

PNNL, 7/30/10, unreviewed estimate

What is the effect of oil reservoir depletion?

PNNL-19508 Rev. 2 (the PNNL report), Table 4.1: flow rate of **65000 bpd**.

This was for Scenario 2 – oil flows from breach at well bottom, upward through casing alone in the lower part of the well, then continued to flow upward through two separate parallel paths. The inner path is through the drillpipe to the sea at sea-floor pressure (2236 psia), with no ΔP imposed to represent ram or other effects. The outer path is annular, around the drillpipe, and then up through the BOP. A ΔP is imposed on the outer-path annular flow before exiting to sea-floor pressure; this ΔP represents the effect of contorted flow paths within the BOP.

- reservoir pressure not depleted (11844 psia)
- 0.072 darcy reservoir permeability, 1000 ft radius (sandface = 10109 psia)
- ΔP across the well breach is 0 psid (negligible resistance entering well)
- ΔP across the BOP is 2150 psid (May 25 value, a best-estimate)
- no riser ΔP accounted for

 Start from the above, which represents the situation after cutting off the riser and before placing top hat, and change two things: (1) impose a depletion pressure loss of 1400 psi on the reservoir pressure, based on slide 71 of the 7/20/10 presentation; (2) scale down the BOP ΔP by assuming it is proportional to the square of the velocity (flow rate).

The resulting flow is **56000 bpd**.
(14% decrease) 54000 (17% decrease)

- reservoir pressure depleted (10444 psia) *10044*
- 0.072 darcy reservoir permeability, 1000 ft radius (sandface = 8942 psia) *8622?*
- ΔP across the well breach is 0 psid (negligible resistance entering well)
- ΔP across the BOP is 1610 psid (scaled down from May 25 value) *1443*
- note: no ΔP accounted for from top hat, kill line, etc.

1800
for attached

OFFICIAL USE ONLY

8628
 Exhibit No. _____
 Worldwide Court
 Reporters, Inc.

7/30/10

Original case

ϕ psid at breach (similar to WIT-analysis assumption)

2150 psid at BOP

0.072 darcy, ~~1000~~ 1000 ft radius (\rightarrow BHP = 10109 psia)

Scenario 2 (in 7" casing @ bottom, drill pipe + annulus \rightarrow BOP parallel in upper well)

Post-depletion case

1800 psi of depletion (distant reservoir pressure 10044 psia)
~~surface pressure now 8622 psia, not total psia~~

ϕ psid at breach

1443 psid at BOP (= 2150 psid + (new flow / old flow)²)

0.072 darcy, 1000 ft radius (\rightarrow BHP = 8622 psia)

Scenario 2

Original case flow = 65300 g bpd

Depleted case flow = 53500 bpd (resistance of kill line, etc., not accounted for)

OFFICIAL USE ONLY

The data included in this transmittal were obtained from a fully implemented NQA-1-1989 QA program, but has not been reviewed for technical accuracy per the QA program yet, therefore, all data is provided "For Information Only".

Integrated Test B

OFFICIAL USE ONLY

LA Mahoney, PNNL

8/18/09

p. 13 of 22

1/8

7/30/00 Multi-Team Telecom

Plance Team - Bill Lehr not on call.
Someone else making unplanned pres
(Steve Werelays)

1/2 PIV, 1/2 manual feather tracked

Relationships between PN to inner V

prior to cut of cap
20-40

after cap cut of cap
35-50

day after, mtg in DC
35-60 KDBC/day

Bill Lehr on at 10:35



inside w/ two
drill pipes in it

flow out of at least one

OFFICIAL USE ONLY

Maclay

Tight sched for contractors Kelkar Hughes Gem

7 days

longer contract
longer pres

Paul Hsieh did his analyses o'rite

Kelker - rock compressibility & no effort

Each case rep by any res pressure prior to
blowout (Geotop report - had many H₂S,
consultants picked rightly off #1)
Bottom hole pressure determined via sum
of # of flow completions

? about depletion - need tabulation

28 & PL

PL at 110m stocktake table
- consultant other, 55

Art Patzyl in Houston may have video

OFFICIAL USE ONLY

3/8

Nodal Team - George

did not look at annulus + up coning
less than 1+2
Gemini did this (unst cam)

p. 45 air permeability

$k \times h = \sim 71,250 \text{ md-ft}$ skin = 0

May 25 data is 'sent - check'

? about coning Scenario 4

all flow thru drillpipe
3000'

202 586-5004

log 43.7% not to due to seafloor
P&T

OFFICIAL USE ONLY

4/8

Paul HsiehDP preferring 10^{-6} psi²

Art gold star!

Kurt at LBWL less gas dissolving
close to liq/gas phase transitionPressure higher than sea pressure
and just little bubbles coming out
in Cap #4 no water in sample

Summary Steve (Chu?)
Re examine - estimate

did collect 27k still gathering

any possible gas after shut-in
not likely!

OFFICIAL USE ONLY

5/8

Marsha - although presumed to get
out - can put all of the scientific
uncertainty we believe necessary.

Committee report for scenario 2
of plan guys

Marsha
Oil Budget?

- 1) Well depletion on flow
- 2) geometry changes when cap on

DIV - Low 50 unreasonable?
Steve if video of vice exit

DOE impedance of low flow rate

Tues

Cabinet
call @ 5pm

in papers

Judy

Rod O'Connor chief of staff
of Carter ... + Neppathus
out into the life



muddy tomorrow

OFFICIAL USE ONLY

6/8

"When is all the oil?" August

minutes conference

by noon tomorrow, P&V cannot
(EST)

- > what's is depletion vs time of
- > sliding cap on end and cutting off riser

~~EST~~
EST

11 AM static bleed out
over by 1
1:30 telecon by 2:30

2-3 PM press time

bill is ~~low~~!

Have pt. 1 - 87 every day.
pub + collected

@ 1 PM 202.287.6677

OFFICIAL USE ONLY

8/8

Doc reviewed @ White Horse
w/ 60 kbb/d at top end

Rate changed \rightarrow 60-50 over time
if not call Secty Nepal \leftarrow of tell her.

10 AM here!

Saving bottom BOP gaze for Tom

OFFICIAL USE ONLY

Subject: Fwd: TIME CHANGE - TELECON SCHEDULED: TODAY, Saturday, July 31, 12:30pm CDT RE: Flow Analysis Activities for the MC252 Well

Date: Saturday, July 31, 2010 9:52 AM

From: George Guthrie <George.Guthrie@NETL.DOE.GOV>

To: <bd@lanl.gov>, <rajesh@lanl.gov>, <CMOldenburg@lbl.gov>, <buscheck1@llnl.gov>, <weisgraber2@llnl.gov>, Grant Bromhal <Grant.Bromhal@NETL.DOE.GOV>, Jim Fort <james.fort@pnl.gov>, "Gauglitz, Phillip A" <phillip.gauglitz@pnl.gov>

Cc: Darren Mollot <Darren.Mollot@HQ.DOE.GOV>, <Robert.Corbin@HQ.DOE.GOV>, George Guthrie <George.Guthrie@NETL.DOE.GOV>

Today's follow-on teleconference regarding flow analysis activities for the MC252 well has been pushed back a half hour. This telecon will be held from 12:30pm-1:30pm CDT (1:30pm-2:30pm EDT, 11:30am-12:30pm MDT).

