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Using Nahr Umr Aquifer as an Additional Source of Injection Water for the X Oilfield

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Abstract

Water injection is the main strategy to increase oil production and support reservoirs pressure in the X oilfield and almost any other oilfield. The available source for the water injection in X field is the Qarmat Ali river which is located 20km to the north. However, the amount of water from that river is insufficient. Therefore, alternative water sources were investigated and among them, it was identified the Nahr Umr aquifer as the most promising. Nahr Umr is a regional giant aquifer; it is composed of high porous high permeable sandstone at an average depth of 2900m. The analysis of Nahr Umr aquifer water showed that it has a very high salinity (240000 ppm) almost composed of sodium and calcium chlorides, free of Oxygen, no solid particles were observed, no quantities of dissolved H_2S, and very low occurrence of bacteria owing to the high water salinity and high temperature of the aquifer. On other hand, aquifer water contains a significant amount of dissolved CO_2 (5.5%) which can cause corrosion. Therefore, there is a need to treat that water to decrease CO_2 or use high corrosion-resistant materials in the pipelines and water source wells.

Keywords: Nahr Umr aquifer, Water Injection.

استخدام خزان نهر عمر كمصدر إضافي لمياه الحقن في حقل X النفطي

الخلاصة:

يعتبر حقن المياه الإستراتيجية الرئيسية لزيادة إنتاج النفط ودعم ضغط المكامن في حقل الزبير النفطي وأي حقل نفطي آخر. المصدر المتاح لحقن المياه في حقل X هو نهر كرمة علي والذي يبعد حوالي 20 كم بأتجاه الشمال. ومع ذلك، فإن كمية المياه من هذا النهر غير كافية. لذلك، تم البحث عن ودراسة مصادر مياه بديلة ومن بينها تم تحديد طبقة المياه الجوفية في تكوين نهر عمر على أنها أكثر المياه الواعدة. نهر عمر هو خزان جوفي إقليمي عملاق. يتكون من صخور رملية عالية النفاذية. أظهر تحليل المياه الجوفية في خزان نهر عمر أنها تحتوي على ملوحة عالية جدًا (240000 جزء في المليون) تتكون تقريبًا من كلوريد الصوديوم والكالسيوم، وخالية من

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الأكسجين، ولم يلاحظ وجود جزيئات صلبة، ولا توجد كميات من غاز كبريتيد الهيدروجين H_2S المذابة، وتواجد قليل جدا من البكتيريا بسبب ارتفاع ملوحة المياه وارتفاع درجة حرارة طبقة المياه الجوفية. من ناحية أخرى، تحتوي المياه الجوفية لخزان نهر عمر على تركيز عالي من ثاني أكسيد الكربون المذاب (5.5٪) والتي يمكن أن تسبب التآكل للأنابيب والمنشآت السطحية.
لذلك، هناك حاجة إلى معالجة تلك المياه لتقليل ثاني أكسيد الكربون أو استخدام مواد عالية المقاومة للتآكل في خطوط الأنابيب والابار المنتجة للماء من خزان نهر عمر.

1. Introduction

1.1 Preface

Water injection, also known as waterflood, is a form of secondary enhanced oil recovery (EOR) production process to increase oil production and support reservoirs pressure in almost any oilfield, it involves drilling injection wells into a reservoir and introducing water into that reservoir to encourage oil production [1]. While the injected water helps to increase depleted pressure within the reservoir, it also helps to move the oil in place [2].

The Nahr Umr Formation is laterally continuous across the region. Well, logs from surrounding oil fields show that the Nahr Umr reservoir is present over many hundreds of square kilometers around X oilfield [3].

The available source for the injection water in X oilfield is the Qarmat Ali river. However, the amount of water from that river is insufficient [4]. Therefore, alternative water sources were investigated and among them, it was identified the Nahr Umr aquifer as the most promising.

1.2 Aims of Study

- Review the geological and petrophysical properties of Nahr Umr Formation in X oilfield.
- Demonstrate the capability of the Nahr Umr aquifer as a secondary and temporary water source for injection.

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1.3 Study Area

The X oilfield was discovered in the 1940s by the Basrah Petroleum Company (BPC), located West of Basrah city. The field is a semi-symmetrical NNW-SSE longitudinal anticline [5]. The main producing reservoirs are Zubair and Mishrif, the X oilfield will require more water for injection in the next years to sustain reservoir pressure and increase oil production [6], [7].

