Water Management Challenges In Greater Burgan Field

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Abstract

As oil fields mature, producing more oil out of maturing reservoirs entails more water production. It is essential to have a successful water management process to be introduce, one that can handle substantial volumes of water produced in order to sustain crude oil production.
At the early stage of the Greater Burgan Field water management was not a major concern. Most of its crude oil was dry and easy production with little water from Burgan & Wara reservoirs in Greater Burgan Field. With maturing of the field, South & East Kuwait Asset has started experiencing an increase in water production from its maturing reservoirs. Also starting water flooding in Wara reservoir to increase oil recovery increased water cut with oil production as expected. These changes made the production facilities to become constrained that cannot fully handle produced water volume and result in production deferral.

To mitigate the high water cut challenges, South East Kuwait set up a multidisciplinary team to review and come up with actions to tackle the produced water handling challenge.
The team looked at an operational initiative to maintain the long-term disposal option of disposing produced water into Shuaiba formation. Shuaiba formation is below Burgan reservoir. During drilling the drilling team encountered heavy fluid losses in Shuaiba. This experience led the study team to support the option of disposing effluent water into fractured Shuaiba carbonate.

Shuaiba formation is classify as carbonate formation, full of vugs and fractures resulted from dissolution due to ancient underground water movement, the dissolution led to collapse and creation of large vugs and fractures around the collapsed area. The collapsed area and fractures are the main mechanism for storage of effluent water and increasing disposal capacity for the production facility. The plan is to drill Horizontal disposal wells targeting the Karst to intercept those vugs and fractures. The team saw a promising option to drill in Shuaiba, to increase the chance of loss fluid circulation and enhance facility capacity.

After drilling few wells and encountering total loss in the horizontal fractured section, along the edge of the karst, and performing injectivity disposing test, the wells showed ability to take up high water rates more than (50,000 BWPD). Based on the success of these disposal wells, Production operations bottlenecks are resolved in disposal well capacity and increasing it to more than (500,000 BWPD). Disposing in Shuaiba, formation will not require any treatment facilities and is an environmentally friendly long-term option

Introduction

A multidisciplinary team consisting of geoscientists and Reservoir Engineers and Production Engineers was form with the following objectives:

- To develop a robust water disposal plan for ~500,000 BWPD from the Greater Burgan Field that the current facilities cannot handle due to water reaching limits in many facilities

- Review existing wells with low or no production potential and establish an opportunity to be convert them as a disposal well. This will save time and reduce cost and enhance some facilities capacities

- The above initiatives will support to handle high water cut and maintain production target of Greater Burgan Field and avoid production cutback

As the oil field matures, producing more oil out of maturing reservoirs entails more water production. It is essential to have a robust water management process in place, one that can handle substantial volumes of produced water in order to sustain crude oil production without any production deferment. Water management was not a major concern for Kuwait Oil Company (KOC) and especially for Greater Burgan Field since inception. Most of its crude oil coming from Burgan & Wara reservoirs in Greater Burgan Field, which were produced mostly dry, easy crude with little or no water production. With maturing of the field, SEK asset is experiencing an increase in water production from its maturing reservoirs, and due to water injected into Wara reservoir to maintain pressure above bubble point. This has severely affected the production facilities as water production reached upper limits that Gathering Centers (GCs) can handle.
The team forecast clearly that producer wells with very high water cut are affecting oil production facilities, as water cut ratio is increasing every year, Effluent Water Disposal plants was proposed as a solution to get rid of excess water and sustain production. However, such projects are costly and have long cycle of completion period.
To mitigate the high water cut challenges, SEK set up a multidisciplinary team to review and come up with action lists to handle the increasing Water-cut challenge.

The team came up with an initiative to build a Centralized Hub, which will act as a flexible and fast long-term solution, which directly reflected positively in Oil Production eliminating water cut concerns. The Disposal Hub is a new initiative in Kuwait Oil Company.

