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Reducing Uncertainty in Idle Well Reactivation: A Novel Integrated Screening Framework for Mature Oil Fields

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ABSTRACT - Mature oil fields are increasingly challenged by declining reservoir performance, resulting in a growing number of idle wells with remaining hydrocarbon potential. Despite their strategic importance, reactivation efforts are frequently constrained by high uncertainty in candidate selection due to fragmented evaluation practices, where production behaviour, well integrity, and reservoir quality are often assessed independently. This limitation often leads to suboptimal decision-making and unsuccessful reactivation programs. This study proposes an integrated screening framework to reduce uncertainty in idle well reactivation by systematically combining production diagnostics, well integrity evaluation, and reservoir characterization within a unified workflow. The proposed methodology integrates Water-Oil Ratio (WOR) trend analysis and WOR derivative analysis for water-production diagnostics, Cement Bond Log (CBL) interpretation for cement integrity and zonal isolation assessment, and petrophysical evaluation to determine reservoir quality and hydrocarbon potential. These parameters are incorporated into structured screening criteria to enable consistent classification of reactivation potential. The framework was applied to Well BP-16 in an Indonesian mature oil field as a representative case study. The results indicate that excessive water production and poor cement bonding are the dominant factors contributing to well inactivity. The integrated evaluation also identified a previously overlooked interval at 693–696 m with favourable reservoir properties and lower water-production risk. Compared with conventional single-domain evaluations, the proposed approach provides a more comprehensive understanding of subsurface conditions by linking production behaviour, well integrity, and reservoir characteristics within a single evaluation framework. This integration improves the reliability of reactivation candidate selection and supports more effective reactivation planning. The proposed framework offers a practical and field-applicable approach for optimizing idle well utilization, improving production efficiency, and extending the economic life of mature oil fields.

Keywords: idle well, well reactivation, integrated screening, water-oil ratio, mature oil field, evaluation

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INTRODUCTION

Mature oil fields play a crucial role in sustaining global hydrocarbon production. However, as these fields age, production inevitably declines due to several factors, including reservoir depletion, increasing water cut, and deteriorating well conditions. These challenges result in a growing number of inactive wells, commonly classified as idle wells. Although idle wells may no longer produce at optimal rates, they often still contain recoverable hydrocarbons, making them valuable assets for reactivation (Babadagli 2007; Bharadwaj et al., 2021. Reactivating idle wells offers a cost-effective opportunity to increase production without the substantial capital investment required for drilling new wells. Nevertheless, reactivation efforts are frequently constrained by inadequate evaluation methods and uncertainty in identifying viable production zones (Ekpenyong & Joseph 2022; Wardana et al., 2021; Yasutra 2025.

In many Indonesian oil fields, idle wells remain underutilized due to the absence of a systematic and practical screening framework (Hani & Sutresno, 2025; Prayitno et al., 2025. Evaluation are often conducted using fragmented approaches in which production data and well-log information are assessed independently. Such practices fail to provide a comprehensive understanding of well conditions, leading to suboptimal decision-making and missed reactivation opportunities. Existing evaluation methods generally do not integrate key factors such as water production behaviour, cement integrity, and reservoir charactecrics, all of which are essential for accurately assessing reactivation potential. Consequently, identifying viable production intervals within idle wells remains a complex and uncertain process (Nugraha et al., 2023; Wardana et al., 2021.

These limitations highlight the need for a more robust and screening methodology capable of addressing the technical and operational challenges associated with idle well reactivation. By combining production diagnostics, well-log interpretation, and reservoir characterization, a more comprehensive and reliable evaluation can be achieved. Such an approach facilitates the identification of promising reactivation zones and supports the optimal utilization of idle wells in mature oil fields (Alfarizi et al., 2023; Idris et al., 2023.