1.4 Geological setting

Nahr Umr Formation was defined by Glynn Jones (1948) based on its type section in South Iraq in well NU-2 at Nahr Umr oilfield (North of Basrah province). According to Bellen et al. (1959), Nahr Umr Formation in southern Iraq is comprised of black shales interbedded with medium-to fine-grained sandstone with lignite, amber, and pyrite, the proportion of sand in the formation increases towards the Salman Zone [8]. The Carbonate unit occurs locally in the upper part of this formation in southeastern Iraq. Nahr Umr Formation overlies the unconformable Shuaiba Formation (Aptian) (Figure 1); the upper contact surface is conformable and gradational with the Mauddud Formation [9]. Nahr Umr Formation extends to the south towards Kuwait, which is also called Nahr Umr and represents part of the Burgan sub-group [10].

Nahr Umr Formation is an alluvial to lower coastal plain to deltaic deposit with shallow-marine and aeolian influences. In southern Iraq, it is comprised of black shales interbedded with medium-to fine-grained sandstone with lignite, amber, and pyrite. Carbonate unit occurs locally in the upper part of this formation in southeastern Iraq [11].

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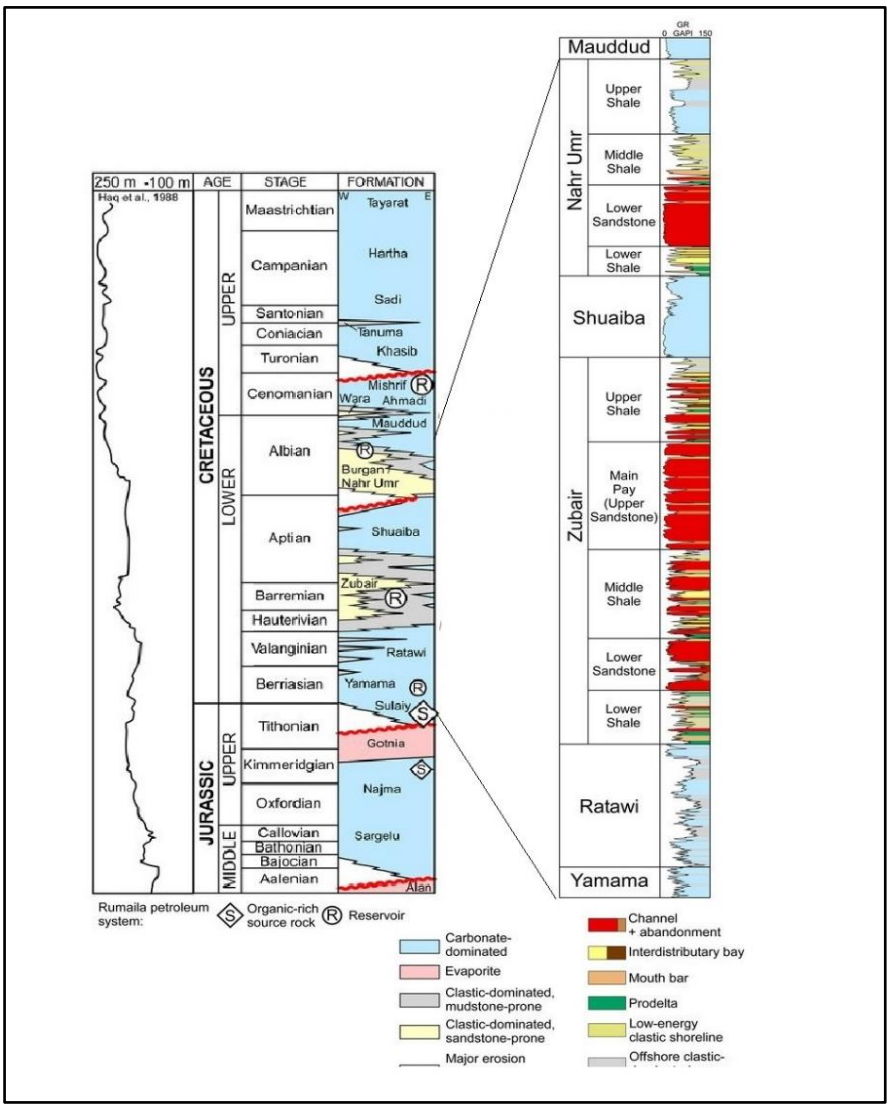

Fig. (1): Stratigraphic section for the Cretaceous period in southern Iraq [12]

2. Methodology

The methodology to achieve the goals of the study included selecting six wells of X oilfield (A, B, C, D, E, F) and collecting appropriate data that include drilling reports, open hole well logs, well tests, water production, and core data, then perform analysis to determine porosity, water saturation and correlate between that wells. Next, collecting available water laboratory analysis results and compatibility tests with Mishrif and Zubair reservoirs in addition to water production data to introduce validity of Nahr Umr water as source water for injection.