Project Impact on the Company

Greater Burgan Field is maturing and as a result, the water cut is increasing in the Gathering Centers. Consequently, disposal facilities have no margin available to handle more effluent water from the Gathering Centers. In addition, the limited capacity in facilities will require oil production cut back. Expansion of said disposal facilities is undergoing through a project, which will be complete by 2026.

However, the impact of high water production will be very severe on the production facilities. With more water production, the liquid load will increase in the flow lines and thereby reduce the amount of oil production at the Gathering centers, especially affect the oil production from new wells. Also as per recent guidelines from the Organization of Petroleum Exporting Countries (OPEC) to cut back production, KOC pledged to reduce production by almost 500,000 BOPD. The production cut also reduced the water injection volumes into Wara reservoir, which resulted in excess of 300,000 Barrel of Water per Day that the GCs cannot handle and need to be disposed in safe and environmentally friendly manner. If no plan implemented to dispose this excessive water, then oil wells need to be close, which will cause approx. loss of 250,000 Barrel of oil per Day.

A Centralized Effluent Disposal Water Hub was propose by the team in order to mitigate the subject bottleneck by installing additional centralized pumps, tanks and drilling new disposal plus re-arrangement of existing disposal wells flow lines connections to attain maximum capacity utilization of the disposal wells. The Centralized hub will generate an additional effluent water handling & disposal capacity approximately 350 MBWPD and will enable us to meet instantly effluent water handling capacity without excess water cut limitations.

What are some of the milestones achieved/set to be upon completion?

Initially, all the planned disposal wells drilled and connected into the operational Centralized hub, with four buffering tanks along with 3 booster and HPS pumps withdrawing around 120 MBWPD from EK I GCs. Currently the HUB is fully operational with full capacity of four buffering tanks along with 8 booster and HPS pumps it will withdraw around 250 MBWPD from EK I GCs.

Key production Challenges

Greater Burgan Field the world's largest clastic reservoir encompasses three producing fields, which are Burgan, Ahmadi and Magwa, with clear structural features distinguishing these areas. The major production comes from Burgan Third Sand and Fourth Sand and Wara Upper, Wara Middle and Wara Lowers reservoirs. Wara reservoir is the largest "water injection pressure maintenance project" in the world with over 700,000 BWPD of water injection. Below Burgan lies a non-hydrocarbon bearing carbonate formation called Shuaiba. Since discovery of the field, production was initiate from the Burgan Fourth Sand and third Sand in early 1940's. For decades, the wells in the field produced dry oil. However, as the field becomes more mature the water production continues to increase. Water production has steadily increased from negligible amounts to over 250,000 BWPD, this effluent water was historically been disposed of with evaporation pits. Nevertheless, several issues arise, as more water is disposed into the pits, the presence of oil layer on top of the water prevented effective evaporation, moreover during cooler months the rate of evaporation decreases significantly, and there was always risk of water leaking into the ground. In addition, the increasingly produced water make the evaporation pits not a long-term solution to handle the water. One of the essential challenges of the development of Greater Burgan Field is the proper management of produced water and disposing of it in a professional manner and environmentally friendly way. Greater Burgan Field always played major role in meeting production targets. With maturation of Greater Burgan field, its requirements and production expanded, especially when it came to boosting the number of drilling rigs, workover-rigs and installation of electrical submersible pumps to increase production capacity. With a target of 1.5 MMOPD set for greater Burgan Field, production operations are becoming increasingly challenging with increasing water above the GCs capacities.

