2018 Performance Presentation
MacKay River Commercial Project
AER Scheme Approval No. 11715
April 1, 2018 to March 31, 2019
PCC-RA-PA-00003
Project Background

- PetroChina Canada ("PCC") owns and operates the MacKay River Commercial Project ("MRCP")

- The MRCP is a bitumen recovery project located within the Regional Municipality of Wood Buffalo ("RMWB") in northeast Alberta; approximately 30 km northwest of Fort McMurray

- The MRCP utilizes steam-assisted gravity drainage (SAGD) technology

- The MRCP is planned for phased development to peak capacity of 150,000bbl/d bitumen
MRCP Phase 1 Overview

- Phase 1 has a bitumen capacity of 35,000 bpd
- The Phase 1 development area (DA) includes:
  - 8 SAGD surface well pads and associated subsurface drainage patterns
  - 42 SAGD Horizontal well pairs
  - 850m long horizontal wells
  - 125m well spacing
  - The Central Processing Facility (“CPF”)
  - Water source wells and associated pipelines
  - Observation wells
  - Borrow areas
  - Access roads
  - Camps
## Directive 078 - Scheme Approval Amendments

<table>
<thead>
<tr>
<th>Amendment No.</th>
<th>Purpose</th>
<th>Approval Date</th>
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<tbody>
<tr>
<td>11715A</td>
<td>Drainage patterns AF and AG were combined into a single subsurface drainage pattern (AF)</td>
<td>12-Jun-2012</td>
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<td>11715B</td>
<td>Equipment reconciliation and design changes at the MRCP CPF</td>
<td>5-Sep-2013</td>
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<td>11715C</td>
<td>Amalgamation of MacKay Operating Corporation and Brion Energy Corporation into a single corporate entity.</td>
<td>15-Sep-2015</td>
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<td>11715D</td>
<td>Addition of 17 down-spaced well pairs in four subsurface drainage patterns (AA, AB, AC and AF) and deferral of the development of AI drainage pattern.</td>
<td>9-Nov-2015</td>
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<tr>
<td>NA</td>
<td>Approval to temporarily exceed the maximum operating pressure for 42 well pairs at MRCP.</td>
<td>21-Dec-2016</td>
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<tr>
<td>11715E</td>
<td>FUSE™ polymer fluid dilation process</td>
<td>03-March-2017</td>
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<td>11715F</td>
<td>Update for Corporate Name Change from Brion Energy Corporation to PetroChina Canada Ltd.</td>
<td>20-Oct-2017</td>
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<td>11715G</td>
<td>Application to Update the MOP at the MRCP</td>
<td>25-May-2018</td>
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<td>11715H</td>
<td>Application for the Steam Stimulation Process (AJ-05 Only)</td>
<td>31-May-2018</td>
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<td>11715 I and J</td>
<td>Application for Gas Cap Pressurization</td>
<td>08-June-2018</td>
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<td>11715K</td>
<td>Application for the Steam Stimulation Process (AF-05 Only)</td>
<td>23-Oct-2018</td>
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<td>11715L</td>
<td>Well Design Enhancements</td>
<td>14-Nov-2018</td>
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<td>11715M</td>
<td>Producer Re-Entries and Sidetrack; Co-Injection for Gas Cap Pressurization; Four Injector Re-Drills</td>
<td>7-Dec-2018</td>
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<td>11715N</td>
<td>Bottom Transition Zone Treatment</td>
<td>18-Dec-2018</td>
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<td>11715O</td>
<td>Polymer Treatment</td>
<td>22-Mar-2019</td>
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<td>11715P</td>
<td>Wellbore Conditioning and Stabilization</td>
<td>Pending</td>
</tr>
</tbody>
</table>
3.1.1 SUBSURFACE ISSUES RELATED TO RESOURCE EVALUATION AND RECOVERY
Scheme Approval Area Overview

- 287 total vertical wells in the MRCP Project Area (“PA”)
MRCP1 Wells – Vertical & SAGD

- 114 vertical wells in MRCP Development Area ("DA")
- 42 horizontal well pairs in MRCP DA