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3. Results and discussions

3.1 Petrophysical properties of Nahr Umr Formation

In the study area, it was found that the upper part of the Nahr Umr Formation is oil-bearing in the southern part of the field, with good porosity. In the northern part of the field the lower part of Nahr Umr Formation comprises a thick highly porous sandy interval, with a good water-bearing.

Figure (2) shows the location of six Nahr Umr water source wells in X oilfield in both flanks of the structure (East and West) and in Figures (3) and (4) a correlation between that wells using open hole logs and perforation intervals, from the logs it can be concluded that the lower section of Nahr Umr Formation is composed of water-bearing clean Sandstone (Low gamma-ray and low resistivity) and high porosity (high neutron log reading and low density).

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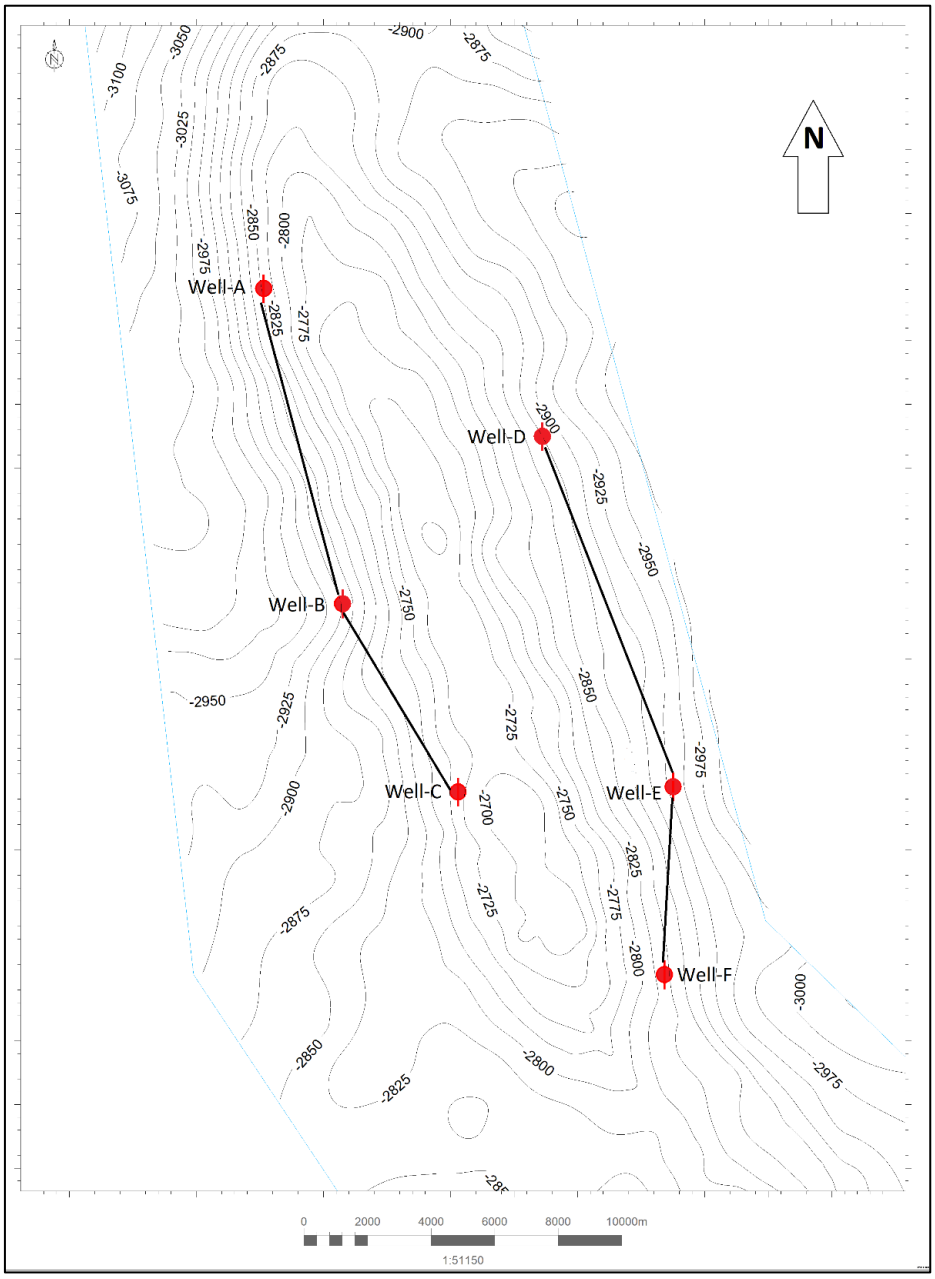