This study addresses this gap by developing a practical integrated screening framework for idle well reactivation. The framework was applied to Well BP-16, an idle onshore production well located in a mature clastic reservoir in Indonesia. The well produces from a sandstone-dominated fluvio-deltaic formation and became inactive due to prolonged high water production and well-integrity -related issues, making it a representative candidate for reactivation studies in mature oil fields across Southeast Asia. Well BP-16 serves as a case study to demonstrate the application of the proposed framework. The evaluation integrates multiple evaluation metrics, including Water-Oil Ratio (WOR) diagnostics, Cement Bond Logs (CBL interpretation), and petrophysical analysis, to provide a comprehensive assessment of well conditions and reactivation potential (Fitrianti et al., 2020; Suhascaryo et al., 2025.

The novelty of this study lies in the development of an integrated screening framework that combines production diagnostics, well integrity evaluation, and reservoir characterization within a unified workflow for idle well reactivation. Unlike conventional approaches that assess production performance, well integrity, and reservoir properties separately, the proposed framework systematically integrates Water-Oil Ratio (WOR) diagnostics, Cement Bond Log (CBL) interpretation, and petrophysical evaluation through a structured screening logic. This integration enables a more consistent assessment of reactivation potential by accounting for the interrelationship among water -production behaviour, zonal isolation conditions, and reservoir quality.

The framework is designed to be practical and field-applicable, allowing engineers to systematically evaluate idle wells using commonly available datasets without relying on complex or data-intensive modelling techniques. By incorporating multiple technical parameters into a single evaluation pathway, the framework reduces subjectivity in candidate selection and improves the reliability of identifying potential reactivation intervals. Furthermore, the proposed methodology provides a clear transition from diagnostic interpretation to operational decision-making, thereby reducing uncertainty in reactivation planning. As a result, it supports more efficient utilization of existing well assets, enhances production optimization strategies, and offers a scalable approach for extending the economic life of mature oil fields while minimizing the need for additional drilling.

METHODOLOGY

This study employs an integrated evaluation methodology to assess idle well conditions and identify potential reactivation zones in a mature oil field. The methodology combines production analysis, well-log interpretation, reservoir characterization, and structured screening criteria to support reactivation decision-making.

The overall workflow consists of production analysis, log interpretation, problem identification, screening criteria application, candidate zone selection, and workover planning. A schematic representation of the evaluation workflow is presented in Figure 1.

Production analysis

Production analysis was conducted using Water -Oil Ratio (WOR) trends to identify abnormal water-production behavior. WOR analysis is widely applied in mature oil fields to diagnose water breakthrough, channeling, and other water-production mechanisms (Bailey et al., 2000). The WOR was calculated following Equation 1,

$$WOR = \frac{q_w}{q_o} \quad (1)$$

where q_w represents the water production rate and q_o represents the oil production rate.

To enhance diagnostic interpretation, the derivative of WOR (WOR′), was calculated as Equation 2.

$$WOR' = \frac{WOR_{n+1} - WOR_n}{t_{n+1} - t_n} \quad (2)$$

The WOR and WOR′ values were plotted on a log–log scale against cumulative production time to generate Chan’s diagnostic plot (Figure 2). This diagnostic approach enables identification of dominant water-production mechanisms, including normal displacement, channelling, and coning, based on the characteristic trends of WOR and its derivative throughout the production period (Abdelaziem et al., 2022).

The log–log plot shows a progressive increase in the WOR trend, characterized by a positive slope, while the WOR′ trend generally exhibits a negative slope throughout the production period. This diagnostic response indicates that water production continuously increases relative to oil production as reservoir depletion progresses. Such behaviour is characteristic of normal displacement with high-WOR conditions, suggesting that excessive water production is primarily associated with reservoir-driven water encroachment rather than sudden mechanical failure or severe behind-casing channelling.

Well log analysis

Well log analysis was performed using Cement Bond Log (CBL) and Variable Density Log (VDL) data to evaluate cement integrity and zonal isolation (Subekti et al., 2023.

Cement integrity is a critical factor in controlling unwanted water influx. Poor cement bonding may lead to interzonal communication, resulting in excessive water production and reduced oil recovery. The analysis focuses on: 1). Identifying zones with poor cement bonding; 2). Detecting potential channelling pathways; and 3). Evaluating zonal isolation effectiveness.