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Wells</th>
<th>Cored Wells</th>
<th>Speciality Logged</th>
<th>Petrographically Analysed</th>
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<td>2009</td>
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<td>2012</td>
<td>16</td>
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<td>2013</td>
<td>29</td>
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<td>5</td>
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<tr>
<td>2014</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2015</td>
<td>19</td>
<td>19</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>2016</td>
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<td>2017</td>
<td>1</td>
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<td>0</td>
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<tr>
<td>2018</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
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<tr>
<td>TOTAL</td>
<td>114</td>
<td>67</td>
<td>50</td>
<td>26</td>
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</table>
MacKay River Stratigraphy

- Caprock is Argillaceous Lower Clearwater
- Wabiskaw sand above McMurray across DA
- Target reservoir is Upper McMurray

Contour Interval = 5m
Oil Sands Pay Facies
MRCP Upper McMurray Facies

**Pay Facies:**
- Includes Facies F8a, F9, F10, F11, F12
- Typically >30% Porosity
- Weight percent bitumen >8%
- Permeability ~0.9-2.7 Darcy’s
Bitumen Net Pay Map – Project Area

- Net pay cut-off at ≥10m
- Thickness ranges from 10-25m in the DA
- Upper McMurray reservoir shows strong NW-SE trend
- DA lies 2km South of AER Oil Sands Shallow Thermal Area
Bitumen Net Pay Map – Development Area

- Net pay cut-off at ≥10m
- Thickness ranges from 10-25m in the DA
- Upper McMurray reservoir shows strong NW-SE trend
- Central processing facility located Southwest of development area
- Majority of 8 drainage boxes are in >15m bitumen pay
• Base of pay is reasonably flat across existing 8 drainage boxes

• Base of pay elevation rises on Southwest side of DA
• Top of Pay is relatively consistent over the 8 drainage boxes in the DA

• The Top of Pay fluctuates only ~6m between 308-314m SS across the entire DA
MCMR Top Gas Isopach Map

- Top gas zone present in the upper McMurray over the DA
- Ranges in thickness from approximately 0 to 3 meters
Lower Transition Zone Map

• Criteria:
  • Porous & clean sandy facies with >50% water saturation (GR ≤ 75API, DPSS≥27%, RT<20ohmm, sandy facies)
  • In communication with and below pay zone

• Characteristics:
  • Thin: <1.0m over most of the Phase 1 drainage boxes
  • Limited Lateral Extent

Contour Interval = 0.5m

<table>
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<th>Parameter</th>
<th>Average</th>
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<tr>
<td>Total Water Saturation</td>
<td>70%</td>
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<tr>
<td>Total Porosity</td>
<td>33%</td>
</tr>
<tr>
<td>Horizontal Permeability (Core)</td>
<td>3300 mD</td>
</tr>
<tr>
<td>Vertical Permeability (Core)</td>
<td>2400 mD</td>
</tr>
</tbody>
</table>
Upper Transition Zone Map

- Criteria:
  - Porous & clean sandy facies with >50% water saturation (GR ≤ 75API, DPSS≥27%, RT<20ohmm, sandy facies)
  - In communication with and above pay zone

- Characteristics:
  - Thin: <1.5m over most of the Phase 1 drainage boxes
  - Limited Lateral Extent
# Geologic and Reservoir Properties – OBIP FOR OPERATING AREA