Fig. (2): Map showing correlation line between 6 water producer wells in the X oil Field (contour lines represent the top of Nahr Umr Formation)

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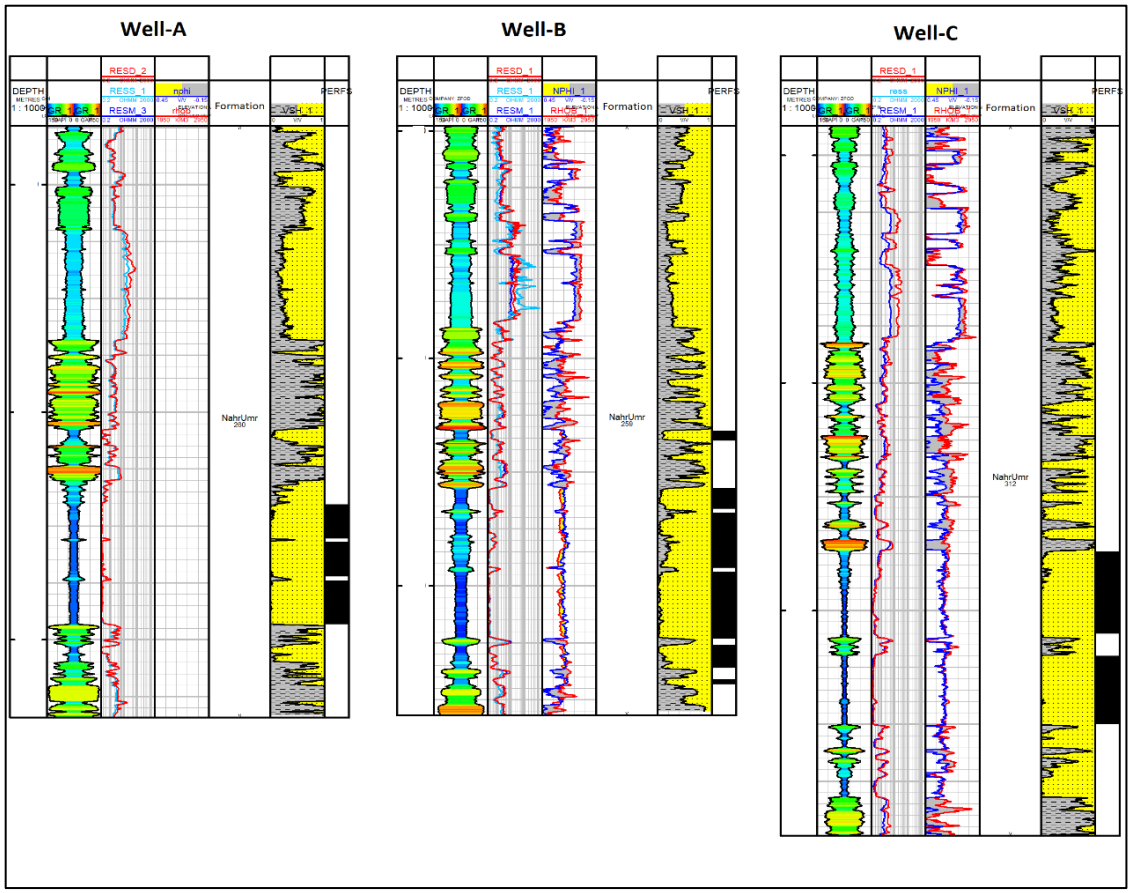

Fig. (3): Open hole logs for wells A, B, and C (West flank of X oilfield)

