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Study and Evaluation of Loss Circulation Mitigation When Drilling Unconsolidated Formaton, Batang Field

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ABSTRACT

Field development of Batang Field through infill drilling was an effort by PHE Siak to contribute to national oil production. Target formation of the drilling campaign was Bekasap Formation which is part of central Sumatera basin. During the drilling execution of these infill wells, loss circulation occurred on some of the wells especially when the drilling reaches 8.5 in hole section. The severity of loss circulation ranging from small partial loss to total loss. To optimize future drilling operation in Batang, analysis will be conducted to determine the cause, prevention, and mitigation of loss circulation event based on drilling history.

Method used in this research begins with analyzing the cause of loss circulation on 8.5 in hole section that commonly occurs. Analysis then proceeded to analyze historical drilling parameter, such as: pump (MW, ECD, Pump Rate, Yp, RPM, SPM, dan ROP) recorded when loss circulation events occurred. Finally, the effectiveness of current method to mitigate loss circulation will also studied.

Based on the analysis, it is known that the possible cause of loss circulation on infill well drilling in Batang is the reservoir properties and condition which having depleted or sub-normal average reservoir pressure and the property of the rock itself which is unconsolidated. Based on the study on drilling parameter history, the severity of loss circulation might be minimized by keeping pump flow rate to under 190 gpm, RPM under 48 rpm, WOB under 2 klbs, and ROP under 135 ft/hr when drilling progresses to 8.5 in hole section. Meanwhile, other parameters have not shown any relation to severity of loss circulation.

Keywords: loss-circulation; drilling; unconsolidated sand; drilling parameter

I. INTRODUCTION

Development drilling is an effort by oil and gas field operators to increase hydrocarbon production of an oil and gas field. During drilling operations there are many kinds of problem that might be faced, one of them is loss circulation. The loss of drilling fluid is a serious problem in drilling operations, and it might potentially cause higher drilling cost due to increasing rig time, loss of drilling fluid material, and damage to productive formation (Ahmed Mansour et al. 2018).

In relation to fulfil plan of further development in Batang Field by PHE Siak, to produce 4.8 MMSTB oil reserve through drilling 30 development wells in Batang Field, PHE Siak plans to conduct drilling campaign. Based on early evaluation 7 first development wells, loss circulation occurs on production zone which part of Bekasap Formation which is a shallow and unconsolidated formation. Based on this obstacle, it is important to evaluate the cause and mitigation of the loss circulation to further optimize drilling cost of the next wells.

On this research evaluation will be focused on several problems, they are: (1) dominance factor that causes loss circulation in Batang Field, (2) recommended drilling parameter value to minimize loss circulation event in Batang field, (3) evaluation on effectiveness of current method to combat loss circulation in Batang field

II. METHODS

Loss circulation events have been identified on several wells during drilling development wells of Batang field. Drilling parameter that may affect the severity of loss circulation had been tabulated and be analyzed. Data required for the analysis are acquired from collection of well daily drilling report, final well report, dan other related technical reports. Based on historical drilling parameter of these wells then statistically analyzed to see the effect of each parameter to the severity of loss circulation on 8.5 in hole section during development drilling in Batang field. Those parameters are: ECD, Yp, WOB, Pump SPM, RPM, and ROP. Beside analysis on drilling parameters, in this research, the effectiveness

of loss circulation combat method that has been applied historically also will be evaluated. The research flow diagram is show in Figure 1.

