INVESTIGATION OF DRILLING PROBLEMS ENCOUNTERED IN AN OILFIELD DEVELOPMENT IN MALAYSIA

by

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16191

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Petroleum Engineering)

FYP II JANUARY 2015

Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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In partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(PETROLEUM ENGINEERING)

Approved by,

____

(Dr. XIANHUA LIU)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JANUARY 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons

(MUHAMMAD ARIFF ABDUL JALIL)

ABSTRACT

In exploration and production of hydrocarbon, drilling process play an important role to determine the most optimise economical cost for the whole project. The smoothness of drilling process should be considered as the main factor for an economic project. However, drilling of a well that covers 10 000 feet to 15 000 feet into the target is a challenge that should be countered so that non-productive time could be minimized. Thus, this project focus on investigation of major drilling problems occurred in oil field development of Malaysia with the latest data provided (2000 – 2014). The most common problems in Malaysia is pipe sticking especially in Sabah and Sarawak as this region was made up of unconsolidated and soft formations. Meanwhile, most of the deep water region in Malaysia encountered with shallow gas hazards including gas hydrates especially at the sea floor or in shallow sediments. Both shallow water and deep water region have different frequent drilling problems as well as different solutions to solve the problems existed in each of the well. It is hoped that based on the investigation finding, further research could be done to develop future technologies to avoid drilling problems and thus an economical target could be achieved for the betterment of oil and gas industry in the future.

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Not to forget to my beloved parents, family, beloved soul mate and friends for the continuous prayers throughout my FYP completion. Without them, I would not be as fortunate as I am today.

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Chapter 1: Introduction

1.1 Background

Drilling is one of the crucial part during exploration and production of a well. Billions of dollars was spend by oil and gas companies just for drilling. One type of drilling that is commonly used in oil gas industry known as rotary drilling, where a constant rotating bit will be use to penetrate any kind of formation within a specific depths (William, 2001). With the help of continuous circulation of fluid, the cuttings are removed along the annular space between the pipe string and the borehole walls. Thus, it is very important to ensure that making drilling decisions are really comprehensive and specific in order to avoid any problem in the future.

In Malaysia, the main three areas of oil fields that are currently producing their crude oil are Sabah, Sarawak and Terengganu. Mohamed & Mya (1986) found that a total of 180 wells in 1978 – 1983 was drilled by Esso Production Malaysia Incorporation (EPMI) including 6 wells in Tembungo field offshore in Sabah. Meanwhile in Sarawak, almost 96 wells was drilled by Sarawak Shell Berhad (SSB) as the main operators in that offshore area.

Most of the formations in Terengganu are dominated by claystones and massive siltstones which are embedded with hard shale streaks and water-reactive type. While in Sarawak, the main four geological provinces are Balingian, Baram Delta, South West and Central Luconia. The main type of formation in Balingian and Baram Delta is clastics where the hydrocarbons are accumulated in anticlines and faults. Same as Sarawak, the sediments in Sabah is mainly with clastics consisting of alternating layer of sand, clays and silts. In addition, they are usually unconsolidated, soft and complex because of strong faulting and folding.

1.2 Problem Statement

On the drilling rig, a well is drilled based on the drilling plan where several of informative data is collected, analysed and interpreted back to the drilling process. On the same period, the well data starts to become a dynamic rather than a static type and continuous evaluations on drilling risks need to be done as the well becoming complex in term of time being. However, there is no well drilled without risk and problems. Most of all, knowing exactly the risks and when they are about to occur could change a loss spent to better spent of drilling.

In general, most of the drilling contractors in Malaysia region faced with drilling problems that related to unconsolidated and soft formations as the main formation of oil fields in this region is occupied with water-reactive formation type or clastics-type. The major problems occur in Malaysia region are:-

i. Pipe sticking
ii. Top hole drilling problems
iii. Blowout
iv. Loss circulation
v. Hydrate zones
vi. Shallow gas anomalies
vii. Cement shrinkage – Primary cementing failures
viii. Pore pressure uncertainties
ix. Tool temperature limitation
x. Wellbore instability

Among the problems stated above, there is other chain problem that are also related with the main problems exist during drilling in this region. This problems may varies with different types of wellbore formation, pore pressure and others.

1.3 Objectives

The main objectives of this project are:-

i. To investigate the problems occurred/encountered during drilling process of selected well in Malaysia
ii. To study the cause/source of each drilling problems for each well.
iii. To suggest an effective/efficient solution to the drilling problems existed.

1.4 Scope of study

The study of this project will involve researching, analysing and interpreting the drilling problems in oil fields development in Malaysia. Hence, this investigation will only focus on:-

i. Investigation of each drilling problems on selected data well drilled in an oilfield development in Malaysia
ii. Analyse the shallow water and deep water drilling case study based on the structured drilling plan of the well.
iii. Identified the most suitable and efficient technique to overcome the most frequent drilling problem occurred while drilling.

Chapter 2: Literature Review

2.1 Terengganu Offshore

Mohamed & Mya (1986) state that the most common drilling problem encountered this region is pipe sticking. Out of 61 stuck pipe problems that occurred, 42 problems was found on Bekok A, Pulai A and Tapis A where these field were one of the earliest platforms operated in Terengganu. 6 wells in Tapis field was drilled via side-tracked method since there were 21 stuck pipe happened. Due to combination of thick mud cake of the formation, differential pressure sticking and inadequate borehole cleaning, Tapis A was the frequent platform that encountered with pipe sticking. As there are presence of massive claystones and siltstones on the seabed, this formations tends to react with water and cause to swell including slough into hole especially when drilled with a water base mud. As the result, the cutting removal will be less efficient and tend to cause the stabilizers and bits to become balled up.

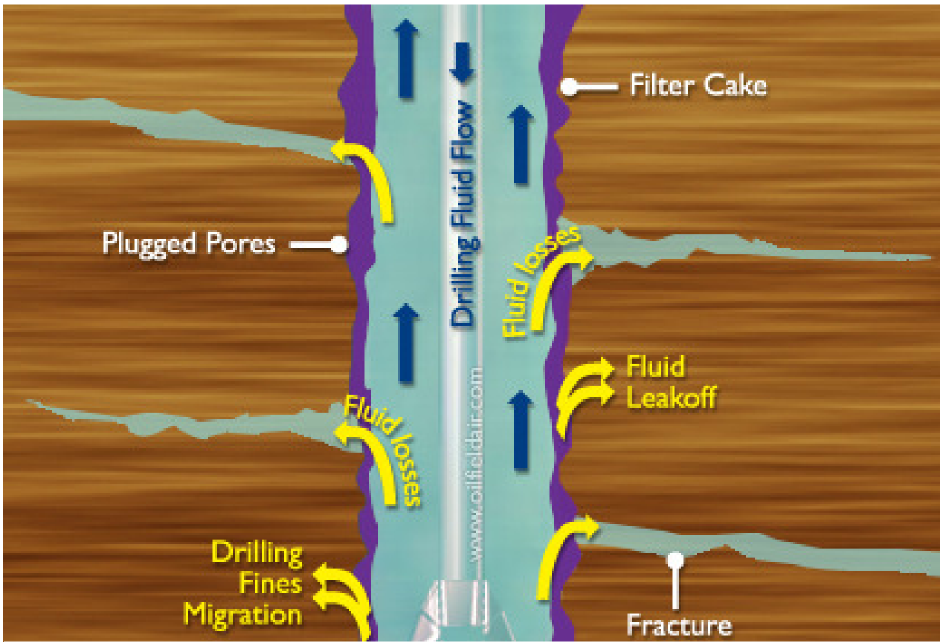


Figure 1: Mud Loss

In addition, stuck pipe also affected from differential pressure sticking where in the bottom of the hole, the motion of the pipe was stopped for connection or directional survey. In Tapis A platform, differential sticking are about to occur as the mud is loaded up to 10.4 ppg rather than the standard value which is around 9.3 ppg – 9.6 ppg. Using a lighter mud weight, the pipe was freed easily after this was reviewed. In this case, the drill string tend to lie on the side of bottom hole that cause contact with the wall of the bore hole due to deviated drilling in bore hole.

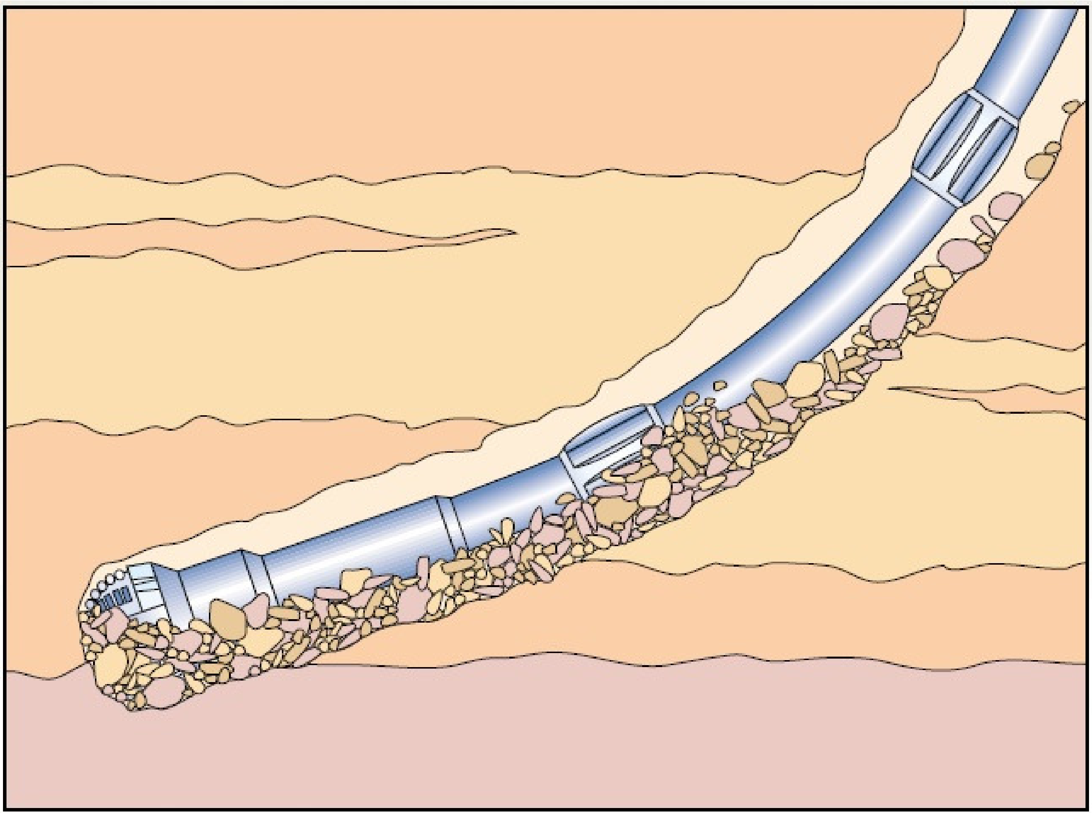


Figure 2: Poor Hole Cleaning

On the other hand, Desa & Anuar (1999) study that JDA Block A18 specifically in Cakerawala-1 and CAkerawala-3 both encountered shallow gas hazards within 1400 feet to 1600 feet below the sea level. The amplitude anomalies are usually classified from low, medium to high risk. Low and high seismic amplitude were related to carbonaceous stringers and lithological changes compared to gas accumulations. Some of them may extended over a huge area or in the form of channel.