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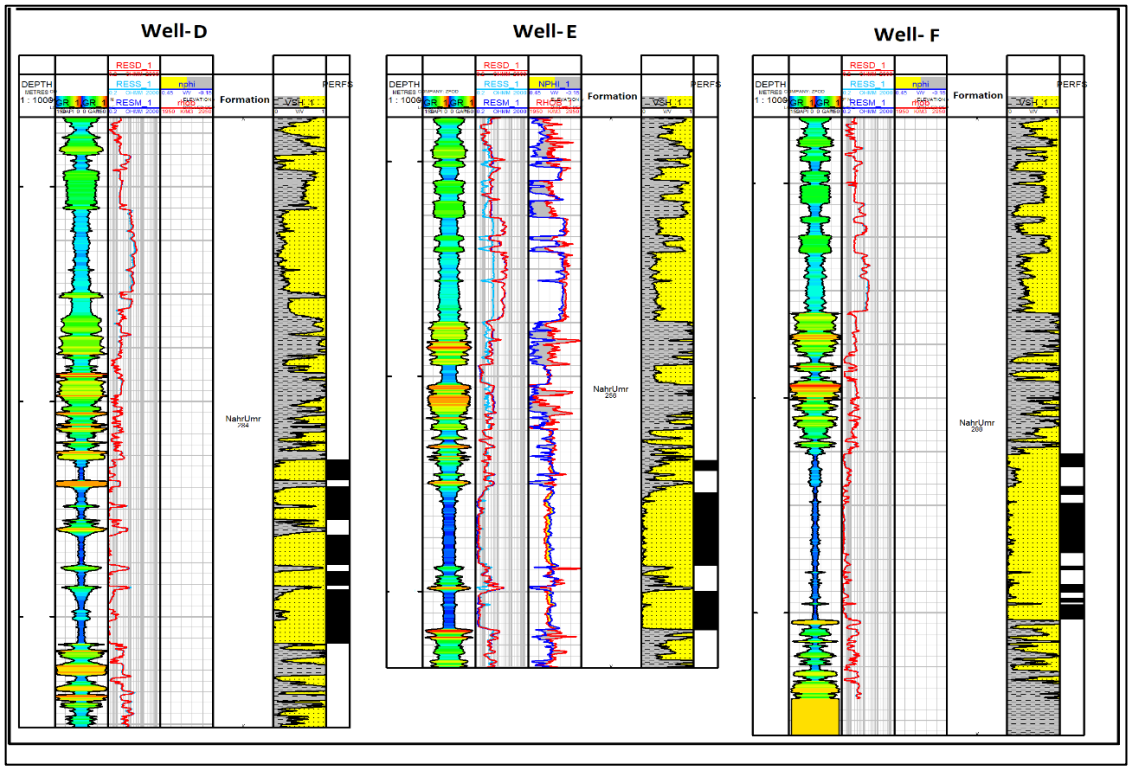

Fig. (4): Open hole logs for wells D, E, and F (East flank of X oilfield)

3.2 Nahr Umr water quality

Laboratory tests on Nahr Umr water showed the following specifications:

- Very high salinity (240000 ppm).
- High Chloride concentration (145000 ppm).
- Absence of Hydrogen Sulfide (H_2S).
- Absence of Oxygen. Therefore, it can be used for injection without adding Oxygen scavengers if the injection system is closed and have no contact with air.
- High concentration of dissolved CO_2.
- High amount of total suspended solids (TSS) about 200 mg/l.
- pH value is 5.9
- Particle size is 73 mm.

The high Salinity and temperatures of the Nahr Umr water will are not limit the presence and growth of corrosive bacteria (Microbial induced bacteria) and the oil

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break-down bacteria (Sulphate-Reducing Bacteria SRB), where these types of bacteria can't live salinity above 140000 ppm, and the high salinity reduces the solubility of Oxygen with water, which causes corrosion to the pipes, on the other hand, the presence of a high proportion of Carbon Dioxide (CO_2) will have a negative impact in pipes corrosion and causes a reduction of pH value, making the water acid.

Nahr Umr water is causative for corrosion for being acid and has a proportion of CO_2 gas, which requires the use of special materials for casing, pipes, and valves.

