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Application of Surveillance and Monitoring in the Mature Waterflood Field

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ABSTRACT

Waterflood is one of the keys to maintaining reservoir health and carrying out oil recovery in the secondary stage. In its development, the implementation of surveillance and monitoring activities is carried out to monitor waterflood performance both from the production and injection sides regularly to maximize production optimization. However, many challenges must be faced in developing waterfloods, some of which are maintaining the Voidage Replacement Ratio (VRR) and the production of unexpected water. Therefore, a simpler and easy-to-apply surveillance and monitoring approach is needed. This paper describes how the application of waterflood surveillance and monitoring principles and practices is carried out in the oil recovery process and monitoring reservoir health. The reservoir health monitoring process includes several aspects such as the Voidage Replacement Ratio (VRR) and Water-Oil Ratio (WOR), as well as the identification of areas of interest in accumulated oil through the Production Attribute approach. The application is carried out on Field 'X' which has a typical production with a fairly high water cut. This approach was successfully applied to Field 'X' and gave the results of the approach that was quite ideal to be applied.

Introduction

In general, the development of oil fields is oriented towards maximizing the profits of a reservoir with existing conditions. To maximize these profits, many problems are faced. (BaniHammad et al., 2019). Therefore, management is needed in developing oil fields, especially old fields with the character of sandstone reservoirs that have natural aquifers, artificial water drives, or a combination of both. This old field requires treatment based on the character of the problems faced and of course, is a challenge in efforts to maintain oil production. (Rini et al., 2021).

One of the efforts that can be made in maintaining the production of old oil and gas fields is to carry out the Waterflood injection method. (Samsudin et al., 2017). The success of waterflood is a comprehensive method to maintain the health of the reservoir. By maintaining the health of the reservoir, production optimization can be carried out optimally and increase oil recovery. (Noer et al., 2021).

The main problem that usually occurs in the waterflood injection process is the increase in the Water/Oil Ratio (WOR). This causes the processing of produced water to increase. In addition, environmental aspects are also beginning to be considered, so it is necessary to have strict supervision and monitoring of waterfloods. (Simbolon et al., 2019). This research will be carried out in the scope of the waterflood field with data and research carried out only covering aspects of reservoirs and production engineering in certain fields. (Sandra & Witcahyo, n.d.).

Water Oil Ratio can be used to monitor production performance and can be used to identify water coning, early breakthrough, and channeling problems. (Satter & Iqbal, 2015). This method is urgently needed because of the problems faced by the development of waterflood fields that produce water so oil experiences a sharp decline in production.

In dealing with these problems, the approach with the Chan Plot method is often used. This method is a technique to be able to diagnose and evaluate reservoir problems. This technique uses WOR plots and WOR derivatives plots plotted on a logarithmic scale so that the trend character of the well data will be seen that show the behavior or production mechanism of the well.

Method

Research Design

The type of research that will be carried out is quantitative and qualitative research on field case study 'X'. The study aims to obtain an actual picture of the performance of waterflood and its effect on oil production and injection so that the conditions and problems that occur in the reservoir in field 'X' can be known. (Agustianti et al., 2022).

Data Collection Methods

The data collection methods used are divided into quantitative secondary and qualitative secondary data collection. Quantitative secondary data is obtained from Field "X" where the field is currently producing with a high-water cut (more than 97%), this data is used to analyze and evaluate the performance of waterflood against oil production. Qualitative data collection methods were obtained from various literature such as scientific journals, and books that are on the research topic. The data needed are:

1. Data reservoir
2. Production and injection data
3. Well data

Data Processing and Analysis

The scope of analysis in the field, area, or well includes:

1. Performance of oil production rate, water injection, and voidage replacement ratio (VRR) over time

2. Water Oil Ratio (WOR)
3. Plot diagnosis (water coning and hall plot injection)
4. Production Attribute

Results and Discussion

Analisa Voidage Replacement Ratio

In this study, the evaluation of waterflood performance includes the evaluation of VRR, pressure, and oil production performance. This VRR calculation uses historical production-injection data and is then calculated through equation (1). With the current production and injection conditions of the 'X' field, the instantaneous VRR obtained is around 4.01 (Aidira, 2022). In the period from 2018 to the present, VRR trending tends to decrease. This is due to a gradual increase in fluid production, but injection conditions tend to be stable at a rate of around 28 to 34 MBWIPD. This decrease in VRR does not affect oil production performance so the decline rate remains stable as shown in Figure 1.