To summarize the challenges

1. Greater Burgan Field has several Gathering Centers, out of which some of them are at the maximum limits with handling produced water based on production trends **Table-1 and Fig-1**
2. 40 wells with 15,000 BOPD were shut in due to high water cut
3. Low value wells were shut in, but without unlocking water handling limits
4. Additional high production wells were subject to shut in with time
5. These limits also impact value of high water-cut workovers and new wells
6. Gathering Center A, is at its oil export limit, and many new wells were drilled and connected but the production gain is not reflected in the system
7. Upcoming Water knockouts projects are delayed
8. Due to Water Handling capacity limitation, Greater Burgan Field is not able to fully align with Wara reservoir injection allowable well by well basis
9. Very high volumes of produced water needs a place to be dispose of, otherwise production will be constrained and will lead to production loss as estimated above of ~250,000 BOPD
10. 1.6 Million BOWPD being produced, 700,000 BWPD was injected into Wara, Burgan for pressure maintenance and 850,000 BWPD needed to be disposed

Solution

In response to the need for a long term water disposal solution, which has to be environmentally safe option and operationally acceptable, Multidisciplinary teams conducted thorough exercise and came up with 2 solutions for the subsurface disposal of effluent water.

A- Converting Existing Wells with no potential (Cost Saving initiative)

Based on reservoir analysis the team recommended to inject produced water in Burgan Fourth Sand (previously oil bearing, now after decades of production the Fourth sand was water out and completely swept) in several idle wells with no oil potential and will not serve as water flood injectors. This Sand is below the main producer, which is Burgan Third sand. The Fourth Sand has a very high permeability during review core analysis such as pore throat measurement was basis for the team recommendation. The team identified three wells with no potential and proposed to recomplete the wells in thick Fourth Sand.

This is important initiative to help support and manage increasing water in one of the Effluent Water Handling Facility. The results were very promising, and locations of converted low potential wells into disposal.

However, team predicts because of quality of produced water that is disposed into the Fourth Sand. The formation will eventually be plug back within a year, and will require acid stimulation cleaning job, so to achieve consistent long term disposing process water treatment is essential, however the team also see this option as a short-term mitigation plan to a very challenging water handling situation using idle wells with no potential.

B- Shuaiba Disposal

In parallel, the multidisciplinary team looked at another operational innovative initiative to maintain long-term disposal option, and came with proposal of building an in house CENTRALIZED DISPOSAL HUB and connecting it with additional drilled Shuaiba disposal wells and existing wells, and disposing

produced water into Shuaiba formation. This formation is below Burgan reservoir and during drilling deeper formations like Marrat and Minagish carbonates; the drilling encountered heavy fluid losses in Shuaiba, this experience lead the study team to support option of disposing effluent water into fractured Shuaiba carbonate.
The Shuaiba formation is classified carbonate formation, **Fig-2**: full of vugs and fractures resulted from dissolution due to ancient underground water movement. The dissolution lead to collapse and creation of large vugs and fractures around collapsed area. The collapsed area and fractures are the main mechanism for storage of effluent water and increasing disposal capacity for the production facility. The plan is to drill disposal wells targeting the Karst to intercept those vugs and fractures. Based on analysis from drilling of +100 wells penetrated Shuaiba and 3D seismic loss circulation is confirm in 90% of the wells in Shuaiba. The team saw a promising option to drill in Shuaiba, to increase chance of loss fluid circulation and enhance facility capacity.

In what way will the Disposal Hub add Value?

One of the Disposal Hub major standing out feature is the dynamic interchangeability in shifting withdrawing origins and disposal destinations. For example, in the past if one of the gathering centers is having a scheduled maintenance shutdown, the other gathering centers cannot dispose water in the well of the shutdown center. Now with the hub, you can easily withdraw more water from the gathering centers and dispose in any well around

In addition, if one of the HPS pumps of a specific GC tripped for any reason, crude oil production had to be cut back to adapt with the disposal limitations. However, with the Disposal Hub you can easily maintain disposing capacity without any crude oil cutbacks even if an HPS pump tripped and that is because of the four buffering tanks available.