Reservoir characterization

Reservoir characterization was conducted using petrophysical parameters derived from well-log data, including porosity, permeability, and fluid saturation. These parameters are essential for evaluating reservoir quality and determining the production potential of specific intervals. Interpretation of these parameters enables the identification of productive zones and assessment of reservoir performance. In this study, reservoir characterization was used to: 1). Identify hydrocarbon-bearing zones with favourable reservoir properties; 2). Evaluate water saturation as an indicator of excessive water-production risk; and 3). Assess reservoir deliverability as an indicator of production potential.

The results of this analysis were integrated with production and well-log evaluations to support the screening process and identify suitable intervals for well reactivation (Amin Nizar et al., 2019).

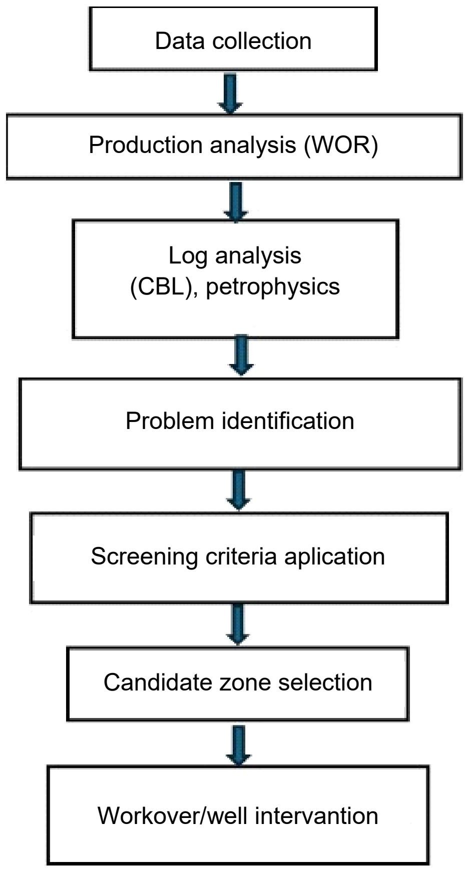

Figure 1. Workflow of Idle Well Evaluation The diagram illustrates a sequential workflow for identifying well problems and selecting candidate zones for targeted workover or well intervention.

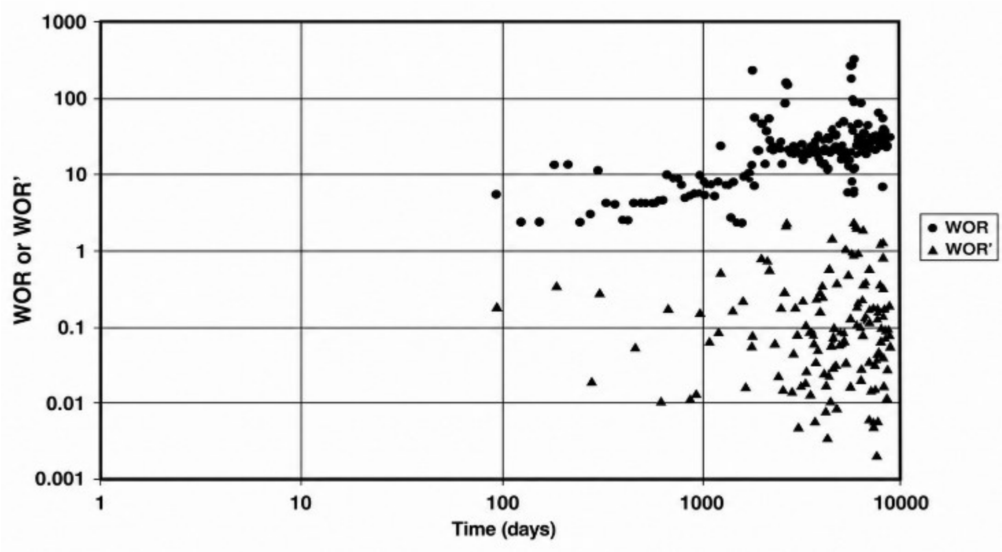

Figure 2. Chan's water diagnostic plot showing normal displacement with high WOR.
The figure shows that although displacement remains normal, the water–oil ratio (WOR) increases significantly over time, indicating increasing water production during the later stages of production (Abdelaziem et al., 2022).