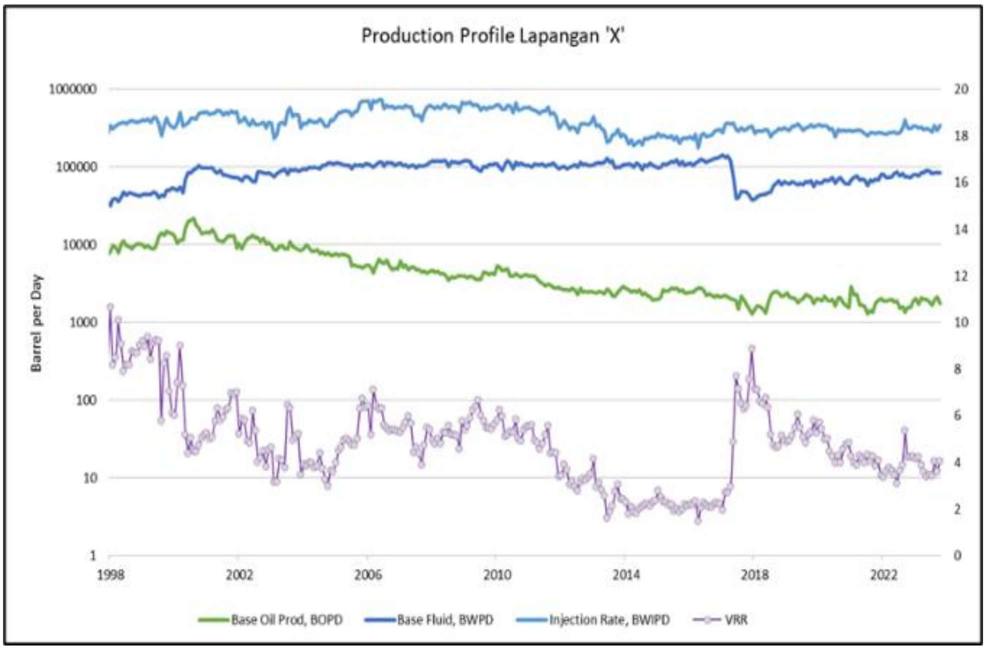

Figure 1 VRR Graph on Field Production and Injection

The decrease in VRR also did not hurt reservoir pressure, as seen in Figure 1, the reservoir pressure of one reservoir seam sample taken on new well drilling (RFT data) tended to be stable at the level of 420 to 470 psi. This is because the injection volume injected is greater than the volume of the fluid produced and the reservoir pressure can remain at the same level.

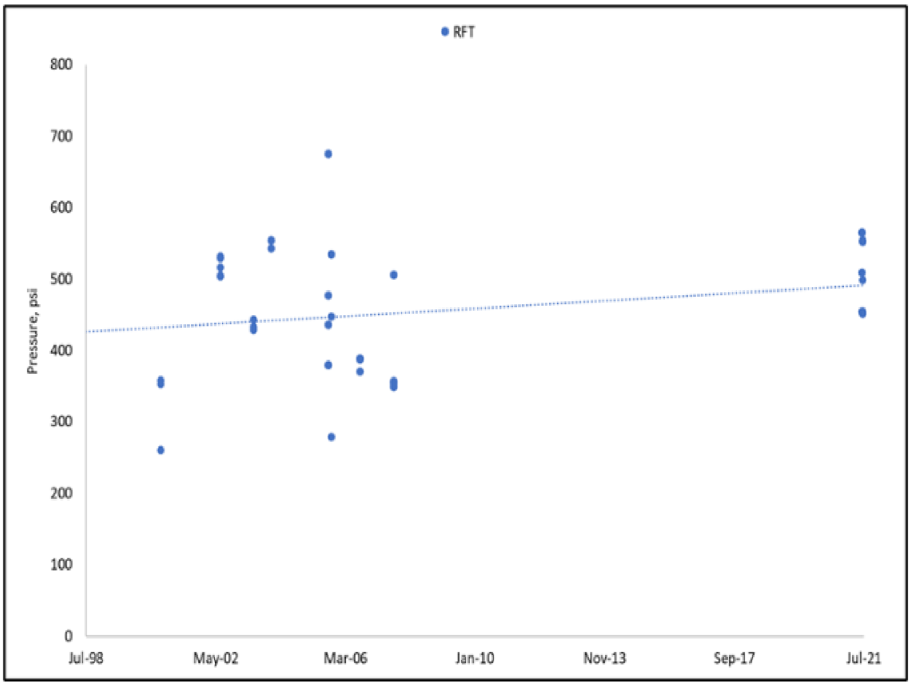

Figure 2 Reservoir pressure (based on RFT) on time

Analisa Water Oil Ratio

Along with the cumulative increase in oil in Field 'X', the Water/Oil Ratio (WOR) also tends to increase, although there are several WOR improvements in 2018 and 2023, due to the workover program that has had a positive impact on oil production. The WOR graph against the cumulative oil can be seen in Figure 2.