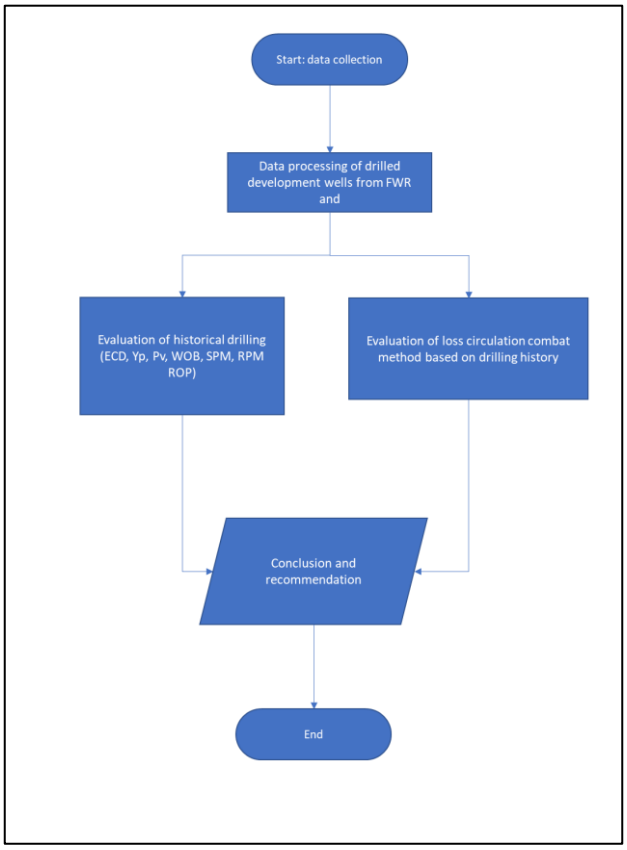

Figure 1. Research Flow Diagram

III. RESULTS AND DISCUSSION

3.1. Data Preparation

In analyzing a problem, data is an important component which become input of analysis. In this section, data related to BTG-P1, BTG-3R, and BTG-4R which become the sample on this research. Well Schematic of BTG-P1, BTG-3R, and BTG-4R are shows in Figure 2.

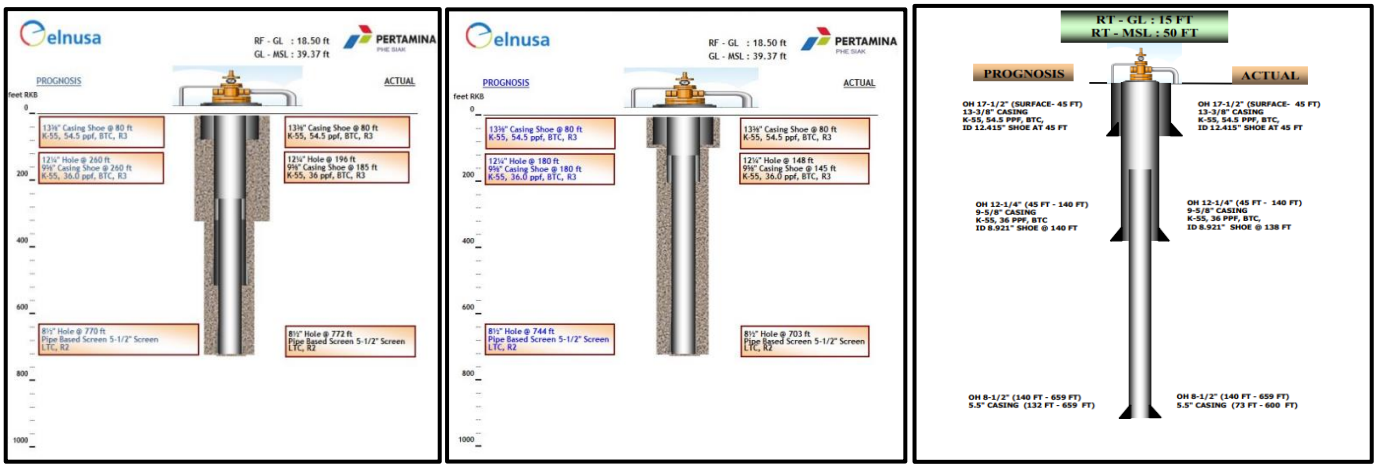

Figure 2. Well Schematic of BTG-P1, BTG-3R, and BTG-4R
(Source: Drilling Report of PHE SIAK)

Pore Pressure

Figure 3 through Figure 5, shows the d-exponent from BTG-P1, BTG-P3R, and BTG-P4R in 8.5 in hole section. Based on the d-exponent of this wells, it is shown that during drilling 8.5 in hole section, the drilling will penetrate zones that have sub-normal pressure that mostly caused by reservoir depletion from production activity from these zones.