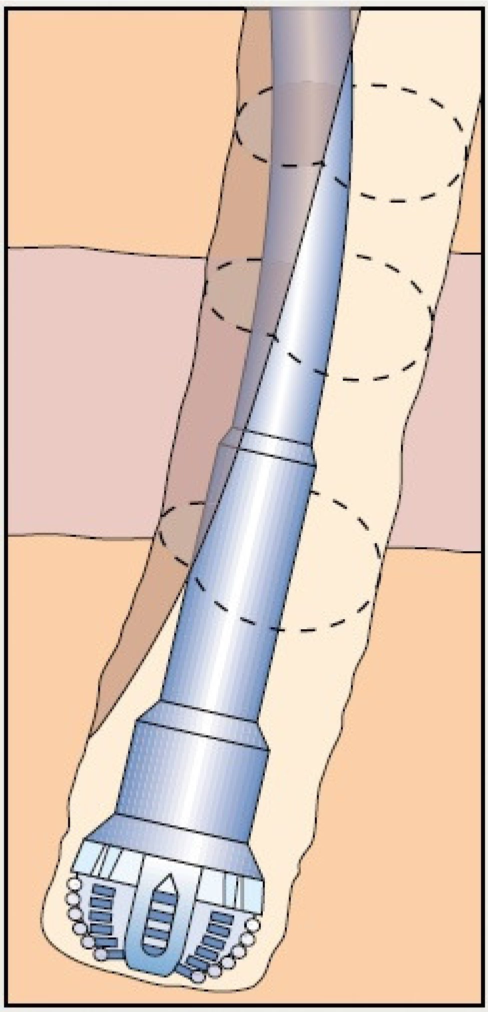


Figure 3: Key Seating

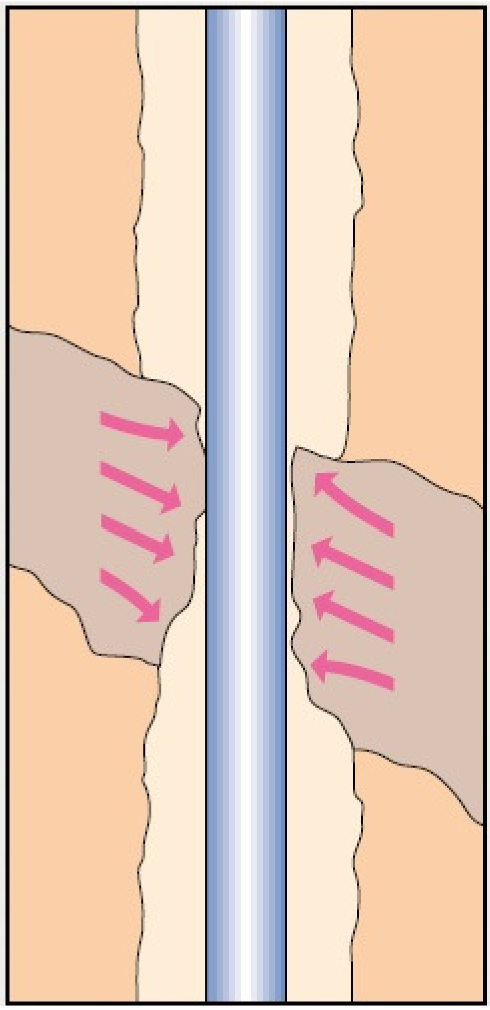


Figure 4: Mobile Formation

2.2 Sabah & Sarawak

Typically, potential of mud losses in gas-bearing carbonates structures M3 and M1 fields in Sarawak have been the most attention problems in this field development. Mud losses problems are usually classified into four categories which are severe, seepage, moderate and total losses. From 103 wells drilled, 45 wells encountered mud losses in various type of risk. Once of every six wells drilled will encountered a total losses (Taib, 1998). The mud overbalance will increase rapidly towards the reservoir and once the voids was hit, the mud losses will occur and the annular level will reduce to the point where the mud hydrostatic will equals to formation pressure at the loss zone.

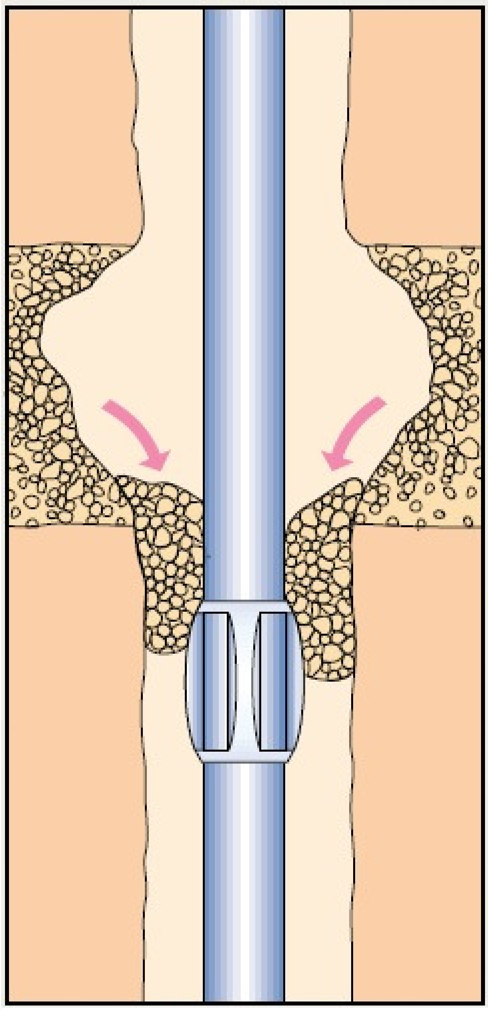


Figure 5: Unconsolidated Zone

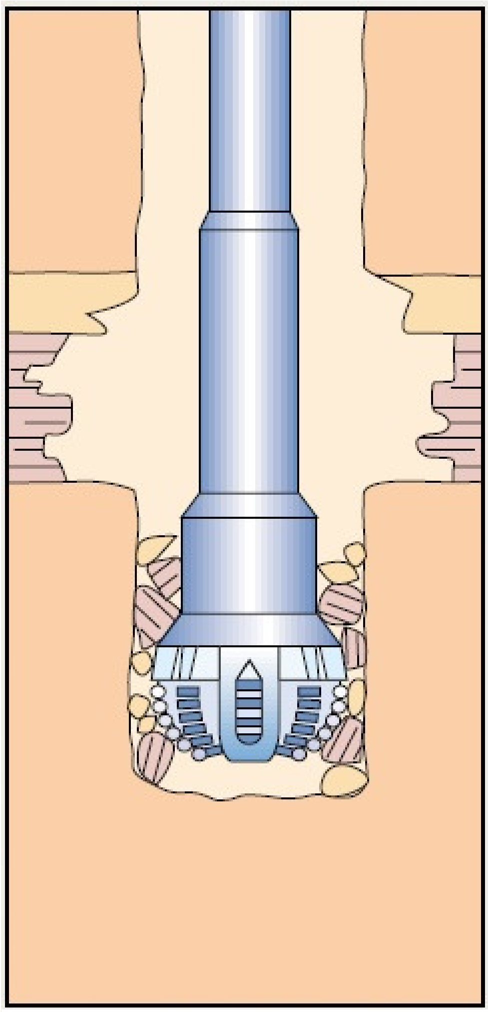


Figure 6: Fracture or Faulted Zone

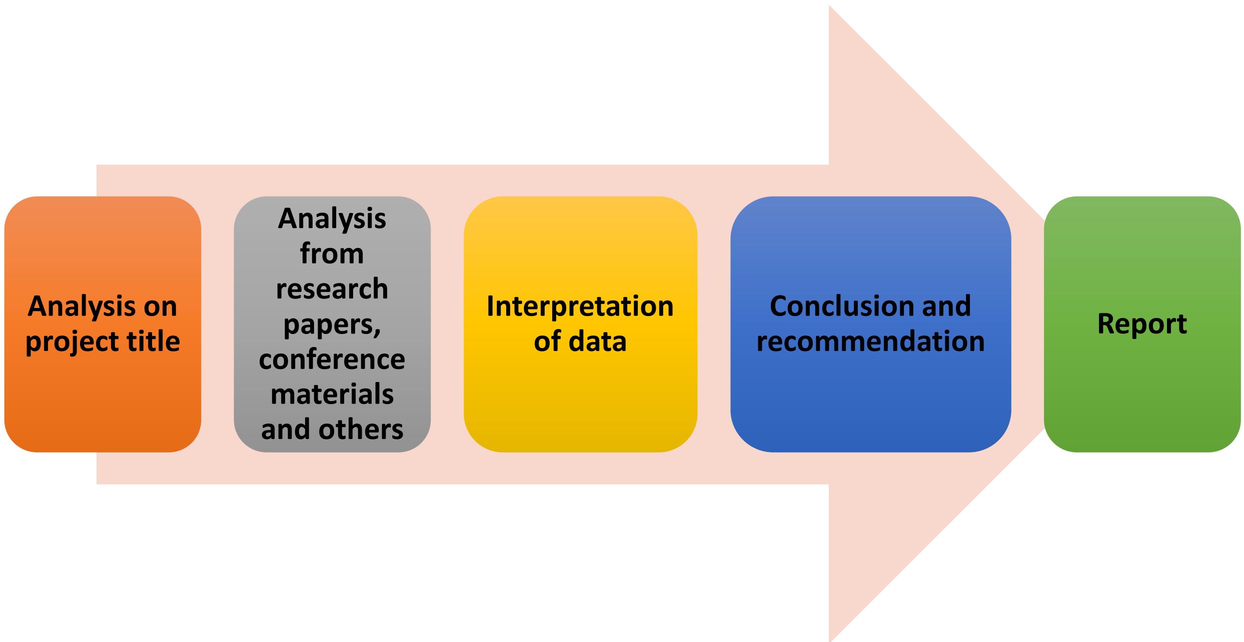
If this underbalance not handled properly, gas will flow into wellbore and pervade up the annulus. Thus, this may result in gas kick and mud losses simultaneously and the rate where the gas percolates in the annulus is much likely depending on permeability of the carbonate formation and formation pressure. Because of mud losses in M3 and M1, 12 wells were abandoned due to large mud losses faced by these wells.

Besides that, bore hole instability also happened in offshore Sabah and Sarawak severely in Erb West field and Bokor A platform. The first 1500 feet of top hole in Erb West field are basically embedded with isolated streaks of clays. Hence, it tends the formation to collapse due to clay swelling once it is in contact with water. As a result, it is prohibited to apply heavy mud in order to avoid hole collapse due to risk of inducing loss circulation. Thus, it can concluded that hole instability and loss circulation are related to each other.

Chapter 3: Methodology/Project Work

3.1 Research methodology

To ensure a smooth project flow, a proper plan or methodology need to specify for this project. The main data of this project will be based on drilling data from PETRONAS CARI GALI SDN BHD and this project should deliver an investigation report which provides solutions or research directions for solving the drilling problems. The chart will be as below:-



1) **Analysis on Project Title**

The title of a project give huge impact on the first perspective or perception towards the background of a project. In this project, Investigation of Drilling Problems in an Oilfield Development in Malaysia was choose as the main purpose of this project is to investigate the numbers of problems occur during drilling process including selection of mud, selection of bit and others. This study focus more in Malaysia since Malaysia also one the country that produce oil in their field and export it to the global market.

2) Analysis from Resources

In order to gain as much accurate results in this project, several of resources was selected from different types of journal, research papers, conference material and others. Thus, the scope of data will be wide and the comparison between these data could be justify accurately. The resource may including from the past 30 years of data until the latest day of the project in order to suit with current data or condition of the well. Hence, the optimization on how to counter the drilling problems could be efficient.

3) Interpretation of the Data

After the analysis of each sources that are available, the data will be arrange to the suitable parameters with the scope and the title of the project. This data will interpret with a good and strong justification so that the interpretation of the data could be accurate and clear.