<table>
<thead>
<tr>
<th>Drainage Box</th>
<th># Well Pairs</th>
<th>Drainage Box Area (m²)</th>
<th>Average</th>
<th>Average</th>
<th>Reservoir Model Average</th>
<th>Reservoir Model Average</th>
<th>Average Bitumen Pay Thickness (m)</th>
<th>Drainage Box OBIP (10⁶ bbl)</th>
<th>Estimated RF (%)*</th>
<th>Estimated Drainage Box RBIP (10⁶ bbl)*</th>
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<tbody>
<tr>
<td>AA</td>
<td>6</td>
<td>698,200</td>
<td>0.83</td>
<td>0.34</td>
<td>2.7</td>
<td>1.1</td>
<td>21.3</td>
<td>26.4</td>
<td>54</td>
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<tr>
<td>AB</td>
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<td>562,600</td>
<td>0.8</td>
<td>0.34</td>
<td>2.7</td>
<td>1.1</td>
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<td>21.8</td>
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<td>AC</td>
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<td>16.7</td>
<td>63</td>
<td>10.5</td>
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<td>AD</td>
<td>5</td>
<td>560,100</td>
<td>0.77</td>
<td>0.33</td>
<td>2.6</td>
<td>1</td>
<td>20.8</td>
<td>18.6</td>
<td>54</td>
<td>10.1</td>
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<tr>
<td>AE</td>
<td>6</td>
<td>674,700</td>
<td>0.76</td>
<td>0.33</td>
<td>2.2</td>
<td>0.9</td>
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<td>22</td>
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<td>AH</td>
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<td>48</td>
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<tr>
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<td>562,300</td>
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<td>0.34</td>
<td>2.5</td>
<td>0.9</td>
<td>20.5</td>
<td>18.5</td>
<td>57</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42</strong></td>
<td><strong>4,746,300</strong></td>
<td><strong>0.79</strong></td>
<td><strong>0.34</strong></td>
<td><strong>2.6</strong></td>
<td><strong>1</strong></td>
<td><strong>21.3</strong></td>
<td><strong>170.2</strong></td>
<td><strong>56</strong></td>
<td><strong>11.9</strong></td>
</tr>
</tbody>
</table>

**OBIP** = Original Bitumen In-Place and measured in 10⁶m³ units and converted to 10⁶ barrels using conversion factor of 6.2898

**NRV** = Net Rock Volume in 10⁶m³ derived from deterministic mapping of SAGDable net pay, or from geomodel calculations

**SO** = Average bitumen saturation from the SAGD exploitable reservoir interval generated from 1-SWT (in fractions)

**PORT** = Average porosity from the SAGD exploitable reservoir interval generated from PORT (in fractions)

\[
OBIP = (NRV \times PORT \times SO)
\]

**Note:**
1. Reservoir Model Average permeability is extracted from history matched reservoir model and may change year to year
2. Core based permeability analysis of reservoir sands within DA
   - Avg Kh = 4,400mD (Range = 500mD – 12,000mD+)
   - Avg Kv = 3,770mD (Range = 200mD – 10,000mD+)
### Geologic and Reservoir Properties – OBIP

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Development Area</th>
<th>Project Area</th>
</tr>
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<tbody>
<tr>
<td>Top of Reservoir Depth (mTVD)</td>
<td>176</td>
<td>175</td>
</tr>
<tr>
<td>Top of Reservoir Depth (TVD masl)</td>
<td>315</td>
<td>311</td>
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<tr>
<td>Base of Reservoir Depth (mTVD)</td>
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<td>193</td>
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<tr>
<td>Base of Reservoir Depth (TVD masl)</td>
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<td>293</td>
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<tr>
<td>Net Pay Thickness (m)</td>
<td>21.3</td>
<td>12.8</td>
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<tr>
<td>Porosity (frac)</td>
<td>0.34</td>
<td>0.33</td>
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<tr>
<td>Bitumen Saturation (frac)</td>
<td>0.79</td>
<td>0.75</td>
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<tr>
<td>OBIP ($10^6$ bbl)</td>
<td>170.2</td>
<td>2890.8</td>
</tr>
<tr>
<td>OBIP ($10^6$ m³)</td>
<td>27.1</td>
<td>459.6</td>
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<tr>
<td>Initial Pressure (kPaa)</td>
<td>220 (top) – 400 (bottom)*</td>
<td>220 (top) – 400 (bottom)*</td>
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<tr>
<td>Original Reservoir Temperature (°C)</td>
<td>6</td>
<td>6*</td>
</tr>
</tbody>
</table>

* Extrapolated from operating area
Structural Cross-Section across MRCP

- Good reservoir quality with continuity along Development Area
- Minor structural variation at base of pay
- Thick and laterally continuous caprock with consistent lithology
NW–SE Structural Cross-Section:
Drainage boxes: AF, AC, AA, AB