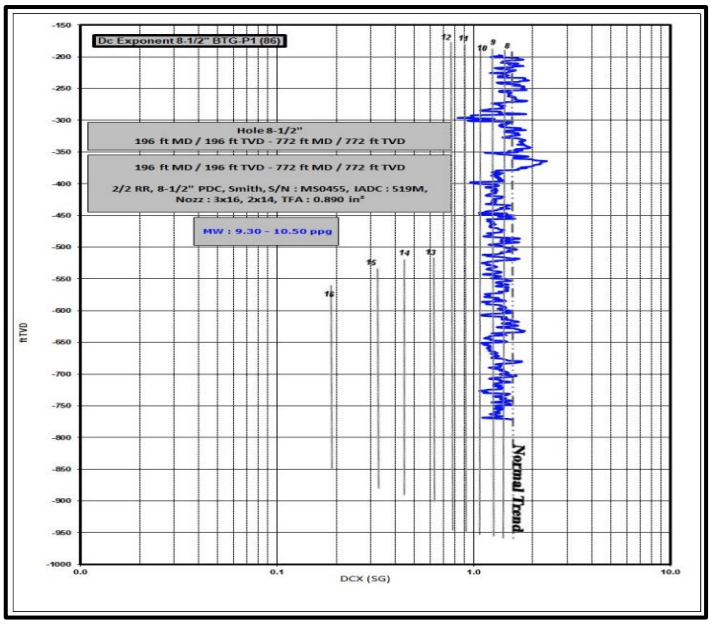

Figure 3. D-exponent of BTG-P1
(Source: Drilling Report of PHE SIAK)

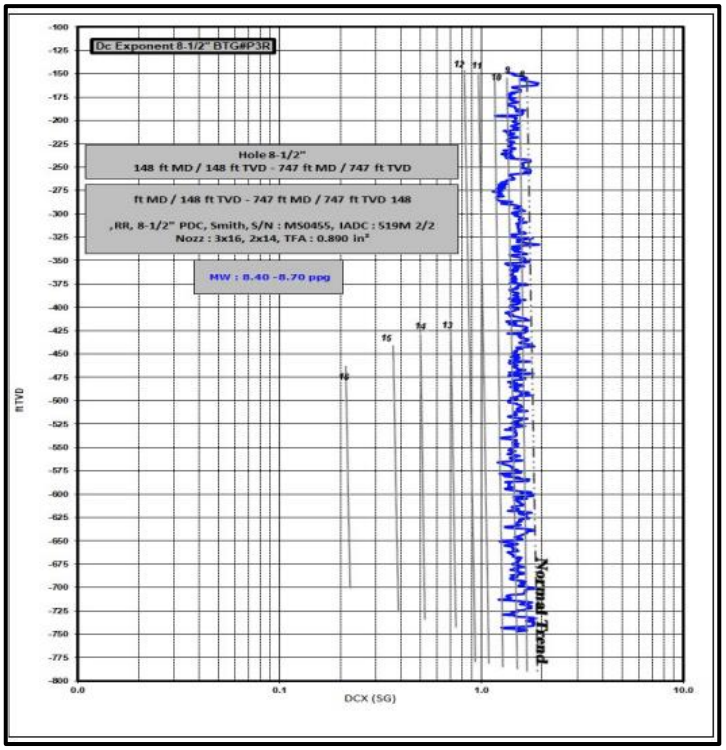

Figure 4. D-exponent of BTG-P3R
(Source: Drilling Report of PHE SIAK)