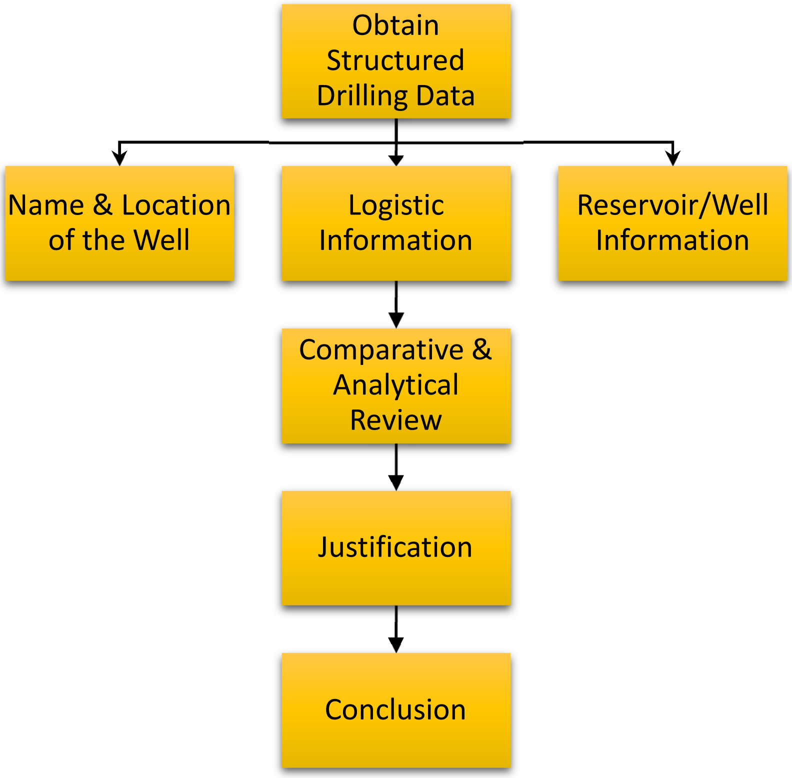
4) Conclusion and Recommendation

With the interpretation of data that was analysed, this project aims to select the best interpretation of the data so that a conclusive and accurate criteria in the future results could be achieved. The data that may not accurate with the final result will be justify and the recommendation could be made for those inaccurate or ineffective data available. At the end of the day, the conclusion could be simulation in the real condition of the problems so that this study could be implement to the industry. This project could be consider as the peer study or foundation study of each drilling problems as well could be improve on the next generation of case study.

5) **Report**

With a proper handling during writing and producing the report, a clear and informative data about the data produce by this project could be successful. The report represent the summary of the project in order to provide a strong and comprehensive justification and explanation of a project. Thus, a proper management of report handling should be done so that other party could understand and confident with a report.

3.2 Flow Process



3.3 Activity

No	Activity	Action By	Date	Note
1	Briefing & update on students progress	Coordinator / Students / Supervisors	**Jan 15, 2015 (Thursday)**	**WEEK 1**
2	Project work commences	Students		**WEEK 1 -7**
3.	**Submission of Progress Report**	Students	**February 25, 2015 (Wednesday)**	**WEEK 7**
4.	**PRE-SEDEX** combined with seminar / **Poster Exhibition**	Students / Supervisor / Internal Examiner	**March 11, 2015 (Wednesday)**	**WEEK 9**
5.	**Submission of Final Draft / Submission of Technical Paper**	Students / Supervisors / External Examiner	**March 31, 2015 (Tuesday)**	**WEEK 12**
6.	**SEDEX 33**	Supervisors / FYP Committee		
7.	**Final Oral Presentation / Viva**	Students / Supervisors / External Examiner	**April 13-14, 2015 (Monday & Tuesday)**	**WEEK 14**
8.	**Submission of hardbound copies**	Students	**April 29, 2015 (Wednesday)**	**WEEK 16**

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3.4 Timelines

Week/ Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Kukusan-1 Sepat-2																
Gambir-1 Kikeh-5																
Murphy Block K Kakap-1																
Block A-18 (MTJA)																
Sabah, Sarawak & Terengganu offshore																
Solution on problems																
Enhanced solution towards selected criteria																
Final result and documentation																
End of project																

Chapter 4: Results and Discussion

Since week 1 until current week (week 7), the progress of this whole project is on track with ongoing progress on Sabah, Sarawak and Terengganu offshore platform. At this moment, there are 7 case study that was analysed and still being compared from each other of case study:-

1) **KUKUSAN – 1**
2) **SEPAT – Deepwater 2**
3) **GAMBIR – 1**
4) **Murphy Block K**
5) **KIKEH – 5**
6) **Block A-18 (MTJA)**

In order to simplify the information gained from each well stated above, the details will be analysed based on selected criteria such as:-

i. **Name of the well/block**
ii. **Location of the well/block**
iii. **Logistic Information**
iv. **Well Information**
v. **Drilling problems occurred**

4.1 KUKUSAN - 1

Name of well: KUKUSAN – 1 EXPLORATION WELL

Location of well: Open BLOCK SB313 / Offshore Sabah

Logistic/Reservoir information:

Reservoir depth, m	Stage IVA Sand : 1317m TVDDF/ 1442m MDDF Stage III Turbidite : 1901m TVDDF / 2236m MDDF (Top of reservoir to be revised based on actual drilling)
Estimated Reservoir pressure, psi (Based on maximum pore pressure estimated at maximum TD)	7200psi
Estimated BHST, Celsius at proposed TD	94.8° C
Reservoir fluid type	Oil and/or Gas
Reservoir rock parameter: Permeability, Porosity, Gross/Net sand thickness	Porosity min=0.16, ML=0.25, max=0.32 Net to gross sand, fraction min=0.3, ML=0.5 Max=0.7
Monsoon season period	Northeast monsoon (November – March)
Oil Density at 15°C (kg/m^3)	N/A
Viscosity (cP) at 40°C	N/A

Well Information:

Well Location	Latitude : 006° 02' 00.615" N Longitude : 115° 32' 44.332" E
Water Depth	±47m-BMSL
Wellhead information	Cameron STC-10, 10,000 psi MWP
Casing Program	30" x 20" x 13-3/8" x 9-5/8" x 7" Liner (Contingency)
Total Depth	2663m TVDDF/ 3272m MDDF
Inclination	42°, Kick Off at 630m TVDDF/MDDF,

Drilling Problems Occurred:

i. Shallow Gas

100m away from the wellbore, there is a shallow channel present. For consideration, the pilot hole will be drilled down to 20" casing planned setting depth. 12 ppg kill mud will be prepared prior to spud and fast response plan is required due to shallow water depth.

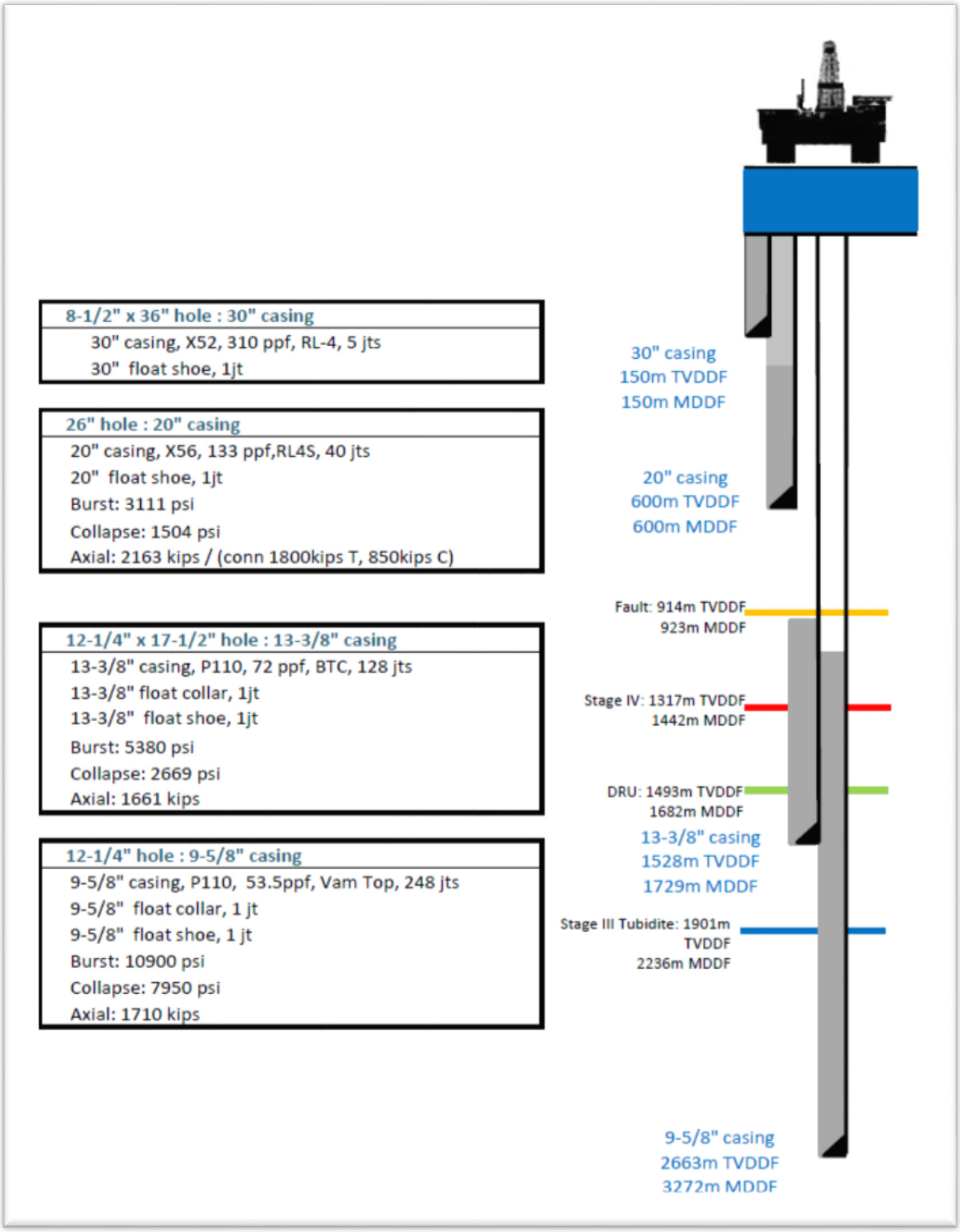


Figure 7: Casing Plan for Kukusan-1

ii. Abnormal Pressure

Pressure ramp is expected to be at drilling unit and older formation tops. Based on pore pressure prognosis, pore pressure profile will be a lot less than collapse pressure. Hence, Kukusan-1 has high overbalance against pore pressure and it is required in order to stabilize wellbore against mechanical instability. Risk of having extreme pressure profile is still possible based on what observed in recent petroleum management unit well, Jemuduk-1. Hence, formation pressure while drilling is required to ensure the hole section drilled to drilling unit with sufficient mud weight for well control. Also, managed pressure drilling will be rig up at final section as contingency.

iii. Stuck Pipe

Stuck pipe event reported in offset well when drilling activity is continue beyond fault. It started with swabbing event, pipe got stuck immediately when attempted to pump out bottom hole assessment of hole. Pipe freed and continue circulation. However, pipe stuck again and unable to break circulation/bridging. For this problem, a minimum mud weight is required to drill through wellbore as measure to mitigate wellbore collapse.

iv. Swabbing Tendency

Swabbing tendency is observed in offset wells due to mud that was lacking of inhibition and encapsulation which shale cuttings became sticky and high fluid loss resulting constriction of wellbore. For this problem, the trip speed need to be monitored.

