

Career Episode 2:

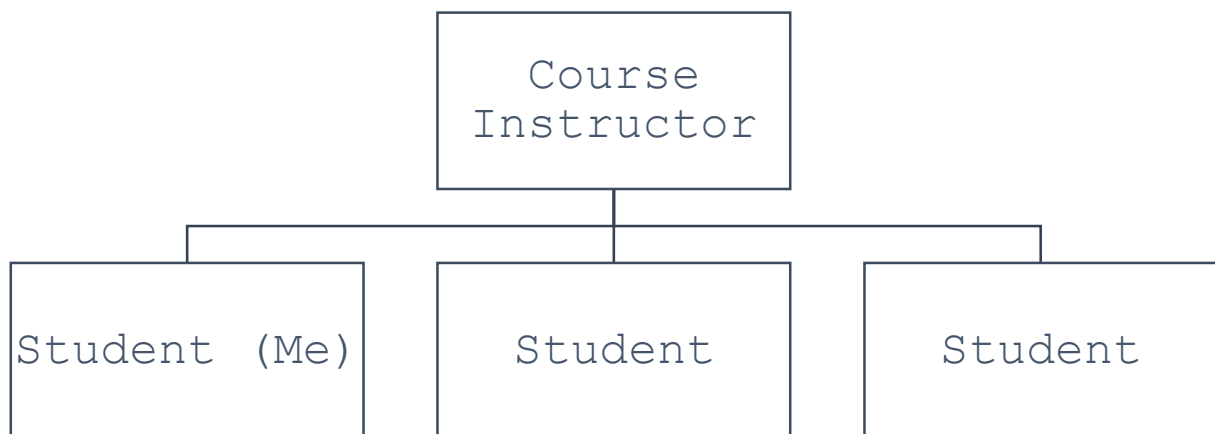
Introduction:

CE 2.1 In this episode, I will describe my involvement in an assessment project I performed as a student during my Bachelor of Engineering (Petroleum) at the ██████ University of Engineering and Technology, ██████. The project involved an Open-Ended Lab module pertaining to the Reservoir Engineering course. The assessment project was conducted in the fall semester of the year ██████.

Background:

CE 2.2 The Open-Ended Lab module was part of the course on Reservoir Engineering during my BE degree at the ██████. The project required a team to collaborate in identifying various reservoir development intricacies with the use of the material balance (MBAL) software. During reservoir development, many essential factors are considered that predict the reservoir behaviour using sophisticated numerical and analytical tools. I as team lead participated in this project by contributing technical and interpretational input with respect to the behavior of reservoirs since my scope of work involved use of Material Balance (MBAL) software. The software ascertains hydrocarbon recovery and plays a vital role in optimizing reservoir performance. Industries focus on mastering material balance analysis and comprehending its profound influence on the formulation of effective reservoir development strategies.

CE 2.3 The project was a collaborative effort undertaken by a team of engineering students under the guidance of the lab instructor. The project granted understanding of the influence of specific reservoir parameters such as porosity, permeability, gas oil ratio (GOR), and formation volume factors on reservoir performance. The objective of the project was to carry out material balance analysis for knowing the driving mechanisms of the reservoir-water influx, compressibility, and fluid expansion-and sensitivity analysis of the critical reservoir parameters including economic evaluation of development strategies. This way, we improved our competence in interpreting reservoir behaviour and developing plans to integrate theoretical concepts with practical applications in petroleum engineering.



Personal Engineering Activity:

CE 2.4 In this assignment, my principal role was that of a technical analyst who would monitor accuracy in computations and assist with the interpretation of behavior in reservoirs using Material Balance (MBAL) software. The project had several stages, which I undertook in preparing data, sensitivity analysis, reservoir management scenarios evaluation, and economic evaluation.

CE 2.5 I initiated the project by compiling all available data provided during the coursework and through open datasets. The data I compiled contained vital information such as porosity, permeability, etc. I verified these datasets with standard values and benchmarks from course materials and to ensure reliability. I first calculated the oil-in-place volume by using the values

available for supply pressure, temperature, and production data. This was a very important step because the results of all the processes depend on the input parameters that are being correct in this case. I calculated the oil-in-place volumes by using the volumetric formula for oil reservoirs:

$$N = 7758 \cdot A \cdot h \cdot \phi \cdot (1 - S_w) / B_o$$

CE 2.6 I had knowledge that geological data needs delineation before reservoir area can be calculated. I performed the delineation and calculated the area of the reservoir. I performed well log interpretations to identify the net pay thickness (h) and obtained porosity and water saturation from the data already provided in the lab assignment. I also consulted open datasets to obtain the oil formation volume factor (B_o). I understood that the accuracy of B_o was necessary to obtain dependable results. To achieve dependable results, I compared my calculations for oil formation volume factor with historical data. I further calculated the total reservoir volume by a simple multiplication of reservoir area with the net pay thickness and multiplied that with porosity to obtain the total pore volume. I then calculated the total hydrocarbon volume by using the formula: *Hydrocarbon Pore Volume* = $PV \cdot (1 - S_w)$.

