Annual Performance Review of In Situ Oil Sands Scheme Approval 9404W

Pelican Lake Asset Team
Conventional Oil & Gas
Cenovus Energy

May 20, 2016
Disclaimer

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Agenda

• Introductions
• Current Approval
• Geological Overview
• Scheme Performance Update
• Simulation Update
• Hot Water Injection Update
• Cap Rock Integrity & Monitoring Program
• Water Usage Update
• Facilities Update
• 2015/2016 Development Activities
• AER Regulatory Discussion & Key Learnings
Current Approval and Enhanced Oil Recovery (EOR) Scheme Area
Approval 9404W – Current EOR Scheme Area

- 9404W was originally approved in April 2014
- No near term requirements to expand beyond existing boundaries and spacing
- Pads shown in green are performance examples shown later in presentation

Interwell spacing distance is from producer to producer
Geological Overview
Geologic Review

The development interval at Pelican Lake is the Wabiskaw Formation

- Wabiskaw and Clearwater are part of the Mannville Group.
- Wabiskaw composed of oil barring shoreface sands.
- Clearwater acts as cap rock and is composed of mudstones and very competent calcified siltstones.
- Reservoir Properties are very consistent and of a high quality across the field.

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<th>Parameter</th>
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<th>Comments</th>
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<tr>
<td>Depth</td>
<td>300 – 450m</td>
<td>Generally deeper in SW</td>
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<tr>
<td>Avg Thickness</td>
<td>3m</td>
<td>Thins towards North, ranges between 1 – 6m</td>
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<tr>
<td>Avg. Porosity</td>
<td>30%</td>
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<td>Avg. Oil Saturation</td>
<td>70%</td>
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<tr>
<td>Avg. Permeability</td>
<td>300 – 3000mD</td>
<td>Generally better rock in Western portions of Pelican Lake</td>
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<td>Reservoir Temp.</td>
<td>12 – 16 C</td>
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<td>Initial Reservoir Pressure</td>
<td>1800 – 2400kPa</td>
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<td>Oil Viscosity (dead)</td>
<td>1000 – 25000+ cP</td>
<td>Most of core land &lt;= 2500 cP Polymer flood typically &lt; 7000cP</td>
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<tr>
<td>Oil Gravity</td>
<td>11.5 – 16.5 API</td>
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Wabiskaw Depositional Environment: Prograding Shoreface Into A Shallow Sea

- During the early Cretaceous, a relative rise in sea level caused a major southward transgression of the Boreal Sea, which in turn created a marine environment for the deposition of the Wabiskaw Member.

- Approximately 133 million years ago a shallow sea filled the basin from the north, with the Red Earth & Granor Highlands protruding as barriers.
  - Large extent Tabular sands a result of Shallow sea environment.

- These barriers are the primary source of sediment supply for the formation of the Wabiskaw.

- The Pelican Lake field is interpreted as a lower to middle shoreface sand which progrades towards the northwest into an offshore environment.

- Shallow Sea Prograding Shoreface Environment, sourced from the Red Earth and Grosmont Highlands.
- A combination of wave action reworking the sand and longshore drift has established a sandstone with excellent reservoir properties.
Core supports the interpretation of the Prograding Shoreface environment.

- Cleans up from approximately 25% mud near the base of the Wabiskaw (interpreted as Lower Shoreface), to under 19% mud at the top of the Wabiskaw (interpreted as Middle Shoreface).
- Coarsens up from Very Fine Upper Sand in the Lower Shoreface to Fine Lower Sand in the Middle Shoreface.
- Trace Fossil Assemblages are less marine, and less diverse toward top of the Wabiskaw. This is a further indicator of a prograding shoreface environment.
- Permeability gets better towards top of core as sand coarsens up.
Wabiskaw Net Pay & Viscosity Fairway

Prograding shoreface environment makes the reservoir very uniform, continuous and predictable

- Net pay bounded by onlap edge to the north and shoreface edge to the south, thinning uniformly from the center of the pool to the edges.