4.2 SEPAT – Deepwater 2

Name of well: ULTRA HPHT SEPAT DEEP -2 (EXPLORATION)

Location of well: Open BLOCK PM313 / Offshore Terengganu

Logistic/Reservoir information:

<table>
<tr><td>Reservoir depth, m</td><td>H100 @ 2542m-MSL</td></tr>
<tr><td>Estimated Reservoir pressure, psi</td><td>4728</td></tr>
<tr><td>Simulated blow-out rate, mmscf/day</td><td>30mmscf/day</td></tr>
<tr><td>Estimated BHST, Celsius</td><td>156° C</td></tr>
<tr><td>Reservoir fluid type</td><td>Gas</td></tr>
<tr><td>Reservoir rock parameter:
Permeability, Porosity, Gross/Net sand thickness</td><td>A. Top H-H100 RESERVOIR
<table>
<tr><td colspan="4">HYDROCARBON RESOURCE ANALYSIS
(GBV METHOD "PETRA" – Top H- H100 Reservoir)</td></tr>
<tr><td>PARAMETERS / PROBABILISTIC</td><td>MIN</td><td>ML</td><td>MAX</td></tr>
<tr><td>Closed Contour (m)</td><td>2510</td><td>2550</td><td>2590</td></tr>
<tr><td>Gross Bulk Volume (Km² *m)</td><td>251</td><td>1250</td><td>4338</td></tr>
<tr><td>NET TO GROSS RATIO (%)</td><td>20</td><td>25</td><td>30</td></tr>
<tr><td>POROSITY (%)</td><td>12.7</td><td>16</td><td>21</td></tr>
<tr><td>HC SATURATION (%)</td><td>20</td><td>50</td><td>70</td></tr>
<tr><td>1/FVF – GAS (SCF/CF)</td><td>270</td><td>285</td><td>300</td></tr>
<tr><td>RF (%)</td><td>70</td><td>85</td><td>90</td></tr>
<tr><td>CO2 (%)</td><td>0</td><td>5</td><td>10</td></tr>
</table></td></tr>
<tr><td>Monsoon season period</td><td>Northeast monsoon (November – March)</td></tr>
<tr><td>Oil Density at 15°C (kg/m³)</td><td>N/A</td></tr>
<tr><td>Viscosity (cP) at 40°C</td><td>N/A</td></tr>
</table>

Well Information:

<table>
<tr><td>Surface location</td><td>Minimum 500m from SD-2</td></tr>
<tr><td>Water Depth</td><td>±63m-MSL</td></tr>
<tr><td>Wellhead, Casing and Mud Program</td><td>Similar as per drilling program</td></tr>
<tr><td>Kick-off point</td><td>600m MD (50m below 20" casing)</td></tr>
<tr><td rowspan="3">Intercepting Target</td><td>11-3/4" casing @ 2200m TVD</td></tr>
<tr><td>9-7/8" shoe @ 2551m TVD</td></tr>
<tr><td>7" casing @ 2929m TVD</td></tr>
<tr><td>Maximum angle</td><td>54°</td></tr>
<tr><td>Maximum Dogleg Severity rate</td><td>To be below 3°/30m</td></tr>
</table>

Drilling Problems Occurred:

i. Mud Losses

Due to presence of coal type formation with high mud weight between narrow pressure margins, the wellbore cause losses to the drilling mud. At this point, geological and geophysical observation need to be specific especially for the depth with a proper controlled drilling and decision tree to handle potential losses in this section.

ii. Tool Stuck

With the presence of coal and soft formations, the wellbore experience few tool stuck problems. This happen as they are differential sticking through the wellbore and the accumulation of junk/debris in the hole. As for recommendation, it is advice to have proper stabilization in bottom hole assessment with drilling jar and accelerator to ensure efficient hole cleaning. For further precautions, fishing package is to be prepared for the well.

iii. Casing Stuck

A fragile formation with insufficient centralizations have been recognised as one of the cause for the well to encounter casing stuck. Due to high equivalent circulating density and flowrate, a high differential pressure was existed. Thus, a wireline caliper log will be able to check the hole gauge with a proper preventive management and few backup tools. On top of that, a good hole cleaning with break circulations and intermediate circulation would be able to solve this problem.

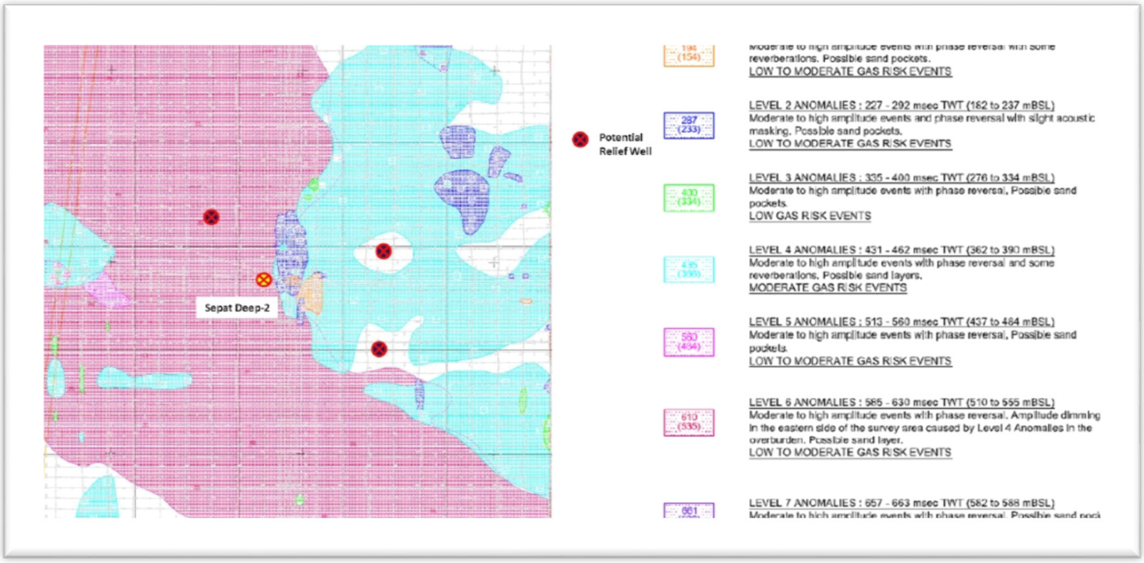


Figure 8: Anomalies in Sepat Deep-2

4.3 GAMBIR – 1

Name of well: GAMBIR – 1

Location of well: Open BLOCK SK308 / Offshore Sarawak

Well Information:

WELL INFO	
WELL	GAMBIR-1
LOCATION	MALAYSIA, BLOCK SK308
RIG NAME/TYPE	SONGA VENUS / SEMI-SUB
WELL TYPE	WILDCAT VERTICAL
PROJECT OWNER	PMU
OBJECTIVES	TEST HC POTENTIAL OF CARBONATE PINNACLE CYCLE IV/V
WATER DEPTH (m-SS)	107.9
SPUD DATE	17th Feb 2012
OPERATIONS AT INCIDENT	Drilling 17-1/2" hole at 1312 m
INCIDENT DATE	2nd Mar 2012
RIG SUPPORTING VESSELS	1. BORCOS THAHIRAH 2. JM PERMAI 3. PETRA EXPEDITION

Drilling Problem Occurred:

i. Well Kick – A full case study event

Description of event

While drilling 17-1/2" hole section at 1307m, rate of penetration reduced from 14.3m/hour to 4.0 m/hour and total gas reading was observed at maximum 23.22% (equivalent depth at 1275m). Drilling resumed to 1312m, observed a sudden and rapid increase in flow returns. For the mitigation action, they space out. Shut-in well on upper annular.

Attempt to close on Middle Pipe Ram (MPR), but no success. Well control data sheet recorded at 100 barrels gain, Shut in Drill Pipe Pressure (SIDP) at 100 psi, Shut in Casing Pressure (SICP) at 250 psi. The well was observed for 55 minutes. SICP increased to 650 psi. Attempt to kill well using Driller's method. Mud Gas Separator (MGS) unload gas upon opening choke and no communication between annulus and drill pipe. Then the well was killed with volumetric method.

Findings

- Casing design and MW selection based on
    - Predicted pore pressure provided in well proposal by Petroleum Management Unit Geology & Geophysical Team, indicating hydrostatic gradient of 8.5 ppg from seabed down to 1475m true vertical depth (TVD). However, pore pressure was calculated at 14.3 ppg at 1312m, after well kick.
    - Prognosed top of carbonate at 1475m TVD. However, negative drilling break and Gamma Ray log indicates possible top of carbonates at 1307m.
- Drilling program was prepared within 4 days due to drilling sequence changed. Initially it was plan for Karupang after Lengkuas, however due to major changes in formation pressure at Karupang, it was decided to drill Gambir after Lengkuas Therefore, minimal time for drilling team to deliberate & challenge (to prevent rig standby).

- Drilling Practices
    - Standard drilling practice was not followed. (Refer Carigali Drilling Guidelines chapter. 2.4.7)
    - When negative drilling break occurred at 1307m, no flow check was performed.
    - Vacuum degasser was not run when gas reading exceed 3%.

- Well Control Procedures
    - Quick response time.
    - Attempt to kill well using Driller's method but no communication between DP and annulus (Suspect well pack-off) leads to well finally killed via volumetric method