From: "Bowen, Amy D" <adbowen@sandia.gov>

Date: Sat, 31 Jul 2010 09:49:28 -0700

To: "Chavez, Anne K" <akchavez@sandia.gov>, <steven.aoki@nnsa.doe.gov>, "Burns, Michael J. (LANL)" <burns_michael_j@lanl.gov>, <chinn3@llnl.gov>, <schu@hq.doe.gov>, <gcooper@berkeley.edu>, <rlg2@us.ibm.com>, <richard_j_garwin@ostp.eop.gov>, "Guffee, Ray M. (LANL)" <guffee@lanl.gov>, <hickman@usgs.gov>, <John_P_Holdren@ostp.eop.gov>, <pahsieh@usgs.gov>, "Hunter, Tom" <tohunte@sandia.gov>, <hunsaker61@comcast.net>, <arun.majumdar@hq.doe.gov>, <mcnut@usgs.gov>, <Ray_merewether@seektech.com>, <mooney@usgs.gov>, <kathryn_moran@ostp.eop.gov>, <rod.oconnor@hq.doe.gov>, <tony.rediger@hq.doe.gov>, <slorum@mit.edu>, <slorum42@gmail.com>, "Stulen, Rick" <rhstule@sandia.gov>, "Ammerman, Curt N. (LANL)" <ammerman@lanl.gov>, "Behr-Andres, Christina B. (LANL)" <behr-andres@lanl.gov>, "Black, Stephen J. (LANL)" <sblack@lanl.gov>, "Blankenship, Douglas A" <dablan@sandia.gov>, "Bowen, Amy D" <adbowen@sandia.gov>, <bowers2@llnl.gov>, "Bultman, Nathan K. (LANL)" <nbultman@lanl.gov>, <kevin.s.cook@uscg.mil>, "Dunn, Paul S. (LANL)" <pdunn@lanl.gov>, "Dykhuisen, Ronald C" <rcdykhu@sandia.gov>, "Griffiths, Stewart" <skgriff@sandia.gov>, <havstad1@llnl.gov>, <hickman@usgs.gov>, "Hurst, Kathleen T" <kthurst@sandia.gov>, <millier99@llnl.gov>, <mooney@usgs.gov>, "O'Sullivan, Donald Q. (LANL)" <dqsulli@lanl.gov>, <missy.owens@hq.doe.gov>, <perfect1@llnl.gov>, "Ratzel, Arthur C" <acratze@sandia.gov>, "Rees, William S. Jr. (LANL)" <wsr@lanl.gov>, "Tatro, Marjorie" <mltatro@sandia.gov>, "Tieszen, Sheldon R" <srtiesz@sandia.gov>, <wapman1@llnl.gov>, <warner2@llnl.gov>, <pahsieh@usgs.gov>, Philip H Nelson <pnelson@usgs.gov>, "Behr-Andres, Christina B. (LANL)" <behr-andres@lanl.gov>, "Maxted, Sarah Jane" <Sarah.Maxted@Hq.Doe.Gov>, "Hampton, Devin" <Devin.Hampton@hq.doe.gov>, <Amy.Bodette@hq.doe.gov>, Catherine B Enomoto <cenomoto@usgs.gov>, <kat_pustay@ios.doi.gov>, <kevin.s.cook@uscg.mil>, <Patrick.E.Little@uscg.mil>, "Knowles, Sara" <Sara.Knowles@Hq.Doe.Gov>, "Dredd, Travis" <Travis.Dredd@hq.doe.gov>, "Girrens, Steven P. (LANL)" <sgirrens@lanl.gov>, "Ferencz, Robert M." <ferencz1@llnl.gov>, "Morrow, Charles W" <cwmmorro@sandia.gov>, "Chavez, Anne K" <akchavez@sandia.gov>, <Bill.Lehr@noaa.gov>, <George.Guthrie@NETL.DOE.GOV>, <Donald.Maclay@mms.gov>, <pahsieh@usgs.gov>, <Donald.F.Cundy@uscg.mil>, Andy Bowen <abowen@whoi.edu>, "Robinson, Bruce A. (LANL)" <robinson@lanl.gov>, <Wereley@purdue.edu>, Alberto Aliseda <aaliseda@u.washington.edu>, <gerald.crawferd@mms.gov>, "Pawar, Rajesh J. (LANL)" <rajesh@lanl.gov>, <buscheck1@llnl.gov>, Mark K Sogge <mark_sogge@usgs.gov>, <Bill.Lehr@noaa.gov>, <George.Guthrie@NETL.DOE.GOV>, <Donald.Maclay@mms.gov>, <pahsieh@usgs.gov>, <Donald.F.Cundy@uscg.mil>, "Robinson, Bruce A. (LANL)" <robinson@lanl.gov>, <Wereley@purdue.edu>, Alberto Aliseda <aaliseda@u.washington.edu>, Andy Bowen <abowen@whoi.edu>

Cc: <mcnut@usgs.gov>, <rcamilli@whoi.edu>, "Bowen, Amy D" <adbowen@sandia.gov>, <thad.w.allen@gmail.com>, <SLV@ios.doi.gov>

Subject: TIME CHANGE - TELECON SCHEDULED: TODAY, Saturday, July 31, 12:30pm CDT RE: Flow Analysis Activities for the MC252 Well

All,

Today's follow-on teleconference regarding flow analysis activities for the MC252 well has been **pushed back a half hour**. This telecon will be held from **12:30pm-1:30pm CDT (1:30pm-2:30pm EDT, 11:30am-12:30pm MDT)**.

OFFICIAL USE ONLY

Follow-on Flow Analysis Activities for the MC252 Well

Report-outs by Government Teams

PREDECISIONAL DRAFT

Saturday, July 31

12:30 – 1:30 PM CDT

OFFICIAL USE ONLY

Agenda

| Time (CDT) | Speaker | Topic |
|-------------|----------------|---|
| 12:30-12:35 | Bill Lehr | Flow Visualization Before TopHat-4 |
| 12:35-12:40 | Dan Maclay | Reservoir – Time of Event with Production |
| 12:40-12:45 | George Guthrie | Nodal Analyses – Pre/Post Cut |
| 12:45-12:50 | Rich Camilli | Doppler Velocities → Kink and more |
| 12:50-12:55 | Paul Hsieh | Reservoir Studies Around Times of Well Integrity Test Shut-in |
| 12:55-1:00 | Art Ratzel | Flow prediction around Well Integrity Shut-in |
| 1:00-1:30 | Tom Hunter | Closure |

7/31/10

PREDECISIONAL DRAFT
Official Use Only

2

Flow Visualization Before TopHat-4

Bill Lehr
Alberto Aliseda
Steve Wereley

BOEM

7/31/10

PREDECISIONAL DRAFT
Official Use Only

3

Reservoir – Time of Event with Production

**Don Maclay
Gerald Crawford**

BOEM/USGS

7/31/10

PREDECISIONAL DRAFT
Official Use Only

4

Flow Estimates Don Maclay (BOEM)

Assumptions for the case include the following:

Permeability = 250 md

Rock compressibility = $10 \times 10^{-6} \text{ psi}^{-1}$

GOR = 2,542 scf/stb

Annular flow outside of the production casing

7/31/10

PREDECISIONAL DRAFT
Official Use Only

5

Results

Base Case

- Initial production rate = 58,000 BOPD
- Flow day 87 = 52,000 BOPD
- Cumulative production = 4,700,000 BO

7/31/10

PREDECISIONAL DRAFT
Official Use Only

6

Nodal Analyses – Pre/Post Cut

George Guthrie

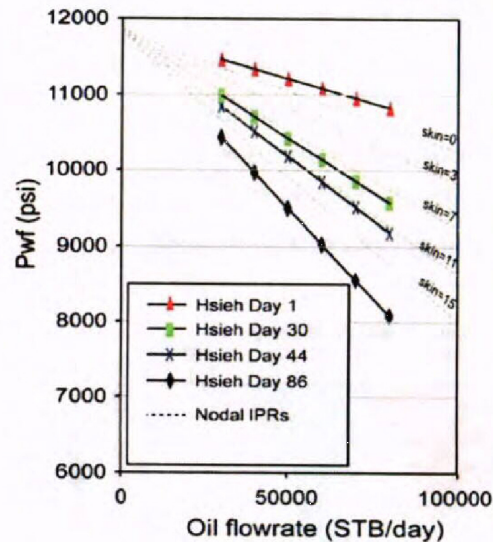
NETL

7/31/10

PREDECISIONAL DRAFT
Official Use Only

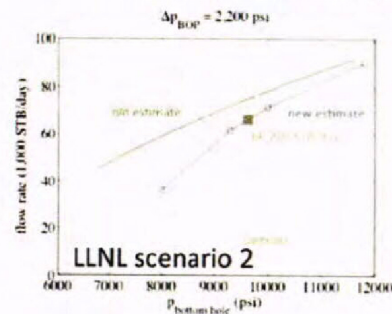
7

Nodal Flow Estimates George Guthrie (DOE NLs)



- New information on reservoir behavior (Hsieh) has been assessed and is consistent with initial reservoir model
 - time variance behaves like skin
 - nodal assessments averaged over skins/time so represent a time-“averaged” rate (but not time weighted)
- Two independent approaches to evaluate impact of depleting reservoir pressure (Hsieh IPR and coupled model) suggest ~15–20% impact over time/pressure depletion
 - effect is larger for scenario 2

| | Scenario 1 | Scenario 2 | Scenario 3 |
|--------|------------|------------|------------|
| Day 1 | 65824 | 122907 | 63433 |
| Day 18 | 45429 | 70092 | 44725 |
| Day 44 | 48799 | 78161 | 48462 |

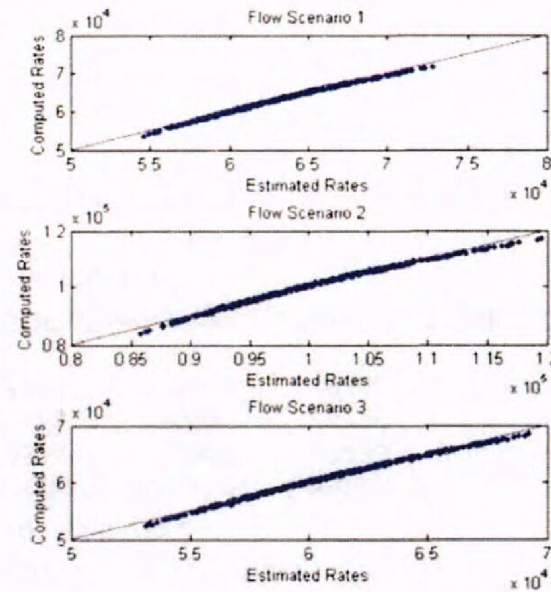
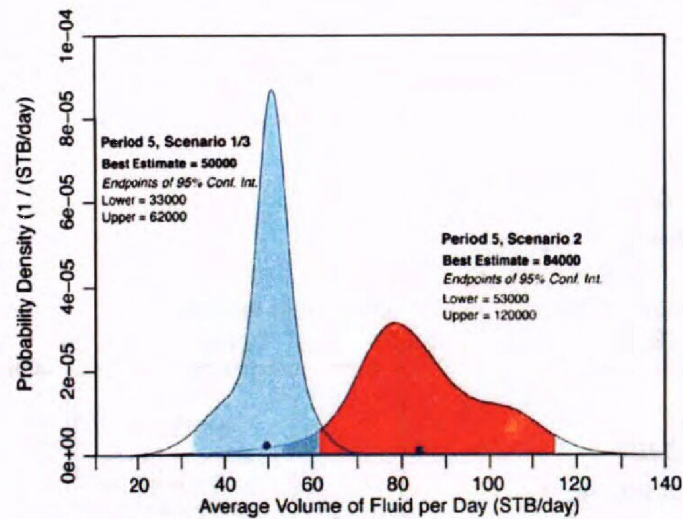


- Assessment of new BOP observations are consistent with BOP treatment in nodal models
 - Nodal approach included impacts of partial closure of rams and uncertainty associated with potential time varying behavior of resistance
 - New BOP data are within
- Nodal models included resistance in drill flow-pipe

7/31/10

PREDECISIONAL DRAFT
Official Use Only

Results



- Nodal analysis results are consistent with flow rates in the range 50–60 kbpd
- Spread in nodal analysis reflects remaining uncertainty in the system, even with incorporation of new data on reservoir (Hsieh) and BOP (additional pressure measurements)
- Primary driver is uncertainty in flow scenario
 - scenario 2 or scenario 1+2 result in flows that are generally higher when honoring reservoir in-flow behavior (reservoir permeability, skin, etc.)