CE 2.7 I then initiated the main part of the project, the utilization of MBAL software to perform material balance calculations. I focused on factors that would influence the production dynamics. I understood that material balance calculations would enable me to predict the reserves and help me understand the behavior of the reservoir over a span of time. As I performed the calculation on the MBAL software, I observed that the trend analysis exhibited that porosity was increasing with a great degree of variance. I understood that the larger variance indicated disequilibrium within the reservoir rock and implied that the properties were not uniform across the reservoir. I realized that this aspect of porosity would influence the fluid storage and transmission properties of the reservoir. I recorded this porosity trend for further analysis.

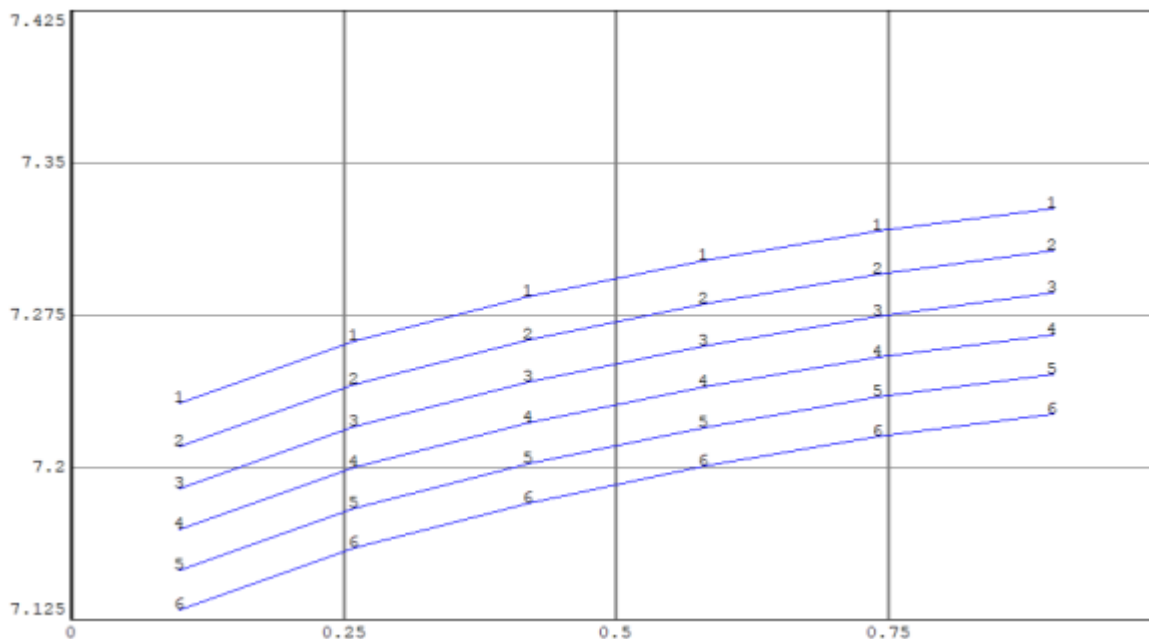


FIGURE 1 ANALYSIS ON POROSITY TREND

CE 2.8 I then plotted a graph to test the oil formation volume factor (FVF) as a function of pressure. I realized that FVF initially was increasing with increasing pressure, but after achieving a pressure of ~1300 psig, it had started decreasing. I had knowledge of the bubble point pressure being the highest pressure possible for the coexistence of gas bubbles with oil. I identified the decrease in FVF was due to achieving the bubble point pressure after which the gaseous hydrocarbons separated from the oil phase. I understood the importance of this phenomenon in determining recovery mechanisms and predicting production. Achieving bubble point pressure before hydrocarbon recovery could result in loss of valuable fractions in feedstock. My understanding of this trend helped me in tendering modifications in pressure management

within the reservoir to reduce liberation of gas and maintain liquid-phase hydrocarbons for longer periods. I also observed that gas formation volume factor decreased with a decrease in pressure and attributed it to the gas compressibility effect.