<u>Before the kicks</u>

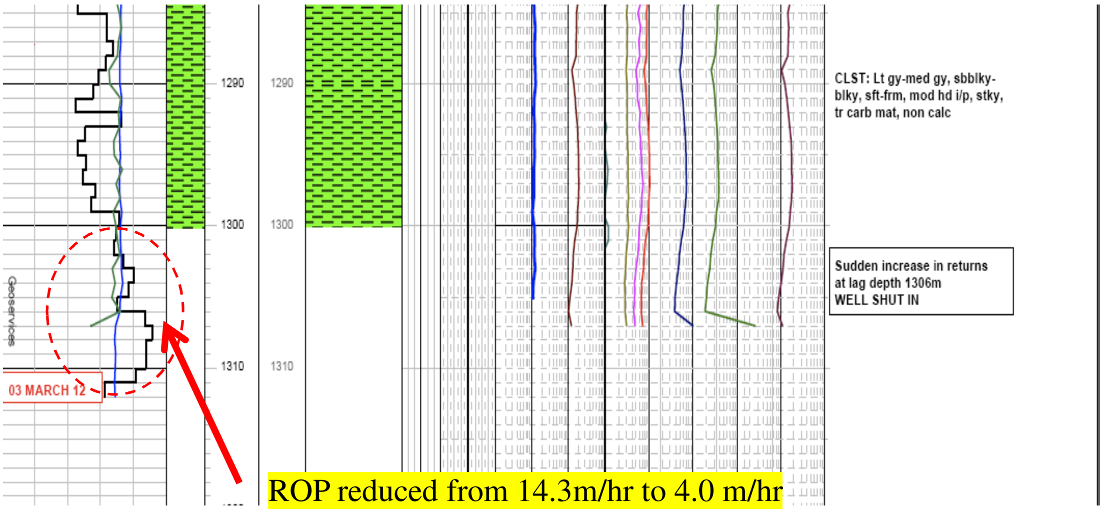


Figure 9: Before Kicks in Gambir-1

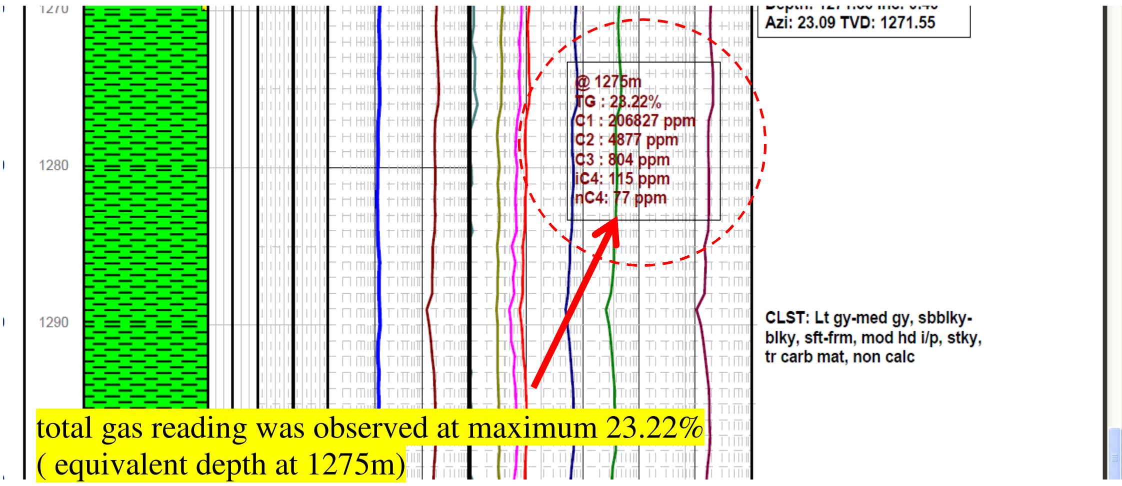


Figure 10: Total Gas Reading at Depth

4.4 MURPHY Block K

Name of well: BLOCK K DEEPWATER LEASES OFFSHORE

Location of well: Sabah

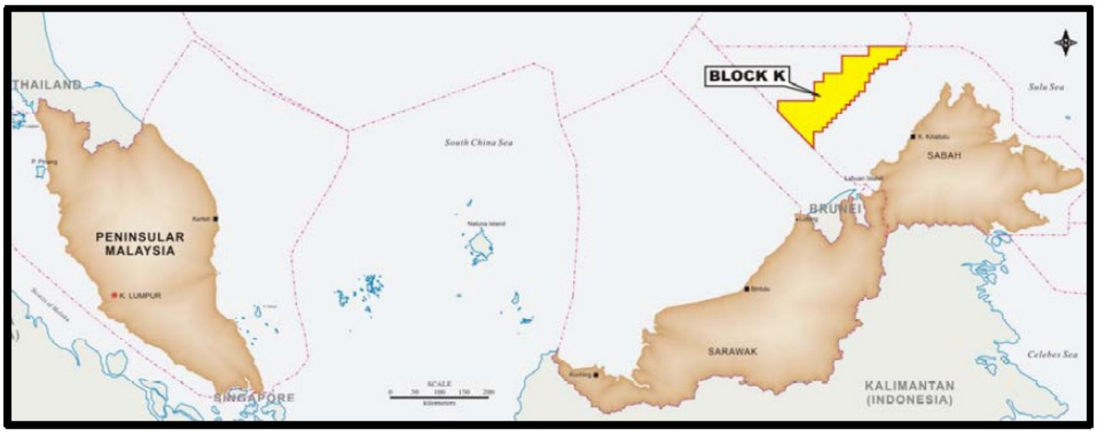


Figure 11: Block K, Sabah

Logistic/Reservoir information:

i. Rig is 10 located 10 hours from Labuan island
ii. 16,000 barrels (16.0 ppg) of water based mud is used.
iii. For the riser, booster line, choke, 6,500 oil based mud is required.
iv. The volume of cement needed is 7,100 cubic foot with 1,500 cubic foot of cement Class G and 1,500 of barite

Drilling Problems Occurred:

i. High Temperature Gradient

Compare to other deepwater provinces, offshore Malaysia has much higher temperature gradient that exceed 9 degrees Fahrenheit 100m below mudline as shown in figure below.

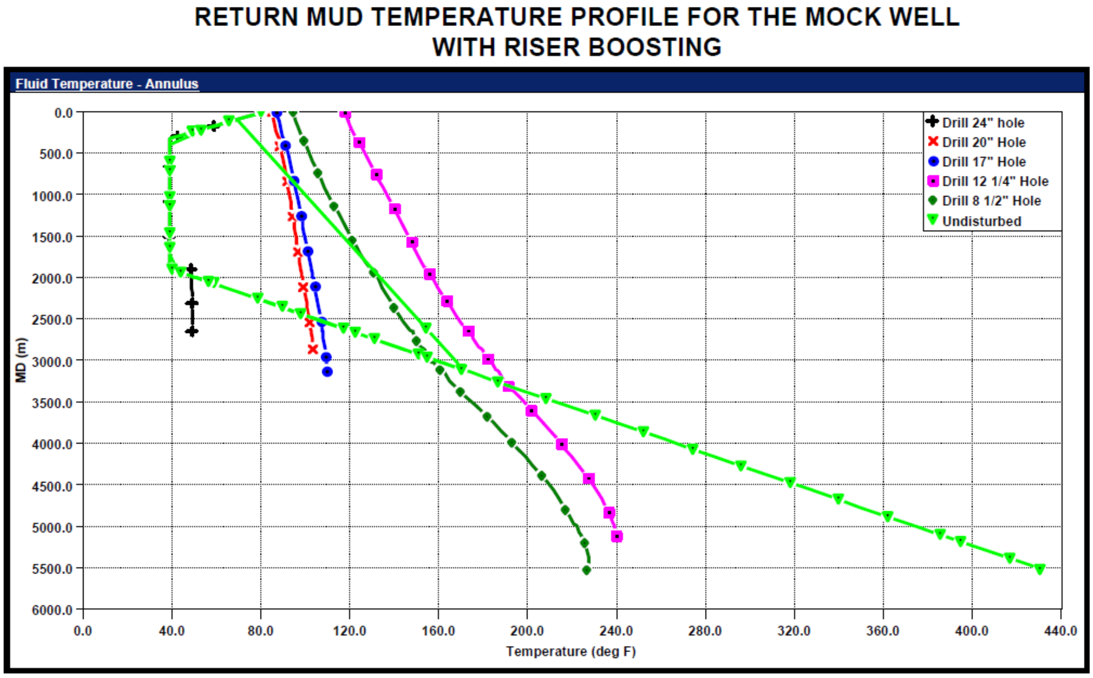


Figure 12: Return Mud Temperature Profile

Since the temperature gradient is high, the casing design was made based on normal drilling criteria such as normal collapse load from lost returns and gas kicks. This high temperature also lead the casing design to be control below safety factors as if the casing was left in “packed off” by any means. As a result, a jeopardy of burst could be happen in the 13-3/8 inch casing. In order to assure that if the barite did fall out from the mud system, a calculation need to done to ensure length of the annulus column from top of cement to casing shoe could accommodate mud solids.

ii. Technology Barrier

In order to support main overall strategy, synthetic oil mud (SOM) is a crucial to allow excellent evaluation ability, hole stability and high penetration rates. Unfortunately, there is no facility existed to build such a huge volumes of oil based mud with a minimum of 5,000 barrels of mud and 1,500 barrels of base oil. Thus, the design of tanks was made based on a standard 40 foot shipping container with locking corner castings that will be transported with a minimum expense. Hence, a liquid plant consist of 16 container type storage tank was installed on the supply base with pump engines at 280 horsepower to provide adequate pumping capability to complete dry bulk up rig. The plant layout was as per below:-

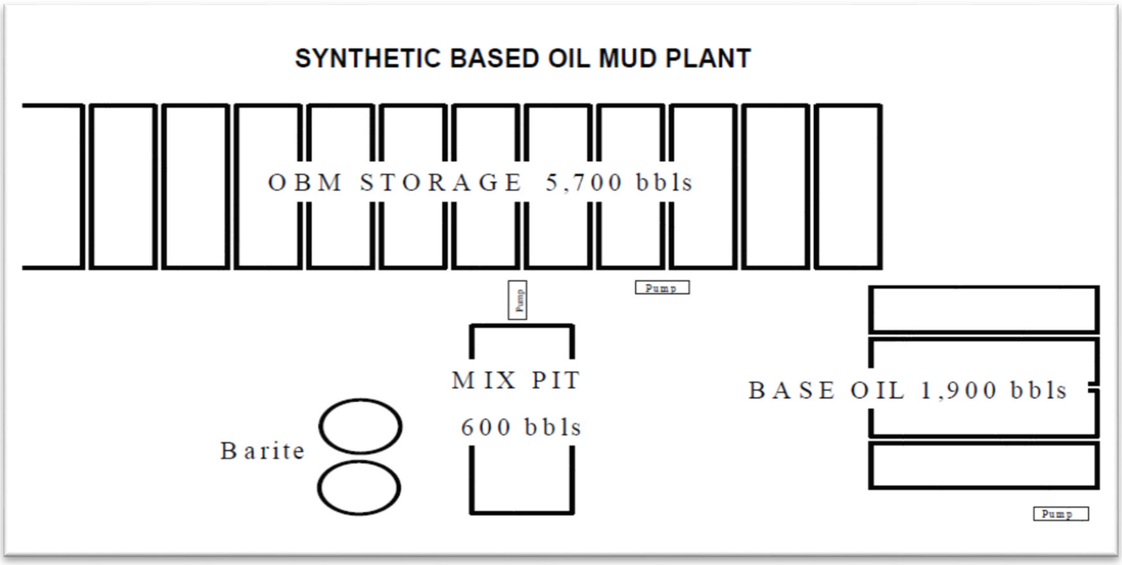


Figure 13: Synthetic Based Oil Mud Plant

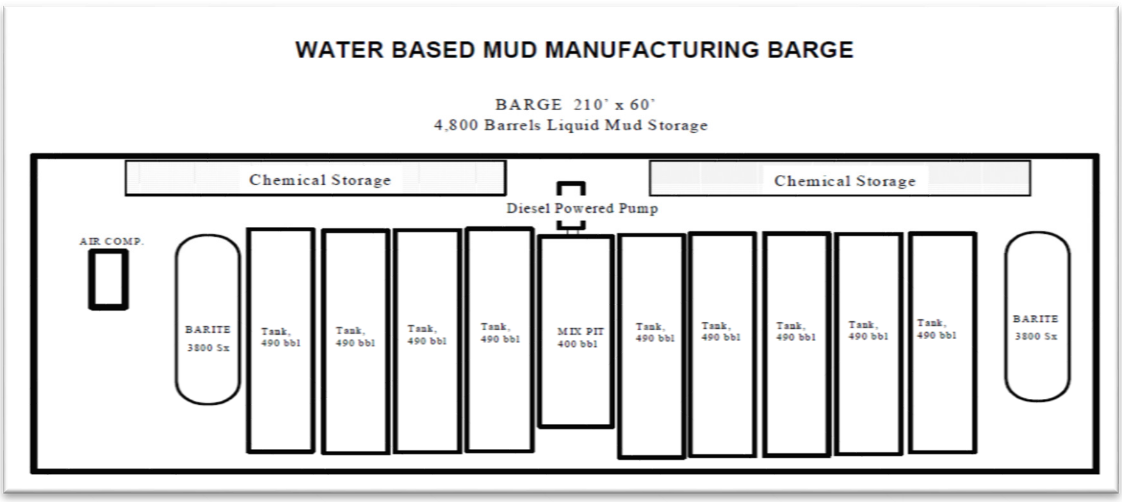
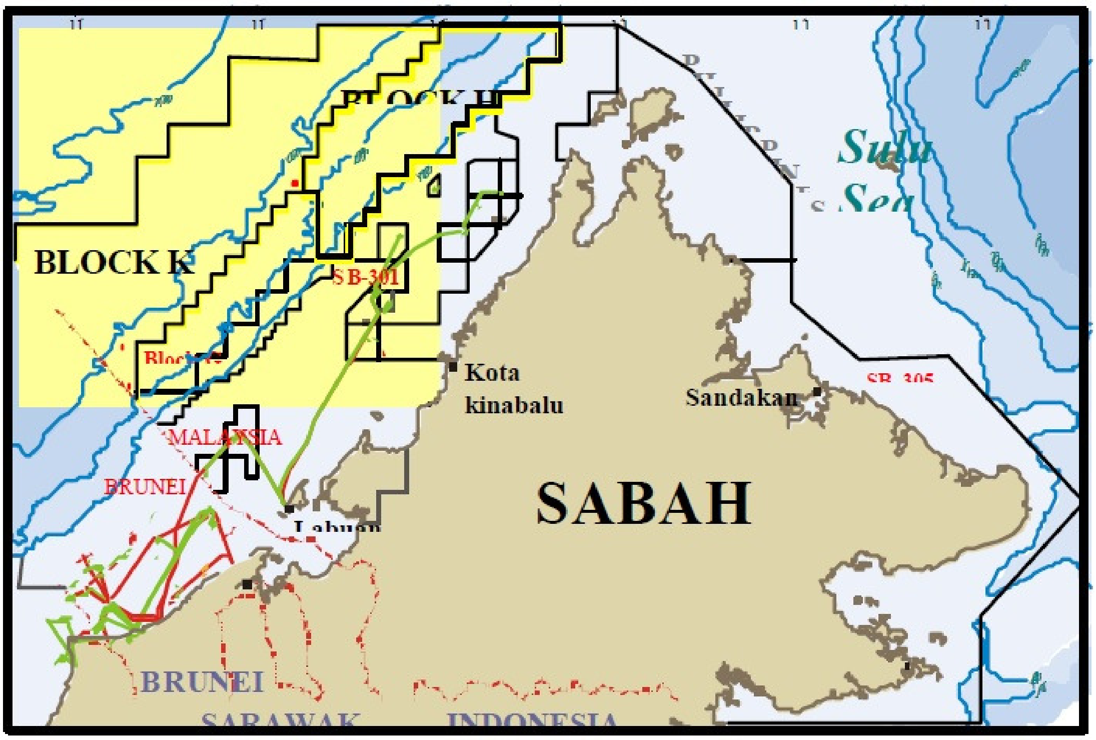