7/31/10

PREDECISIONAL DRAFT
 Official Use Only

9

Doppler Velocities → Kink and more

Rich Camilli
Andy Bowen

WHOI

7/31/10

PREDECISIONAL DRAFT
Official Use Only

10

Flow Estimates

Rich Camilli, (WHOI)

Acoustic flow measurements were completed using a 1.8 MHz imaging multibeam sonar and 1.2MHz acoustic Doppler velocity profiler (ADCP) mounted to a work class remotely operated vehicle (ROV). Flow measurements were recorded at two distinct plume sites, above the riser pipe and at the kink above the BOP. Velocity estimates are derived from three different ADCP view angles above the riser pipe and three ADCP view angles above the BOP. Plume cross section measurements were completed using the imaging multibeam sonar concurrently with the ADCP on the ROV.

These acoustic measurements, (composed of approximately 16,000 ADCP data points, and 2,600 imaging sonar cross-section images) are used in conjunction with a liquid petroleum fraction of 43.7% (calculated from IGT sample) to calculate a flow rate on 5/31/10 of approximately 59,000 bbls/day.

Based on this 5/31/10 flow estimate and the DOE Tri-Lab Flow Modeling Team's WIT shut-in estimate (53,000 bbls/day), a linear flow rate trend is extrapolated for the interval between 4/20/10 and 7/14/10. The summation of each day's flow rate is then used to calculate a cumulative total flow from the well. This approach is consistent with the hypothesis that flow rate decreases approximately linearly with time as a result of well pressure decrease. Additional well flow/pressure data collected between 4/20/10 and 7/14/10 should be examined to ascertain if a non-linearly decreasing flow model would be more appropriate for estimating initial flow rate and cumulative release from the well.

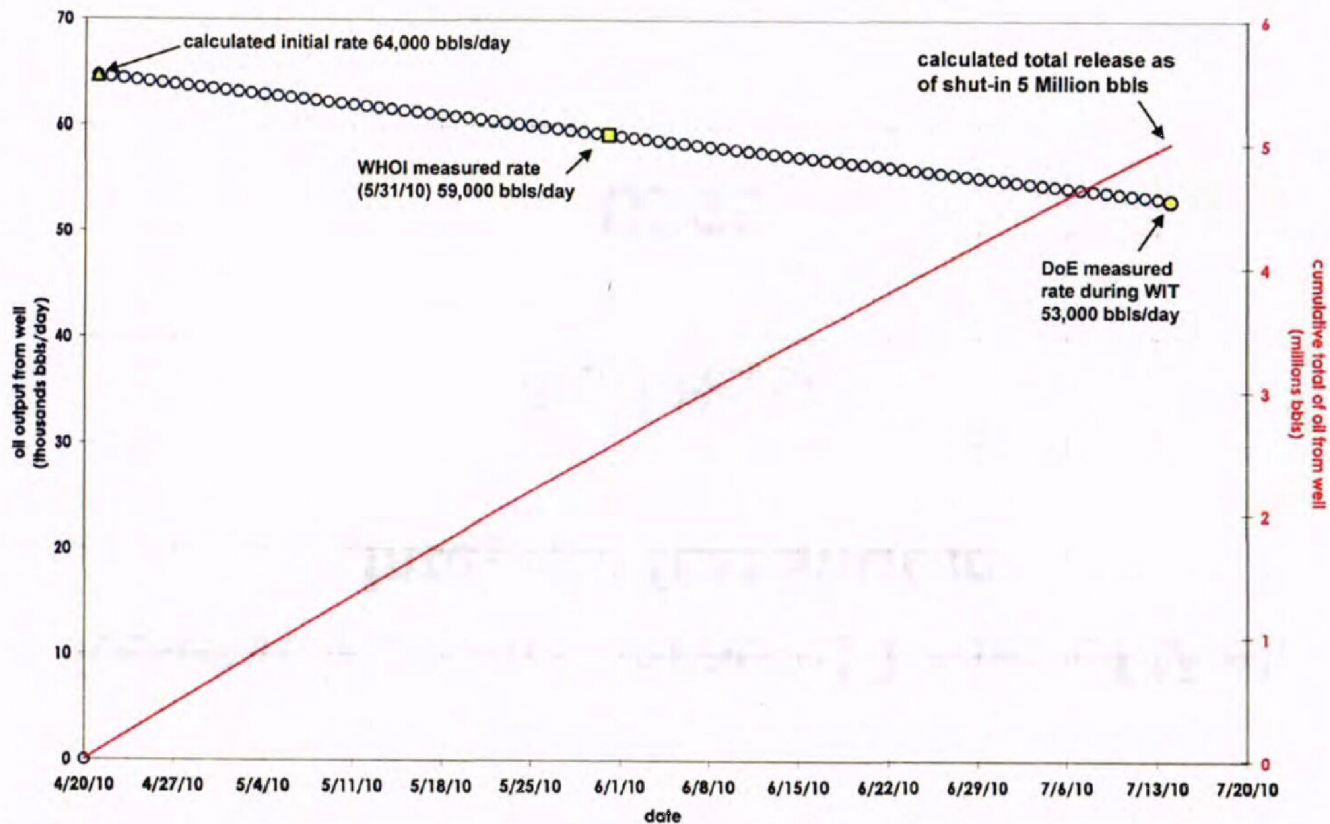
7/31/10

PREDECISIONAL DRAFT
Official Use Only

11

Results

Oil flow from Deepwater Horizon MC252 well



7/31/10

PREDECISIONAL DRAFT
Official Use Only

12

Reservoir Studies Around Times of Well Integrity Test Shut-in

Paul Hsieh

USGS

7/31/10

PREDECISIONAL DRAFT
Official Use Only

13

Flow prediction around Well Integrity Shut-in

Art Ratzel

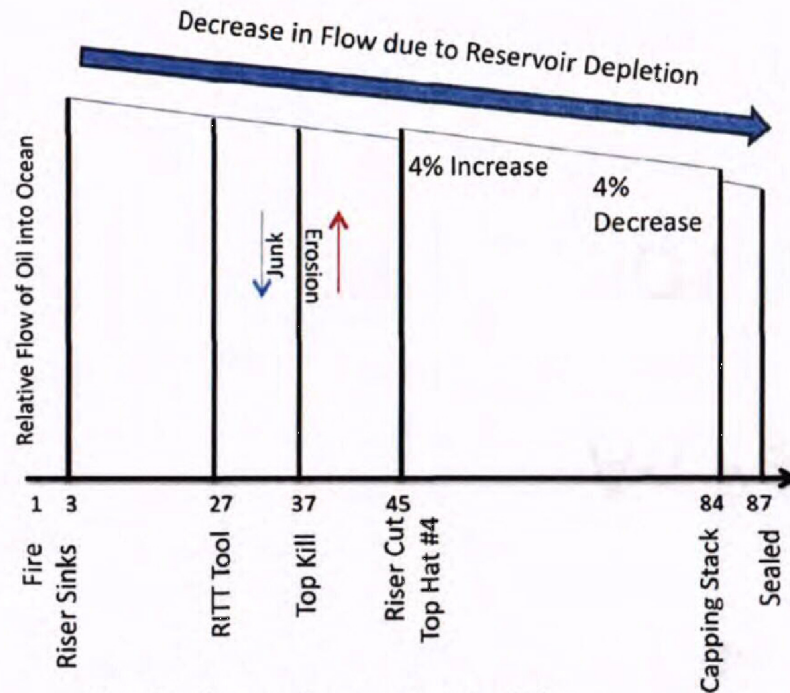
DOE Team

7/31/10

PREDECISIONAL DRAFT
Official Use Only

14

DOE Team Estimates for Flow Rates



Assumptions

- Linear fit for Reservoir Depletion of 1800psi (Hsieh est.)
 - Pinitial = 11850psi
 - Pfinal = 10050psi
- Events effecting flow rate (see chart)
 - Riser cut and stacking cap
 - Top Kill effect not considered (indeterminant)
- Oil directly recovered: 804k bbls (per BP)