Viscosity is low enough for mobile oil over the majority of the Pool. However as we approach the edges of the pool the viscosity gradient is very steep.

- Full development inventory lies in the mobile oil area

Structure is driven by Paleozoic unconformity and rises dramatically to the NE.

- A number of Gas caps exist on associated highs, mostly in the NE part of the reservoir and are avoided when planning our future development wells.

Reservoir properties of the step out areas in both the Mobile and Hot Water development plans compare very favorably to the rest of the field.

Small zone of potentially perched water in the South Central part of the field.
- Wabiskaw Pay zone is uniform throughout the pool, along strike (SW to NE).
- Clearwater Cap rock is approximately 80 m thick across the whole pool. It is a very competent formation comprised of shale and calcified siltstone, which makes it a very robust cap rock.
- Structure rises as you move north due to the rising of the Paleozoic Unconformity.
- We start to lose accommodation space for the Wabiskaw toward the NE as we approach the Paleozoic high.
Top Clearwater to top Wabiskaw porosity includes Clearwater Formation, Wabiskaw tight streak and Wabiskaw shale.

75 to 95 m thick over the oil development area, very gentle dip to the SW.

Clearwater Formation can be correlated across entire region.

Clearwater subdivided into 4 units: 3 cycles (Clearwater C, B, and A) and a shale unit at the top. The siltstone at the top of the 3 packages has been cemented into a tight streak or a package of calcareous streaks.

The Clearwater units and associated packages of tight streaks can be correlated regionally.

The Wabiskaw tight streak is present in every well across the area and can be correlated regionally as well.

Clearwater formation deposition is unaffected by karsting or carbonate dissolution. Therefore Clearwater deposition occurs after these events.
Scheme Performance Update
Milestones

1. Primary production (400m inter-well spacing)

2. Waterflood pilot (400m inter-well; injector infilled)

3. Commercial Waterflood

4. Polymer Pilot

5. Commercial Polymer

6. Injection rates lowered to arrest watercut increases. Injection shut-in on pads for infill drilling program

7. Infill Drilling to 100m and 133m inter-well spacing

8. Hot Water Pilot (Pad E29)

9. Field-wide Optimization of Injection Rates and Polymer Consumption
2015 Highlights

Injection rate/polymer consumption optimization

• Enhanced flood management focus in 2015
• Injection rates lowered in areas where estimated impact on production was considered low
• Polymer consumption optimized as supported by technical work
• Several polymer flooded pads reverted to water after reaching the optimal polymer slug
  • Decision backed by detailed reservoir & simulation modeling work
  • Facilities decommissioned in a way that allows safe restart if required
Current and Expected Ultimate Recovery Factors

- **West:**
  - Cum Pad RF to Date = 11-23%
  - Estimated Ultimate PDP Pad RF = 12-38%

- **Central:**
  - Cum Pad RF to Date = 3-21%
  - Estimated Ultimate PDP Pad RF = 8-35%

- **East:**
  - Cum Pad RF to Date = 4-26%
  - Estimated Ultimate PDP Pad RF = 11-33%

- Recovery Factors (RF) are dependent on reservoir quality, heterogeneity, pad maturity, well density/spacing, and if gas caps are present.
- Cumulative pad recovery factors include primary recovery.

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**Cenovus Energy**
SW16 – Good performance

- Polymer started in 2009
- Water cut started to drop immediately
- Oil rate increased as a result and remains flat
NE02 – Average performance

- Polymer started in late 2010
- Decline rate arrested due to declining water cut
- Oil rate stable for the last five years
SW11 – Below average performance

- Polymer started in 2009
- Minor decline in water cut offset by declining liquid
- No observable upside to polymer
Simulation Update
Hot Water Injection Update
Pelican Lake Hot Water Injection Pilots

Pilot areas are only hot water (no polymer)

**SE29 (Edge and circulation):**
- 3 Horizontal Wells
  - 1 Producer
  - 2 Injectors
- 3 Vertical Observation Wells
- Oil viscosity ~ 4000 - 10000 cp