Figure 14: Water Based Mud Manufacturing Barge

4.5 KIKEH – 5

Name of well: KIKEH DEEPWATER BLOCK

Location of well: Block K, offshore Sabah, East Malaysia



Logistic/Reservoir information:

i. Cementing of 20 inch surface casing

ii. Water Depth : 1335 m (4,380 feet)

iii. 36-in. casing jetted to 98 m (322 feet) below mean sea level (BML) 20-in. section cased to 700 m (2,297 feet) BML

Drilling Problems Occurred:

i. Low Fracture-Temperature Gradient

Low fracture-pressure gradient normally caused by deepwater environment that usually requires low density slurry to ensure that there is no losses during cementing activity thus to have full returns into seabed. To achieve the compressive strength specified for this application, a conventional low density cements are not considered due to extremely low temperature of hostile environment. In general, the actual seabed temperature was recorded at 3 degree Celsius. As a result, a nonlinear temperature gradient from sea currents and water column cause the acceleration of fluids cooling in the well.

ii. Gas Migration

Any shallow water or gas flows in weak unconsolidated formations is particularly recognized for zonal isolation as the key concerns. For instance, invasion of formation fluids into the annulus due to imbalance of pressure at the formation face. Thus, it is important to prevent the gas from entering the cement at the hydrostatic pressure above the gas zone. At the time the slurry begins to hydrate, the properties of itself change from a true fluid by transmitting full hydrostatic pressure into a partially self-supporting gel-like material. As the static gel strength exceeds the limit of critical wall shear stress, the formation gas or water begin to enter the slurry as the pressure transferred by the slurry drops below the pore pressure.

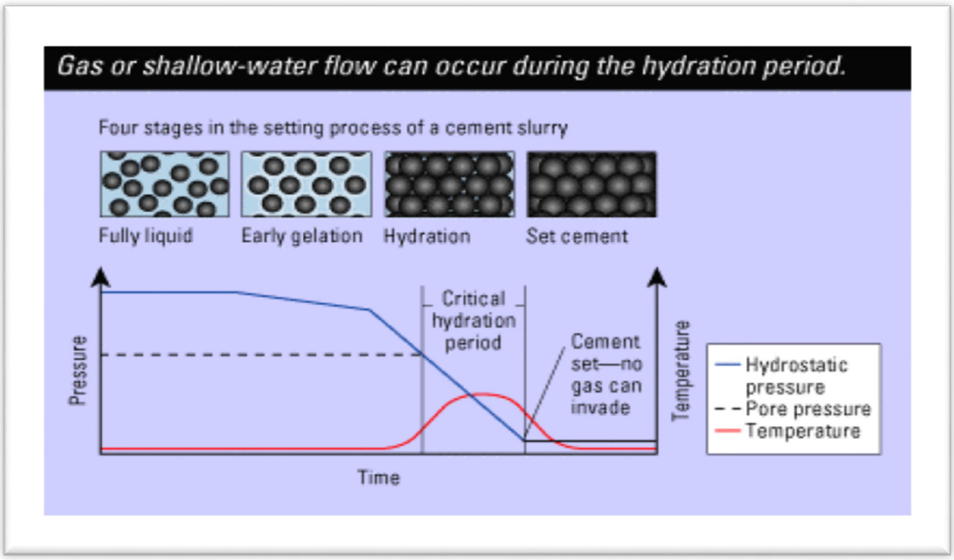


Figure 15: Hydration Stages

As a results to this, a short critical hydration period (CHP) is required to limit fluid and gas migration into the slurry where a good chances of preventing gas migration through the cement matrix could be achieve as if the slurry structure can develop its gel shear strength at a fast rate.

iii. Potential Shallow Hazards

It is a concern for many deepwater environments including deepwater in East Malaysia as there is presence of shallow hazards including gas hydrates. Generally, gas hydrates exist naturally and located at the sea floor or in shallow sediments as the temperatures and pressures are conducive to the formation of natural gas hydrates. The shallow depths of surface casing settings give a challenge maintain enough hydrostatic pressure in the annulus above the shallow gas zone. Furthermore, a low fracture pressure gradient of the formation below the seabed cause an impossible case to pump a normal to high density slurry to achieve higher hydrostatic pressure due to risk of lost circulation. Meanwhile, low temperature of seabed cause the CHP of the cement larger than the usual.

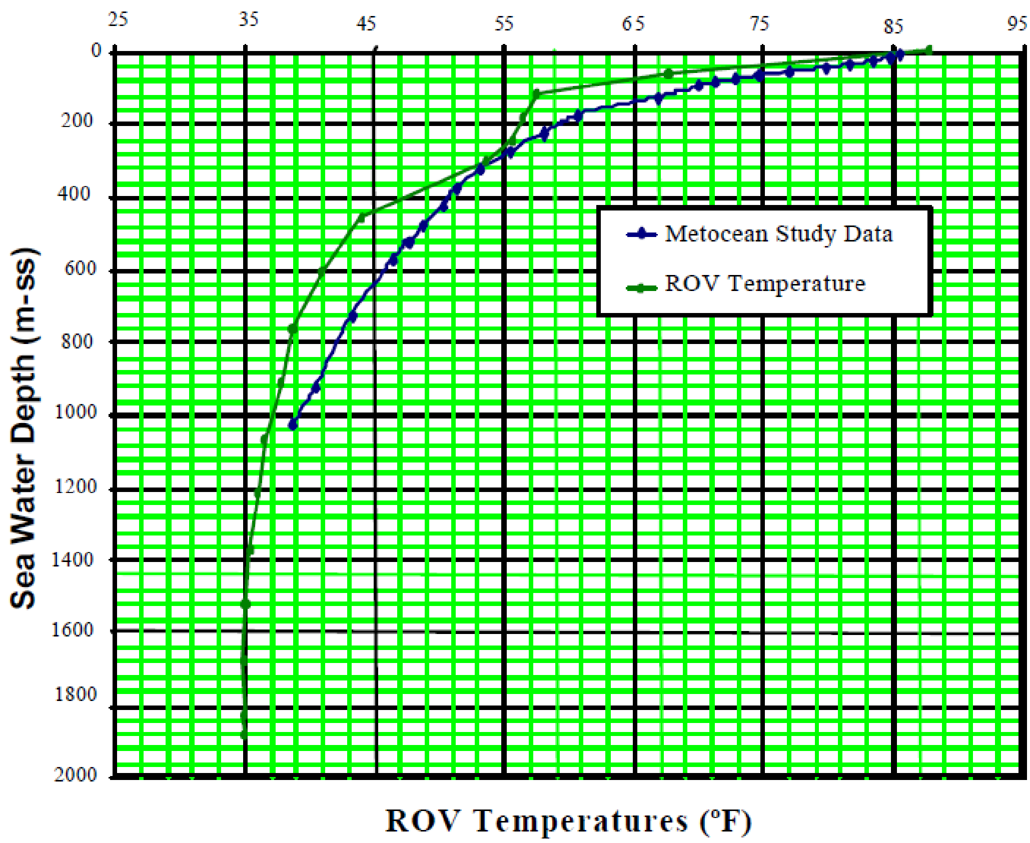


Figure 16: Seabed Temperature Data

4.6 BLOCK A-18 (MTJA)

Name of well: MALAYSIA – THAILAND JOINT AUTHORITY (MTJA) JDA BLOCK A-18

Location of well: Block A-18, offshore North-eastern Peninsula Malaysia and Southern Thailand

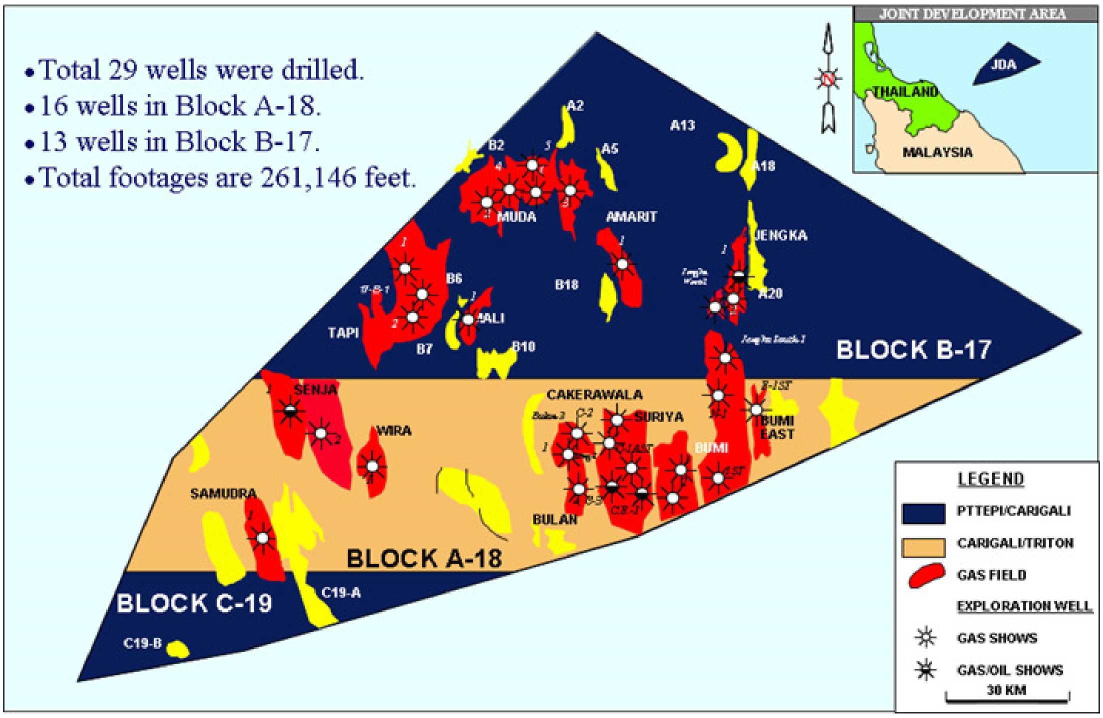


Figure 17: Block A-18

Well Information:

i. Most hydrocarbon located below 3,600 feet

ii. Sand and shale are the most common lithology found with some dolomite, pyrite and interbedded coal.

iii. The mud weight allowable is 13.5 ppg to 16.9 ppg

iv. Average temperature may varies from 310 F to 370 F

Drilling Problems Occurred:

i. Rapid Pore Pressure Increase

An unpredictable and huge increase in pore pressure occur at a short interval, 10.0 ppg (6500 feet) to 15.5 ppg (7100 feet) i.e. 3.8 psi/feet where the fracture pressure does not rise but the pore pressure tend rises rapidly. In details, tight margin or gap between pore and fracture pressure cause mud loss circulation which complicating the well control. In addition, for some cases, a small increase in mud weight such as 0.5 ppg or even more could change the well condition from taking a kick to losing circulation. In order to counter back this problem, the lost circulation material (LCM) will be pump in the mud or on the other hand if the LCM did not manage to block the formation, it is desire to spot and squeeze cement through open-ended drill pipe. Besides that, it is easier to spot the cement through the bit as if there is no measurement while drilling (MWD) or downhole motor is in the bottom hole assessment.

