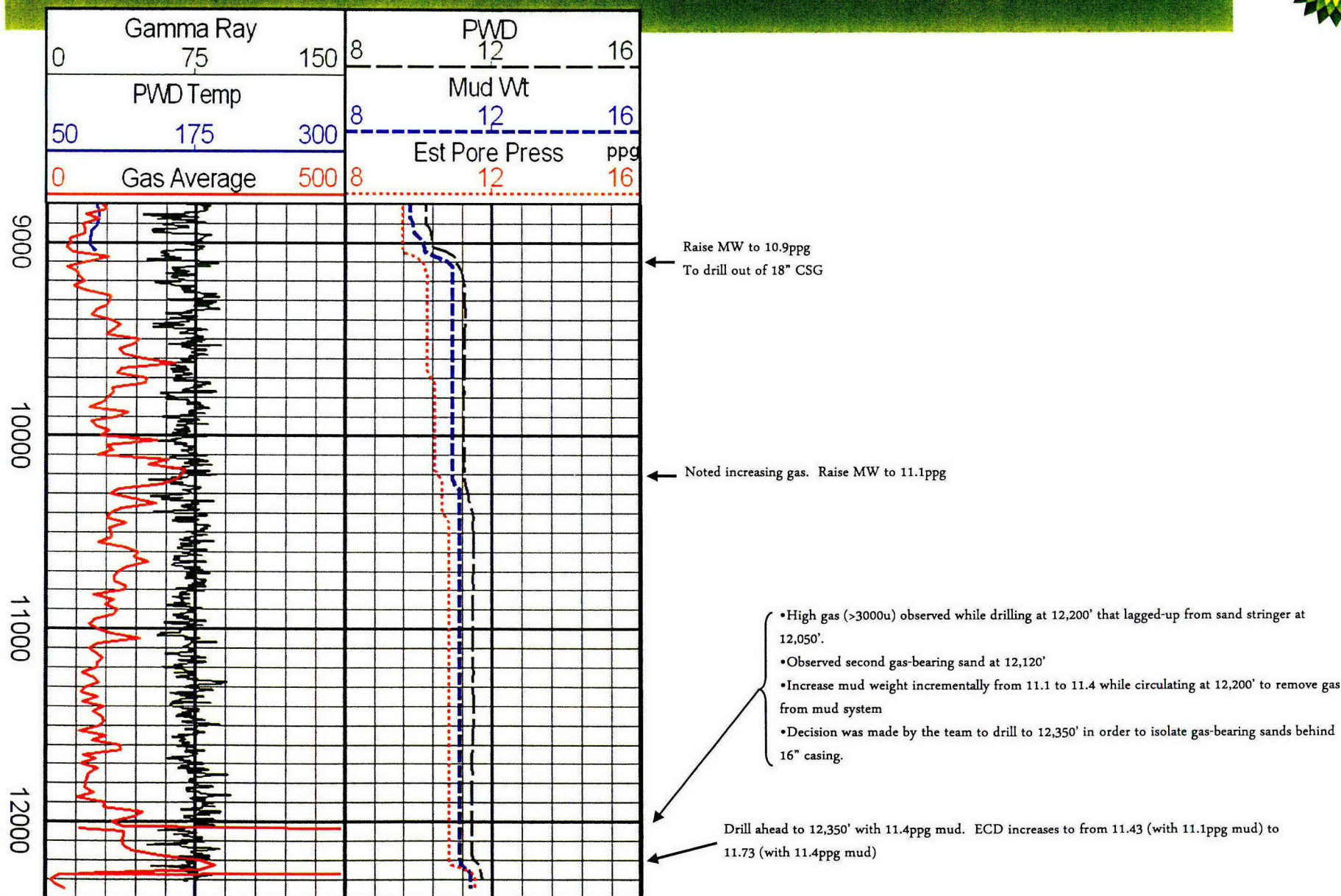
Downhole fracture – 11.88ppg MW equiv.