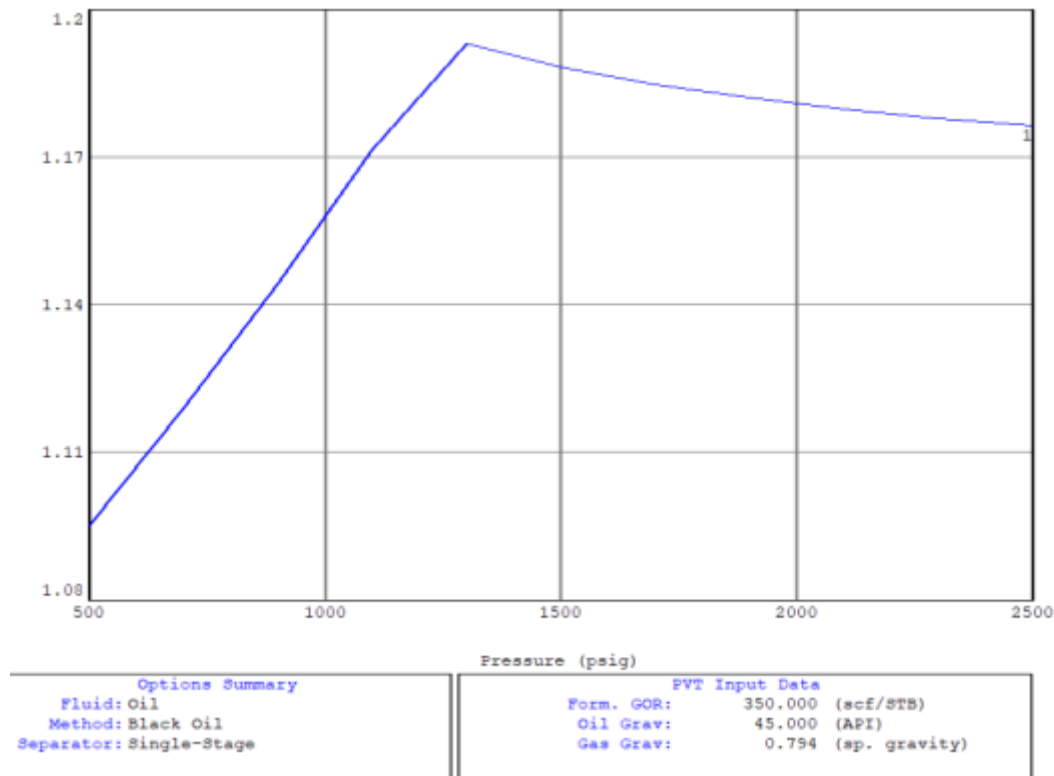


FIGURE 2 OIL FVF

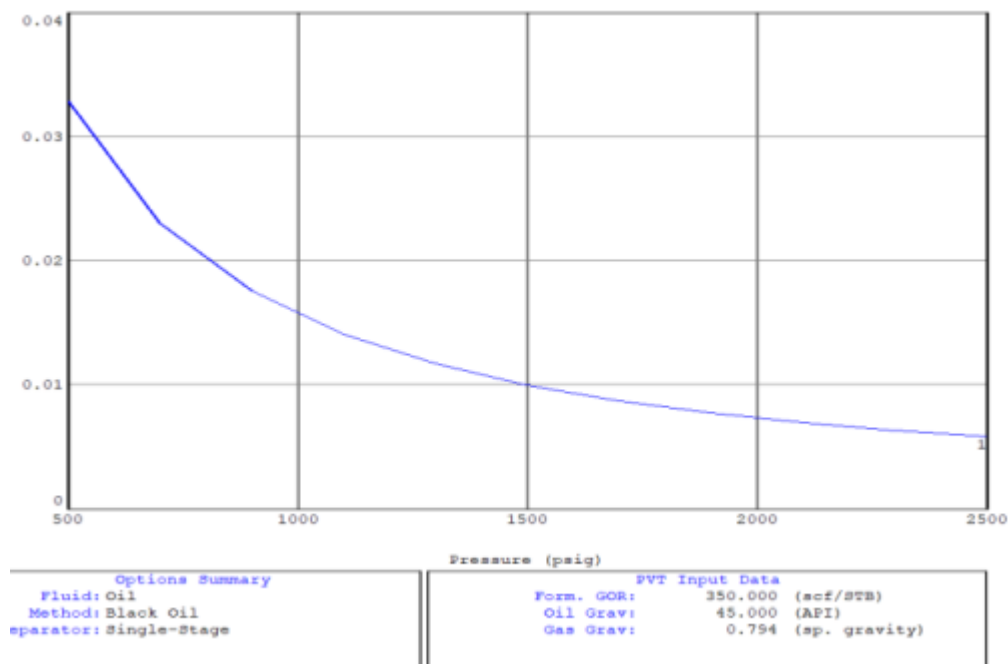


FIGURE 3 GAS FVF

CE 2.9 I then conducted sensitivity analysis between porosity and permeability on the MBAL software. I conducted the analysis by making two distinct groups for analysis: varying porosity with a constant permeability, and varying permeability with a constant porosity. I observed that when permeability values are varied while keeping porosity constant in a reservoir, the alterations impact the flow characteristics of fluids within the rock formation. If permeability values are increased, fluids, such as oil or water, can flow more easily through the rock. I understood that enhanced permeability can lead to improved reservoir performance, increased production

rates, and potentially higher recovery of hydrocarbons, while a decrease in permeability may restrict fluid flow, reducing production rates and making it more challenging to extract resources efficiently. I also observed that variable porosity values with a constant reservoir permeability directly impacts the reservoir's fluid storage capacity without altering the ease of fluid flow through the rock. I realized that if porosity values are increased, the reservoir's capacity to store fluids also increases as more space is available for fluid accumulation. I concluded that this phenomenon could lead to an increased estimate of hydrocarbon volumes such as oil in place (OIP), whereas, decreasing porosity reduces the available space for fluid storage, resulting in lower estimated hydrocarbon volumes.