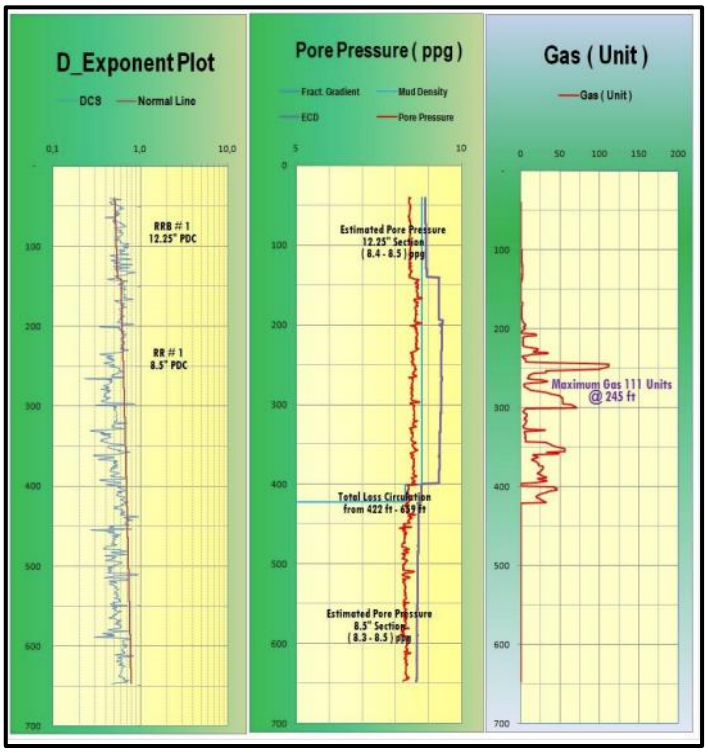

Figure 5. D-exponent of BTG-P4R
(Source: Drilling Report of PHE SIAK)

Cutting Description

Based on cutting description of BTG-P1, BTG-3R, BTG-4R that range from 300-500 ft which is included in 8.5 in hole section, it is known that cuttings from these depths consist of mainly of loose rocks that indicate the formation in these depths is shallow and unconsolidated.

Reservoir Properties

Table 1 shows the summary of average reservoir parameter from GGR study done by PHE Siak. Based on this summary of average value of reservoir properties, it is known that the target formation of Batang development drilling which is part of Bekasap formation has relatively high permeability and reservoir pressure that less than normal pressure gradient that my cause this formation prone to loss circulation events.

Table 1. Summary of Batang Target Reservoir Properties

Parameter	Nilai
Average depth	500 ft
Pre-steam reservoir pressure	100 psi
Pre-steam reservoir temperature	100°F
Average net pay thickness	120 ft
Average porosity	0.34
Average initial oil saturation	0.53
Average permeability	1500 md
Rock compressibility	57 x 10^{-6} psi^{-1}
Average oil gravity	20°API
Oil volume formation factor	1.02 RB/STB
Solution gas-oil ratio	15 scf/STB
Oil viscosity at 100°F	330 cp
Oil viscosity at 300°F	8.2 cp
Irreducible water saturation	0.40
Residual oil saturation to water	0.25
Residual oil saturation to steam	0.10
Rock heat capacity	33.2 BTU/ ft^3-°F
Reservoir thermal conductivity	27.4 BTU/ ft-day-°F

3.2. Drilling Parameter Analysis on Loss Circulation Severity

Figure 6 through Figure 13 are showing the relation between historical drilling parameters (MW, ECD, Yield Point, pump SPM, pump flow rate, drill string RPM, WOB, and ROP to the loss circulation severity of previous sample wells. From this plot, data trend equations are acquired and values for minimizing loss in Bekasap formation can be calculated. From the plot, it is also known that not all drilling parameters showed distinct relation to loss circulation severity. There are some parameters that cannot give clear relation to the severity of loss circulation in Batang field, such as: ECD and Yp that may be caused by lack of data variation of these parameters. Recommended drilling parameters for minimizing loss circulation in Batang field are tabulated in Table 2.

