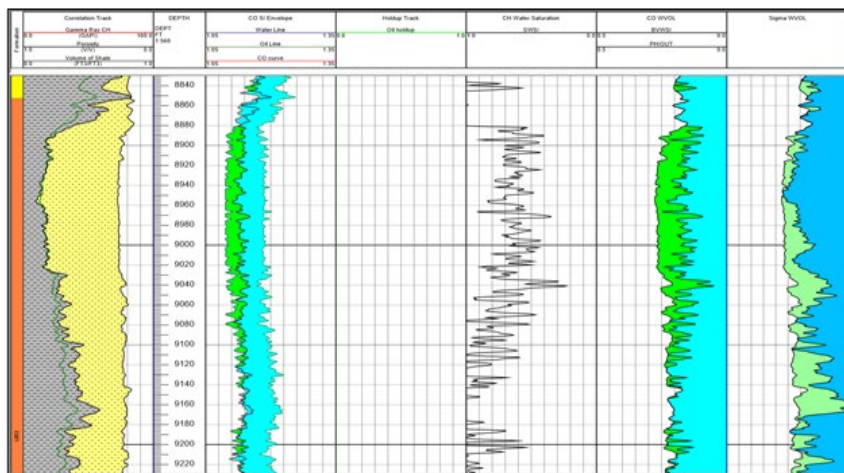


## Raptor<sup>®</sup> Cased-Hole Evaluation System

### Logged C/O and Sigma in First Horizontal Well, Revealed Precise Up-Dip Oil Saturation



The raptor C/O and sigma analysis plot for the interval from 8,830 to 9230 ft (2,691 to 2,813 m).

#### LOCATION

Kuwait

#### WELL TYPE

Horizontal producer

#### FORMATION

Upper Burgan

#### HOLE SIZE AND ANGLE

8-1/2 in., 90°

#### CASING SIZE AND TYPE

7-in., #26, L-80

#### DEPTH

9,230 ft (2,813 m)

#### PRODUCTS/SERVICES

- Wireline services
- Raptor cased-hole evaluation system

### Objectives

- Study quantitatively the oil saturation, monitor the injection effect, and precisely estimate up-dip oil saturation across a mixed salinity formation. The horizontal well suffered from high water cut with 160 STB/D oil. Some perforations were perforated at high up-dip structure with the inclination build up to 91°, creating a water sump zone and increased water cut.

### Our Approach

- In consultation with the customer, Weatherford experts decided to record carbon/oxygen (C/O) and sigma data with a wireline tractor. Sigma has a deeper depth of investigation while a shallow investigation log was needed, such as C/O, which is not affected by the mixed salinity due to the injection from the surface in nearby wells.
- The tools were deployed via a Raptor Cased-Hole Evaluation System, a pulsed neutron wireline-logging device that provides advanced analysis of oil, water, and gas saturation behind casing.
- The sigma log was selected to estimate the formation mixed salinity using a salinity inversion model, while an advanced C/O processing approach using the C/O data from three detectors was used to quantify the oil saturation across all the zones of interest including the high up-dip structures.



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### Our Approach (continued)

- The C/O advanced interpretation showed oil at the top of the main sand formation (Upper Burgan 3, UB3) and the rest of zones were watered out as clearly seen from C/O.
- Across the same section, sigma was affected by the higher depth of investigation and the effect of the high dip-structures. As a result, it was reading high capture units, showing water mainly, while C/O showed good oil saturation of 17.5 % around the well drainage area of the UB3 formation.
- The results of the sigma salinity inversion model were very helpful to accurately estimate the mixed formation salinity profile across the zones of interest with a salinity ranging from 50 to 200 kppm.
- The data revealed that sigma was not good in highly deviated/horizontal wells where oil-water contact is nearby, as the deeper investigation is highly affecting and manipulates the capture cross section. A better method is to log C/O with sigma as C/O has shallower depth of investigation and provides more accurate saturations.
- The oil gain was 490 STB/D from a total of 2,800 STB/D from intervention of the last workover in October 2022. Previously, the oil gain was only 160 STB/D of oil from a total of 4,259,490 STB/D.

### Value to Customer

- The advanced C/O processing approach precisely estimated up-dip oil saturation because of using an advanced characterization technique and the C/O data from three different detectors rather than the two detectors traditionally used by most PNC tools for C/O processing.
- The first detector from the bottom was closer to the source which helped quantify the oil saturation accurately in the well drainage area with an oil gain of 490 STB/D.