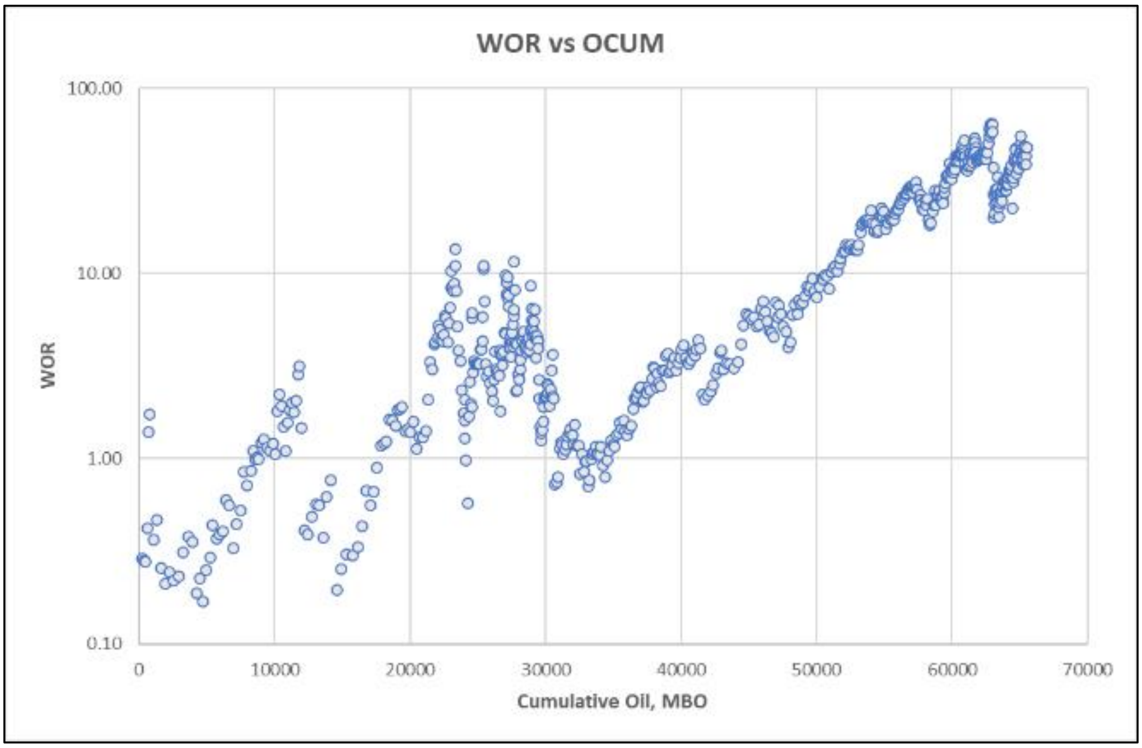

Figure 2 WOR graph against oil cumulative

WOR has experienced a fairly high increase in recent times, showing indications of an increase in water cuts so that the cumulative oil produced has not increased significantly in recent years (Panuju, 2019). Although WOR rose quite sharply in 2023-2024, this trend is normal for WOR where typical reservoirs produce a fairly high *water cut*. The typical tendency of reservoirs in the 'X' field is evidenced by a sample of the Chanplot diagram on two wells, namely X-15 in Figure 3.