3.3 Nahr Umr Well design

There are two well design options for using Nahr Umr as a water source well:

A- Dump flood design

Dump flood design based on extracting water from Nahr Umr Formation using an electric submersible pump (ESP) installed inside the well where water will flow inside the tubing to the surface, then inject that water through the annulus into Mishrif reservoir in the same well (Figure 5), this design is considered a cheaper option as there is no need to drill new source water well. However, this design does not indicate the amount of produced and injected water and limits the produced water treatment.

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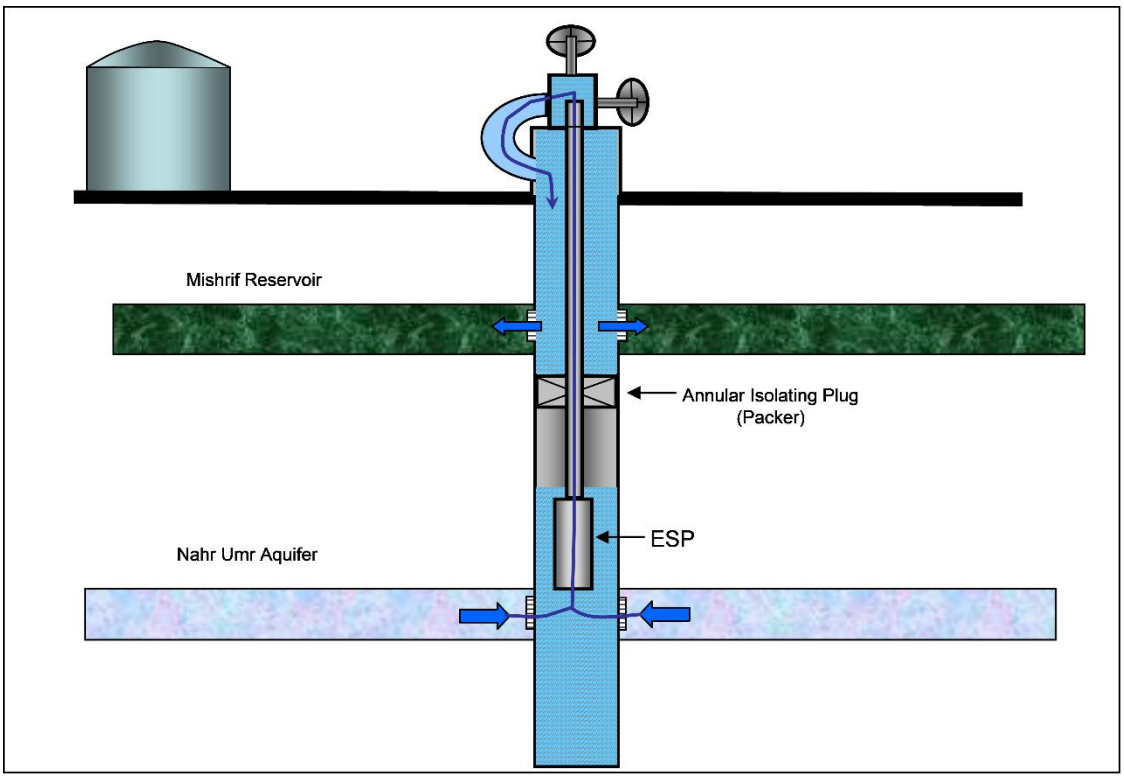

Fig. (5): Diagram showing the dump flood water injection system

B- Conventional water injection system

This system depends on drilling dedicated new Nahr Umr source water wells, in these wells the water is pumped to the surface from the water source well using an electric submersible pump (ESP), then re-inject that water using a surface pressure booster pump. The water can be filtered, de-gassed, and treated with a biocide (to kill bacteria), before being re-injected (Figure 6). Water is being sourced, in this example, from the deeper Nahr Umr aquifer.