- Clean and consistent reservoir thickness over the 4 drainage boxes
- Bitumen thickness ranges from 15 to 20+m
- Producer wells placed 1m from base of pay
- Injector wells placed 5m above producer
NW–SE Structural Cross-Section: Drainage boxes: AB, AD, AE, AH

- Clean and consistent reservoir thickness over the 4 drainage boxes
- Bitumen thickness ranges from 15 to 20+m
- Producer wells placed 1m from base of pay
- Injector wells placed 5m above producer
W–E Structural Cross-Section: Drainage boxes: AB, AJ

- Bitumen thickness ranges from 10 to 20+m
- Producer wells placed 1m from base of pay
- Injector wells placed 5m above producer
MRCP Seismic

Coverage Across MRCP includes:
- ~96 km of 2D
- ~58.4 km² of 3D
- ~3.9 km² of 3D baseline for 4D
- ~3.5 km² of 4D in 2018 - Interpreted
- ~3.0 km² of 4D in 2019 – Processing

3D acquired in MRCP to help:
- Assess Caprock
- Plan/drill horizontal well trajectories
- Assess McMurray reservoir

4D seismic survey acquired at MRCP in 2019
- Will monitor steam chamber growth
- Updated 4D coverage 2019 acquisition
4D-Derived Steam Chambers from 2018 4D

Interpreted Steam Chamber Bodies

4D RMS Amplitude Differences

4D Anomalies

4D Inversion
Special Core Analysis – Petrographic Analysis

- PCC has conducted a combination of different studies on 26 cored wells in the initial Development Area.
- Studies done on highlighted wells include:
  - CT Scan - 1
  - XRF - 3
  - SEM - 17
  - XRD - 26
  - Thin sections - 24
  - Grain size analysis – 24
  - Hyperspectral Imaged – 4
Reservoir Pressure Update

- MRCP reservoir was initially at low pressure:
  - Initial pressure of 100 – 200 kPag at the top of McMurray Formation reservoir
  - Initial pressure of 300 - 400 kPag at the base of McMurray Formation reservoir and the Bottom Transition Zone
  - Pressure of 900 to 1,000 kPag in Wabiskaw sand above reservoir indicates competent isolation from the McMurray

- MRCP Pressure Update:
  - In May 2018, PCC received AER approval to increase the Maximum Operating Pressure (MOP) to 2,594 kPag at MRCP (set point 2,525 kPag)
  - Since project start-up the pressure build-up and pressure distribution in the various zones in the reservoir has been closely monitored by PCC through its observation wells network.
    - Operating Pressure within the approved range is applied in SAGD well pairs in the field on a case by case basis. Current range is from 2,525 kPag in North DA to 1,450 kPag in South DA.
    - Gas cap pressurization started in Sep 2018, pressure ranges from ~2,000 kPag in Central and North areas of DA (influenced by SAGD activity & gas injection) to ~300 kPag in outer areas of DA under surveillance
    - Bottom Transition Zone pressure has also increased, ranging from 2,400 kPag in North DA (thinner BTZ) to 1,100 kPag in South DA (thicker BTZ)
    - Wabiskaw sand remains at ~1,000 kPag
Gas Cap Pressurization

- Purpose of gas cap pressurization at MRCP is to increase the pressure in the gas cap to operate at a more favourable pressure balance between steam chambers and top thief zones to minimize steam losses
  - Initial gas cap pressure of 200 kPag, presented a challenge to SAGD operation pressure balance
  - Evidence of steam chamber communication to the gas cap since early 2018
  - The pressurization process started in Sep 2018. Natural gas is injected in the vertical well 103/05-13-090-14W4-00, at rates close to the approved limit of 80,000 Sm3/d
  - PCC is monitoring the pressurization process through the pressure gauges installed at the gas cap level in observation wells. Permanent evaluation of the reservoir performance and response to injection will determine optimum pressure target
  - Gas co-injection started in Jan 2019, mainly in South DA to support gas cap pressurization in areas distanced from injector 05-13, typical co-injection rates ranges from 2,400 to 4, 200 Sm3/d (approved 5,000 Sm3/d)
Observation Well Overview