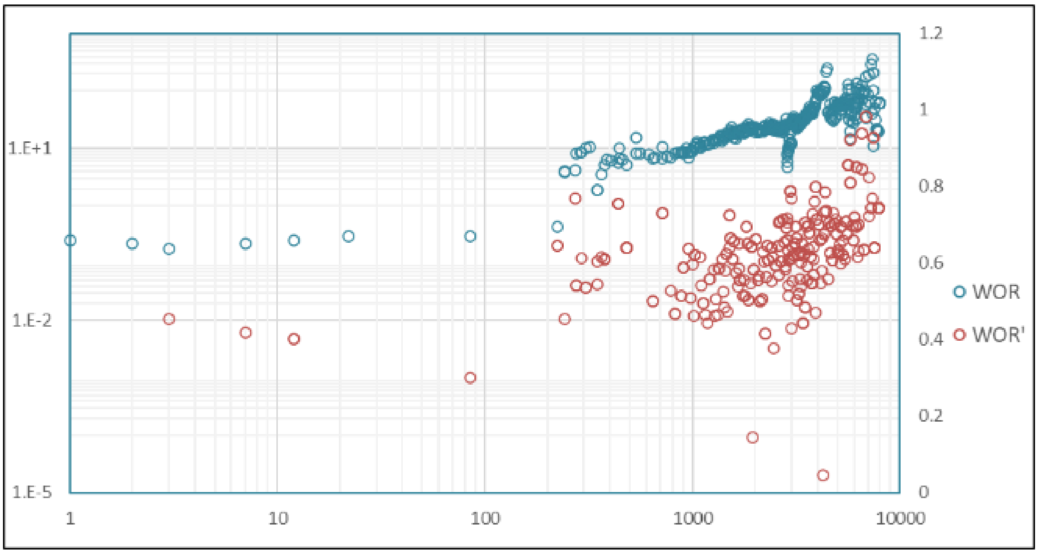

Figure 3 Sample of Chan Well Plot X-15

The Chanplot graph shows a normal indication of displacement with a typical high water cut.

Hall plot Analysis

In this study, Hallplot analysis was also carried out from the injection site, by calculating the cumulative injection volume and wellhead pressure from 2011 to 2024, and then a hall plot derivative was carried out using the hallplot equation, as attached to Figure 4.

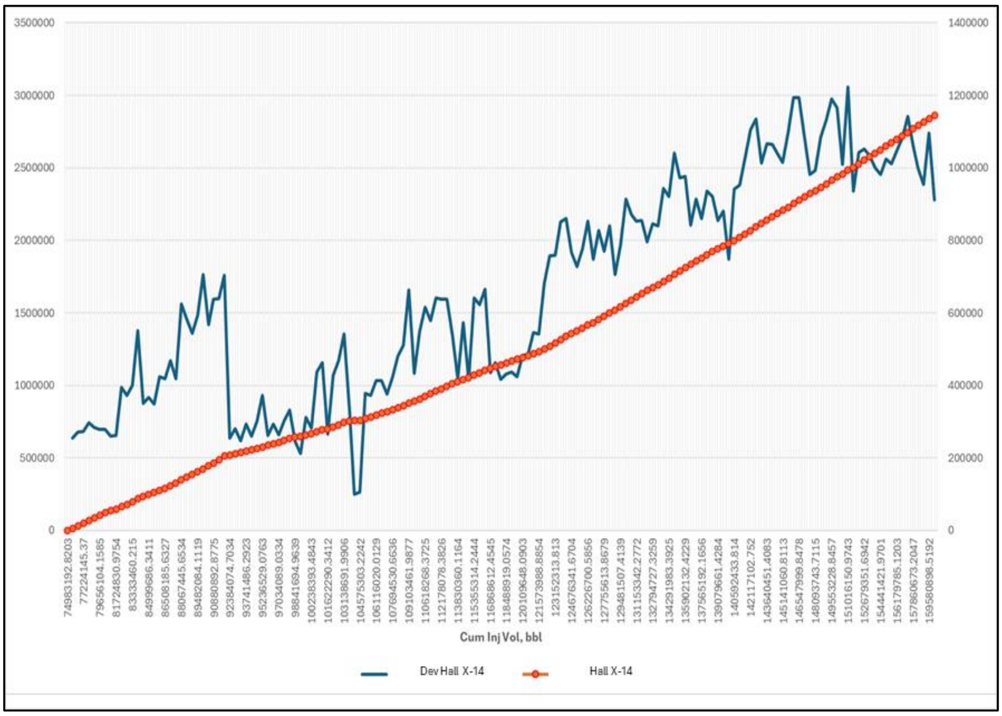

Figure 4 Derivative Hallplot of the X-14 Well

The X-14 well, which currently has a cumulative injection of 159.6 MMBWIPD, tends to have a typical normal injection with a trending cumulative injection volume and wellhead pressure that continues to rise and is stable. The upward trend was due to changes in the completion and change of injection layers, but the graph still showed indications of normal injection.