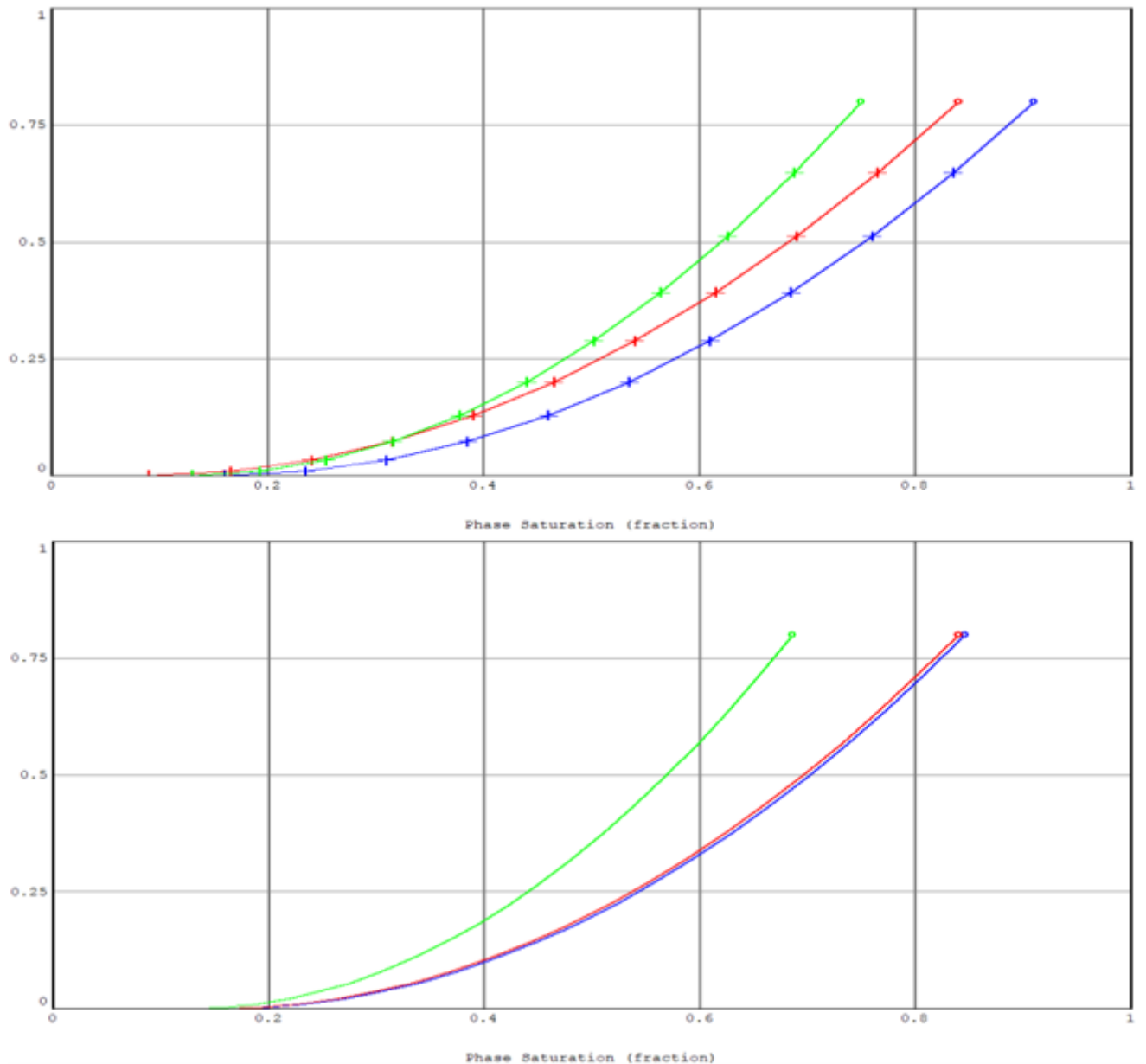


FIGURE 4 SENSITIVITY ANALYSIS ON PERMEABILITY AND POROSITY

CE 2.10 Following the MBAL reservoir calculations, I prepared the reservoir management scenarios to establish the long-term performance of the reservoir. I had knowledge of the three types of drive mechanisms that can affect the performance of the reservoir over time. I analysed the water drive, gas cap drive and depletion drive for the reservoir. I understood that a low influx of water was suggestive of the fact that water was an insignificant contributing factor to the drive mechanism of reservoir and could be a result of efficient water barriers that could stop

water from reaching the reservoir or absence of a regular water flow. The compressibility of the rock was implied to be moderate from the ratio of pressure volume (PV) compressibility. It also implied changes occurring in pressure as a cause of volume adjustment and could be because of the geo mechanical effects or reservoir rock compaction. I observed that the fluid expansion portion was suggestive of variability in pressure having imminent impact on the hydrocarbon volume. I understood that it could be credited to various factors such as thermal effects, adjustments in phase behaviour, or release of dissolved gases.

