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Judy Creek Swan Hills CO2-EOR

Michelle Lund, Femi Talabi, and Andre Chow
Conifer Energy

Joel Collins, Consultant
Rod Batycky, Streamsim Technologies, Inc.

Abstract

The Judy Creek Beaverhill Lake "A" Pool has been on production since 1960 and has strong potential as a CCUS reservoir due to its large pore volume, detailed geological characterization, and existing solvent injection infrastructure. Historical original oil in place (OOIP) values range from 750 to 1100 million barrels of oil (MBO) which results in a 34 - 50% recovery factor. This field has undergone pattern waterflood followed by water alternating gas (WAG) hydrocarbon miscible flood from 1985-2016. A successful CO2-EOR pilot conducted in 2007 demonstrated the technical and economical viability of a quaternary CO2-EOR flood in the Judy Creek Beaverhill Lake (BHL) oil pools.

Through a rigorous analysis of reservoir data, historical original oil in place calculations, full field streamline simulation forecasts, and the outcomes of the CO2 Pilot, Conifer Energy Inc. (Conifer) illuminates the reservoir's intrinsic value for hydrocarbon extraction and carbon sequestration. The significant oil recovery and CO2 storage potential of pools in the Swan Hills trend are also highlighted.

Geoscience update

In 2023-24, Conifer conducted a geological evaluation and reassessed resource volumes to aid with CCUS development planning. This effort required (1) a revisit of all porosity data, (2) a porosity-water saturation (phi-Sw) transform and (3) an update of the stratigraphic framework. Seventy-two core descriptions were leveraged to better understand facies distributions and to pick stratigraphic surfaces. In addition, Conifer consulted with Swan Hills experts to align with the regional stratigraphic framework under development for the 2025 Canadian Stratigraphic Atlas.

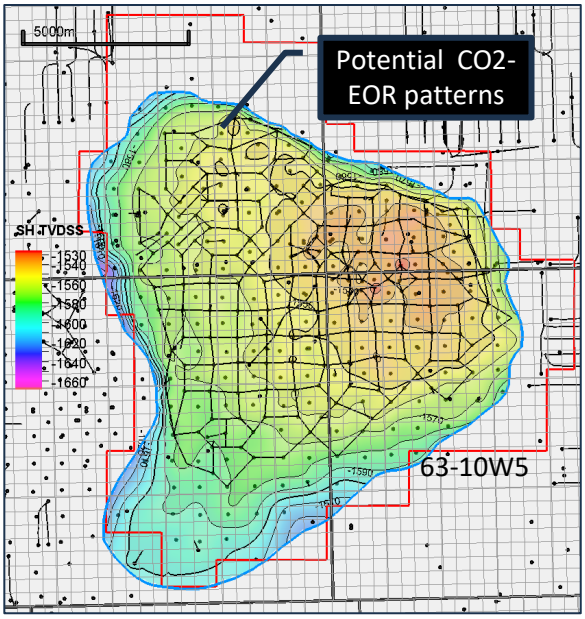
These updates were built into 3-D stochastic geomodels. Four petrofacies were modelled: (a) mid-lower forereef, (b) reef margin/reef flat/upper forereef, (c) high-energy tidal flats/shoal/beach, and (d) low-energy lagoon/tidal flat. Porosity and net-to-gross (NTG) histograms for each petrofacies were used to populate cells beyond the wells. The phi-Sw transform was used to calculate Sw for each cell. Volumes were calculated from the geomodel to establish base case values for future work. History-matching of the static 3-D geomodel and simulation forecasts was undertaken to assist in planning CO2-EOR pattern development.

Results

The Swan Hills formation has three key sequence boundaries, P4, R0.5, and R4, that demonstrate subaerial exposure within the buildup. The P4 surface overlies a series of backstepping ramps representing the transition from platform to isolated buildup[4] and is used as the base of the model. It shows exposure toward the leeward (western) side of the buildup. The R0.5 is at the top of a reef-rimmed prograding wedge that marks the initial stage of isolated buildup development. Toward the leeward margin, it is an exposure surface on top of a lagoon-tidal flat succession, while on the windward (eastern) side, it is characterized by cyclic shallowing in reef flat to reef margin facies. Above the R0.5, the Judy Creek buildup consists of aggrading to slightly backstepping reef cycles leading up to the R4, a regional unconformity associated with a shale-rich layer at the top of the reef. The final stage of the Judy Creek buildup contains a series of backstepping high-energy ramp or shoal cycles above the R4 that culminate with drowning of the buildup. Within the geomodel, additional subunits were defined to identify separate flow units.

Improvements were made in the following areas:

(1) Better defined stratigraphy in the lower units (R1 – P4) due to incorporation of core facies and exposure surface observations and recognition of the R0.5 surface
(2) A clearer picture of the facies distributions for each subunit and their impact on reservoir quality
(3) Higher-confidence OOIP value and resource distribution across the field due to a more consistent approach to porosity calculations and application of phi-Sw transform.



Simulation and Development Planning

A. Commercial Vision

Under current exploitation, about 550 MBO representing 53% of the OOIP in the Judy Creek BHL A & B pools will be un-recovered. CO2 flooding may assist in recovering an additional 3-5% or 30-50 MBO, and up to half of the un-recovered hydrocarbon solvent about 15% of the previously injected solvent or 30-60 Bcf of the injected C1-C2+. It is estimated that 1 to 2 million tonnes per year of CO2 can be sequestered in the intervals subjected to quaternary CO2 flooding.