Results from Flow Rate Models

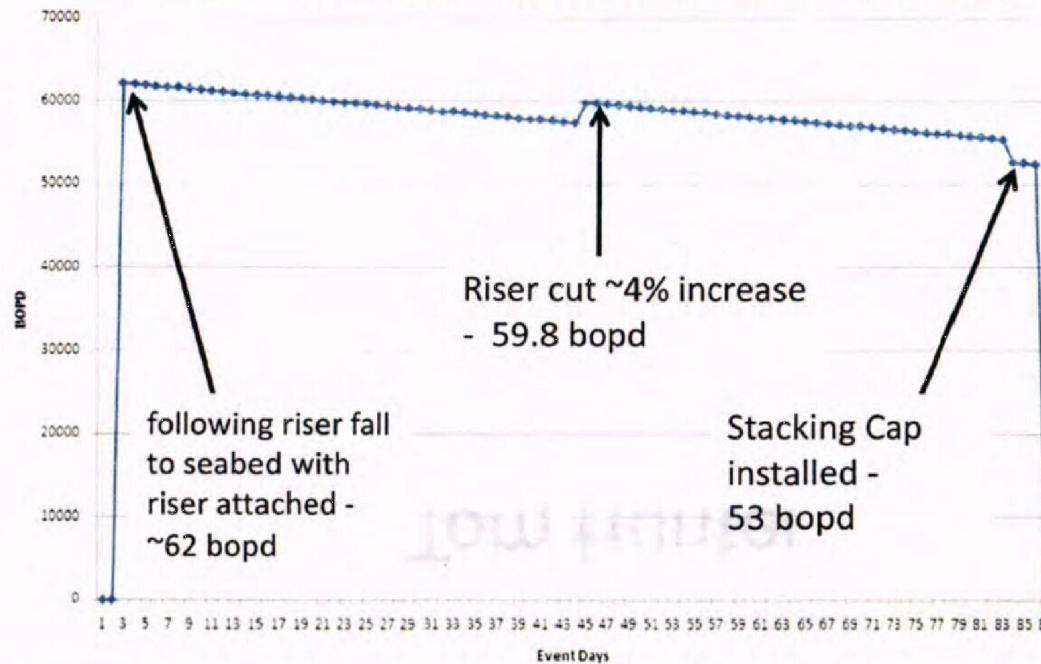
- **Shut-in flow rate:** Used DOE Team methods 1 & 2 (Kill Line models) – 53K bopd
- **Initial State:** Used reservoir initial condition and DOE team methods (Reservoir-to-Sea models) ~65K bopd (did not correct for riser pipe in the calculation)
- **Riser cut:** DOE team predicted 4% increase
- **Install of Capping Stack:** DOE team computed ~4% decrease in flow rate

7/31/10

Official Use Only

15

DOE Team Flow Results for 87 Days



Checked assumption of linearity for flows against results for linear reservoir depletion model and good agreement

Integral Release ~4.9 million barrels

Oil Collected ~0.8 million barrels (from BP)

7/31/10

PROFESSIONAL LIBRARY
Official Use Only

16

Discussion and Close-out

Tom Hunter

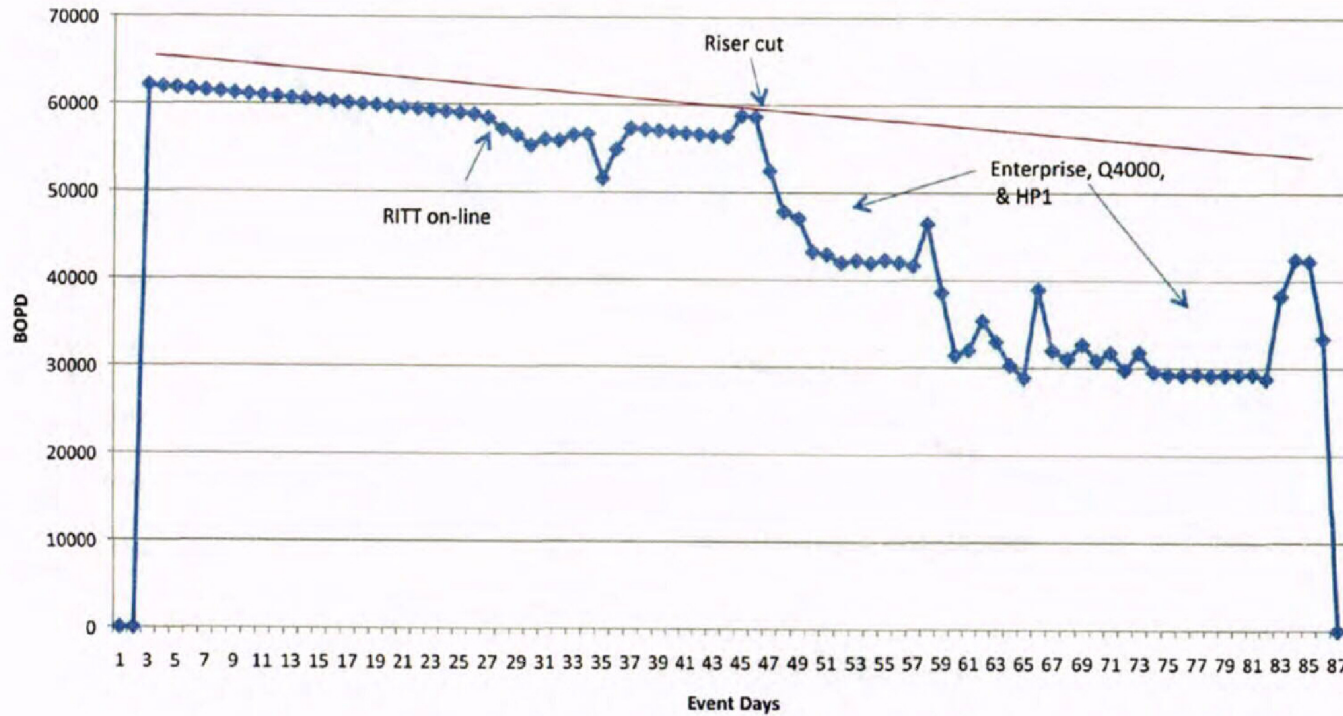
7/31/10

PREDECISIONAL DRAFT
Official Use Only

17

Total Loss less Directly Collected by BP

Flow Rate Minus Oil Recovered

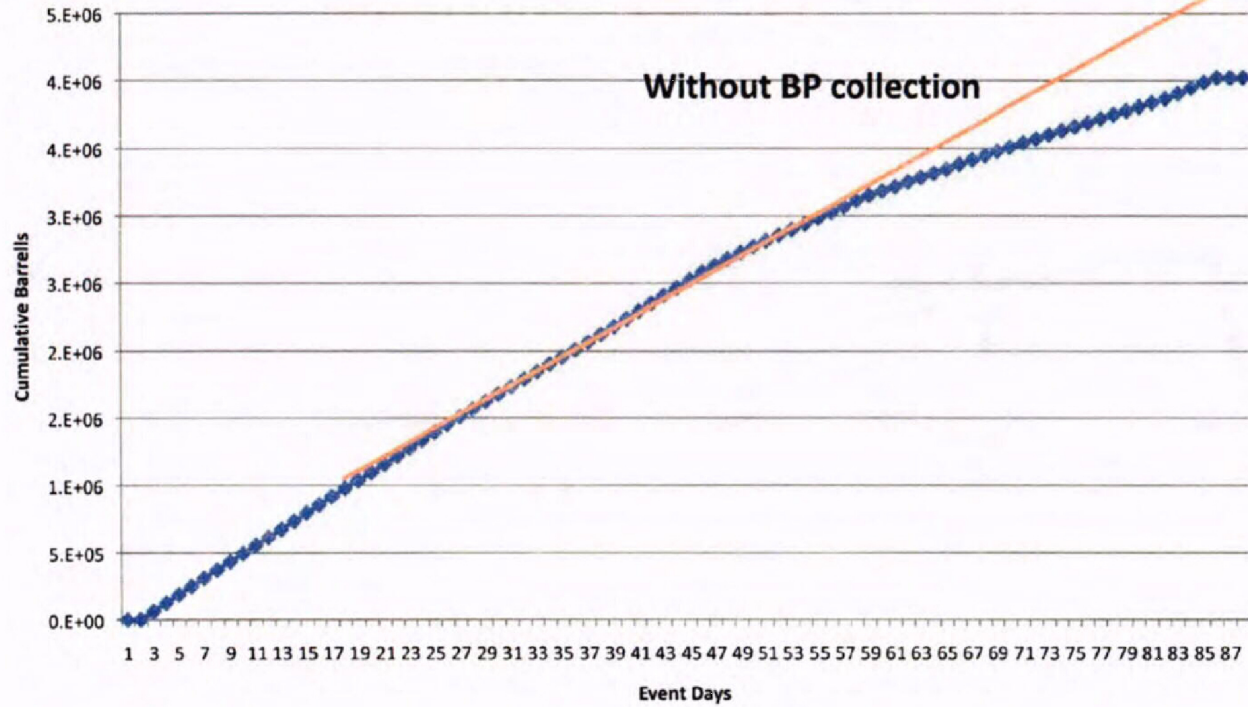


7/31/10

PREDECISIONAL DRAFT
Official Use Only

18

Total Barrels of Oil Released (4.9M) Minus Barrels directly recovered (0.8M) = (4.M)