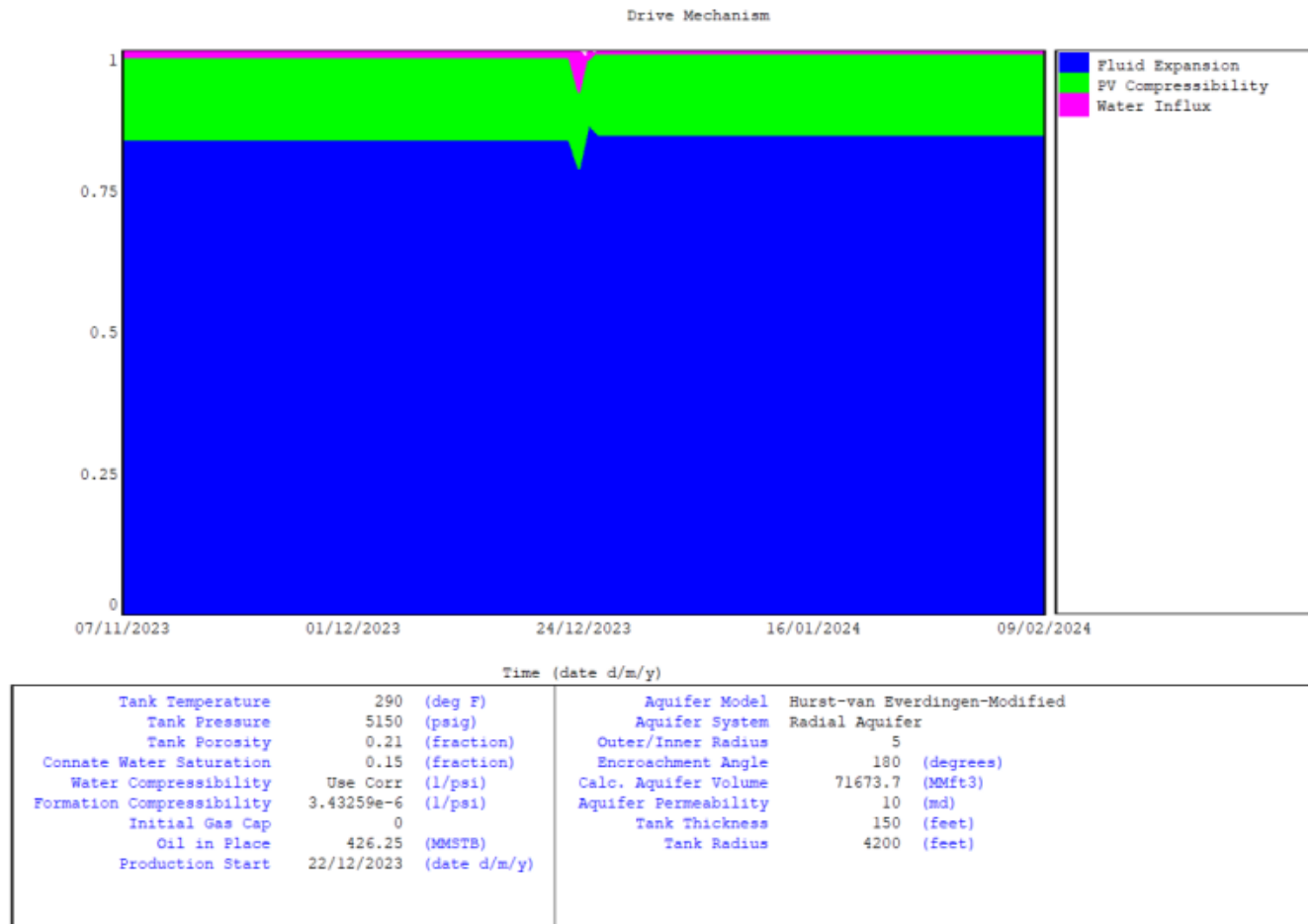


FIGURE 5 DRIVE MECHANISMS

CE 2.11 To conclude the project, I performed the economic evaluation based on the conducted material balance analysis. For different oil price scenarios, I evaluated the Net Present Value (NPV), based on a 10-year project life and 10% discounting. This helped me assess the monetary feasibility of development in the reservoir. Next, I calculated the Internal Rate of Return (IRR) which is useful for determining how well the project is doing financially under differing circumstances. Moreover, I got the Profitability Index (PI) from which I measured the benefit of cash inflows to the investments. High oil prices coupled with lower operating costs improved the economic picture of the project significantly.

CE 2.12 Throughout the assessment project, I communicated with my course supervisor weekly for guidance and evaluation on the progress of the assessment project. I planned and divided the assessment tasks within team members and held meetings daily to track progress on the work. During the tenure of the experiment, I upheld systematic measures along with creative problem-solving techniques to yield precision as well as reliable results. The survey of sensitivities first did not have any true data on porosity and permeability. Hence, I faced an error-prone reservoir calculations marred by errors in the results. I undertook a systematic analysis of available well logs and core analysis reports to discover trends and patterns in the data as a solution to the problem. This would help with the development of interpolation techniques to calculate the missing values for critical reservoir zones. Comparisons were done using theoretical models, for example Archie's equation, and compared with analogous

reservoir data for validation. Through this approach, it was ensured that the calculated parameters matched geological characteristics of the reservoir to derive a more accurate model.

CE 2.13 Another challenge I faced was the lack of capability of the MBAL software to simulate a detailed water influx model layout. I compensated this by adopting some of the software output and incorporating that with analytical computations from the Carter-Tracy water influx model figures. By applying this manually, I estimated the aquifer contribution quite precisely, and then integrated these results into reservoir simulations for a holistic view of water influx behaviour. This enabled me to solve significant problems and safeguard all project results, hence sharpening the problem-solving ability and boosting the technical ability in reservoir engineering.

Summary:

CE 2.14 In this assignment, I focused on analysing and improving the reservoirs behavior with material balance or MBAL software. Alongside the calculations and balance computations for predicting reservoir performance, I collected and validated critical datasets and calculated oil-in-place volumes. I identified major varying parameters like porosity and the effects of fluid expansion in production by means of sensitivity analysis, porosity and permeability effects on reservoir performance were assessed. I reviewed drive mechanisms and suggested pressure management strategies. At the end, I conducted the Economic evaluation of this project using parameters such as NPV, IRR, and PI. This assignment sharpened my analytical, problem-solving, and technical collaboration skills.