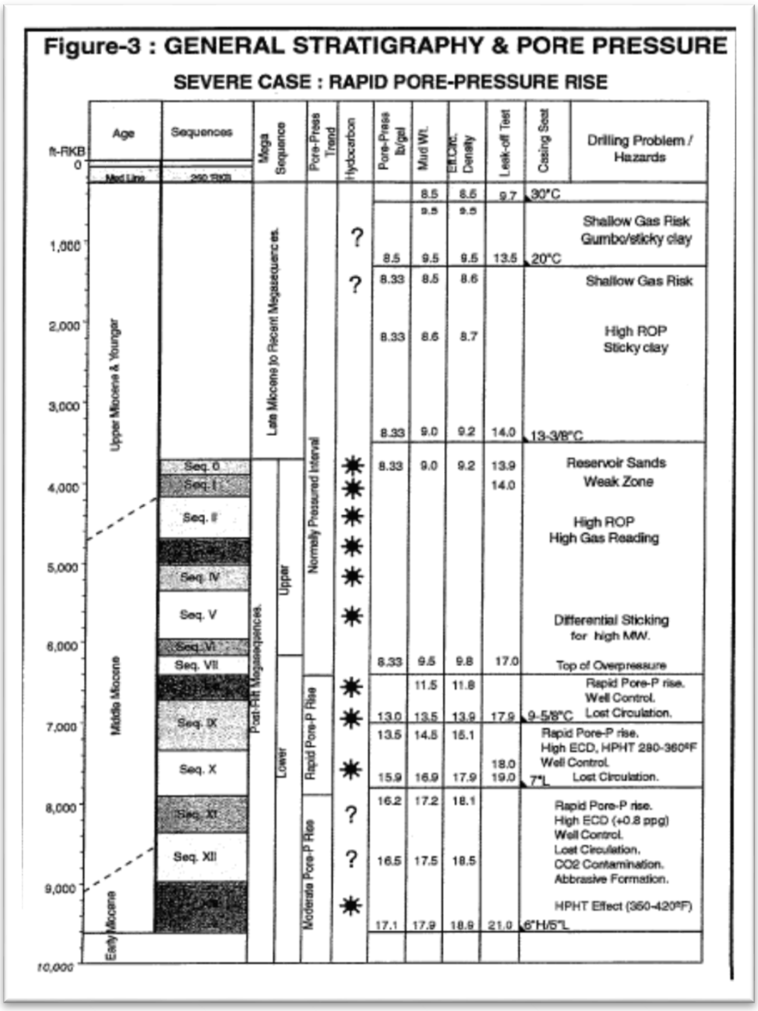


Figure 18: General Stratigraphy & Pore Pressure

ii. CO_2 & H_2S Contamination

Presence of high levels of carbon dioxide are usually common in Block A-18 regarding hydrocarbon bearing formations. There will be poor rheology, barite settling and excessive pumping pressure that may lead to mud gelation as if there is CO_2 remain in water based drilling fluid. Hence, excess calcium will be used in form of gypsum to react in the mud system with any carbon dioxide. On the other hand, H_2S usually raise the pH value in the mud system once it is react. In general, excessive of H_2S contamination will be treated with zinc oxide.

Chapter 5: Conclusion and Recommendation

Conclusion after thorough analytical study and comparative study, this project concluded that most of the formations structure in oilfield development in Malaysia influence the most on the drilling problems occurred. The complex integrity of geological formation plays an important role to determine a strong structured drilling plan. Thus, the conclusion of this study are:-

i. Most of the well in shallow water encountered with pipe sticking and kicking while drilling mostly due to soft and unconsolidated formations.
ii. Potential shallow hazards and gas hydrates are common drilling problems in deep water oil field development in Malaysia because of shallow sediments of the well.
iii. Each of the problems existed are mainly due to natural phenomenon of behaviour in the wellbore and some cases is due to lack of data and information towards geological and geophysical aspects such borehole uncertainties.
iv. Many drilling problems may arise in the future for the deep water oil development as more different types of ultra-deep water are currently being explored in Malaysia.

This project recommend a suitable solution in order to solve the drilling problems existed in an oilfield development in Malaysia such that:-

i. All geological & geophysical data should be gather entirely for the whole entire well with a continuous confirmation and monitoring regarding the data collected during the drilling process.
ii. Proper and enhanced structured drilling plan should be evaluate from time to time to avoid any further or unexpected problems with a proper backup plan or contingency plan.

iii. For pipe stuck and tool stuck, acid is the best solution to release the tool/pipe by washing it through the area of sticking.

For further studies on investigation of drilling problems encountered in an oilfield development in Malaysia, a specific scope of study which focus on a single drilling problems happened. On the other hand, another study also could be done for only a single well where all drilling problems and event regarding that certain well is analysed and observed. With a specific scope of study, the result may have a better and clear understanding towards the main objective of the project.

Objectives of this project were achieved with successful outcome of drilling problems encountered in Malaysia. The results of this project will be helpful in finding a specific and thorough understanding for drilling problems and hopefully this project can bring a better understanding and improvement to encounter drilling problems in the future.

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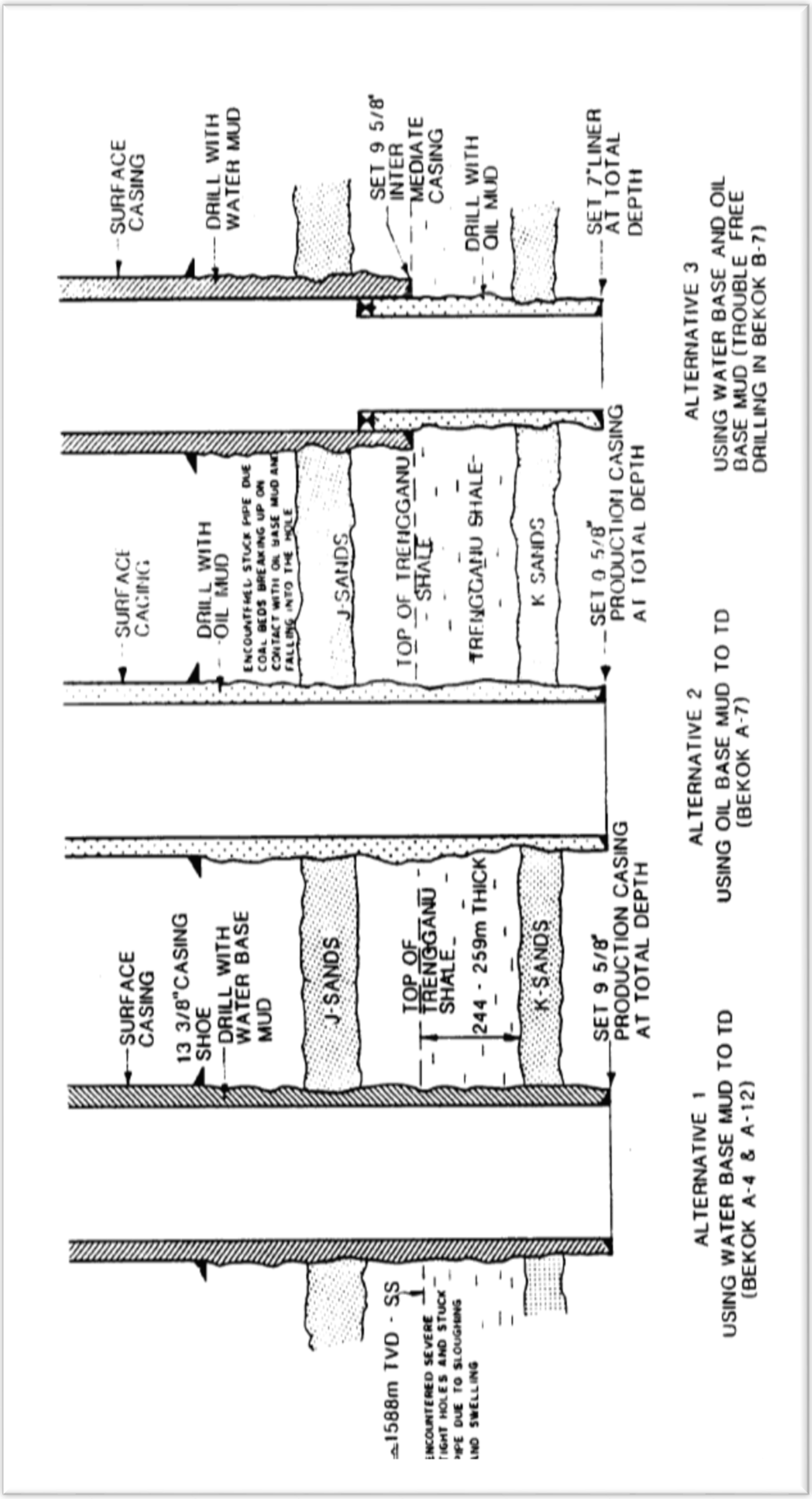
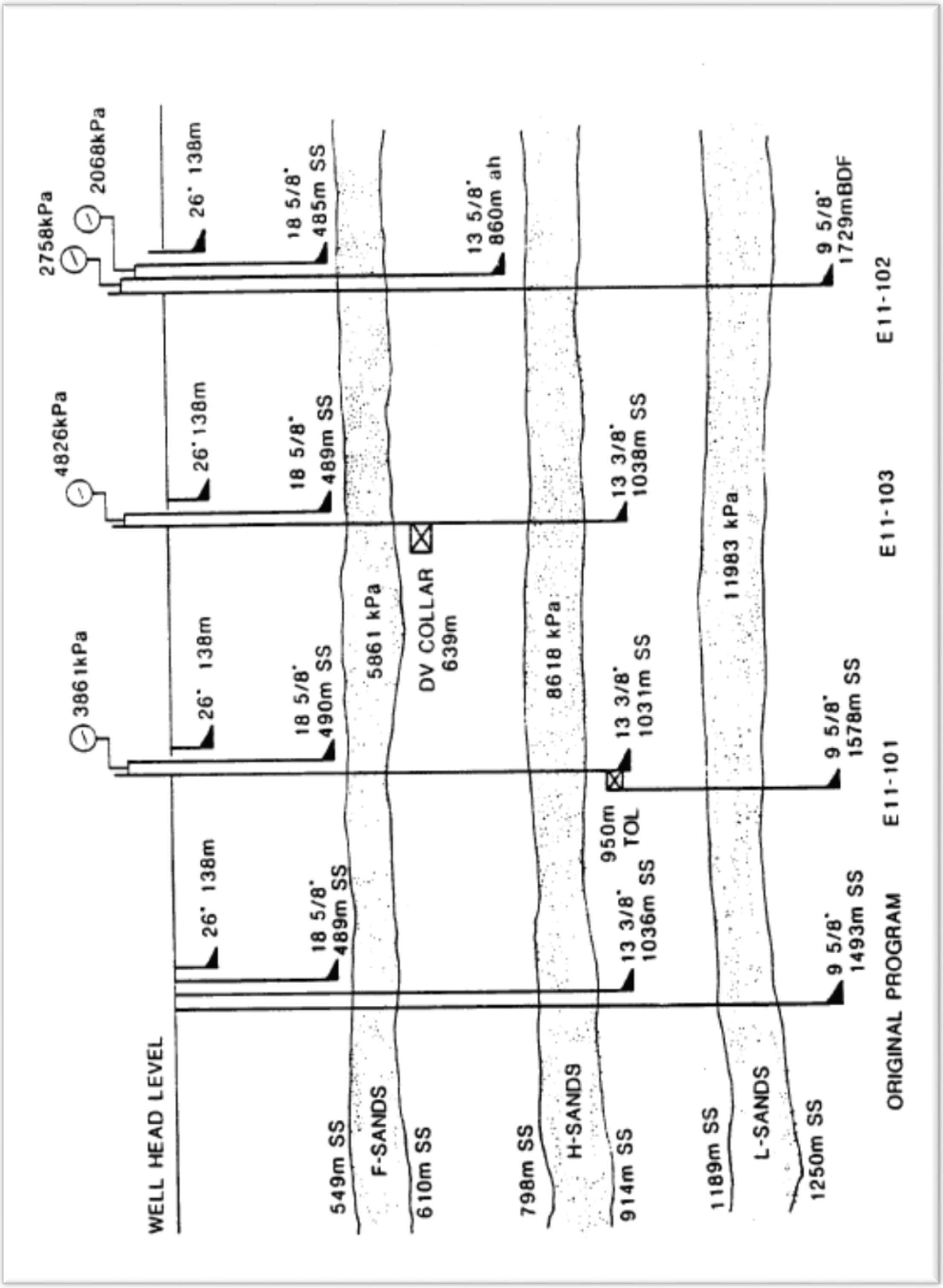
APPENDICES