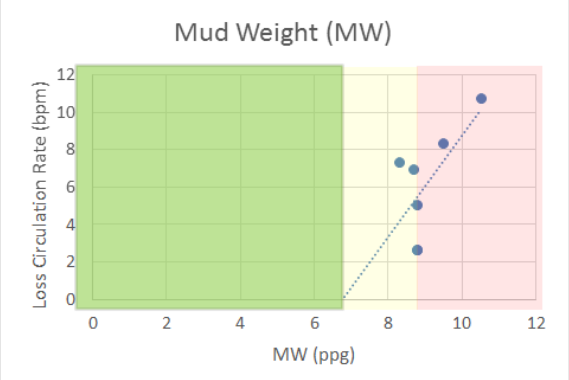

Figure 6. Relation of Mud Weight to Loss Rate

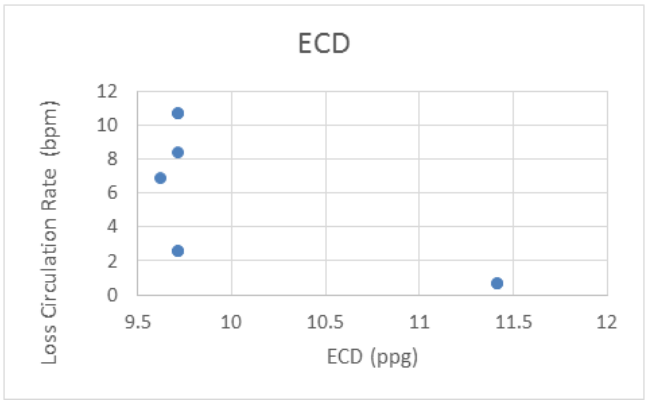

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Figure 7. Relation of ECD to Loss Rate

