

Top Quartile Oil Sands Reservoirs - EnCana Foster Creek SAGD Project, Cold Lake Area, Alberta, Canada*

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Abstract

The EnCana Foster Creek SAGD project is located along the southern end of the Primrose Ridge. The estimated 1.5 billion barrels of exploitable bitumen consisting of high quality, continuous pay is created by multiple stacked channel deposits. Stacking is achieved because of the McMurray river system being forced to diverge westerly and easterly around the Primrose Ridge. This interpretation is supported by paleocurrent data from over 300 borehole imaging logs (FMI) and examination of over 80 McMurray cores.

Introduction

The Lower Cretaceous Mannville Group contains most of Canada's oil sands resource, and within it, the Wabiskaw-McMurray deposit ([Figure 1](#)) is the largest with 902 billion barrels (AEUB, 1996; Wightman, 2003). In-situ production of McMurray Formation oil sands at the EnCana Foster Creek project ([Figure 2](#)) currently exceeds 30,000 barrels of oil per day (bopd) with the potential to expand to 100,000 bopd within the next 10 years. Approximately 1.5 billion barrels of exploitable bitumen in place has been identified for this project, which is sufficient for 20+ years of production at these rates.

Production ([Figure 3](#)) is obtained by steam assisted gravity drainage (SAGD). To optimize SAGD production and achieve the lowest operating costs, EnCana targets continuous, high permeability bitumen pay averaging 20 to 40 m thick over 700 m horizontal well lengths. Heterogeneity is found on all scales and predicting reservoir continuity is challenging. Due to the inherent heterogeneity associated with McMurray Formation oil sands, vertical delineation wells are drilled at a minimum of 400 m spacings and one well in every four is cored.

A predictive model for the EnCana Foster Creek property is presented that integrates an understanding of regional and local paleocurrent data, mapping paleotopography on the sub-Cretaceous unconformity and detailed sedimentology. Data is provided by approximately 600 vertical

delineation wells, 34 horizontal well pairs, examination of over 80 McMurray Formation cores and 300+ borehole imaging logs (FMI). For non-cored wells, detailed lithofacies identification is achieved with a high level of confidence by integrating FMI interpretation.

Reservoir Lithofacies

A representative core selected for the Foster Creek oil sands reservoir is ECAOG D11 Fisher 11-19-70-4W4 (Figure 4). The key oil sands pay interval consists of fine grained to medium grained, trough cross-bedded sands interpreted as lower point bar deposits. The cross-bedded sands have an average of 33% porosity, 80% oil saturation and 5 to 10 Darcy (D) permeability. Associated with the base of some channels, are breccia intervals consisting of trough cross-bedded or massive sand with mudstone clasts. Although overall oil saturations are lower due to the mudstone clast content, breccia intervals are limited in lateral extent and are not interpreted as significant permeability barriers to steam rise and subsequent SAGD production.

Inclined heterolithic stratification (IHS; Thomas et al., 1987), is comprised of interbedded sands and mudstones deposited along the mid to upper point bar (Mossop and Flach, 1983). Within sand-dominated IHS, interbedded sands typically have permeabilities approximately 1 to 4 D, slightly lower porosity, and oil saturation than the cross-bedded sands. Interbedded mudstones exhibit an order of magnitude reduction in permeability (10 to 300 mD) compared to cross-bedded sands and breccias, and can adversely affect SAGD production (Strobl et al., 1997). The presence of trace fossils, including *Cylindrichnus*, within the IHS interval, indicates periods of marine influence during deposition. These successions are interpreted as fluvially dominated estuarine channel deposits.

The SAGD reservoir is commonly constrained by a combination of channel deposits with mudstone-dominated IHS, laterally continuous mudstone beds associated with floodplain or lacustrine deposits and mudstones associated channel abandonment (Figure 3 and Figure 4).

Importance of Stacked Channel Deposits to SAGD

Ideal SAGD reservoirs commonly consist of intervals dominated by high permeability, trough cross-bedded sands with little or no IHS. This can be achieved by stacking two or more channel deposits. Each younger channel succession successively erodes mid to upper point bar deposits of the older channel, preserving predominantly trough cross-bedded sands and minimizing the thickness of the IHS interval.

Commonly, only the uppermost (youngest) channel succession contains preserved upper point bar deposits, resulting in optimal SAGD reservoir thickness and continuity (Figure 5). Based on the dimensions of fully preserved channel deposits, consisting of both lower and upper point bar successions, McMurray channels in this area, are interpreted to have been 20 to 25 m deep and probably 200 to 300 m wide.