• Total of 46 observation wells for MRCP
  o One additional observation well conversion: North West of Pad AF
• This network has been designed to monitor the following themes:
  o Caprock Monitoring
  o Reservoir Top Gas
  o Bottom Transition Zone
  o Baffles/barriers above injector
  o Baffles/barriers between producer/injector
  o History Match / Chamber Development
    ▪ Early Stage (< 10 m)
    ▪ Late Stage (> 10 m)
  o Lateral/Regional Monitoring (> 100m)
• According to their design, they are classified as:
  o Obs Wells w/ just Thermocouples
  o Obs Wells w/ Thermocouples and EREs
  o Perforated Obs Wells w/ Thermocouples and/or EREs (Single Zone)
  o Perforated Obs Wells w/ Thermocouples and/or EREs (Multi Zone)
Typical Observation Well Design

- Example of the types of observation well design and instrumentation configurations at MRCP:

  **Vendor provided diagrams: Petrospec Engineering Ltd. and Packers Plus**

  **Type of gauge reading:**
  - (T) Only temperature
  - (P/T) Temperature & Pressure
Observation Well RST

- Reservoir Saturation Tool (RST) is used to track steam chamber development over time
- MRCP DA RST Logging:
  - Two RST logs run in 2017 to calibrate pre-steam baseline
  - Nine RST logs run in 2018 (~6-8 months of SAGD production) distributed across most pads
  - No RST logging in 2019
  - PPC is evaluating the time for next round of RST logging
- Examples:

AC03A: 1m from Producer AC03 (heel)  
AA01E: 3m from Producer AA01 (toe)  
AD05E: 3m from Producer AD05 (toe)

RST logging was conducted in 9 observation wells during Q1, 2018 to assess saturation changes.
- Initial stage of steam chamber development
- RST correlates with observation well temperature records
Characterization of Caprock

PCC has collected the following dataset for caprock characterization from delineation and coreholes within the DA:

- Formation Image logs for 37 wells
- Cored 67 wells
- 4 Caprock core
**MRCP Geomechanics: Mini-frac tests**

- Mini-frac tests were conducted between 2009-2016, no new test since 2016
- The results are in agreement with local and regional trends
- The average caprock fracture gradient measured for the MRCP region within the argillaceous Clearwater is 21.59 kPag/m
- Approved maximum operating pressure (MOP):
  - In 2018, PCC obtained approval to increase its MOP to 2,594 kPag calculated from base of Clearwater caprock in Phase 1 area of 150.2 mTVD and a gradient of 14.7 kPag/m. PCC has chosen to set SAGD operating pressure at 2,525 kPag (injection pressure set point)

<table>
<thead>
<tr>
<th>Well</th>
<th>Year</th>
<th>Formation</th>
<th>Fracture Gradient (kPag/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/04-23-90-14W4M</td>
<td>2009</td>
<td>McMurray Oil Sand</td>
<td>16.7</td>
</tr>
<tr>
<td>1AA/06-07-90-13W4M</td>
<td>2009</td>
<td>Clearwater Caprock</td>
<td>21.5</td>
</tr>
<tr>
<td>1AA/14-28-90-14W4M</td>
<td>2013</td>
<td>McMurray Oil Sand</td>
<td>14.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clearwater Caprock</td>
<td>20.6</td>
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<tr>
<td></td>
<td></td>
<td>Wabiskaw shale</td>
<td>21.3</td>
</tr>
<tr>
<td>100/03-14-090-15W4</td>
<td>2016</td>
<td>McMurray Oil Sand</td>
<td>16.9</td>
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<td></td>
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<td>Clearwater Caprock</td>
<td>22.3</td>
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<tr>
<td></td>
<td></td>
<td>Wabiskaw shale</td>
<td>18.8</td>
</tr>
</tbody>
</table>
MRCP Geomechanics

- Caprock integrity testing and geomechanics

  - Caprock core testing was completed in well 1AA/06-07-090-13W4: tri-axial laboratory testing, and X-ray diffraction analysis.