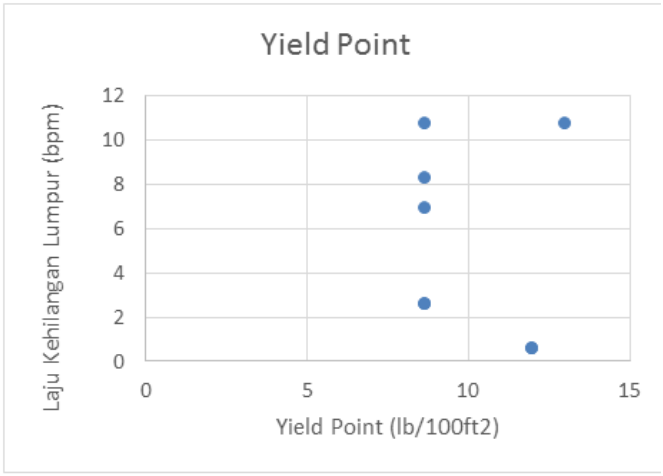

Figure 8. Relation of Yield Point to Loss Rate

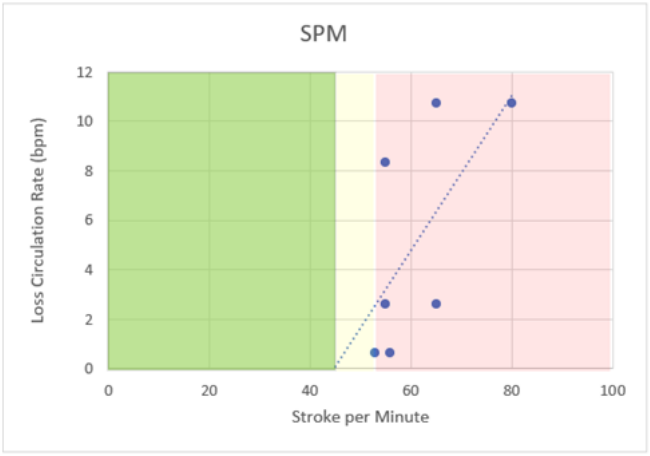

Figure 9. Relation of Pump Stroke per Minute to Loss Rate

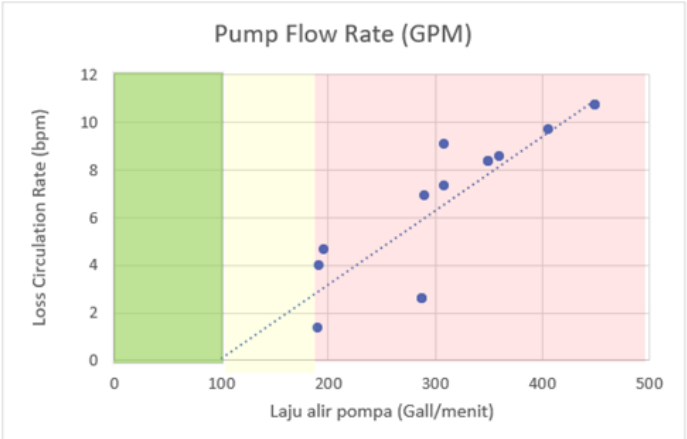

Figure 10. Relation of Pump Flow Rate to Loss Rate

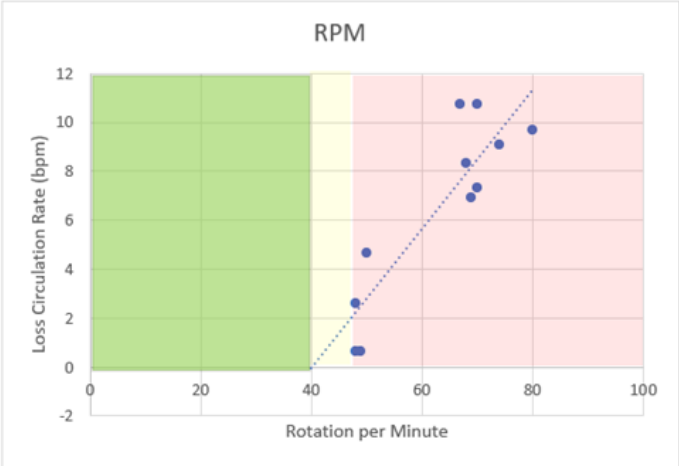

Figure 11. Relation of String RPM to Loss Rate

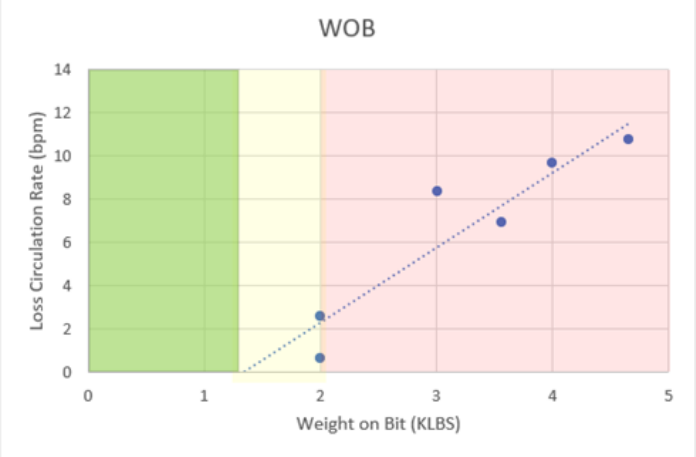

Figure 12. Relation of Weight on Bit to Loss Rate

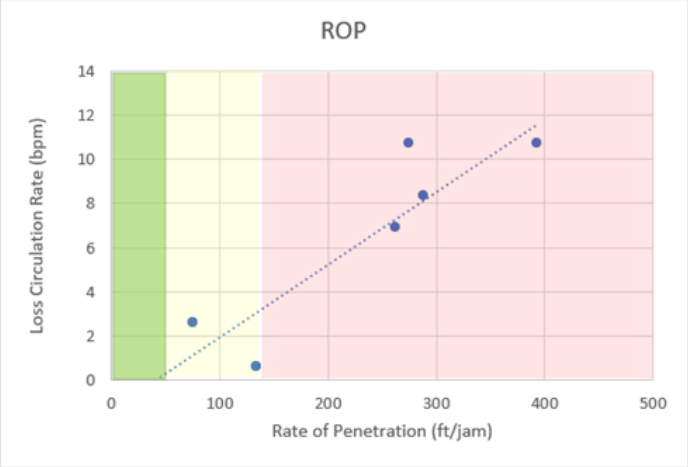

Figure 13. Relation of Rate of Penetration to Loss Rate

Table 2. Summary of Drilling Parameter Analysis

Parameter	Before	Recommended *Maximum Allowable*	Unit
Mud Weight (ppg)	8.8-10.5	7-8.8	ppg
Pump Flow Rate (GPM)	280-450	100-190	GPM
Rotation per Minute (RPM)	70	40-48	RPM
Stroke per Minute (SPM)	43-80	43-53	SPM
Weight on Bit (klbs)	2-4.66	1.3-2	klbs
Rate of Penetration (ft/jam)	275-393	50-135	ft/hrs

3.3. Analysis of Cause oof Loss Circulation of BTG-P1, BTG-P3, dan BTG-P4

Analysis of Cause of Loss Circulation of BTG-P1, BTG-P3, dan BTG-P4 will be conducted by comparing drilling parameter recommended values from previous part of research to the historical drilling parameters value of each well on depth where the loss circulation event firstly happen. The result is shown in Table 3.

Table 3. Evaluation of Drilling Parameters of Sample Wells