Influence of the Primrose Ridge

Top quartile SAGD reservoirs, in which stacked channel successions predominate, do not appear to be random. A paleo-topographic high on the sub-Cretaceous unconformity, informally named the Primrose Ridge (Wightman et al., 1995), appears to directly influence deposition of the McMurray river system (Figure 5 and Figure 6). Amalgamated channel belts are commonly found flanking the Primrose Ridge, where up to

3 stacked channel successions are preserved. Paleocurrent data obtained from FMI interpretation consistently shows that the river system originating from the south was forced to diverge westerly and easterly around the high resulting in multiple stacking within a relatively confined area.

Conclusions

The EnCana Foster Creek SAGD project is located along the southern end of the Primrose Ridge. The estimated 1.5 billion barrels of exploitable bitumen consisting of high quality, continuous pay is created by multiple stacked channel deposits. Stacking is achieved because of the McMurray river system being forced to diverge westerly and easterly around the Primrose Ridge. This interpretation is supported by paleocurrent data from over 300 borehole imaging logs (FMI) and examination of over 80 McMurray cores.

Utilizing paleogeography, regional and local paleocurrent data, in combination with detailed sedimentology, provides a tool for predicting the quality and lateral extent of exploitable oil sands reservoirs. Identifying areas prone to trough cross-bedded, sand-dominated stacked channel successions helps to reduce some of the risk associated with SAGD recovery from the McMurray Formation, well known for its inherent reservoir heterogeneity.

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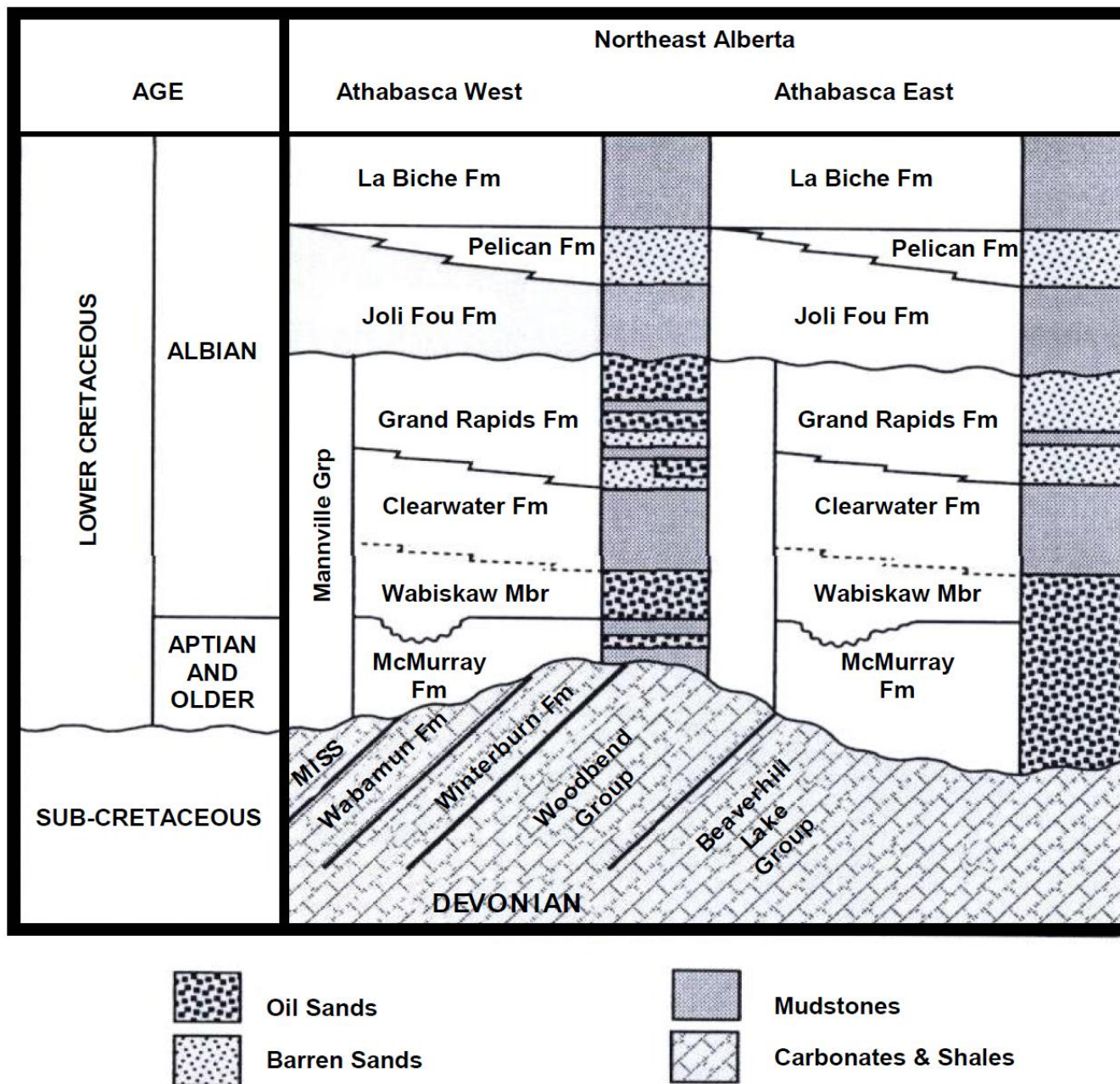