  - Field measured in-situ stress conditions and fracture criteria were also inputs to the geomechanical model, minifrac: 1AA/06-07-090-13W4 / 100/04-23-90-14W4M

  - Geomechanical simulations using ABAQUS, a commercial finite element stress analysis software, ran by BitCan were conducted to provide confirmation that SAGD operations at MRCP will not pose any risk to the caprock integrity.

  - Additional studies were conducted by CGG GeoConsulting for PCC in 2018 to support MOP increase application, main conclusion indicated that an increased MOP of 2,594 kPag is safe and does not present a significant risk of shear failure of the caprock.
• **Overburden intervals:**
  1. Quaternary Sediments: from surface to the Grand Rapids
  2. Grand Rapids, overlies Clearwater
  3. Clearwater Formation, which is the gross caprock
  4. Argillaceous interval of Clearwater, primary caprock for MRCP. It is present across the MRCP DA, is a thick (>21 m), and laterally continuous, consistent, clay-rich caprock, free of influence of any vertical pore pressure transmission pathways.

Some instrumentation is set outside casing of observation wells to monitor the Clearwater intervals

5. Wabiskaw sand, which is the first known horizontal pathway on top of the reservoir. Main target for reservoir containment assurance and/or caprock integrity monitoring, early warning for pressure buildup.

6. Wabiskaw shale lies above the McMurray reservoir, and this is the lower-most interval included within the overburden monitoring strategy.
Caprock Monitoring: Observation Wells

- Monitoring caprock pressure and temperature in 9 vertical wells
- Electromagnetic Resonating Element (ERE) gauges for pressure and temperature on exterior of production casing or interior with perforation.
- Wabiskaw Sand Monitoring:
  - 2 vertical wells drilled to base Wabiskaw (isolated from McMurray reservoir): AJ02CR and AC02CR
  - Equipped with interior pressure/temperature ERE
- Caprock Monitoring – Wabiskaw and Clearwater:
  - 7 vertical wells drilled to the base of the McMurray Formation: AB05E, AD05E, AF04A, 00-03, AB04B, AE03C and AD05C.
  - Pressure and temperature in one to four layers within the caprock intervals on the exterior of production casing.
Caprock Monitoring: Pressure and Temperature in Wabiskaw Sand

Wabiskaw sand is the first line of defense of MRCP caprock

- Wabiskaw average pressures and temperatures:
  - Pressure 900 – 992 kPag (initial range: 900 - 950 kPag)
  - Temperature 6-14 °C (initial range: 5-7 °C)
  - Pressure and temperature changes since mid July. Slow pressure and temperature build-up expected.
- Caprock observation well data pressure and temperature is reviewed bi-weekly.

ERE gauge in obs well AD05C (@ Wabiskaw sand) has been identified as having communication through the cement with the lower part of the well (see slide No. 57 for more information)

- Off trend Pressure and temperature build-up
  - 1,022 kPa & 12°C @ Mar 2019
- PCC is closely monitoring this well and will execute remedial actions in 2019-2020
Surface Displacement Monitoring

- PCC has an extensive network of corner reflectors installed for surface displacement and heave monitoring
  - PCC implemented ground displacement monitoring using 104 corner reflectors over MRCP using Synthetic-aperture Radar Interferometry (InSAR) technology.
  - The total amount of displacement measured from September 2014 to March 2018 is shown in the map
  - Subsidence more dominant in Northern Pads AF, AC & AA
  - Other areas of localized subsidence were identified off pad
  - Subsidence coincide with Muskeg areas
  - Central and southern pads AJ, AB, AD, AE and AH show heave
  - Maximum and minimum values of cumulative displacement per pad, Sep 2014 – Mar 2018 are shown in the following table:

<table>
<thead>
<tr>
<th>Pad</th>
<th>September 2014 to March 2018 Cumulative Displacement (mm)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF</td>
<td>-24.0 T4 +10.8 H2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>-26.4 H11 +19.2 T8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>-20.2 H26 +15.2 H34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>-18.4 H36 +35.2 H37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AJ</td>
<td>-22.1 T15 +43.3 H39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AD</td>
<td>+9.7 H45 +32.5 H47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE</td>
<td>+5.2 T16 +28.2 H59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AH</td>
<td>-13.7 H61 +36.7 T18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI</td>
<td>-3.8 R9 +15.5 H70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-pad</td>
<td>-36.9 R6 +18.6 H38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Map and image showing ground displacement monitoring using corner reflectors over the Mackay River Oil Field, Alberta](image-url)
SSP – Field Test

- Steam Stimulation Process (SSP): injection of a limited amount of steam at high pressure to create a dilation of the reservoir rock surrounding the selected SAGD well pair. During the SSP steam is injected in a SAGD well pair in order to cause the rock matrix around the wellbore to dilate and increase porosity and permeability, improving fluid mobility through mud laminations or low permeability streaks.