Workflow

Guided by the 3D seismic, nine horizontal wells were plan to hit fracture near a collapse area. The wells were placed near the high demand production facilities, within 3-4 KM distance to ensure high rate of water is disposed, **Fig-3** is the satellite image of GC C and the its distance to the Shuaiba disposal proposed location. Fig-8: 3D image of Shuaiba attribute shows both karst and channel like fractures and the three wells planned along these karst features to be drilled and connect to GC A. Well#4 was drilled encountered formation loss, as soon as the bit came close to the collapse area. Well planned to drill 1500’ of total loss to increase probability of encountering fractures along the edge of the karst. However, due to high risk of being stuck, the team decided to TD the well after drilling 780’ with total losses. After acidizing and stimulating the formation, the well showed the ability to take high water rate @ more than (55,000 BWPD). **Fig-4** is showing the Shuaiba attribute on 3D seismic. The data integrated with other fields in joint operations, shows Shuaiba formation in Greater Burgan Field is a promising long-term disposal option even with little uncertainty of fractures connection in Shuaiba. The team proceeded and drilled all 4 remaining wells, with varying results and loss intervals, details given as table in **Table-2**. All the wells have
High injectivity (>50 MBWPD).
Based on the success of this test Production operations is requesting support to drill disposal wells to enhance water-handling capacity of the GC’s.

Disposal Hub Start Up

Connecting the wells drilled into the Disposal Hub enabled the facility to retain its production and maximize disposal capacity to the production facilities. The plan is to drill and connect remaining wells and already now, other areas in Kuwait oil Company are considering the disposal hub as a best practice to be adopted for long-term water handling challenges.

Building in house a CENTRALIZED DISPOSAL HUB, **Fig-5** & **Fig-6** and connecting it with 4 new disposal wells, 5 more are planned to be drilled in this project, so far the team managed to drill & complete 4 successful wells. All wells placed with help of 3-D seismic to maximize chance of intersecting fractures. As on date, 4 wells were drilled successfully intersecting fractures in Shuaiba and had complete circulation loss (shows connectivity to vugs) and further supported by injectivity test. With these disposal wells, water-handling capacity increases more than 200,000 BWPD to the production facilities. Another achievement to the team is conclusion of Shuaiba capacity to take untreated water quality, which is less of an issue, compared with the Burgan fourth Sand. Disposing in Shuaiba, formation will not require any treatment facilities and is an environmentally friendly long-term option and building in-house the Shuaiba Disposal Hub which to mitigate the bottleneck and attain maximum capacity utilization of disposal wells and generate additional disposal capacity in the facilities and avoid production cutback. All of this was accomplish during the COVID 19 Pandemic, which shows high commitment of team members with health regulations and passion of completing the work on time.

Conclusion & Way forward

1. Produced water disposal in the subsurface Shuaiba formation shows it is the most environmentally friendly option.
2. Complete the remaining 5 disposal wells as planned to increase the water disposal capacity more than 250,000 BWPD.
3. Evaporation pits are no longer able to handle large amounts of water coming from the GC's, more over the pits should be lined to ensure water does not leak into the ground and pollute the ground water table.
4. Shuaiba Disposal Centralized Hub is a new initiative in Kuwait Oil Company, which proved to be successful and cost effective, the experience and knowledge obtained with the Hub reliability will be considered for implementation in other locations in Kuwait oil Company,
5. Currently wells are connected to the Hub and successfully disposing more than 250,000 BWPD associated with the field hydrocarbon Production.

Reference

- Various internal company reports and documentations
- Effluent Water Disposal Experience in the Greater Burgan Field of Kuwait, Hamad Al-Ajmi, IPTC 11551
- Water Flood Optimization and its Impact using Intelligent Digital Oil Field (iDOF) Smart Workflow Process, IPTC-17315
- Integrated Water Management Challenges, IPTC-18936-MS
- Evaluation of Long Term Effluent Water Disposal Options in the Greater Burgan Field, SPE 49219