Figure 1. Stratigraphy of the Mannville Group and surrounding strata in Northeastern Alberta (From Wightman et al., 1995).

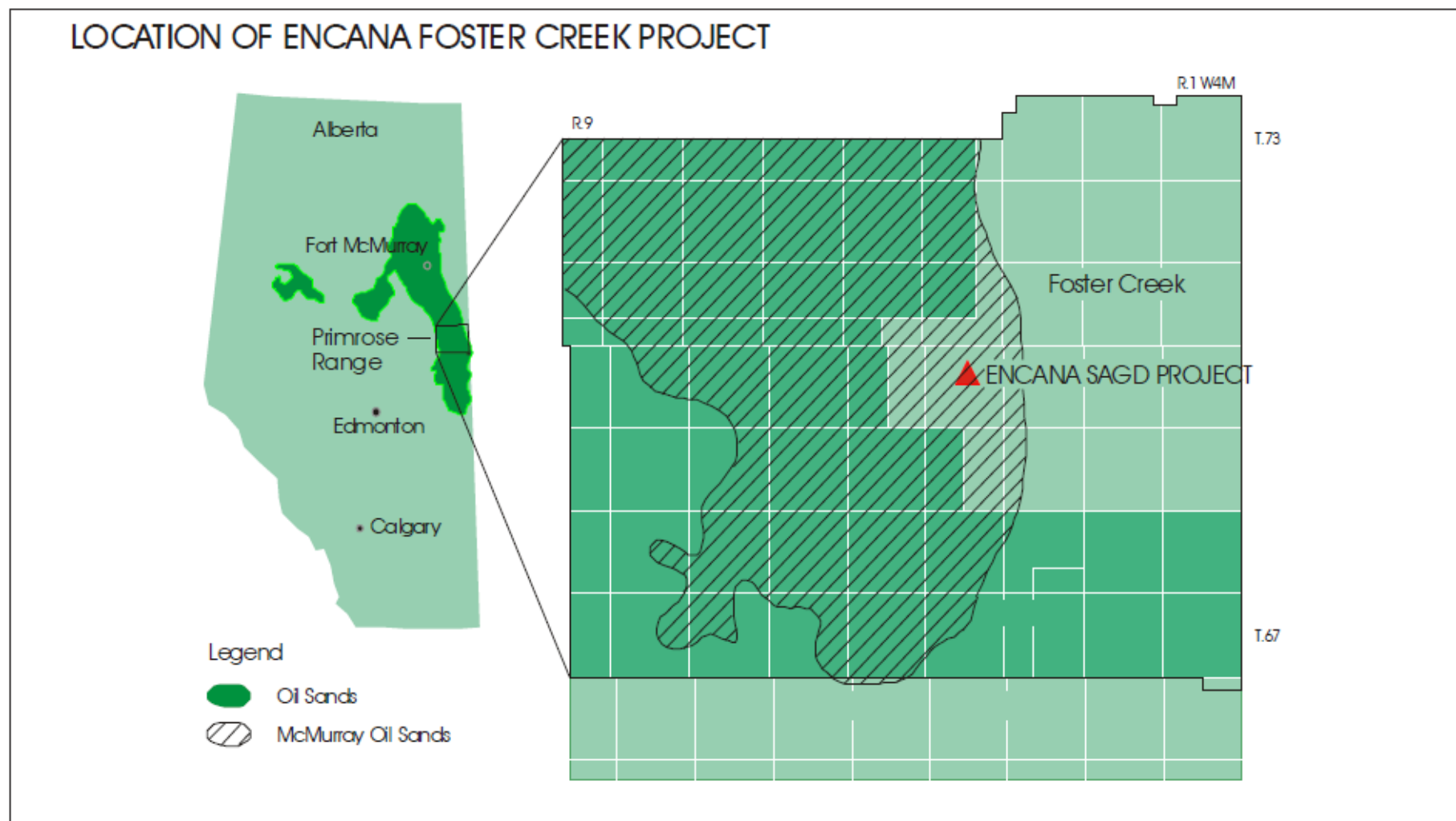


Figure 2. Location map of the EnCana Foster Creek SAGD project.