Screening process

The screening process integrates the results of production analysis, well-log interpretation, and reservoir characterization to systematically classify well conditions and evaluate reactivation potential. A set of screening criteria was developed based on key technical parameters that directly influence well performance, enabling more accurate classification of reactivation potential while reducing uncertainty in candidate selection.

The proposed screening framework (Table 1) provides a practical, field-applicable method for supporting efficient decision-making in idle well reactivation programs and can be applied to mature oil fields with similar characteristics (Prayitno et al., 2025.

The screening criteria incorporate:

- WOR trends representing water-production behaviour;
- Cement integrity derived from CBL interpretation; and
- Reservoir quality indicated by porosity and permeability; and 4). production history reflecting reservoir performance over time.

These parameters were selected because they represent the primary factors controlling production sustainability and water intrusion in mature oil fields. Integrating these parameters enables a more comprehensive evaluation of well conditions, thereby improving the reliability of candidate classification and reducing uncertainty in reactivation decision-making.

Table 1. Screening criteria for Idle well reactivation

Parameter	Indicator	Interpretation	Reactivation po
Water-oil ratio (WOR)	Highly increasing trend	Water breakthrough/channelling	Low–Moderate
Cement bond log (CBL)	Poor bonding	Zonal isolation failure	Moderate
Porosity	>10%	Good reservoir quality	High
Permeability	>1 mD	Flow capability	High
Production history	Declining trend	Reservoir depletion or damage	Moderate

The table summarizes key parameters and indicators used to evaluate idle wells, showing how Water-Oil Ratio, cement bond, porosity, permeability, and production history determine the well's reactivation potential.

RESULT AND DISCUSSION

High water cut analysis

Well BP-16 is classified as an idle well due to excessive water production, with a water cut approaching 99%, resulting in uneconomic production conditions. To investigate the dominant cause of the excessive water production, a diagnostic analysis was conducted using Chan's plot method. This approach involves plotting the Water-Oil Ratio (WOR) and its derivative (WOR′) on a log–log scale against cumulative production time to identify the dominant water-production mechanism. The analysis focused on the productive Layer XII/XIII interval to ensure a more accurate evaluation of reservoir behaviour. The WOR and WOR′ values were calculated using diagnostic equations described previously, and the results are summarized in Table 2. The calculated data were subsequently plotted to generate the Chan's water diagnostic plot, as presented in Figure 3. The log–log relationship between WOR and WOR′ versus cumulative production time indicates that the WOR curve exhibits a continuously increasing trend, reflecting a substantial increase in water production relative to oil production. In contrast, the WOR′ curve generally displays a declining trend throughout the production period. This diagnostic behaviour is characteristic of normal displacement under high-WOR conditions, suggesting that excessive water production is primarily controlled by reservoir

Table 2. Calculated WOR and WOR' values

Well	Date	Oil cum (Mbbl)	Water cum (Mbbl)	Time	WOR	WOR'
BP-16	5-Dec-09	0.01	5.70	94.00	21.13	0.01
BP-16	6-Dec-09	0.02	5.82	95.00	18.00	0.03
BP-16	7-Dec-09	0.03	5.94	96.00	19.10	0.01
BP-16	8-Dec-09	0.03	6.03	97.00	15.40	0.04
BP-16	9-Dec-09	0.04	6.13	98.00	15.20	0.00
BP-16	10-Dec-09	0.04	6.21	99.00	13.50	0.02
BP-16	11-Dec-09	0.05	6.29	100.00	13.70	0.00
BP-16	12-Dec-09	0.06	6.38	101.00	14.40	0.01
BP-16	13-Dec-09	0.06	6.46	102.00	13.30	0.01
BP-16	14-Dec-09	0.07	6.53	103.00	12.50	0.01
BP-16	15-Dec-09	0.07	6.61	104.00	13.20	0.01
BP-16	16-Dec-09	0.08	6.70	105.00	13.50	0.00