GC	Parameters	Design Capacity for Effluent Water (a) MBWPD	EW Prod. Forecast as per AAP – 20/21 (b) MBWPD	Gap in Effluent Water Handling Capacity (c) MBWPD	Duration – 1 Year Delay (d) Days	Cutback in Oil Prod. Per WC~60% (e) MBOPD	Revenue Loss / Year (60xdxe)* $
GC-A	EW Prod. & Dispatch Capacity	120,000	131,000	11,000	365	8,800	192,700,000
GC-B	EW Prod. & Dispatch Capacity	130,000	166,000	36,000	365	14,400	299,592,000

Table-1 two GC's revenue loss forcasted

Well	Reservoir	Losses intervals	Injectivity Test Result	WHIP
Well#4	**Shuaiba**	**780 feet**	**55,000 BWPD**	**650 PSI**
Well#5	**Shuaiba**	**430 feet**	**49,000 BWPD**	**757 PSI**
Well#6	**Shuaiba**	**800 feet**	**65,000 BWPD**	**790 PSI**
Well#7	**Shuaiba**	**1200 feet**	**70,000 BWPD**	**460 PSI**

Table-2 Injectivity test for disposal wells

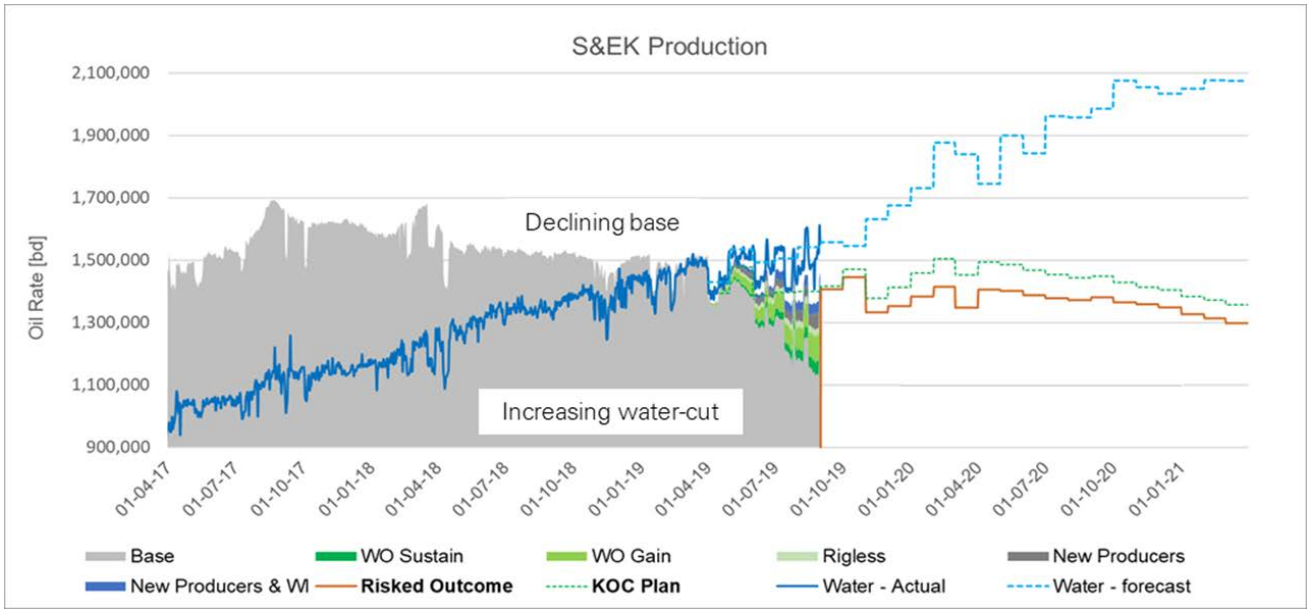

Fig-1 Water Handling Capacity is critical for Greater Burgan oil production

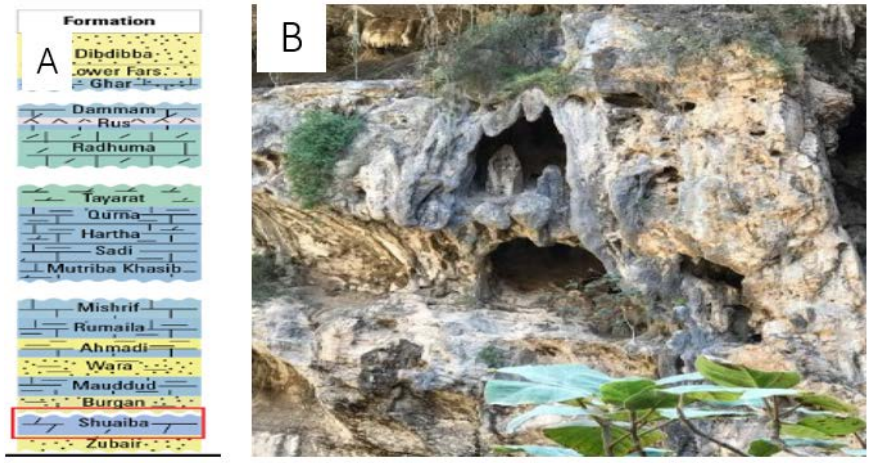

Fig-2: pic A: stands for Kuwait Sequence Stratigraphy, Shuaiba located beneath Burgan Reservoir. Picture B: Tawi Atir Sinkhole and karst features in Salalah Oman, analog to Shuaiba Formation in Kuwait

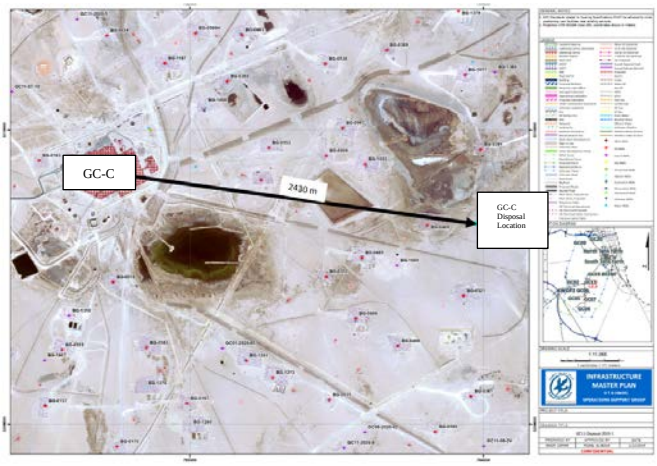

Fig-3 distance from production Gathering Center No C to the Shuaiba disposal proposed target

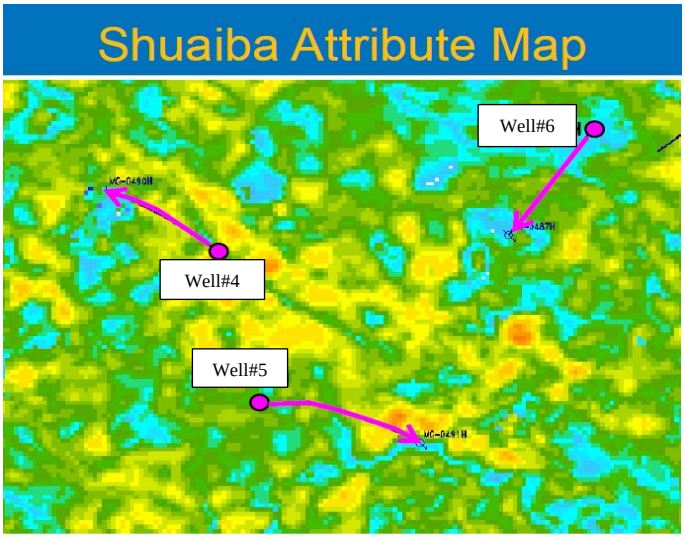

Fig-4 distance from production

Fig-5 Preview for the Centralized Disposal Hub

Fig-6 Disposal Hub Demonstrated Computer System showing all process details