7/31/10

PREDECISIONAL DRAFT
Official Use Only

19

Flow prediction around Well Integrity Shut-in

Art Ratzel

DOE Team

7/30/2010

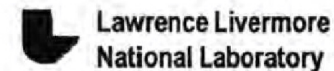
PREDECISIONAL DRAFT
Official Use Only

75

Flow Modeling Activities

Art Ratzel,
Sandia National Laboratories

Representing the work of the DOE
Tri-Lab Flow Modeling Team



7/30/2010

PREDECISIONAL DRAFT
Official Use Only

76

Time & Situation Problem Statement

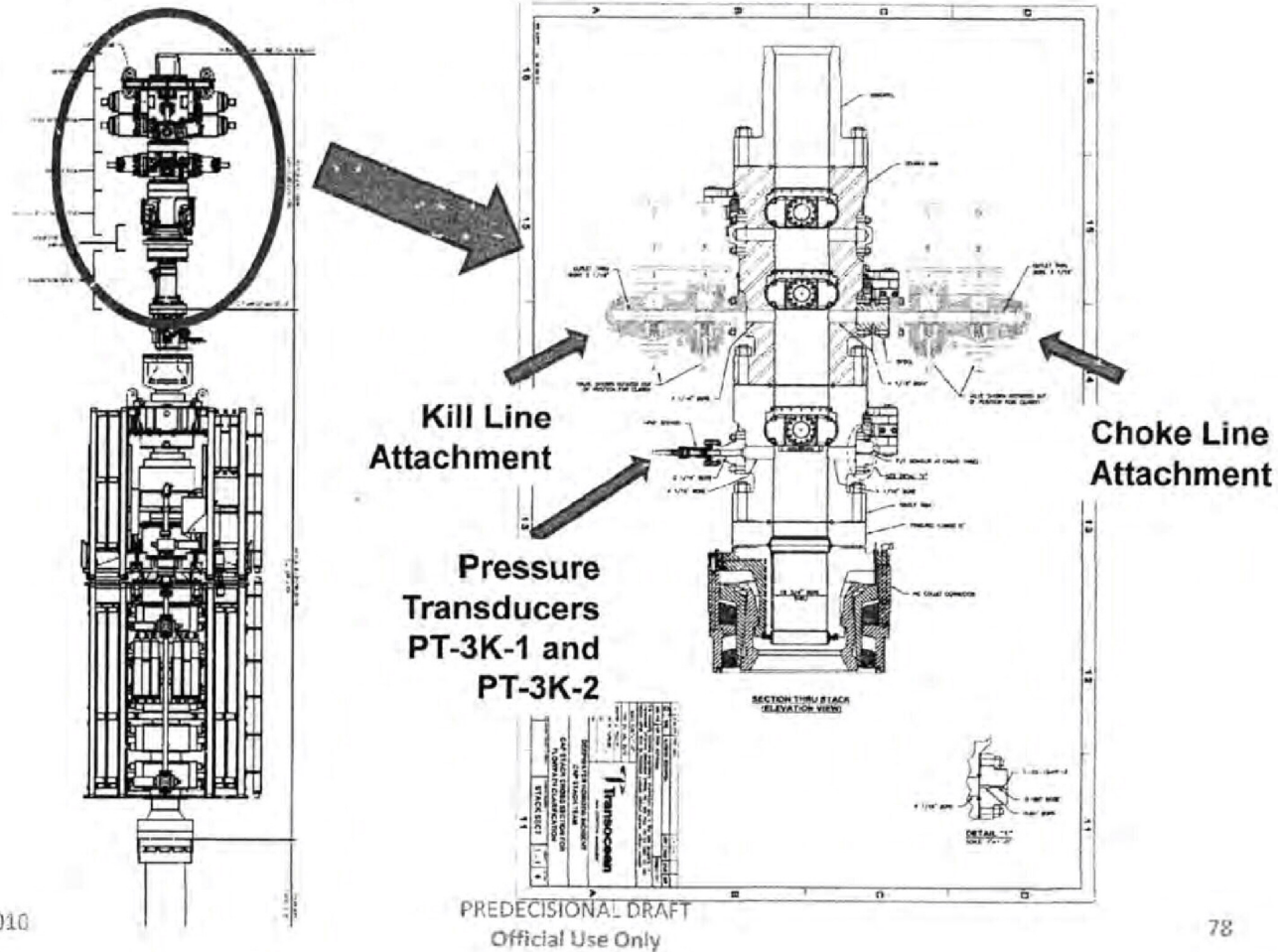
As part of preparations for the Well Integrity Test, analyses were performed to predict key attributes for a contained and leaking well.

In support of the Well-Integrity studies related to shut-in, the flow modeling team was tasked with predicting the liquid volume "flow" rate (stock-tank barrels of oil per day)

Related questions

- Can the results from the WIT Shut-in test be used to predict the flow rate for other times/events after the accident?
- What is the flow path inside the well – central, annular, or both?
- Is the well leaking?
- What is the pressure in the well below the BOP?

Shut-in of the 3-Ram Capping Stack provided opportunities for estimating flow

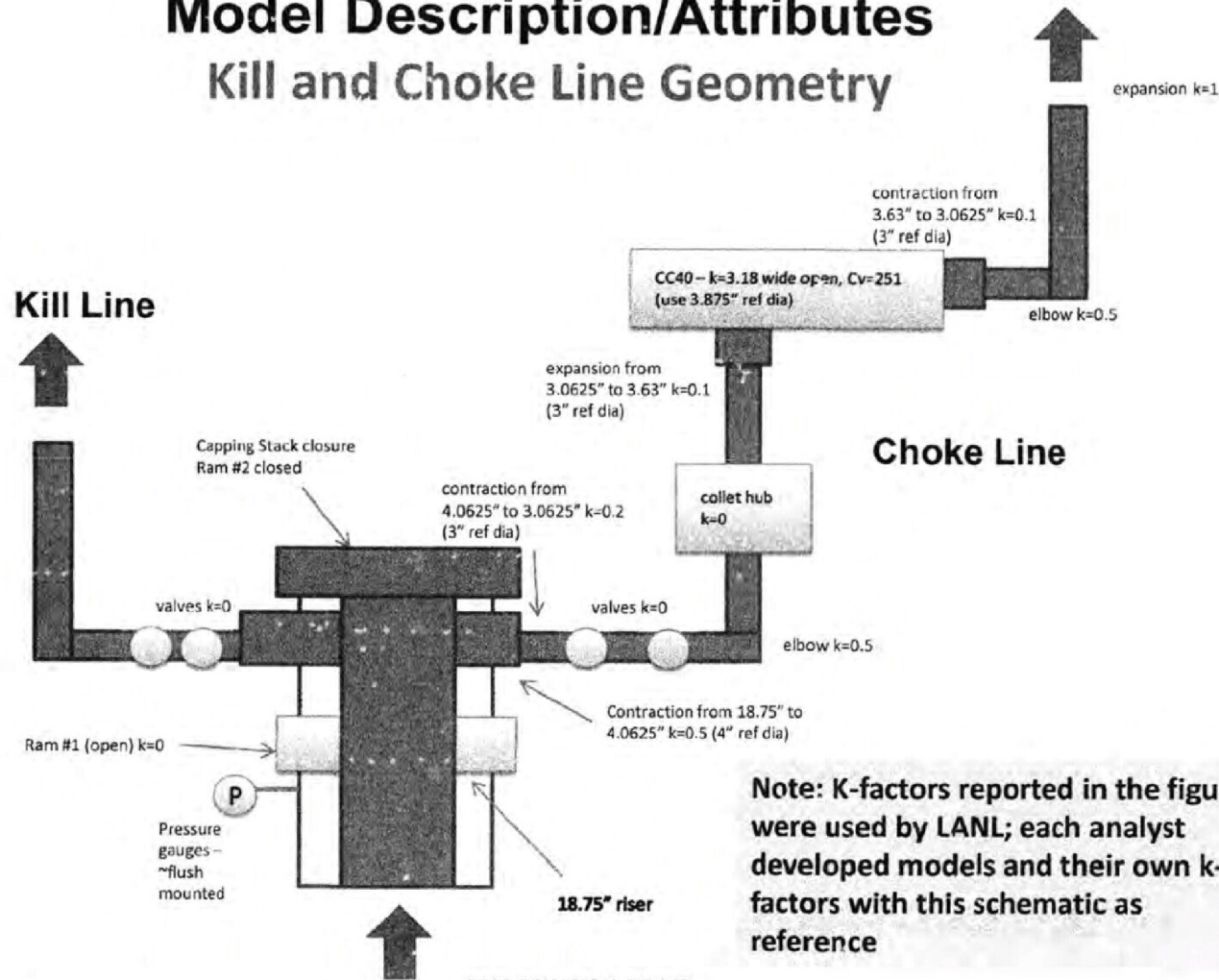


7/30/2010

78

Model Description/Attributes

Kill and Choke Line Geometry

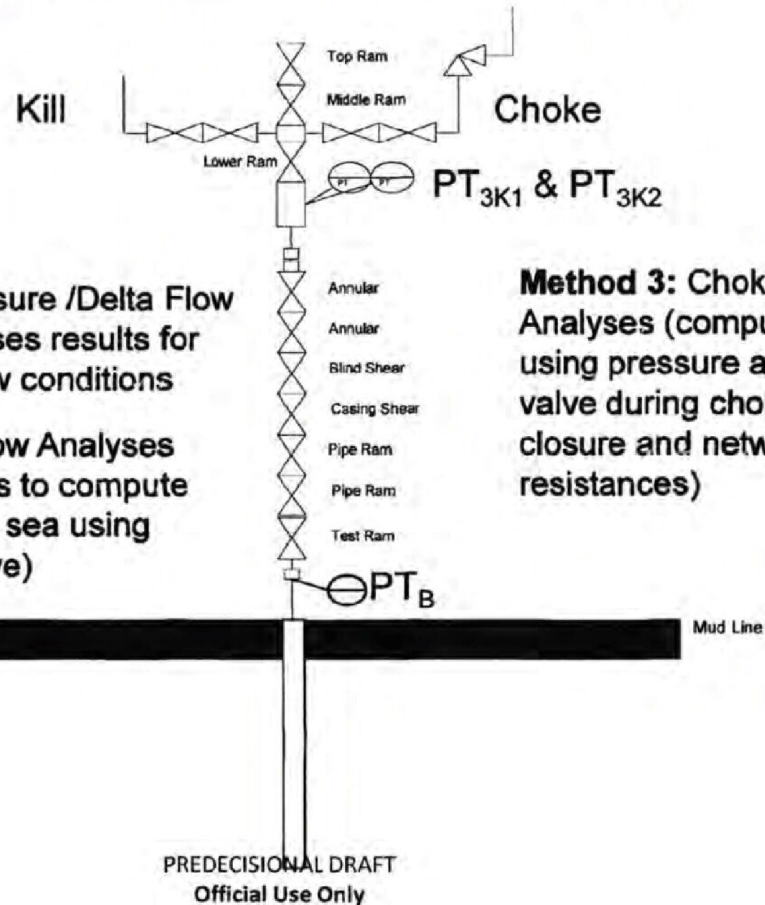


7/30/2010

PREDECISIONAL DRAFT
Official Use Only

79

Summary of Three Computational Methods Pertaining to Well Integrity Test Configuration