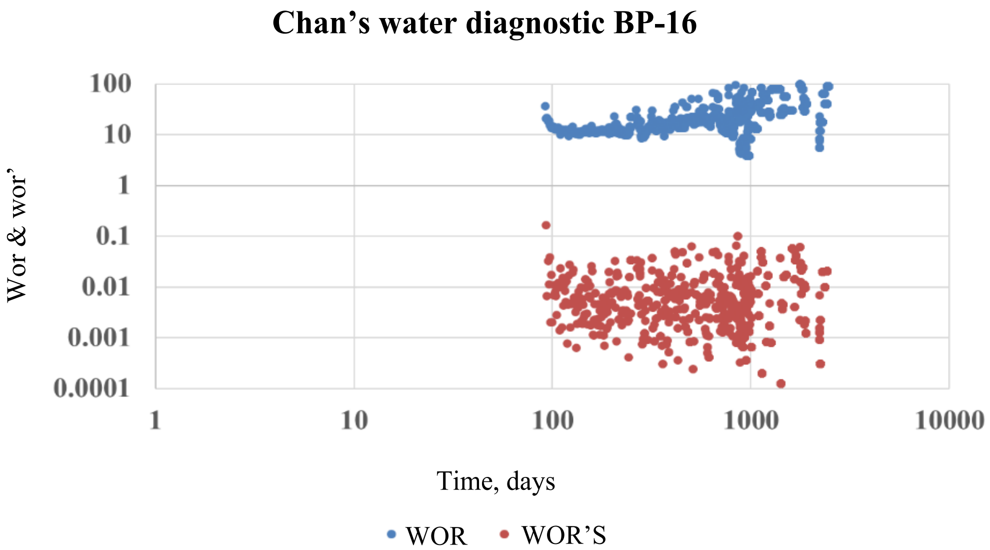

Figure 3. Chan's Water Diagnostic Plot for Well BP-16.
The plot shows that both WOR and its derivative (WOR') increase over time, indicating progressive water breakthrough and deteriorating production performance.

depletion and progressive water encroachment rather than sudden mechanical failure or severe behind casing channelling.

The increasing dominance of water production indicates that the movable oil saturation within the reservoir has significantly decreased as the field matured. The analysis confirms that the extremely high water cut observed in Well BP-16 is mainly associated with reservoir performance deterioration and inefficient sweep efficiency, ultimately resulting in uneconomic production and well inactivity.

These findings highlight the importance of integrating production diagnostics with well integrity and reservoir evaluation to accurately identify potential reactivation intervals and reduce uncertainty in reactivation planning.

Well log analysis

Petrophysical log analysis was conducted to evaluate reservoir characteristics and identify potential production problems based on subsurface conditions. The analysis provided both quantitative and qualitative information, including lithology, porosity, permeability, resistivity, and fluid saturation. These parameters are essential for identifying hydrocarbon-bearing zones, determining water-bearing intervals, and assessing reservoir quality. In addition, log interpretation can identify potential issues such as high water saturation and poor zonal isolation that may contribute to well inactivity. Figure 4 presents the petrophysical log interpretation of Well BP-16.

The interpretation highlights the selected interval in Layer XII/XIII, where re-evaluation was performed. The identified zone exhibits more favourable reservoir characteristics than previously perforated intervals, making it a promissing candidate for reactivation. The selected interval also indicates lower water saturation than the surrounding zones, further supporting its suitability for reactivation.

Screening of idle well

Based on integrated evaluation, Well BP-16 was classified as having moderate reactivation potential. The principal issues identified were: 1). High water cut; 2). Poor cement bonding; and 3). declining production trend.

The table indicates that well BP-16 is currently idle with high water cut and poor cement bonding issues, resulting in moderate reservoir quality and moderate potential for reactivation.

Candidate zone selection

The integrated evaluation identified a potential reactivation zone at a depth of 693–696 m. This interval exhibits more favourable reservoir properties and lower water risk of excessive water production than previously perforated zones.

The results demonstrate that combining production diagnostics, well-log interpretation, and reservoir characterization provides a reliable and practical approach for evaluating idle wells. The identification of excessive water production and poor cement bonding as the primary causes of well inactivity further emphasizes the importance of integrating reservoir performance analysis with well integrity evaluation.