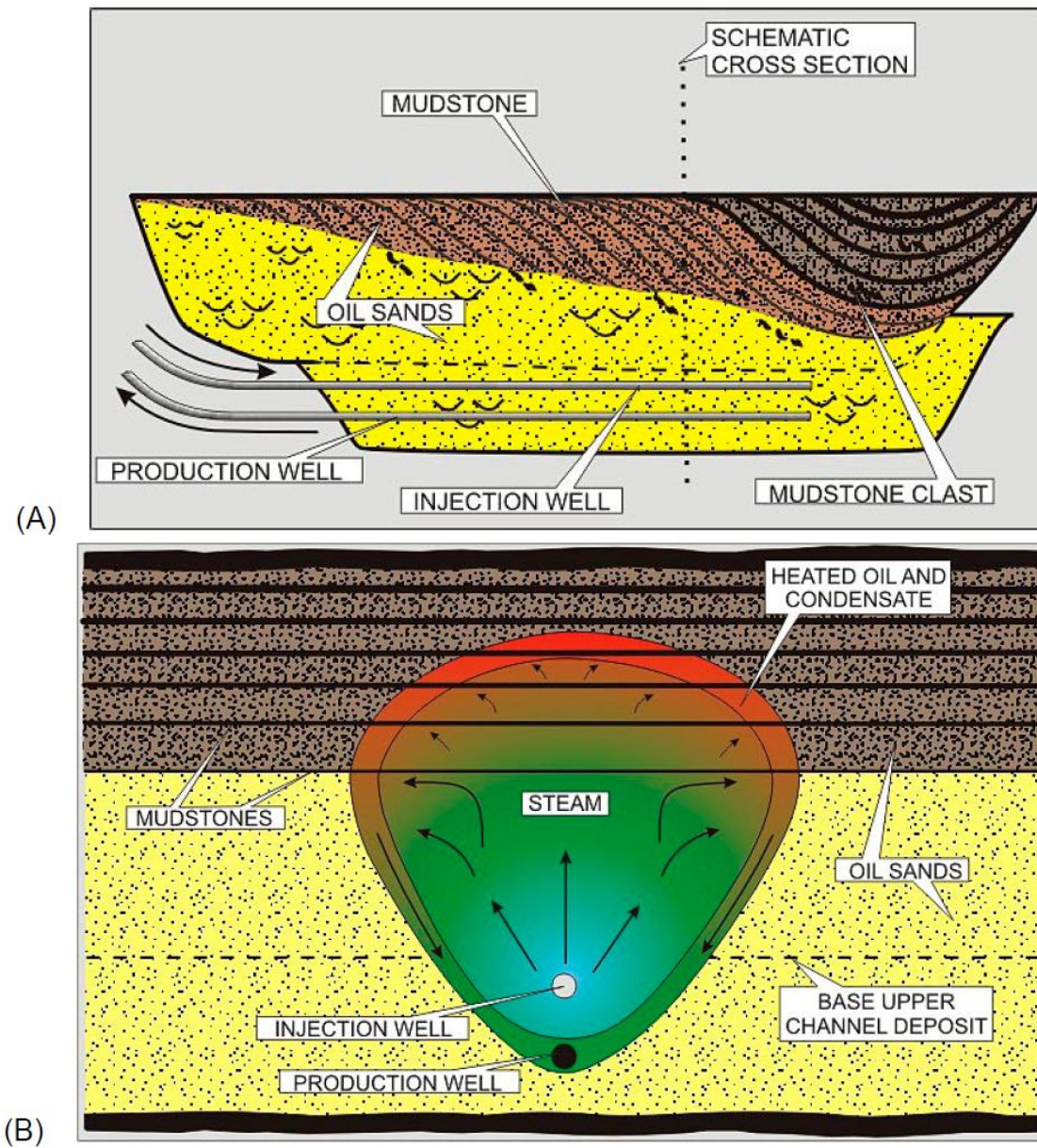


Figure 3. Schematic diagram of Steam Assisted Gravity Drainage in two stacked channel deposits. (A) Longitudinal profile of horizontal well pair. (B) Cross section of (A) showing development of steam chamber