- After leak-off test, displaced well to 10.9ppg SOBM, drilled ahead



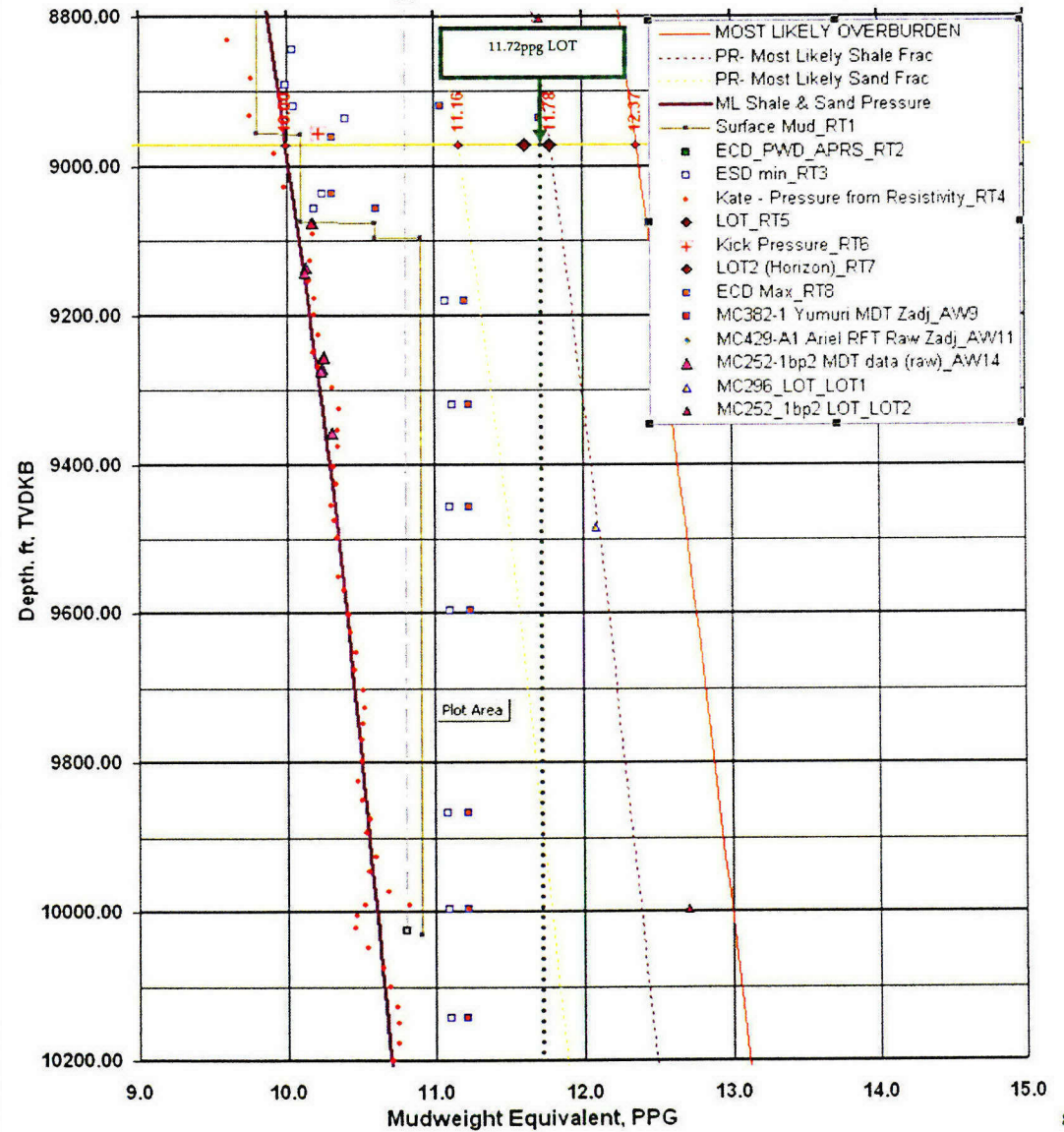
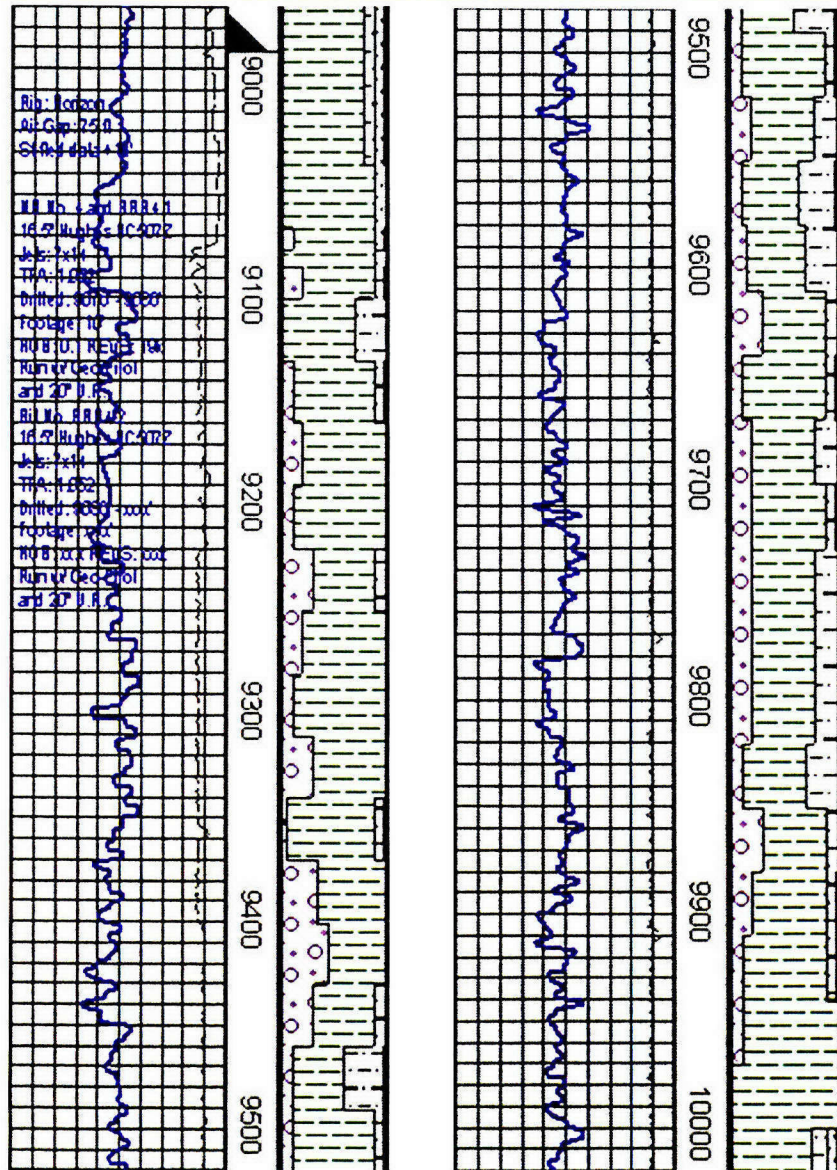