**SE28 (Edge injection only):**
- Work in progress
- 4 Horizontal injectors
- Oil viscosity ~ 4000 - 10000 cp

- Both pilots target higher oil viscosity areas within Pelican Lake
- Expansion opportunities being evaluated offsetting current SE29 pilot
Pelican Lake Hot Water Injection Status

SE29 Pilot Status Update (Edge and Circulation)

• Phase 1 Complete
  • Primary production: November 28, 2010 - May 31, 2011
• Phase 2 Complete
  • Hot waterflood: June 1, 2011 – March 13, 2012
• Phase 3 Ongoing
  • Boiler facilities shut-in February 2015, pilot underwent cold waterflood and cold water circulation during remainder of 2015
  • Warm water injection in 2016 (high efficiency line heaters)

SE28 Pilot Status Update (Edge Only)

• Four injectors at SE28 initially targeted a surface injection temperature of 80°C using energy efficient line heaters (max temp 90°C)
  • Actual injection temperatures remained much lower than target in 2015 due to technical issues with line heaters, design optimization has been completed and will be implemented in early 2016

Cenovus proprietary
• Circulation Temperature entered 2015 at ~160°C prior to being ramped down in February 2015

• Injection Rate is representative of total injection from circulation & offsetting injectors

• Oil rates returned to approximately 5m³/d in 2015 after resuming cold waterflood operation, limited impact from cold circulation in Q4-2015

• Work underway to install lineheater and return to warm circulation in 2016
Continue to operate under the constraint that the water injection temperature never exceeds bubble point temperature (as indicated by graph).

- All injected fluids have remained as a liquid (no steam injection)

- SCADA set-points in place ensuring operation not in steam envelope

- Planning to operate “warm” in 2016 after installing lineheater
Water injection temperature never exceeds bubble point temperature.

As expected, injection pressure decreases over time as heat stimulates the reservoir.

Observation wells are also continuing to see an increase in temperature, even after reverting to cold injection in 2015 (25m away from injector).

Currently planning to remain on cold injection going forward.
SE29 “Warm” Injector Performance

- Existing primary well on pad converted to injector – casing spec not suitable for high temperature injection (~55 C max)

- Switched to cold injection (at reduced rates) in 2015 similar to 103/11-33 injector, planning to remain cold going forward
Cap Rock Monitoring Program
Cap Rock Monitoring Summary

No indication of caprock breach based on ongoing flood surveillance

- Previous third party studies indicate the Clearwater shale caprock is safe against the failure mechanisms studied at injection pressures up to 14 Mpa (bottomhole)
  - Allowable maximum wellhead injection pressure 7MPa
- Real time monitoring of Wabiskaw injection pressures and regular review of pattern Voidage Replacement Ratio (VRR)
  - Injection pressures and VRR’s support containment within the Wabiskaw. Currently overall VRR=1.1 (instantaneous) with average wellhead injection pressure 4.5 MPa
  - Using an automated field wide alarm system in SCADA-ProcessNet to monitor and notify engineers of any changes in injectivity
  - Long term monitoring: Hall plots
- Real time monitoring of the bottom hole pressures and rates in Grand Rapids water source wells and bottom hole pressures in Grand Rapids observation wells. No increase in pressures in the Grand Rapids observation wells to suggest any communication with Wabiskaw formation

Annual water analysis on all Grand Rapids water source wells

- No increases in total dissolved solids (TDS) observed that can be attributed to a loss of caprock integrity.
Pressure data from observation wells (Wabiskaw & Grand Rapids) indicate no caprock breach occurred in 2015
Grand Rapids Water Source Well TDS Tracking

- Continued annual surveillance of Grand Rapids TDS at the observation wells
- No deviation from TDS baseline through time
**Injection pressure: Maximum & Average**

- Total 628 injection wells
- Allowable Maximum Wellhead Injection Pressure = 7,000kPa
  - SCADA system logic has alarm and shut-downs set below 7,000kPa
- Average injection pressure hasn’t changed ~4,530 kPa
Alarm Definitions – Anomalous Injector Behavior