retarded by mud-dominated inclined heterolithic stratification (from Wightman, 2003).

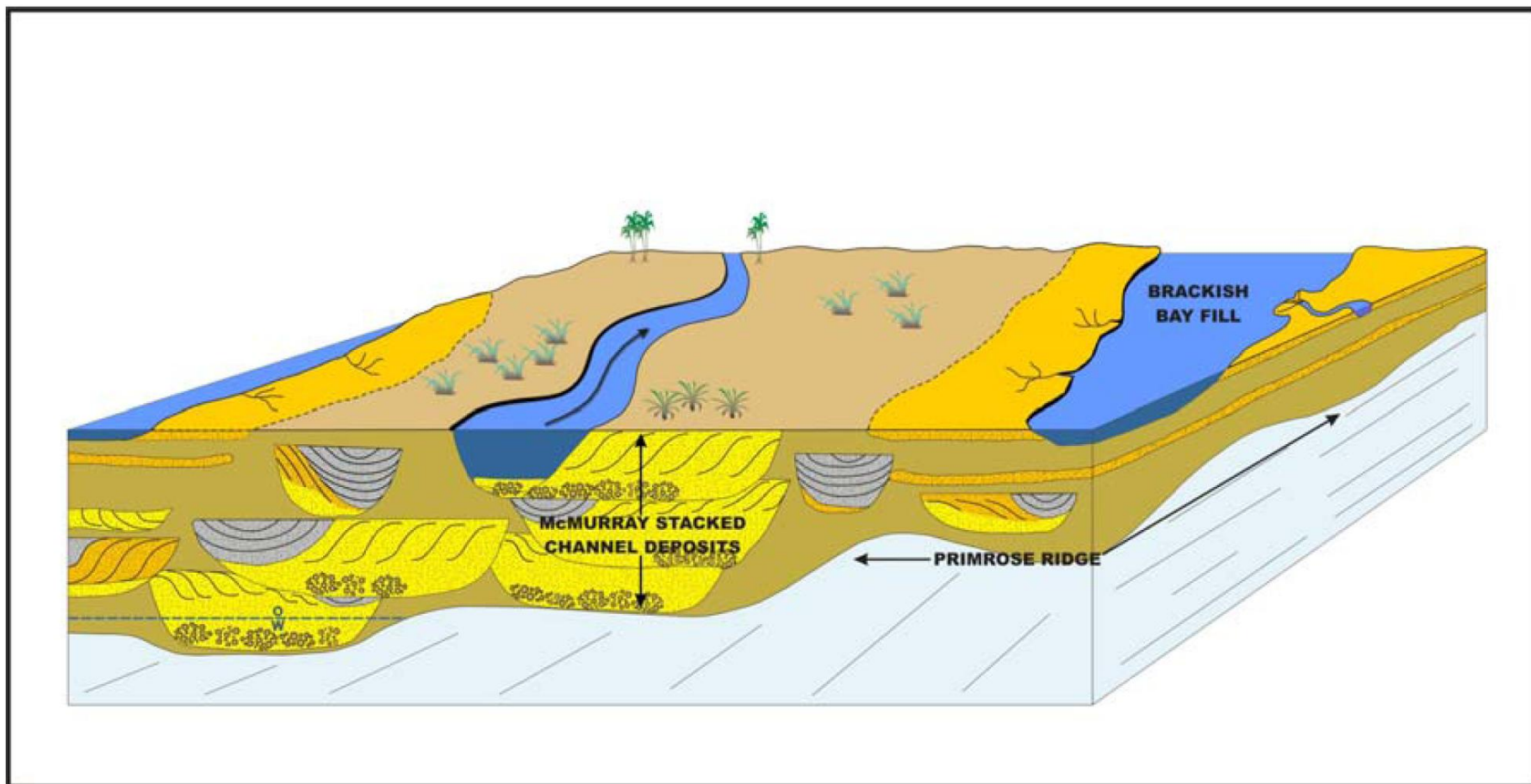


Figure 5. Depositional model for stacked channel successions in the McMurray Formation, Foster Creek SAGD project.