The proposed screening framework offers several advantages: 1). Provides a systematic evaluation of idle wells; 2). reduces uncertainty in candidate selection; 3). Supports more efficient operational decision-making; and 4). Can be applied to multiple wells in mature oil fields.

Table 3. Summary of well evaluation

Well	Status	Main Problem	Reservoir quality	Reactivation potential
BP-16	Idle	High water cut, poor cement bonding	Moderate	Moderate

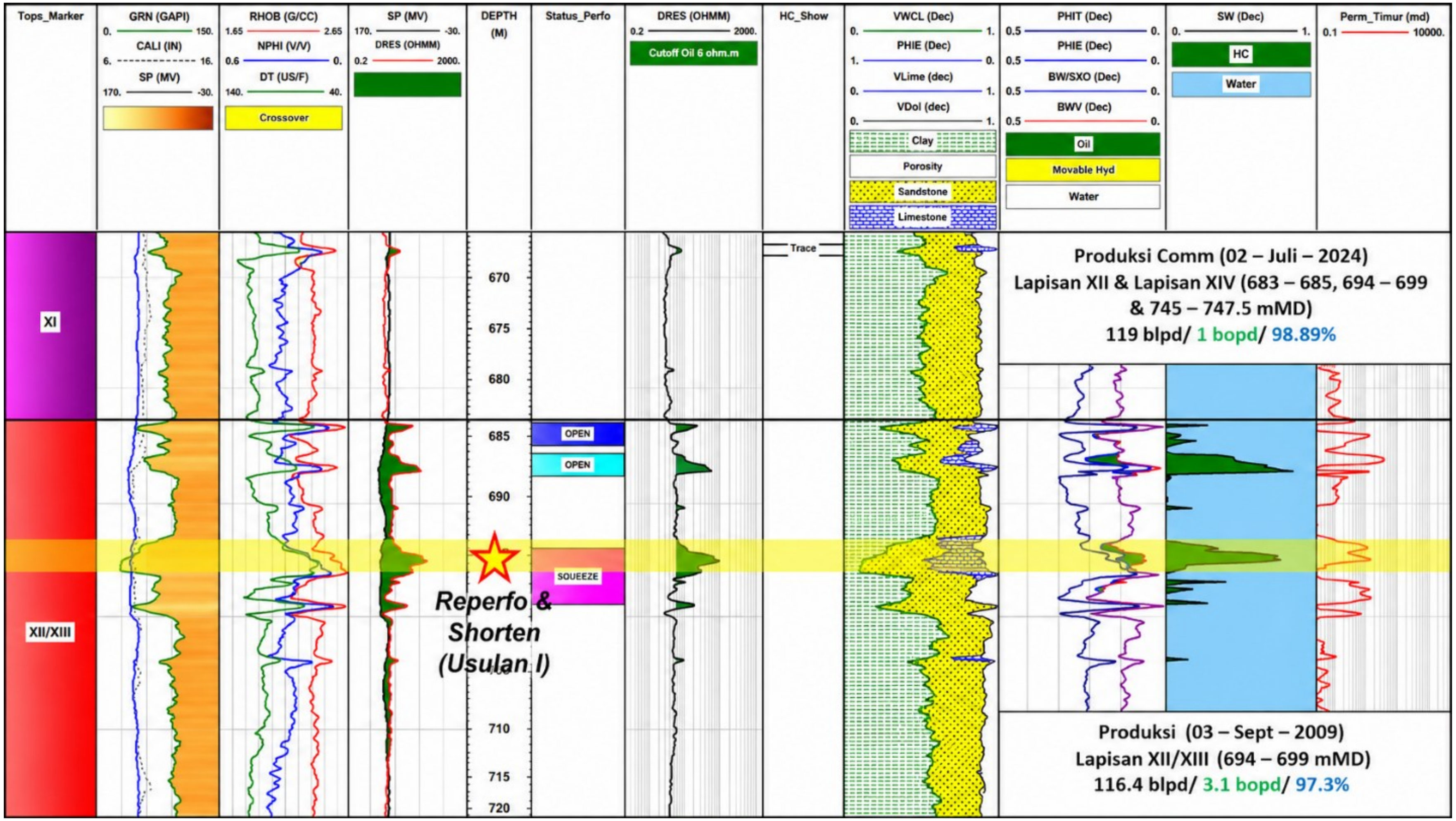

Figure 4. Petrophysical log interpretation of BP-16 well showing the selected reactivation interval within layer XII/XIII.