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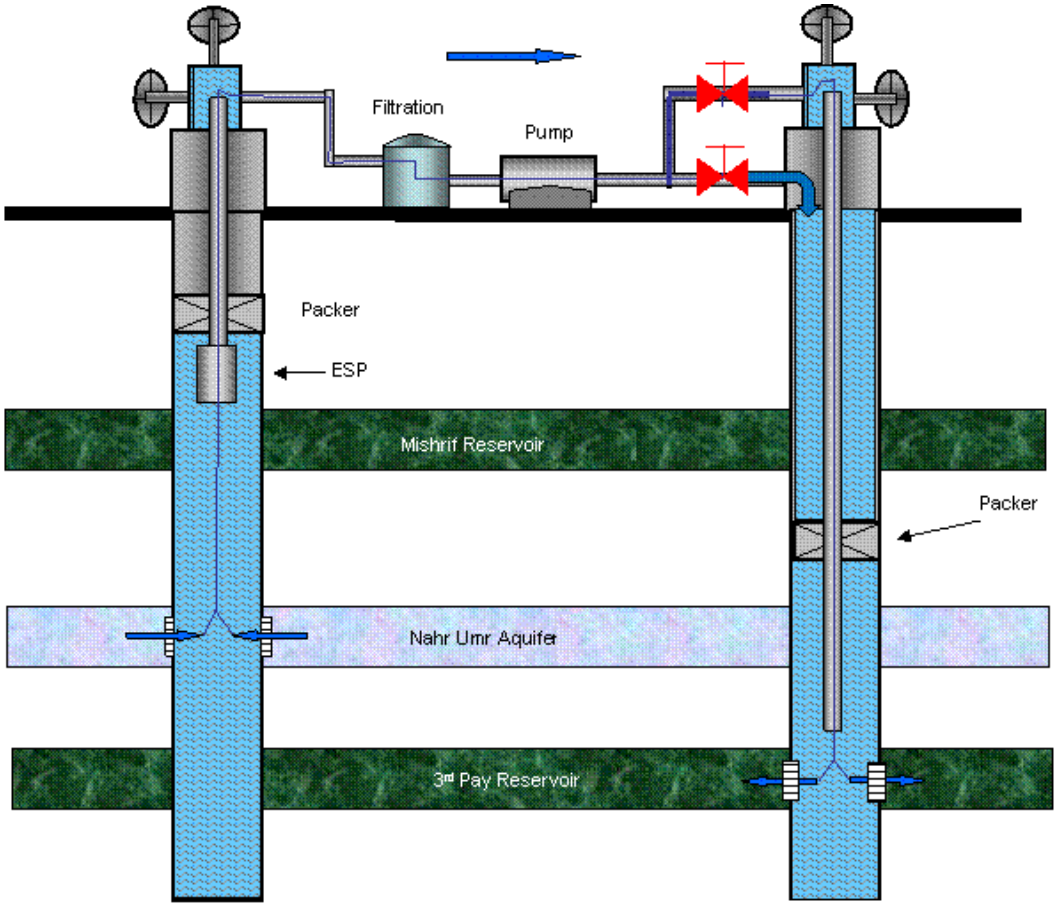

Fig (6): Diagram showing the water injection system

3.4 Compatibility between reservoirs water and Nahr Umr water

Waters are considered compatible with reservoir water if they can be mixed without producing chemical reactions among the dissolved solids in the waters and precipitating insoluble compounds. The precipitated insoluble compounds are undesirable because they can reduce the permeability of a porous petroleum-productive rock formation, plug input wells in water-flood systems, and cause scale formation in water pumps and lines [13].

A- Compatibility between Zubair and Nahr Umr water

All the mixtures under reservoir conditions are undersaturated with respect to Calcium Carbonate (Aragonite and Calcite mineralogical forms) and Calcium, Strontium Sulphate (Anhydrite and Celestite). It is not expected insoluble salts depositions (Figure 7).

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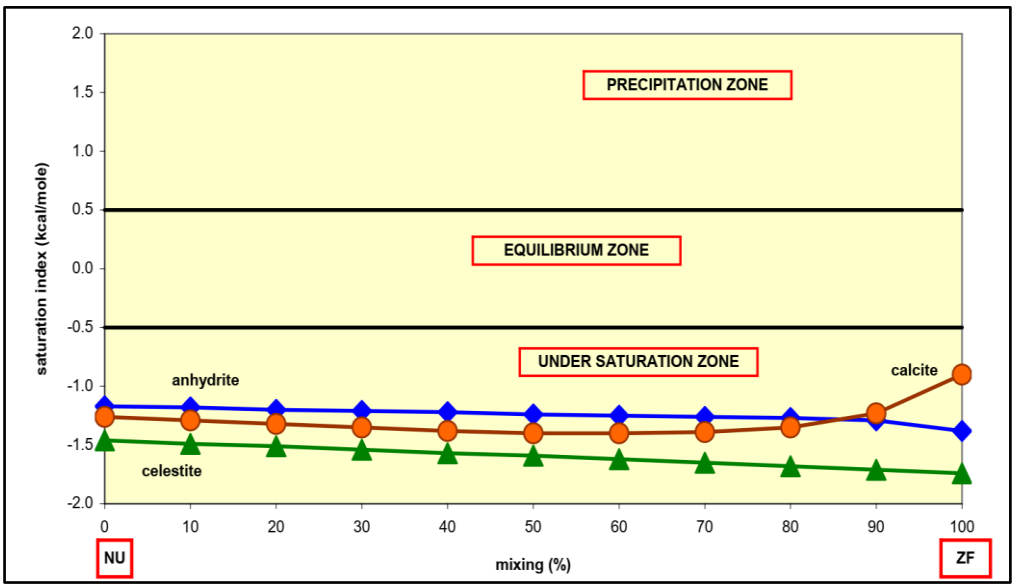