## While drilling: overview



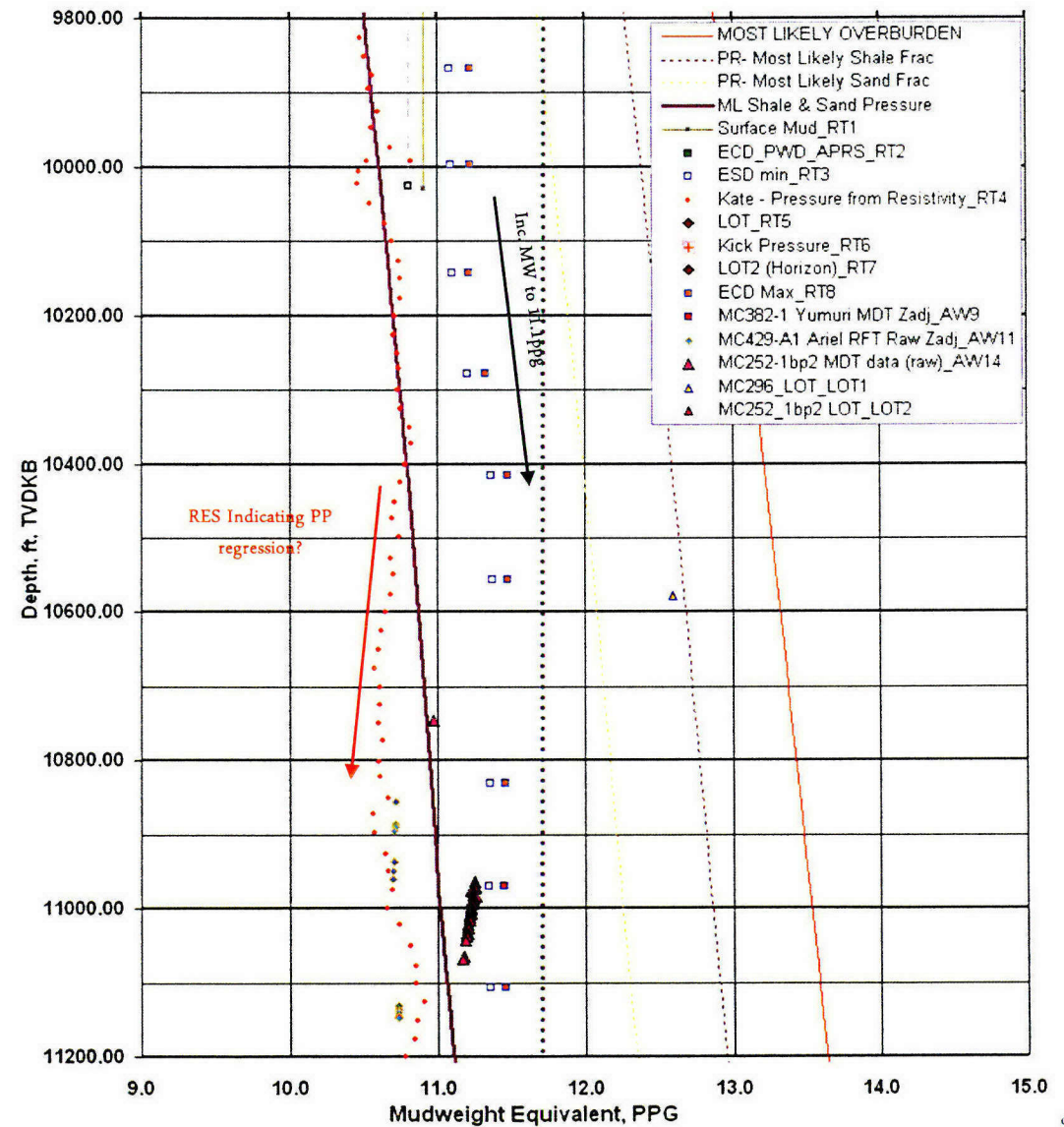
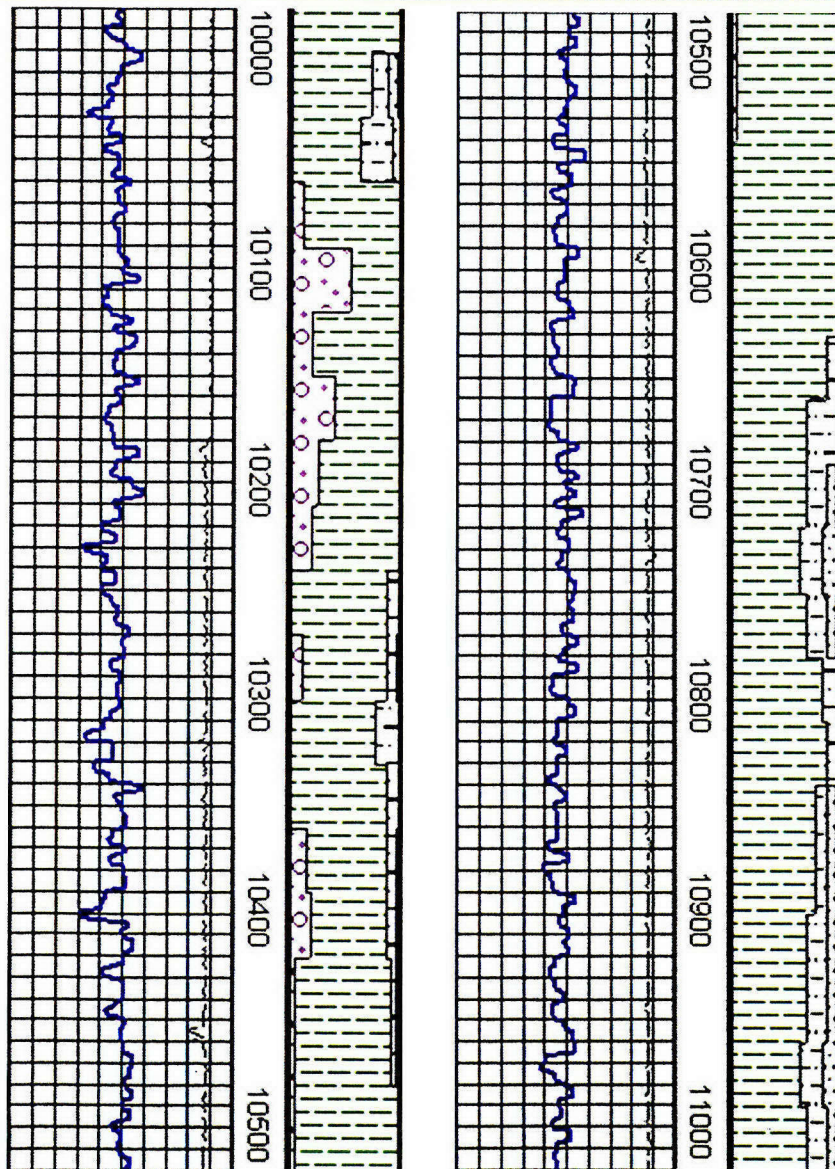