- **Method 1:** Delta Pressure /Delta Flow Analyses (Kill Line); uses results for different times and flow conditions
- **Method 2:** Kill Line Flow Analyses (network of resistances to compute flow through kill line to sea using pressure at choke valve)

Method 3: Choke Line Flow Analyses (computes flow using pressure at choke valve during choke valve closure and network of resistances)

7/30/2010

80

Well Integrity Test Modeling Efforts: Knowns, Assumptions and Uncertainties

Knowns

- Known geometry for the Capping stack
- Pressure readings from 2 gauges in 3-Ram Capping Stack with pretest calibration at seabed
- Surface vessel recovery rates and volumes during some operations

Assumptions

- Reservoir pressure prior to accident and estimates for depletion (~1800 psi)
- Temperature of flowing hydrocarbon at wellhead (before initiation of well integrity test) - estimated at 180-200F
- No well leakage
- Steady state flow
- Productivity Index of the reservoir (PI assumed to be ~50)

Uncertainties

- EOS and multiphase flow models
- K-factors and choke valve vendor data for multiphase flow regimes

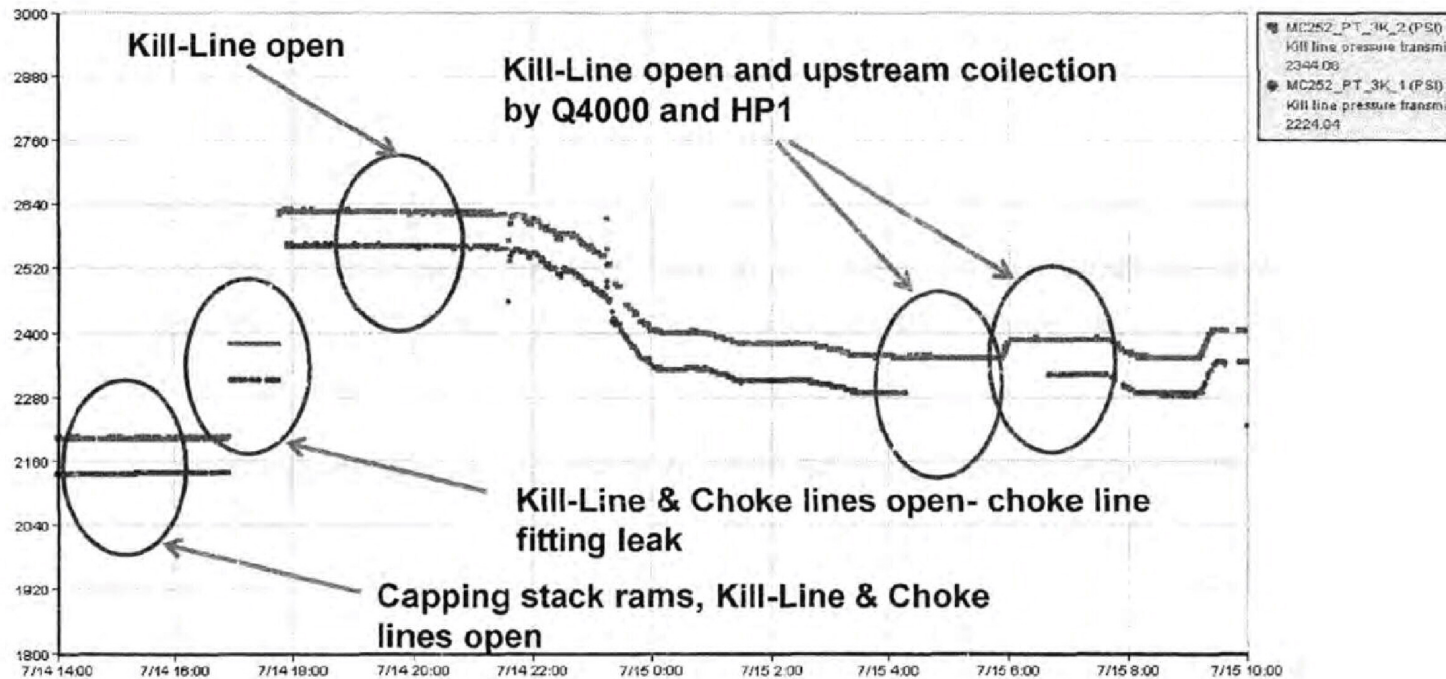
7/30/2010

PREDECISIONAL DRAFT
Official Use Only

81

Choke Pressures on July 14-15 Under Differing Flow Conditions through Kill Line

Well Integrity Test --- Boa Subsea



“Preferred” transducer is in green – has 10 psi DC offset not corrected in figure; evaluations performed at seabed

7/30/2010

PREDECISIONAL DRAFT
Official Use Only

82

Delta Pressure Analyses – Method 1

- Analysis Method: Use two steady flow conditions
 - Initially all flow through the Kill Line
 - Later flow split through the Kill Line and collection lines (HP1 and Q4000 collection)
 - Back out total flow due to change in Kill Line pressure
- Assumptions
 - Assumes fluid density does not significantly change - 15% change in density may yield a 8% error in flow rate.
 - Assumes resistance does not significantly change (relaxing multiphase effects assumption not yet verified)
 - Requires an estimate of flow decrease from well due to changing back pressure

Flow estimates for step change in flow and pressure measurement

- Flow through a constant resistance when **collection** exists: low choke pressure, late time

$$\Delta P_2 = KQ^2$$

- Modify flow rate due to known collection rate change (w) and less flow up well (g): high choke pressure, early time (**base case**)
- Solve for Q and K from two equations

$$\Delta P_1 = K(Q + w - g)^2$$

Delta Pressure Analyses – Method 1 (cont'd)

- Model Advantages
 - Geometrical effects minimized – Does not require determining K from single phase relations, nor does it require a two phase correction
 - Uses steady flow measurements for comparison to a steady model
- Model unknowns
 - Pressure measurement +/- 10psi
 - Flow decrease due to back pressure increase 1000 +/- 500 bopd
 - Ambient pressure 2189 +/- 2 psi
 - Collection rates +/- 1000 bopd
- Results: total flow out the kill and collected at beginning (Q+w)
 - Total flow range (**collection case**) from **52,600 to 52,900 bopd** (no parameter variation) for various quasi-steady time periods
 - Error bars are difficult to estimate due to use of single phase concepts for a multiphase flow (model inaccuracies).
 - Ignoring model inaccuracies, the flow range is **48,000 to 58,000 bopd** given model unknowns above. Total error may be greater.

Kill Line Analyses – Method 2

- **Analysis Method: Flow through the Kill Line**

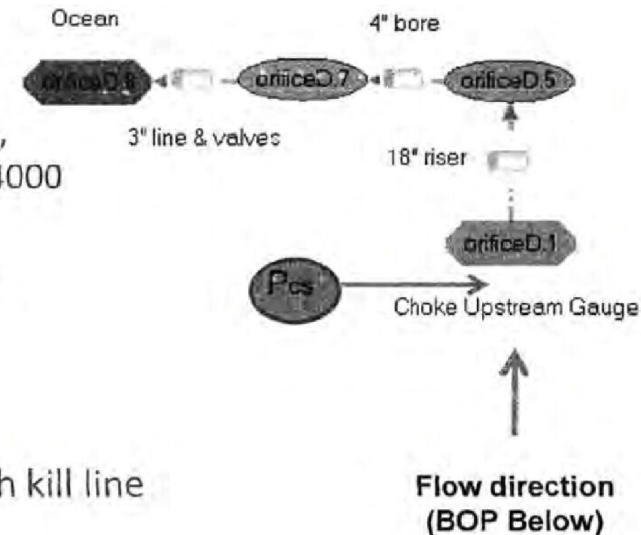
- Model flow restrictions between the choke pressure gage and exit into sea
- Use measured P_{cs} and known P_{sea}
- Two cases:

- Flow only through kill line to exit
- Some flow through the Kill valve to exit, some diverted upstream to HP1 and Q4000 collection vessels

- **Resulting Model: Network Model**

- **Assumptions**

- Kill line gate valves are wide open
- All flow into 3-ram stack exits through kill line
- No elevation change of kill line



7/30/2010

PREDECISIONAL DRAFT
Official Use Only

26

Kill line Analysis Results Method 2

Kill Line open and no shipboard collection

| Lab | P_choke (psia) | P_sea (psia) | Oil from kill line (bopd) | Oil collected on ship (bopd) | Total oil flow (bopd) |
|--------|----------------|--------------|---------------------------|------------------------------|-----------------------|
| Sandia | 2615 | 2192 | 51000 | 0 | 51000 |
| LLNL | 2615 +/- 10 | 2192 | 47,900 49,200 | 0 | 47,900 49,200 |