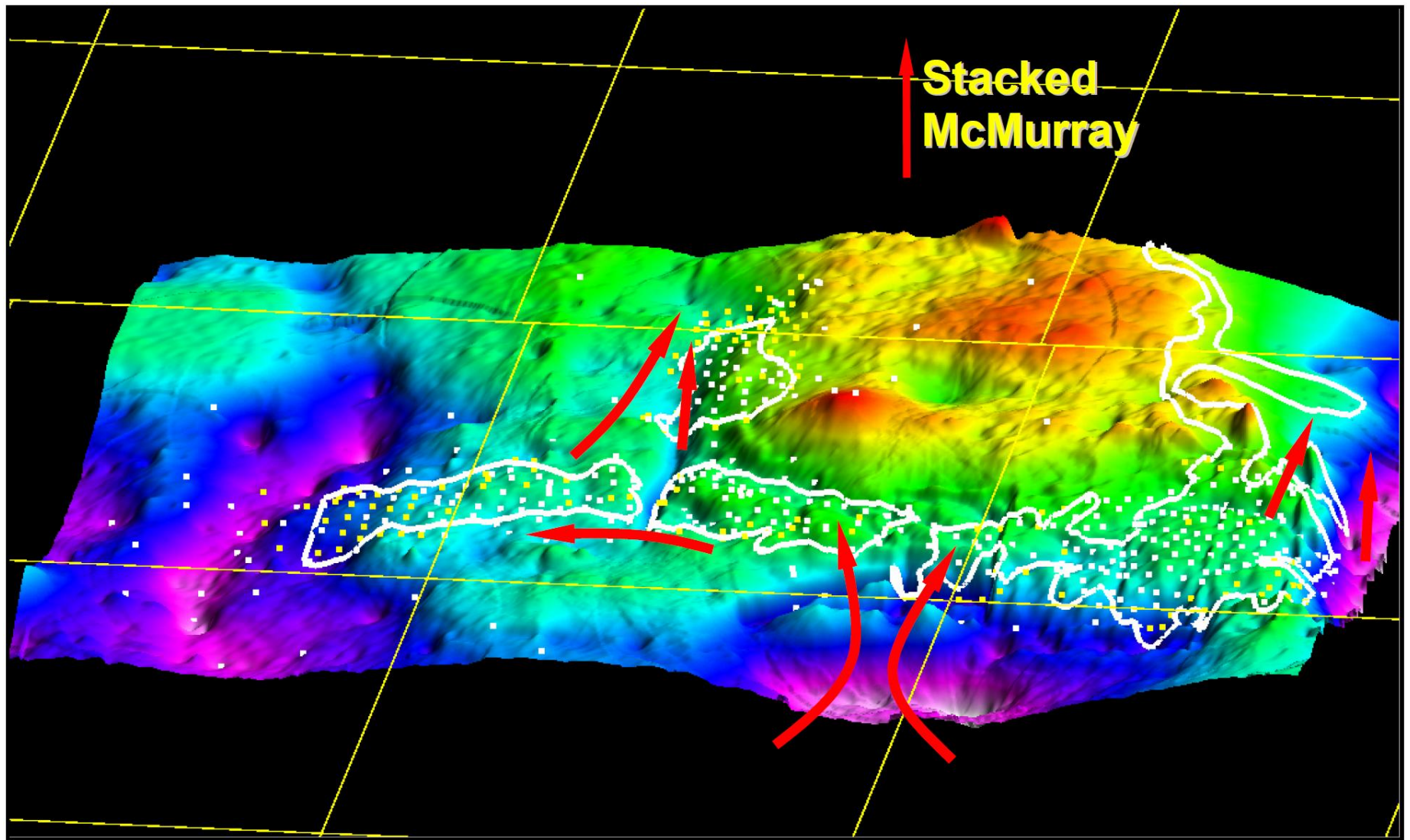


Figure 6. Paleogeography and associated channel stacking along the southern flank of the Primrose Ridge, Foster Creek SAGD project. White outline indicates current exploitable bitumen pay for SAGD production.