Defined two levels of anomalous behavior

i. **Level 1/yellow** - Gradual decrease in pressure behavior that is contrary to the expected result. Non-urgent but flagged as a “watch/monitor” with regular reviews to monitor, until stabilization occurs. Some examples would be:
   
   i. Decreasing pressure after an increase in injection rate  
   ii. Decreasing pressure after an increase in polymer concentration  
   iii. Decreasing pressure after no change in operational conditions

ii. **Level 2/red** - Large instantaneous drop in injection pressure when either:

   i. There is no change in operating conditions, or  
   ii. a corresponding instantaneous increase in injection rate

**Level 2 alarm occurrence requires notification of AER within 72 hours**

No alarms diagnosed as Level 2
Monitoring System - ProcessNet

- All alarms are evaluated by the area technical team

No alarms diagnosed as Level 2
Alarm Example: Well adjacent to a gas cap

- Typical response from a gas cap. Usually pressure fluctuations filling in gas caps
- Alarm triggered eight times due to pressure fluctuations.

Other Common Causes:
- Injection rate change
- Well started/stopped
- Pressure reading deviation well within normal operating range
Water Usage Update
• Grand Rapids non-saline water source wells are predominantly located at polymer make-up sites throughout Pelican Lake
• Five saline Grosmont wells are used to supplement injection volumes required to meet well target injection rates
2015 Pelican Water Usage

- Produced water recycle over 97%
- Non-saline Grand Rapids use is effectively managed
- Reduced injection
- Reduced Grosmont saline water use in 2015 through optimized VRR and reservoir management
In 2015 Cenovus had 26 water diversion licenses from the AER that allowed for 3,059,555 m$^3$ of non-saline water usage for polymer injection in the Pelican Lake area.

In 2015, Cenovus used 40% of the total licensed volume.

Optimization projects are continually executed and evaluated to ensure that the non-saline water is being used to its full benefit for polymer hydration.

### Non-saline Water Use Summary

<table>
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<tr>
<th>Well Location</th>
<th>Zone</th>
<th>Licensed Rate (m$^3$/d)</th>
<th>Licensed Volume (m$^3$/year)</th>
<th>2015 Average Diversion Volumes (m$^3$/d)</th>
<th>2015 Total Diversion Volumes (m$^3$/year)</th>
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Totals: 8,801, 3,059,555, 3,335, 1,217,183
Key Water Disposal Well: 102/11-07-082-22W4

- Required water disposal rates have remained steady
- 102/11-07 well at Main Battery handled approximately 90% of disposal needs in 2015

2015 Cumulative disposal at 11-07 well: 115,418 m³
Facilities Update
2015 Facility Modifications

• 11-07 South Battery shell & tube heat exchanger upgrade (carbon steel to stainless steel tube)
• No major facility modifications planned for 2016
2015 Pipeline Upgrades

- NE63-NE69 bare steel emulsion pipeline replacement (Started Q4 2015 and completed Q1 2016)
- NE59 cathodic bed upgrade
- Water injection riser replacements
  - SW41 to NW11.5, SE16.5 to SE11 & SE24.5 to SE28
- Miscellaneous emulsion pig barrel replacement
- Continued with proactive group emulsion/injection pipeline improvement program
- Target to complete the NE63 to NE69 water injection riser replacement scope in 2016
Pelican Lake Corrosion Mitigation Summary

Emulsion Pipeline Liner Pull / Replacement – 93% Complete
Emulsion Pad Piping Replacement – 84% Complete
Injection Pad Piping Replacement – 82% Complete
Injection Riser Replacement – 82% Complete
Major Facility Piping Replacement – ongoing

Currently discontinued – will not be in operation until liners are installed

Replacement completed in Q1 2016

Emulsion Pipeline Legend
Green – Liner Installed
Red – Bare Steel

11-07 South Battery
SE10.5 Satellite
13-11 Satellite
Measuring & Reporting Protocol

Methods of Measurement

• Oil and water: Flow meters on every producer and injector
• Solution gas: Proration from Gas Oil Ratio (GOR) testing

Typical Well Testing:

• Frequency and duration; well testing as per Directive 17
• No test tanks on any wells; all wells have flow meters

Field Proration Factors

• Within acceptable range (Oil: 0.90, Water: 0.95)
2015 Greenhouse Gas Emissions

• Vapor Recovery Units (VRUs) installed on production tanks (no routine gas venting off tanks)
• Air compressors (‘instrument air’) installed for operating pneumatic equipment (no gas venting)
• Glycol dehydrator at 11-07 South Battery. Still column vent tied in to Low Pressure flare (vent gas is combusted, not vented to atmosphere)
• Gas conserved on pads where economically feasible
• Total greenhouse gas emissions: 111,666 tonnes CO₂ equivalent
2015 – 2016 Development Activities
2015 Development Initiatives

• No drilling in 2015

• 2015 priorities:
  • Operating cost reductions
  • Optimizing injection rates, non-saline water usage, and polymer consumption
  • Flood Management
  • Polymer efficacy
  • Workover frequency reductions

• Continued reservoir characterization and simulation modeling to enhance long term field development strategy
AER Regulatory Discussion & Key Learnings
Current approval and downspacing is flexible for Cenovus to continue its infill program.

Cenovus is in compliance with all conditions of the approval and regulatory requirements.

Value in amending approval conditions for Scheme 9404 approval update to the AER every 2nd year?
End
Back-Up Slides
## Gas volumes - Total flared gas

- **Total flared gas:** 314.6 e3m3/year

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## Gas volumes - Total vented gas

### Total vented gas: 3,865.3 e3m³/year

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# Gas volumes - Total produced gas

- **Total produced gas:** 16,292.8 e3m3/year

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Gas volumes - Total fuel gas consumed

- Total fuel gas consumed: 21,357.3 e3m3/year

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Gas volumes - Total purchased gas

- **Total purchased gas: 15,974.6 e3m3/year**

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Gas volumes- Total fuel gas sold

- Total fuel gas sold: 0.0 e3m3/year
Pelican Lake Development History

- 1997 - Primary production (400m spacing), limited AEC exposure
- 1998 – AEC acquires Amber’s Interest in Pelican Lake
- 2001 - Waterflood pilot (400m spacing; infilled with injectors @ 200m)
- 2003 - Commercial Waterflood
- 2004 - Polymer Pilot
- 2006 - Commercial Polymer
- 2010 - Injection rates lowered to arrest watercut increases
- 2010 - Injection shut-in on pads for infill drilling program
- 2011 - Infill Drilling to 100 and 133m interwell spacing
- 2011 - Hot Water Pilot (Pad SE29)
- 2015 – Optimize field (low oil prices)
Typical Well Schematic: Example
Phase 3: Hot water circulation (SE29)

- Infill hot water injector
- Infill producer
- Existing well warm water injector
- Observation wells (T, P)

Hot water injection in edge wells
Circulate hot water (from toe) in center well and produce (from heel)

100 m
Pelican Lake Major Facilities Description

13-11 Satellite

- Utilizes two inclined free water knock out vessels (cold) to remove as much free water as possible from emulsion before sending to South Battery for processing
- Free water is pumped into high pressure injection line

SE10.5 Satellite

- Utilizes one inclined free water knock out vessel (cold) to remove as much free water as possible from emulsion before sending to South Battery for processing
- Free water is pumped into high pressure injection line

11-07 South Battery

- Utilizes inclined free water knock out (cold), heated knock out vessels, plate and frame heat exchangers, and 5 treaters to dewater emulsion to sales oil spec
- De-oiled water is pumped into high pressure injection line
Facility: 13-11 Satellite Process Flow
Facility: SE10.5 Satellite Plot Plan
Facility: SE10.5 Satellite Process Flow
Facility: SE10.5 Satellite Process Flow
Facility: SE10.5 Satellite Process Flow
Facility: 11-07 South Battery Plot Plan
Facility: 11-07 South Battery Plot Plan
Facility: 11-07 South Battery Process Flow
Facility: 11-07 South Battery Process Flow
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