The log and production data suggest that reperforation combined with interval shortening within Layer XII/XIII could improve hydrocarbon production performance. The highlighted intervals indicate the distribution of oil, water, and movable hydrocarbons within the reservoir.

Compared with conventional evaluation methods, in which production behaviour, well integrity, and reservoir properties are typically assessed independently, the proposed integrated screening framework provides a more comprehensive and reliable evaluation by explicitly integrating these parameters within a unified workflow. This integration enables cross-validation among datasets, facilitating clearer identification of the dominant causes of well inactivity and differentiation between reservoir-driven water production and integrity-related problems.

The proposed framework also introduces a structured screening logic that reduces subjectivity in interpretation and improves the reliability of candidate selection. This capability is particularly important in mature oil fields, where high water cut does not necessarily indicate poor reactivation potential if supported by favourable reservoir quality and effective zonal isolation.

The effectiveness of the approach is demonstrated through the BP-16 case study. A conventional single-domain evaluation would likely classify the well as unsuitable for reactivation because of its extremely high water cut (~99%). However, the integrated analysis successfully identified a potential reactivation interval at 693–696 m with a more favourable reservoir properties and lower water-production risk. These results demonstrate the ability of the framework to identify overlooked opportunities and support more reliable reactivation decisions.

CONCLUSION

This study presents a practical screening framework for evaluating idle wells for reactivation in mature oil fields. By integrating production data analysis, well integrity evaluation, and well -log interpretation, the proposed approach enables more comprehensive assessment of the factors contributing to well inactivity, particularly excessive water production and poor cement bonding. Application of the framework to Well BP-16 successfully identified a potential reactivation interval at 693-696 m, demonstrating the effectiveness of the approach in supporting data -driven decision-making.

Compared with conventional single-domain evaluation methods, where production behaviour, well integrity, and reservoir properties are commonly assessed independently, the proposed framework provides a more reliable and consistent evaluation through the integration of these critical parameters within a unified screening workflow. This integrated approach enables clearer identification of the dominant causes of well inactivity and reduces the risk of misclassification during candidate selection.

The framework is practical and readily applicable to mature oil fields, particularly in data-limited environments where complex modelling approaches may not be feasible. Its primary advantage lies in reducing uncertainty and minimizing subjectivity during the evaluation process while improving the transition from diagnostic interpretation to operational decision-making.

Consequently, the framework offers a more efficient and cost-effective alternative to conventional evaluation practices by supporting better utilization of existing well assets, improving production optimization, and extending the economic life of mature fields without requiring additional drilling investment.

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DECLARATIONS

Author contribution

S.H. Prayitno: Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Hariyadi: Writing – review & editing, Validation, Methodology, Supervision. I. Widiyaningsih: Writing – review & editing, Visualization, Formal analysis. N. Cahyaningtyas: Writing – review & editing, Visualization, Methodology. M.F. Helmy: Writing – review & editing, Visualization. B. Pramuditha: Writing – review & editing, Visualization.

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Conflict of interest

The authors declare that they have no conflict of interest related to this study.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

GLOSSARY OF TERMS AND SYMBOLS

Terms & Symbols	Definition	Unit
qw	Water rate	Bbl/day
k	Permeability	Darcy
Ps	Static pressure	psi
P_{wf}	Well flowing pressure	psi
qi	Initial rate	Bbl/day
WC	Water cut	Fraction
P10	Persentil ke-10	Fraction
P50	Persentil ke-50	Fraction
P90	Persentil ke-90	Fraction
qo	Oil rate	Bbl/day
Qmax	Maximum rate	Bbl/day

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