Sumur	Bit (in)	Interval (ft)	MW (ppg)	ECD (ppf)	GPM (gpm)	RPM (rpm)	ROP (ft/hr)	WOB (klbs)	Loss Rate (bpm)
BTG-P1	8.5	288	10.5	11.4	367	48	393	14.32	2
BTG-P3	8.5	321	8.7	9.42	290	69	262.74	3.5	6.9
BTG-P4	8.5	395	8.8	9.72	400	77	121	4	9.524

3.4. Analysis of Historical Loss Circulation Combat Method

Evaluation is also done to determine the effectiveness of loss circulation combat methods that have been done to combat loss circulation in Batang field. The method used for loss circulation combat was still mostly by pumping LCM to loss formation. The data used for evaluation are shown in Table 4 through Table 6. From the evaluation it is concluded that current loss circulation combat method was not effective to mitigate loss circulation event in Batang field drilling.

Table 4. LCM Pumping History in BTG-P1

Well	Date	Time	Interval (ft)	Type	Vol Pumped (bbl)	Cum (bbls)	Concentration (ppb)	Kum LCM (Lbs)	Loss Rate Before (bpm)	Loss Rate After (bpm)
BTG-P1	06-Jan-20	20:00-21:00	288	LCM	40	40	40	1600	0.647	0.647
BTG-P1	06-Jan-20	22:30-23:30	288	LCM	40	80	40	3200	0.647	0
BTG-P1	07-Jan-20	01:00-01:30	288	LCM	40	120	40	4800	2	2
BTG-P1	07-Jan-20	02:30-03:30	288	LCM	40	160	40	6400	2	0
BTG-P1	08-Jan-20	01:00-01:30	288	LCM	40	200	40	8000	2	2
BTG-P1	08-Jan-20	02:30-03:30	288	LCM	40	240	40	9600	2	0
BTG-P1	08-Jan-20	05:30-06:00	296	LCM	40	0	40	1600	2.6	2.6
BTG-P1	08-Jan-20	09:00-09:30	296	LCM	40	80	40	3200	2.6	0