A significant portion of the remaining oil resides in reservoir facies of lower quality or within the lower sections of the continuous pay intervals. These areas were bypassed due to gravity override of the injected hydrocarbon miscible flood solvent. Additionally, there are regions such as the target zones (R5A and B reef stages) that were not sufficiently swept by hydrocarbon solvent due to unfavorable mobility ratios.

Over the past few years, Conifer has continuously progressed a commercial CO2-EOR vision, preparing for an anticipated injection of 2,000 tonnes per day of CO2.

B. 07-02 CO2-EOR Pilot

A CO2-EOR pilot (injector 07-02-064-11W5) was initiated in February 2007 to evaluate recovery and operational considerations for CO2 flooding post-hydrocarbon solvent flooding. CO2 injection for this pilot was successfully completed in April 2009 with oil recovery estimated between 3-5% OOIP.

Conifer is positioned to build on the success of the 07-02 CO2-EOR pilot and commercially develop CO2-EOR patterns within the Judy Creek BHL “A” Pool. Development will commence with the 08-01 Pattern (injector 08-01-064-11W5) and expand to other patterns within the pool.

Given the time interval since the 07-02 project, Conifer believes it is prudent to start slowly, apply new technologies, and ensure operational training and procedures are optimized to safely inject CO2.

C. Pattern 1: 08-01 Pattern

Preparations for CO2-EOR in the 08-01 Pattern have been underway since Q4 2022. These preparations include the acquisition of baseline MMV samples, facilities engineering, forecast of oil production and CO2 injection rates, securing a CO2 supply, 08-01 injector testing for R5-zonal isolation, procurement of well workover and facilities long lead items, and an update to the existing Emergency Response Plan (ERP).
Encouragingly,

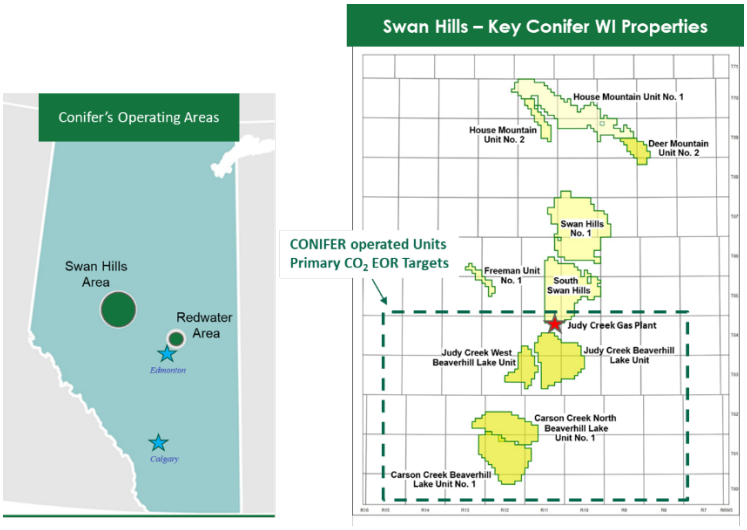
- Tests have demonstrated isolation of injection into the target R5 interval, aligning with historical hydrocarbon solvent injection observations.
- Condition and integrity of the 08-01 injector has been confirmed to be suitable for CO2 injection by recent CBL and CIL logs.
- Recent pressure measurements within the pattern show that pressure within the pattern is above the Minimum Operating Pressure (MOP) 24 MPa.

D. History-Matching & Forecasts

The revised stochastic model was in a full-field streamline simulation model, which was then history matched at the field level. A satisfactory history match was achieved and the history-matched model was then used to generate oil recovery and CO2 storage forecasts for the Judy Creek A BHL field.

Simulation forecasts indicate that a CO2-EOR Quaternary flood of the Judy A Creek BHL pool could result in an oil recovery factor of 3-5% of the OOIP. Additionally, the pool has the potential to store 30-40 Mega tonnes of CO2 over a 30-year period.

E. Swan Hills CO2-EOR Hub - Oil and CO2 storage potential



Several other sizable fields in the Swan Hills area possess reservoir and oil characteristics that render them suitable candidates for large-scale CCUS. Like the Judy Creek BHL A pool, some of the fields in the Swan Hills area have undergone hydrocarbon miscible flooding in. Based on work completed to date, we can assume a quaternary CO2-EOR flood of these previously hydrocarbon miscible flooded fields could result in the recovery of between 3-5% of their OOIP. Fields that were not previously hydrocarbon miscible flooded, such as Carson Creek North, could recover 10-12% OOIP under tertiary CO2 floods. Overall, CO2-EOR initiatives in the Swan Hills area could potentially recover up to 200 MMBO while sequestering an estimated up to 150-200 Mega tonnes of CO2 over a 30-year period.

CONCLUSION

The Judy Creek BHL A Pool is a remarkable asset with significant potential for additional hydrocarbon recovery and carbon sequestration. Moreover, the field has a CO2 ready injection system which reduces the development capital. By capitalizing on the reservoir's excellent geological attributes and embracing proven technologies, Conifer can unlock new avenues for sustainable resource development and carbon mitigation strategies within the province. The Judy Creek BHL A Pool is strategically located near other CO2-EOR amenable fields, making it a potential anchor pool for the development of a broader CO2-EOR development and storage hub.