While drilling 9,000' – 10,000':



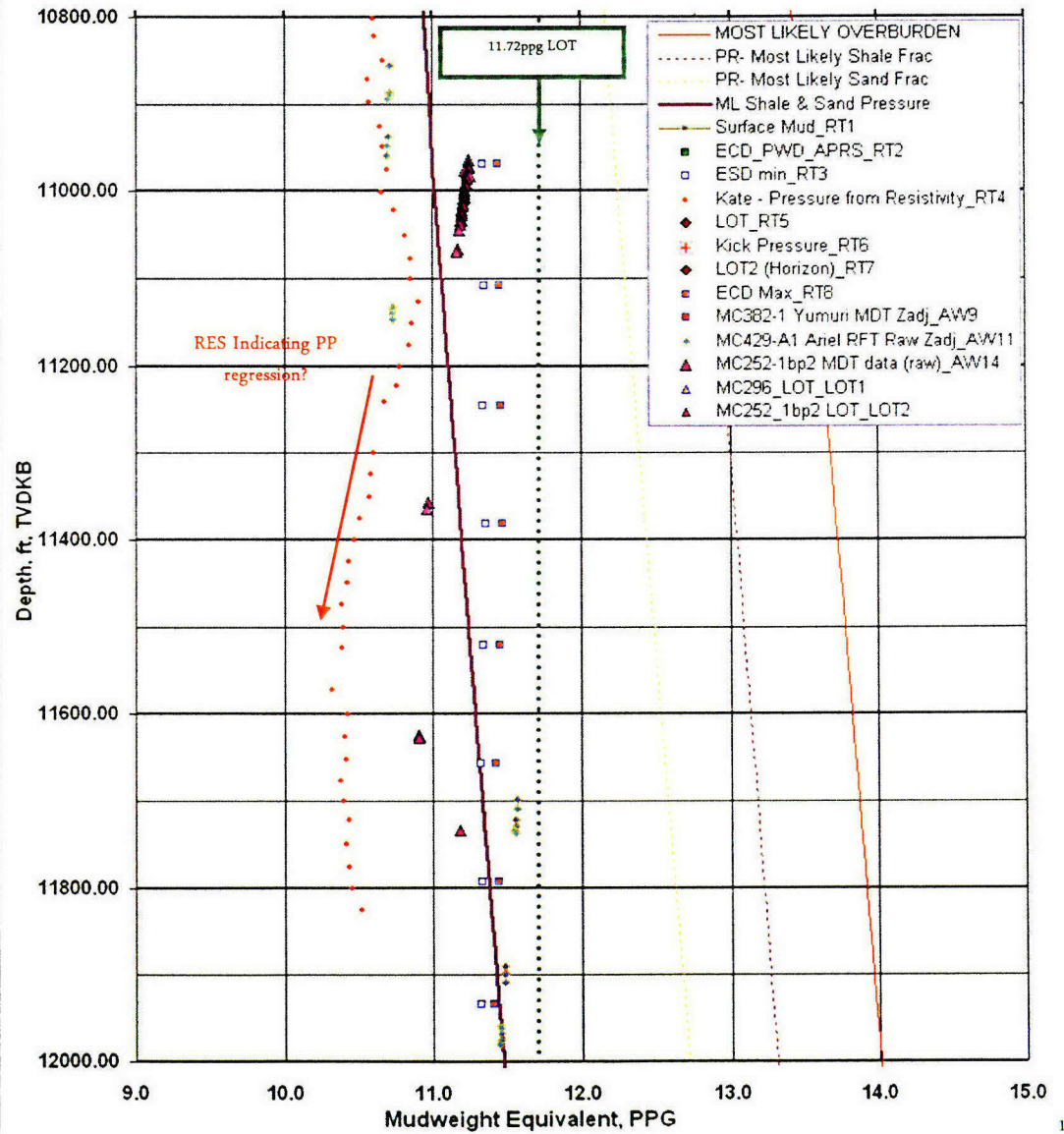