Kill Line open and shipboard collection; 04:30-05:30

| Lab | P_choke (psia) | P_sea (psia) | Oil from kill line (bopd) | Oil collected on ship (bopd) | Total oil flow (bopd) |
|--------|----------------|--------------|---------------------------|------------------------------|-----------------------|
| Sandia | 2343 | 2192 | 29700 | 22100 | 51800 |
| LLNL | 2343 +/- 10 | 2192 | 26,500 28,400 | 22,000 +/- 1100 | 47,400 51,600 |

Kill Line open and shipboard collection; 06:30-07:30

| Lab | P_choke (psia) | P_sea (psia) | Oil from kill line (bopd) | Oil collected on ship (bopd) | Total oil flow (bopd) |
|--------|----------------|--------------|---------------------------|------------------------------|-----------------------|
| Sandia | 2376 | 2192 | 32900 | 18,900 | 51800 |
| LLNL | 2376 +/- 10 | 2192 | 29,660 31,450 | 18,940 +/- 950 | 47,650 51,340 |

Range Min 47,430 bopd Range Max 51,570 bopd

7/30/2010

Pressure and collection data uncertainties are being developed by BP – uncertainty analyses to follow

87

Kill Line Analyses – Method 2 (cont'd)

- Model Advantages
 - Simple geometry, does not include reservoir or well.
 - Well-defined geometry and boundary conditions-fully prescribed problem
 - Trust in pressure boundary conditions
- Model Limitations/Issues
 - Two-phase flow losses may be inaccurate
 - Head loss at closed ram/angle into kill line (stagnation flow) not fully understood

Results Summary

- Flow only through Kill Line: Average Flows of **48-51K bopd**
- Flow through Kill Line with ~**19-22K bopd** removed upstream: : Average Flows of **47-52K bopd**

7/30/2010

PREDECISIONAL DRAFT
Official Use Only

88

Extrapolation to earlier times: Approximate Model Results

- **Three time periods to consider**
 - WIT with all flow out kill line (base case)
 - 10050 psi reservoir to 2600 psi at kill line exit
 - Just before WIT without capping stack
 - 10050 psi reservoir to 2175 psi ambient
 - Initial state (maximum flow)*
 - 11850 psi reservoir to 2175 psi ambient;

***Note: This case never existed (i.e. initial state included resistance at kink in riser), but this does allow an estimate of a limiting maximum flow**

| | Base case | w/o capping stack | Maximum flow |
|------------------------|--------------|-------------------|--------------|
| linear | 53000 | 56950 | 73300 |
| quadratic | 53000 | 54940 | 62330 |
| realistic | 53000 | 55170 | 63450 |
| Full Well Model | 53000 | 56000 | 65900 |

**The model captures key attributes of the full well model
without the added complexity**

(703) 648-4454 (fax)
 (571) 296-6730 (bb)
 (831) 915-4699 (cell)
 www.usgs.gov
 USGSUSGSUSGSUSGSUSGSUSGSUSGSUSGSUSGSUSGS

From: Chavez, Anne K <akchave@sandia.gov> [mailto:Chavez, Anne K <akchave@sandia.gov>]
Sent: Thursday, July 29, 2010 7:21 PM
To: "Chavez, Anne K" <akchave@sandia.gov>; "Bill.Lehr@noaa.gov" <Bill.Lehr@noaa.gov>; "George.Guthrie@NETL.DOE.GOV" <George.Guthrie@NETL.DOE.GOV>; "Donald.Maclay@mms.gov" <Donald.Maclay@mms.gov>; "pahsieh@usgs.gov" <pahsieh@usgs.gov>; "Donald.F.Cundy@uscg.mil" <Donald.F.Cundy@uscg.mil>; "Andy Bowen" <abowen@whoi.edu>; "Robinson, Bruce A. (LANL)" <robinson@lanl.gov>; "Wereley@purdue.edu" <Wereley@purdue.edu>; "Alberto Aliseda" <aaliseda@u.washington.edu>
Cc: "Ratzel, Arthur C" <acratze@sandia.gov>; "hunsaker61@comcast.net" <hunsaker61@comcast.net>; "mcnuttt@usgs.gov" <mcnuttt@usgs.gov>; "Dr. Richard Camilli (rcamilli@whoi.edu)" <rcamilli@whoi.edu>; "Bowen, Amy D" <adbowen@sandia.gov>; "Hurst, Kathleen T" <kthurst@sandia.gov>; "Hunter, Tom" <tohuntes@sandia.gov>
Subject: REMINDER - TELECON SCHEDULED: TOMORROW, Friday, July 30, 12:00pm CDT RE: Flow Analysis Activities for the MC252 Well
Importance: High

All,
 Thank you in advance for your participation in tomorrow's teleconference regarding flow analysis activities for the MC252 well. As a reminder, this telecon will be held from 12:00pm-5:00pm CDT (1:00pm-6:00pm EDT, 11:00am-4:00pm MDT).
Please use 202-287-6677 for this call. The intent of this meeting is to review the different methods, evaluate the uncertainties, and to come to consensus on a revised, more informed estimate on flow. Senior leadership is expecting a consolidated report by Friday night.

We have attached a slide template for your use with some recommended guidelines to help keep discussions in line with the day's agenda (see page 2 of the attached). We encourage you to work your portion of the response with your colleagues, but in the interest of time, we request that only the individuals listed on the agenda actually present information. Should questions associated with technical details arise, your colleagues are welcome to contribute to the discussion.

OFFICIAL USE ONLY

Subject: FW: RE: REMINDER - TELECON SCHEDULED: TOMORROW, Friday, July 30,12:00pm CDT RE: Flow Analysis Activities for the MC252 Well
Date: Friday, July 30, 2010 10:09 AM
From: Gauglitz, Phillip A <phillip.gauglitz@pnl.gov>
To: Jim Fort <james.fort@pnl.gov>

From: George Guthrie [mailto:George.Guthrie@NETL.DOE.GOV]
Sent: Friday, July 30, 2010 10:00 AM
To: Rajesh Pawar; Curt Oldenburg; Todd Weisgraber; Grant Bromhal; Gauglitz, Phillip A
Subject: Fwd: RE: REMINDER - TELECON SCHEDULED: TOMORROW, Friday, July 30,12:00pm CDT RE: Flow Analysis Activities for the MC252 Well

FYI...

>>> "Marcia K McNutt" <mcnutt@usgs.gov> 7/29/2010 8:58 PM >>>
Participants in the flow rate discussion -

I have had a few conversations while I was back in Washington, DC today about the needs of our leadership for an outcome for the meeting Friday afternoon. A few things have changed since we first set up the meeting, not the least of which has been significant media coverage speculating on an oil budget. It would be most helpful if the meeting could result in a flow rate or rates as a function of time that could be used to estimate the oil released over the duration of the incident. (Numbers are well in hand to correct for the oil that was captured through containment, etc.)

Clearly this number or these numbers should be expressed with their full associated uncertainties.

I will be calling into the meeting tomorrow between airplane flights, but hope to make most of the meeting except for about an hour or so. I want to express my appreciation to everyone for convening on such short notice.

Thanks.

Marcia

USGSUSGSUSGSUSGSUSGSUSGSUSGSUSGSUSGSUSGS
Dr. Marcia K. McNutt
Director, U.S. Geological Survey
12201 Sunrise Valley Drive MS 100
Reston, VA 20192
(703) 648-7411 (office)

OFFICIAL USE ONLY

Please send your completed slide package to me no later than 9:00am CDT tomorrow so they can be distributed prior to the discussion at noon.

Please contact me with any questions. Thank you.

Annie Chavez
Sandia National Labs
505-414-5149

OFFICIAL USE ONLY

**Flow Analysis Activities
for the MC252 Well
Report-outs by Government Teams**

PREDECISIONAL DRAFT

Friday, July 30

12:00 – 5:00 PM CDT

PREDECISIONAL DRAFT
Official Use Only

Introduction and Intent

Tom Hunter

7/30/2010

PREDECISIONAL DRAFT
Official Use Only

2

Agenda

| Time (CDT) | Speaker | Topic |
|-------------|----------------|---|
| 12:00-12:15 | Tom Hunter | Intro/Intent/Chronology |
| 12:15-12:45 | Bill Lehr | Flow Visualization Before TopHat-4 |
| 12:45-1:15 | Dan Maclay | Reservoir – Time of Event with Production |
| 1:15-2:00 | George Guthrie | Nodal Analyses – Pre/Post Cut |
| 2:00-2:15 | <i>Break</i> | |
| 2:15-2:45 | Andy Bowen | Doppler Velocities → Kink and more |
| 2:45-3:15 | Paul Hsieh | Reservoir Studies Around Times of Well Integrity Test Shut-in |
| 3:15-4:00 | Art Ratzel | Flow prediction around Well Integrity Shut-in |
| 4:00-5:00 | Tom Hunter | Discussion and Close-out |