Mapping Attribute Production

After the analysis in terms of production and injection performance is carried out, the results of the analysis show that the current performance of field 'X' can be categorized as normal displacement with typical high-WOR where, therefore, field 'X' still has residual oil that can be developed. Identification of remaining oil can be done by mapping areas that have been significant contributors over the past year. From the calculation results, the largest PoA comes from the X-19 well with a PoA value of 10.571 bbl, and the main contributor comes from the N-1600 layer. Meanwhile, X-27 and X-18 have PoA values of 3,276 bbl and 2,722 bbl.

Table 2

Wells with the Largest Oil Contributors based on PoA Calculations

Sumur	PoA, bbl oil	Biggest Sand Contributor
X-19	10,561	N-1600
X-27	3,276	M-1910
X-18	2,722	M-1880

The results of the calculation are then plotted into a bubble map that is superimposed on the base map as shown in Figure 5.

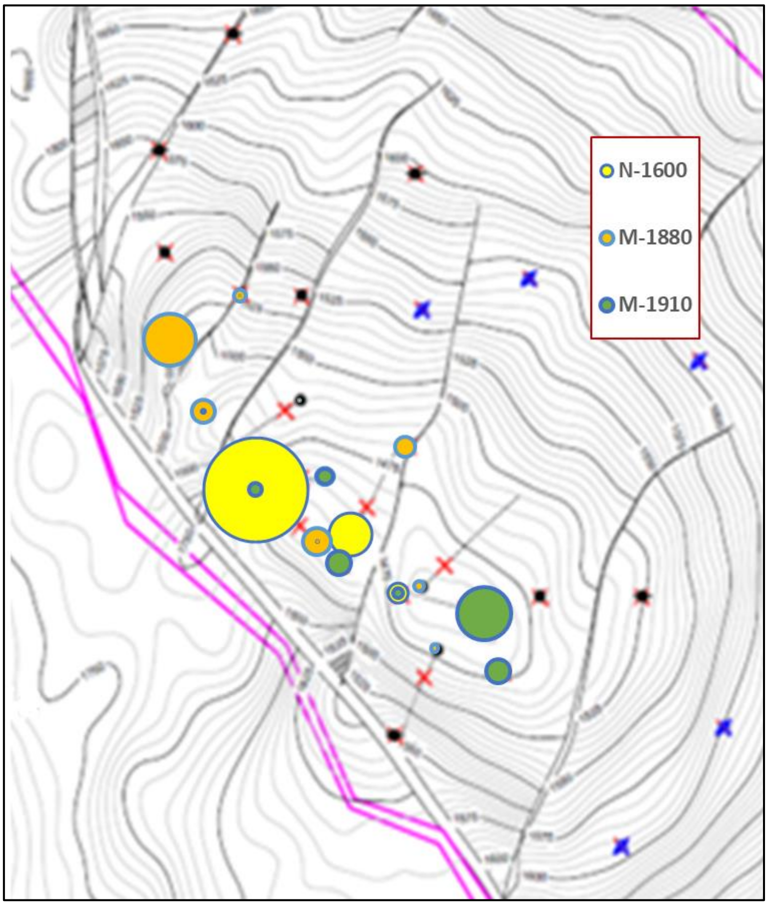

Figure 6 Base Map Overlay with Bubble Map

On the base map, it can be seen that throughout the past year, the N-1600 layer has been produced quite well so the cumulative oil produced is quite large, so there is still the potential for bypass oil in the surrounding area that is a yellow bubble (central area). As for the M-1880 and M-1910 layers, they developed in each area, where M-1880 sand contributed enough to the northern and central areas (the area around the orange bubble and M-1910 contributed to the southern area (green bubble).

Conclusion

Based on the results of the above analysis, the researcher concluded that Field "X" has a character produced in a hi-watercut manner, where the Chan Plot diagram shows an indication of normal displacement even though the WOR graph has increased quite a bit in the last two years. In addition, Field "X" also has a fairly stable reservoir pressure based on the RFT results, even though the VRR is valued at more than 1. In terms of injection, the typical injection in the injector well is quite normal as reflected in the Hallplot in the X-15 well. The identification of residual oil is quite reflected in certain areas, where the N-1600, M-1880, and M-1910 layers have a fairly high PoA value in the past year. Overall, Field 'X' still has the potential to be developed.

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