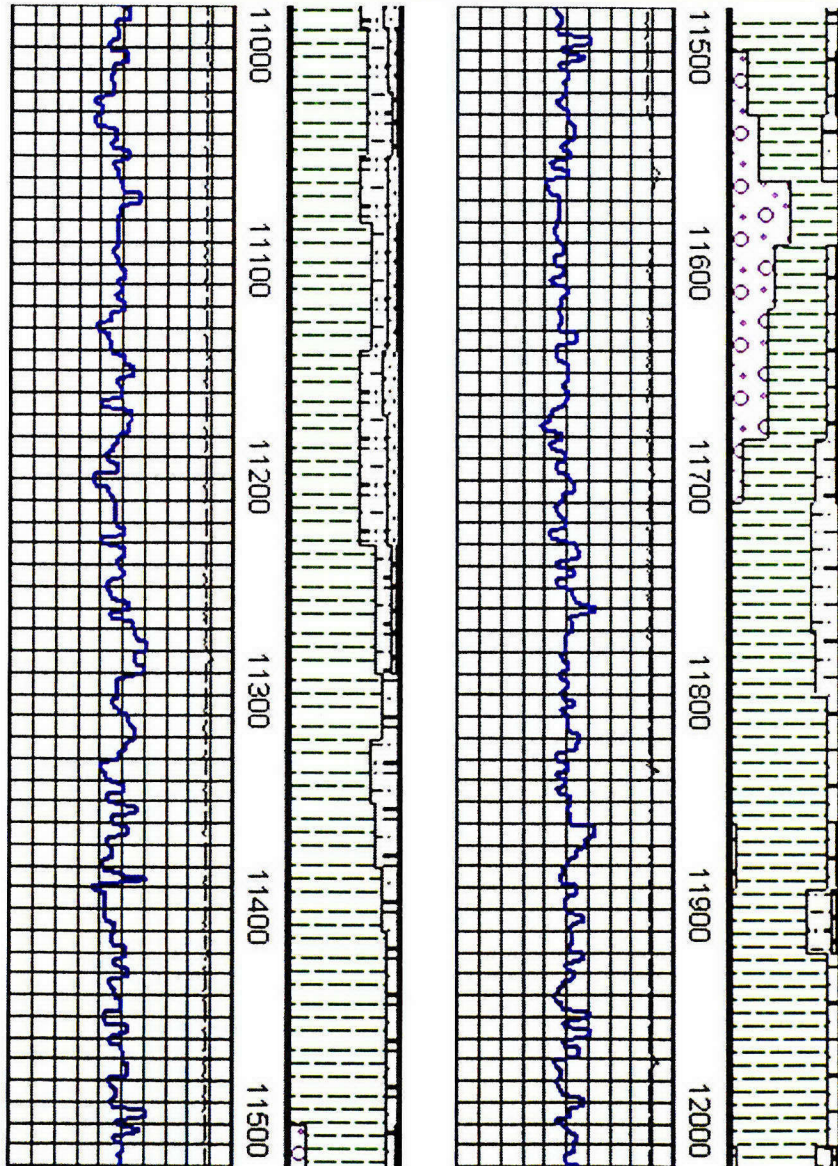


While drilling 10,000' – 11,000':