Table 5. LCM Pumping History in BTG-P4R

Well	Date	Time	Interval (ft)	Type	Vol Pumped (bbl)	Cum (bbls)	Concentration (ppb)	Kum LCM (Lbs)	Loss Rate Before (bpm)	Loss Rate After (bpm)
BTG-P4R	16-Mar-20	12:30-13:00	390	LCM	40	40	100	4000	5	1
BTG-P4R	16-Mar-20	14:30-15:00	390	LCM	25	65	120	7000	5	0.5
BTG-P4R	16-Mar-20	18:30-19:00	390	LCM	25	90	140	10500	0.5	8
BTG-P4R	16-Mar-20	21:30-22:00	390	LCM	25	115	140	14000	8	2.2
BTG-P4R	16-Mar-20	23:30:24:00	390	LCM	25	140	140	17500	2.2	3.6
BTG-P4R	17-Mar-20	01:30-02:00	390	LCM	25	165	140	21000	3.6	0.82
BTG-P4R	17-Mar-20	03:00-04:00	390	LCM	25	190	140	24500	0.82	0.28
BTG-P4R	17-Mar-20	05:30-06:00	422	LCM	25	25	140	3500	0.28	TOTAL
BTG-P4R	17-Mar-20	07:00-07:30	422	LCM	25	50	140	7000	TOTAL	0
BTG-P4R	17-Mar-20	08:30-09:00	422	LCM	25	75	140	10500	TOTAL	1.4
BTG-P4R	17-Mar-20	10:30-11:30	422	LCM	40	115	140	16100	TOTAL	4.7
BTG-P4R	17-Mar-20	13:00-13:30	422	LCM	25	140	140	19600	4.7	4.6
BTG-P4R	17-Mar-20	14:03-15:30	422	LCM	30	170	140	23800	4.6	0.8
BTG-P4R	17-Mar-20	16:30-17:30	422	LCM	25	195	140	27300	0.8	0.4
BTG-P4R	17-Mar-20	21:00-22:00	422	LCM	25	220	140	30800	TOTAL	3.2
BTG-P4R	17-Mar-20	23:30-24:00	422	LCM	25	245	140	34300	TOTAL	2.6
BTG-P4R	18-Mar-20	01:30-02:00	422	LCM	25	270	140	37800	TOTAL	1
BTG-P4R	18-Mar-20	05:30-06:30	422	LCM	25	295	140	41300	TOTAL	1.9
BTG-P4R	18-Mar-20	08:30-09:00	422	LCM	5	300	140	42000	TOTAL	0

Table 6. LCM Pumping History in BTG-P3R

Well	Date	Time	Interval (ft)	Type	Vol Pumped (bbl)	Cum (bbls)	Concentration (ppb)	Kum LCM (Lbs)	Loss Rate Before (bpm)	Loss Rate After (bpm)
BTG-P3R	20-Jan-20	11:30-12:30	321	LCM	60	60	40	2400	TOTAL	3.2
BTG-P3R	20-Jan-20	12:30-13:30	321	LCM	60	120	40	4800	3.2	1.93
BTG-P3R	20-Jan-20	14:30-16:00	321	LCM	40	160	40	6400	1.93	1.47

IV. CONCLUSION

From this study, there are several conclusions that can be made, they are:

1. Based on analysis of drilling parameters in drilling 8.5 in hole section of Batang field, SPM, GPM, RPM, WOB, and ROP have positive trend to severity of loss circulation
2. Rate of loss circulation in Batang field hopefully can be minimized by ensuring drilling parameter to its minimum value, MW: 7 ppg to 8ppg, GPM 100-190 gpm, RPM 40-48 rpm, WOB 1.3-2 klbs, ROP 50-135 ft/hrs.
3. Pumping LCM, which is the current method, use to mitigate loss circulation in Batang field drilling is not effective to mitigate loss circulation
4. Based on GGR data and data unit data related to properties of Batang development drilling target formation, the formation can be described as unconsolidated, high permeability, and having sub normal pressure, which is ultimate combination for loss circulation event. It is recommended to evaluate alternative drilling methods such as air drilling, aerated drilling, and mud cap drilling as option to mitigate this issue.
5. Based on the evaluation of cause of loss circulation in sample wells it is known that BTG-P1 had higher value of MW, GPM, ROP, and WOB from recommended drilling parameter value, BTG-P3R had higher value of

GPM, RPM, ROP, and WOB from recommended drilling parameter value, BTG-P4 had higher value GPM, ROP, and WOB from recommended drilling parameter value

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