Fig. (7): Nahr Umr Water Compatibility with Zubair Water [14]

B- **Compatibility between Mishrif and Nahr Umr water**

The mathematical simulation at reservoir conditions shows that the Zubair water (ZW) and Mishrif water (MW) are undersaturated with respect to Calcium and Strontium Sulphate (Anhydrite and Celestite) and Calcium Carbonate (Aragonite and Calcite mineralogical forms) [14] as illustrated in Figure (8).

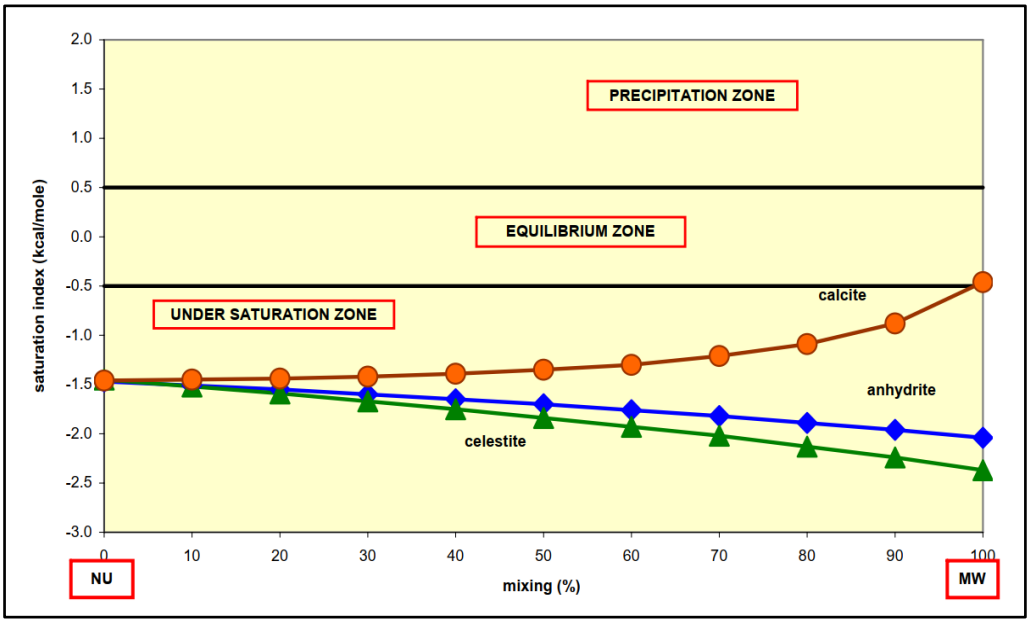

Fig. (8): Nahr Umr Water Compatibility with Mishrif Water [14]

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4. Conclusions

- The Nahr Umr aquifer is estimated to be a giant aquifer that will sustain the production of a substantial amount of water without a significant pressure drop.
- Nahr Umr aquifer is a highly porous high permeable sandstone with a productivity of up to 400 bwpd/psi and should be suitable to provide 25,000-30,000 bwpd per well.
- The Nahr Umr water is free of H_2S but has a low pH which may be due to the presence of CO_2
- Nahr Umr water is currently contributing to about 1/3 of total injection water in X oilfield.
- At reservoir conditions Nahr Umr injection water and Zubair Formation water are compatible for all the percentages of mixing and it is not expected insoluble salts depositions.
- Nahr Umr water quality is acceptable for water injection (<10 mg/l suspended solids).
- Recommend the Nahr Umr aquifer as a temporary source of additional water, to be used to augment the water supply from the Qarmat Ali river, until sufficient quantities of alternative water source are available.

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