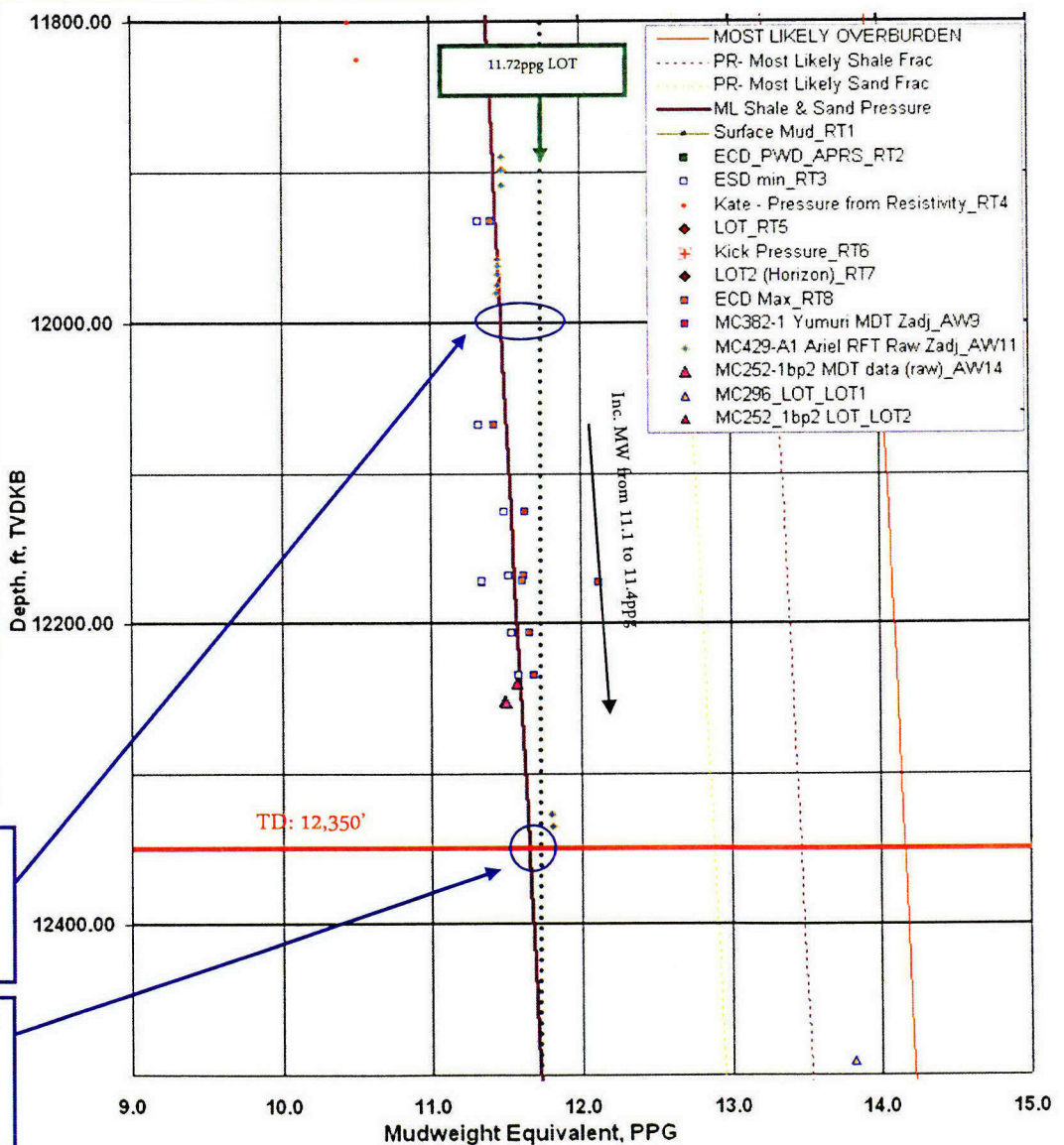
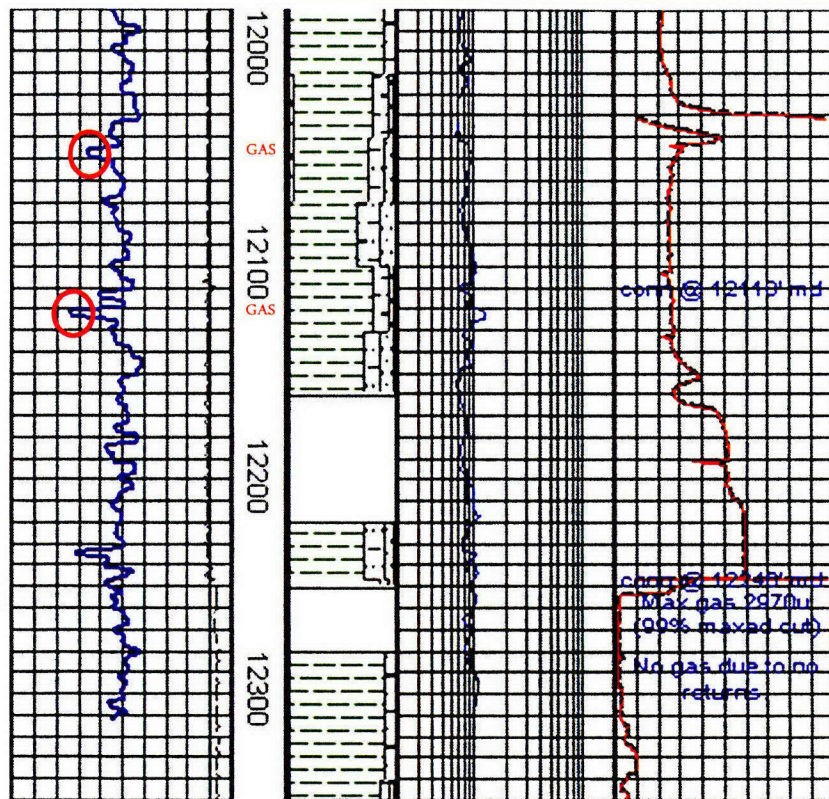