7/30/2010

PREDECISIONAL DRAFT
Official Use Only

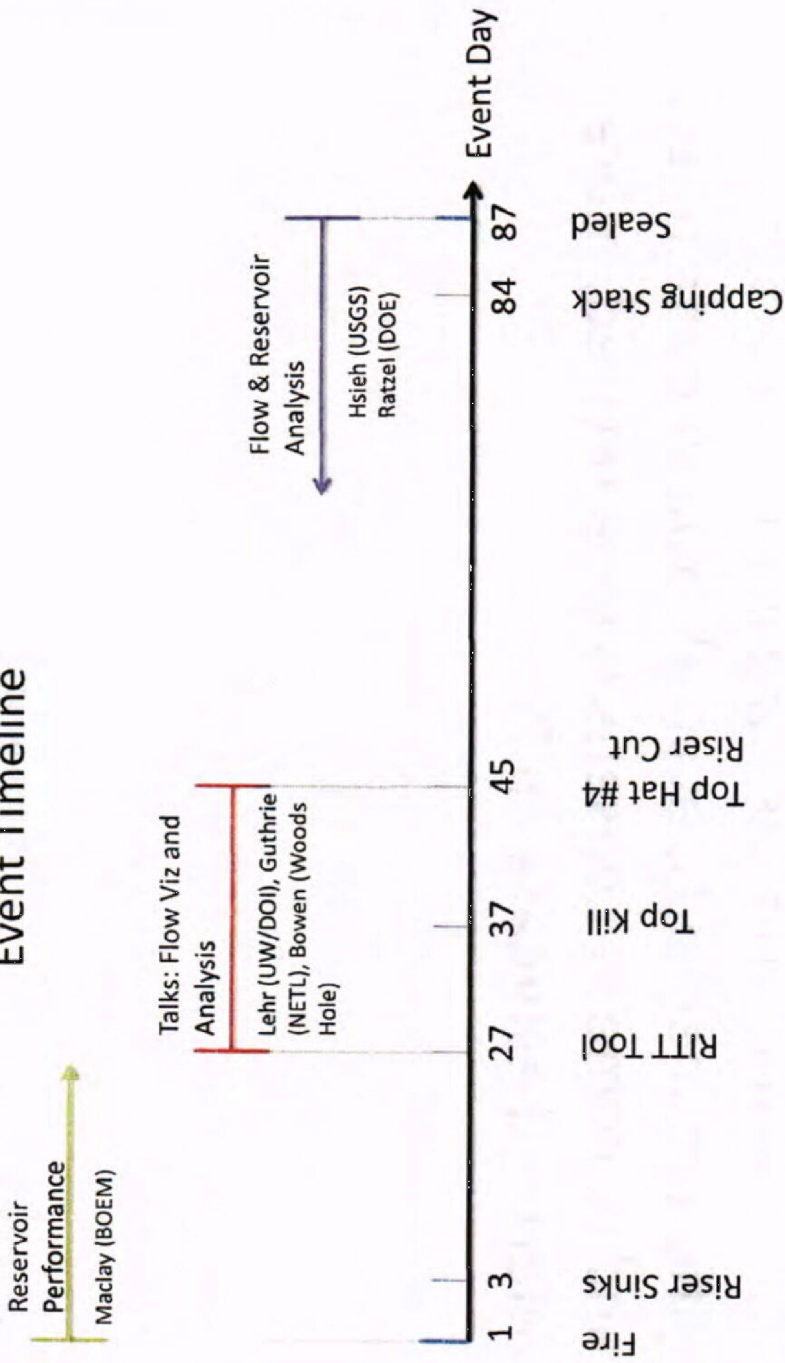
3

Timeline for the Deepwater Horizon Events

| Date | Time if available | Events – Flow Conditions | Collection |
|--------|-------------------|--|------------------------------------|
| 20-Apr | | Explosion and fire; oil continues to flow to damaged platform at ocean surface | None |
| 22-Apr | | Rig sinks; oil and gas flow into ocean from sunken riser | None |
| 5-May | | One of three leaks stopped on broken riser | None |
| 8-May | | Cofferdam lowered on broken riser; fails due to icing | Attempted |
| 16-May | | Riser Insertion Tool (RITT) begins to recover some oil | RITT on-line |
| 25-May | | Riser Insertion Tool (RITT) removed | None |
| 26-May | | Top kill begins | None |
| 29-May | | Top kill ends - unsuccessful | None |
| 1-Jun | | First Shear Cut | None |
| 3-Jun | | Second Shear Cut | None |
| 3-Jun | | Top Hat # 4 Installed (Enterprise recovering) | Enterprise on-line |
| 16-Jun | | Top Hat # 4 Operational (Q4000 on line and recovering from BOP manifold line) | Enterprise and Q4000 on-line |
| 29-Jun | | 2nd set of Pressure Transducers introduced into Top Hat #4 to support flow rate estimation | Enterprise and Q4000 on-line |
| 10-Jul | | Top Hat #4 Removed | Q4000 on-line |
| 12-Jul | | Flange Removed - Spool Flange Installed | Q4000 on-line |
| 12-Jul | | 3-Ram Capping Stack Landed/secured | Q4000 on-line |
| 13-Jul | | HP1 came on-line; recovering from BOP manifold line | Q4000 online; HP1 coming online |
| 13-Jul | ~4:00 PM | Started Well Integrity Test - shut-in operations initiated | None |
| 13-Jul | 5:48 PM | Terminated shut-in test due to leak in choke line of stacking cap flow diverted to kill side of stack only | None |
| 15-Jul | 12:15 AM | Recovery resumes(during repairs to choke line) with Q4000 and HP1 operational | Q4000 and HP1 brought back on-line |
| 15-Jul | ~12:00 PM | Recovery stopped - Well Integrity shut-in begins | None |
| 15-Jul | 2:30 PM | Well Integrity test shut-in completed | No flow; shut-in |

OFFICIAL USE ONLY

Event Timeline



7/30/2010

PREDECISIONAL DRAFT
Official Use Only

Problem Statement

- The intent of this meeting is to review the different methods, evaluate the uncertainties, and to come to consensus on a revised, more informed estimate on flow.

7/30/2010

PREDECISIONAL DRAFT
Official Use Only

6

Saturday, July 31, 2010 7:10 AM

Subject: Fwd: TELECON SCHEDULED: TOMORROW, Saturday, July 31, 12:00pm CDT RE:Follow-on to Flow Analysis Activities for the MC252 Well
Date: Friday, July 30, 2010 4:36 PM
From: George Guthrie <George.Guthrie@NETL.DOE.GOV>
To: Rajesh Pawar rajesh@lanl.gov, Curt Oldenburg CMOldenburg@lbl.gov, Tom Buscheck buscheck1@llnl.gov, Todd Weisgraber weisgraber2@llnl.gov, Grant Bromhal Grant.Bromhal@NETL.DOE.GOV, Jim Fort James.fort@pnl.gov, Gauglitz, Phillip A phillip.gauglitz@pnl.gov
Conversation: TELECON SCHEDULED: TOMORROW, Saturday, July 31, 12:30pm CDT RE:Follow-on to Flow Analysis Activities for the MC252 Well

>>> "Bowen, Amy D" <adbowen@sandia.gov> 7/30/2010 7:19 PM >>>
 All,

We have scheduled a follow-on teleconference for flow analysis activities for the MC252 well TOMORROW, Saturday, July 31, from 12:00pm-1:00pm Central (1:00pm-2:00pm Eastern, 11:00am-12:00pm Mountain). **Please use 202-287-6677 for this call. If you are able to attend in person, this meeting will be held in BP Westlake Four, room 1814.**

Agenda is attached. Presentation materials will be distributed tomorrow morning prior to the call.

Please contact me with any questions. Thank you.

| Time (CDT) | Speaker | Topic |
|-------------|----------------|---|
| 12:00-12:05 | Bill Lehr | Flow Visualization Before TopHat-4 |
| 12:05-12:10 | Dan Maclay | Reservoir - Time of Event with Production |
| 12:10-12:15 | George Guthrie | Nodal Analyses - Pre/Post Cut |
| 12:15-12:20 | Andy Bowen | Doppler Velocities - Kink and more |
| 12:20-12:25 | Paul Hsieh | Reservoir Studies Around Times of Well Integrity Test Shut-in |
| 12:25-12:30 | Art Ratzel | Flow prediction around Well Integrity Shut-in |
| 12:30-1:00 | | Open Discussion |

Amy Bowen
 Sandia National Labs
 575-770-1729

OFFICIAL USE ONLY

Page 1 of 1

7/31/10 Multi Team Telecon

1/3

David Hays of Rob O'Connor for Washington

Marsha GOR charged on time, BP
says typical 0.29 → more oil of time
@4000, Enterprise

[Phineas]

riser cut on Day 45

"Does anyone want to put a number on log, fine" Steve W
used 29% part, now 43-44%

1.75 x sea floor to

"Day 45 could be in high 50's"

[Don]

annular fin outside the casing
a little over 1000 psi depletion (1100)

clear to 16-18

[George]

OFFICIAL USE ONLY

Prop 4400 ^{topkill} _{junk} 2/3
[Wood Hole] 9000 pi / 3500
drop

[Paul Hsieh]

gave IPRs to NL modelers

1800 psi soon after shut in
w/ gradual recovery
probably ~1500 psi

if AC @ 54/psi what reservoir now?
47

7000 + 8 / 12000 13000 w/ + Res

Slightly ~~near~~ 10,000 10,000 psi

[WIT]
[Dustin]

David Hays there at time of
fire - no visible oil, assuming
all burned

OFFICIAL USE ONLY

did also not believe any diesel

ok w/ (1090 ancient) P.
art → Sheldon → Sheldon quotes meeting stated
by Seth Chou "gov best estimate" will end. to refine"
So Sheldon want no error bar!

3/7

Tom Hunter still

Pushing for 10% , integrated or daily

Will add

Cabinet wants clean nice number

Uncertainty still being worked out

 $\pm 10\%$ feels better $\pm 5\%$ too tight4.9 mbbt $\pm 10\%$ as final cont. ref. this

"As far as US Gov neg w/ DP this is good enough." (Steve)

reopening negotiation w/ Indian people

DP collects 0.8 M certifying that w/ Cabinet this week

Rod of Secty writing up

"Concept of share" to all Secty Clerk

OFFICIAL USE ONLY