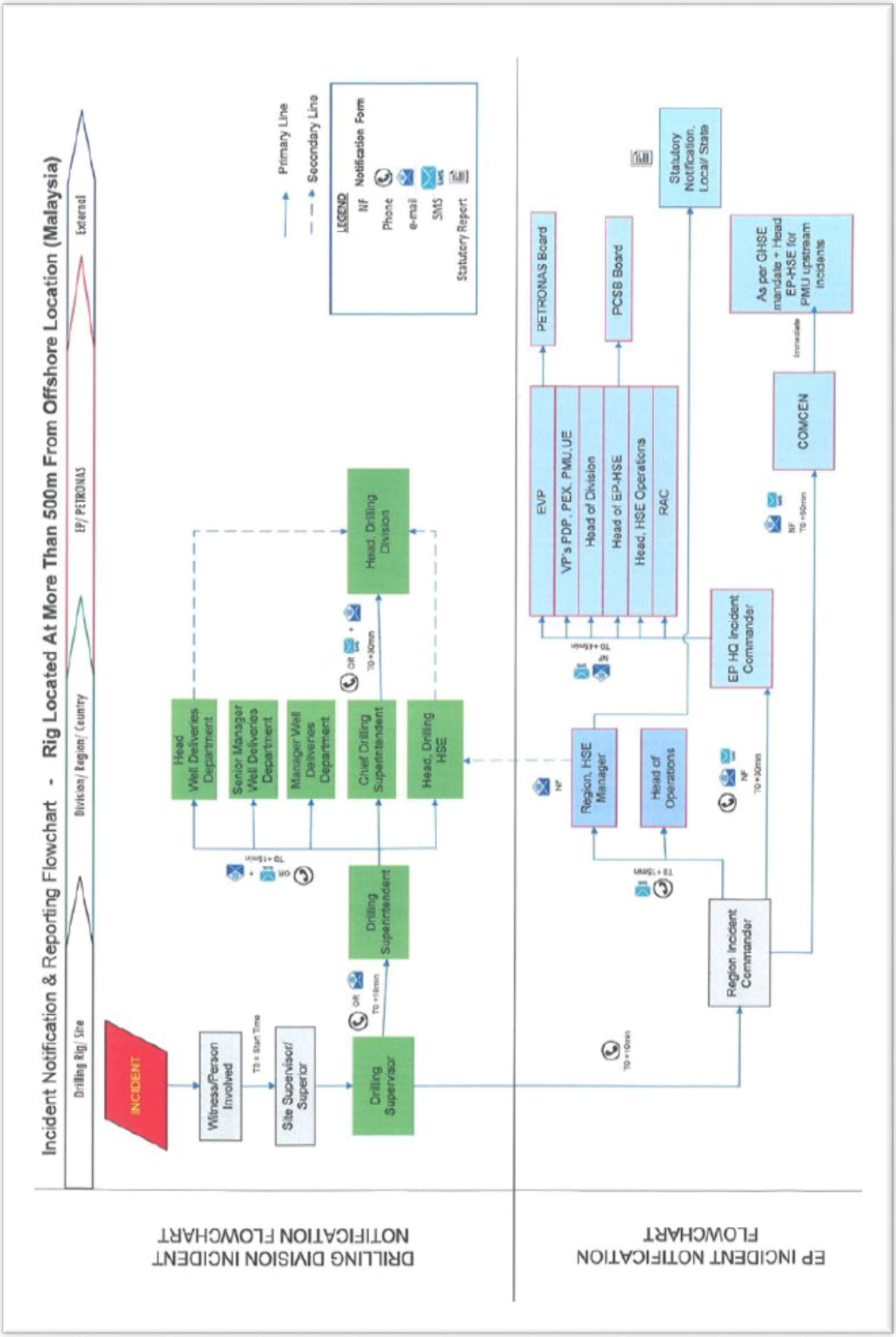
Alternative Drilling Programme in Bekok A-7

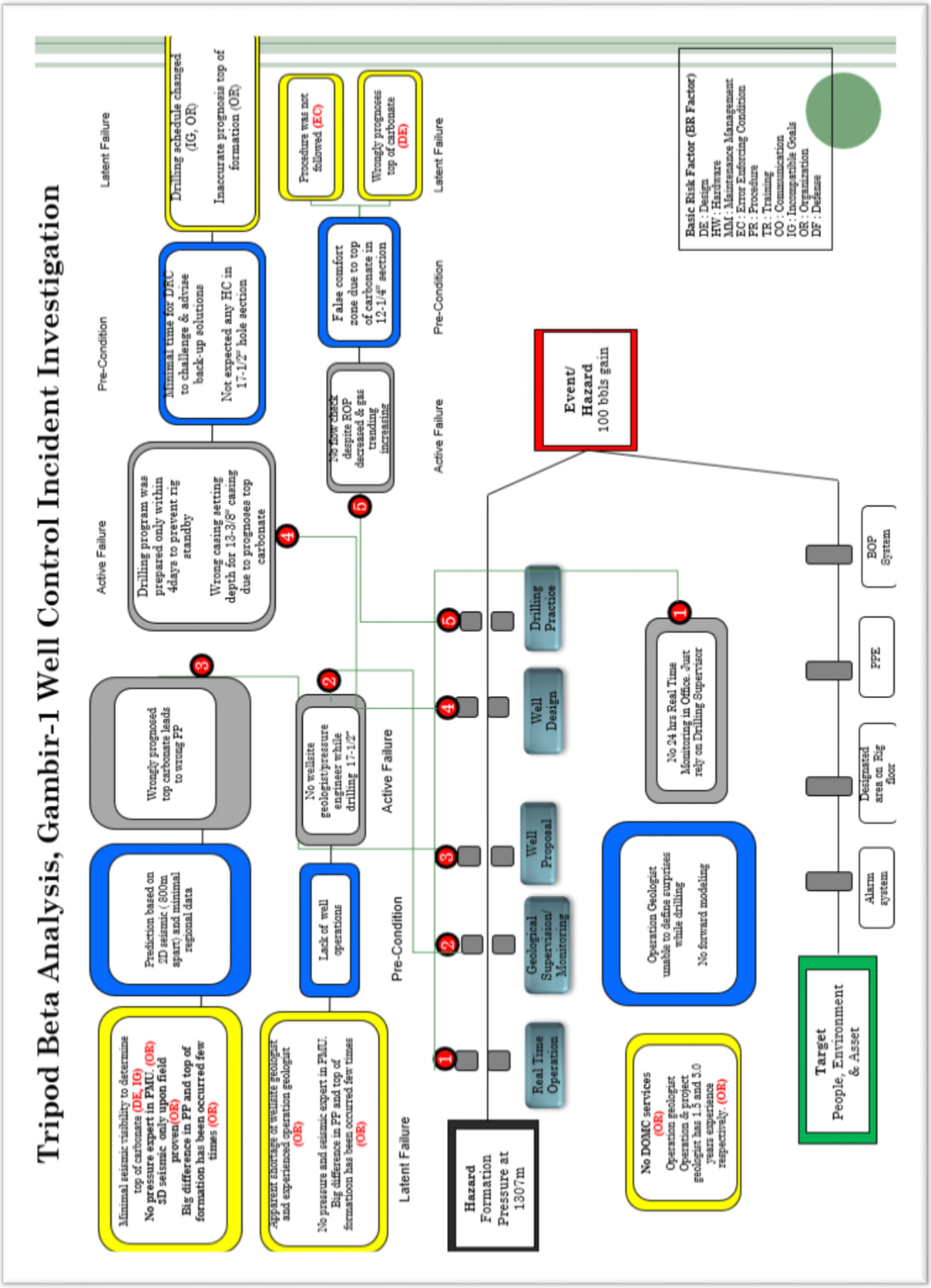


Well Showing the Three Shallow Sands and Build-up Pressure in Annuli



Initial Response and Notification Flow of PCSB




Tripod Beta Analysis, Gambir-1 Well Control Incident Investigation
Latent Failure
Pre-Condition
Active Failure
Minimal seismic visibility to determine top of carbonate (DE, IG)
No pressure expert in PMU. (OR)
3D seismic only upon field proven(OR)
Big difference in PP and top of formation has been occurred few times (OR)
Prediction based on 2D seismic (800m apart) and minimal regional data
Wrongly prognosed top carbonate leads to wrong FP
Drilling program was prepared only within 4days to prevent rig standby
Wrong casing setting depth for 13-3/8" casing due to prognoses top carbonate
Minimal time for DRC to challenge & advise back-up solutions
Not expected any HC in 17-1/2" hole section
Drilling schedule changed (IG, OR)
Inaccurate prognosis top of formation (OR)
Apparent shortage of wellsite geologist and experienced operation geologist (OR)
No pressure and seismic expert in PMU. Big difference in PP and top of formation has been occurred few times (OR)
Lack of well operations
No wellsite geologist/pressure engineer while drilling 17-1/2"
No flow check despite ROP decreased & gas trending increasing
False comfort zone due to top of carbonate in 12-1/4" section
Procedure was not followed (EC)
Wrongly prognoses top of carbonate (DE)
Event/ Hazard 100 bbls gain
Hazard Formation Pressure at 1307m
Real Time Operation
Geological Supervision/ Monitoring
Well Proposal
Well Design
Drilling Practice
No DOMC services (OR)
Operation geologist Operation & project geologist has 1.5 and 3.0 years experience respectively. (OR)
Operation Geologist unable to define surprises while drilling
No forward modeling
No 24 hrs Real Time Monitoring in Office. Just rely on Drilling Supervisor
Target People, Environment & Asset
Alarm system
Designated area on Rig floor
PPE
BOP System
Basic Risk Factor (BR Factor)
DE : Design
HW : Hardware
MM : Maintenance Management
EC : Error Enforcing Condition
PR : Procedure
TR : Training
CO : Communication
IG : Incompatible Goals
OR : Organization
DF : Defense