While drilling 11,000' – 12,350' (TD):





# Zone of interest – 12,000' – 12,350' (TD):



The threshold of 0.3ppg margin between ECD and downhole leak-off value was breached at approximately 12,000'

At hole-section TD, the pre-drill estimated pore-pressure, downhole leak-off, and ECD values are approximately equal.



## 16" casing point decision:



- While drilling at 12,000', the team convened to discuss casing point.
  - Geophysicist indicated, from seismic data, that a sand-prone interval was likely present below 12,500'. Thin sands observed from log data in the offset Rigel wells corroborated this assertion.
  - It was accepted amongst the team to call casing point before 12,500'
  - The exact depth was the subject of further discussion.



## 16" casing point decision:



- Observations while drilling ahead at 12,000':
  - The leak-off test value at the 18" casing shoe was 11.72ppg
  - Pre-drill predicted pore-pressure at 12,000', from seismic velocities, and Rigel MDT pressure data, was 11.5ppg downhole equivalent.
  - ECD values while drilling with 11.1ppg mud to 12,000' were 11.43ppg
  - ECD values were below predicted pore-pressure
  - Drilling indicators suggested pore-pressure was lower than predicted.
    - No connection gas, no cavings or splintered shale in cuttings, and resistivity was modeling a pore-pressure regression.
  - Sand intervals observed in the Rigel wells were not encountered while drilling at Macondo
- Decision:
  - The decision was made to drill ahead past 12,000' with 11.1ppg mud towards an eventual TD closer to 12,500'

## 16" casing point decision:



- Outcome:
  - Drilled ahead past 12,000' with an 11.1ppg MW.
  - While drilling at ~12,200', circulated up excessive gas (greater than 3,000u) from a thin sand at 12,050', and a connection at 12,110'.
  - Stopped drilling at ~12,200' and incrementally increased mud weight to 11.4 circulate out, and squelch gas.
  - Decision was made to drill ahead with an 11.4ppg mud to 12,350'. This depth would ensure the reamer was sufficiently past the gaseous sand stringers, and that they could be isolated behind the 16" casing.
  - Drilled to 12,350' with 11.4ppg mud. Maximum ECD values observed were 11.73ppg mud weight equivalent.
  - Reached a drill depth of 12,350'. Picked-up off bottom, and lost full returns.



## Lost circulation event:



- Finished drilling to hole-section TD at 12,350'. Circulated, and lost full returns after pulling off bottom.
  - Pumped LCM pill and circulated to spot pill at 18" casing shoe.
  - Lost 2300bbls while circulating LCM pill to shoe.
  - POOH into 18" casing shoe
- Pumped various LCM applications to attempt to curtail losses
  - Calcium carbonate of variable size and concentration, form-a-squeeze, form-a-set, swell LCM, and EZ-squeeze were utilized.
  - An application of 200bbls of form-a-squeeze followed by a spacer and 200bbls of form-a-set ceased losses brought the well to static. A plug of form-a-set was left in the bottom of the 18" casing.
- Mud weight was cut from 11.4ppg to 11.2 ppg. Well was static.
- POOH for a clean-out BHA