- The objectives of the SSP are as follows:
  - Enhance communication between injector and producer wells following conversion to SAGD mode.
  - Enhance SAGD well productivity and overall bitumen recovery by increasing the porosity and permeability of the reservoir around the wellbore.
  - Evaluate the applicability of this technology for use in future well pair additions to the MRCP and other PCC oil sands projects.

- During the reporting period, 2 SSP tests were conducted at MRCP:
  - AJ05 (Jul-Aug, 2018)
  - AF05 (Dec, 2018 – Jan, 2019)
SSP – Field Test

• Summary of SSP execution: AJ05 & AF05

SSP safely executed
• All observation wells pressure gauges and adjacent SAGD well pairs steady
• No interference observed, no alarms triggered
• Reported to AER:
  • No improvement after SSP – Challenging Reservoir Conditions
  • Requested approval for testing SSP in other candidates
  • Requested flexibility on time constrains for future tests

Summary of SSP - Time and Volume Constraints vs. Test Actuals

<table>
<thead>
<tr>
<th></th>
<th>Max Press (kPag)</th>
<th>Days injecting at Max Press</th>
<th>Days injecting above 3,400 kPag</th>
<th>Volume injected above 3,400 kPag (m³)</th>
<th>Max Days operating above MOP</th>
<th>Max injected Volume above MOP (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorized by AER</td>
<td>4,500</td>
<td>2</td>
<td>7</td>
<td>6,000</td>
<td>30</td>
<td>16,000</td>
</tr>
<tr>
<td>AJ05 Actuals</td>
<td>4,400</td>
<td>0</td>
<td>7.1 *</td>
<td>4,335</td>
<td>27.5</td>
<td>8,423</td>
</tr>
<tr>
<td>AF05 Actuals</td>
<td>4,400</td>
<td>0</td>
<td>6.2</td>
<td>2,262.1 (+125)**</td>
<td>25.8</td>
<td>4,022.5 (+125)**</td>
</tr>
</tbody>
</table>

* Time exceedance (2h; 22m) during final depressurization stage, timely communicated to AER by PCC
** Additional volume due to passing valves identified after steam S/I, timely communicated to AER by PCC
**MRCP Standard Completion Schematic**

**Injector**
- 16" Surface casing at 40 - 45° spud angle (406.4 mm, 96.73 kg/m, K-55, Hydril 521, ~90 mMD).
- 11 3/4" Intermediate casing (298.5 mm, 80.36 kg/m, TN80TH, Tenaris Blue, ~400-455 mMD)
- 8 5/8" Slotted liner (219.1 mm, 47.62 kg/m, TN55TH, Tenaris Blue Thermal Liner, ~1250-1305 mMD to TD)
- 11 3/4" Intermediate casing (298.5 mm, 80.36 kg/m, TN80TH, Tenaris Blue, ~400-455 mMD)
- 8 5/8" slotted Liner (219.1 mm, 47.62 kg/m, Tenaris Blue Thermal Liner, ~1250-1305 mMD to TD)

**Producer**
- 1/4" Capillary line clamped onto the 4 1/2" Heel string for redundant bubble gas BHP.
- 16" Surface casing at 40 - 45° spud angle (406.4 mm, 96.73 kg/m, K-55, Hydril 521, ~90 mMD).
- 11 3/4" Intermediate casing (298.5 mm, 80.36 kg/m, TN80TH, Tenaris Blue, ~400-455 mMD)
- 8 5/8” Slotted Liner (219.1 mm, 47.62 kg/m, Tenaris Blue Thermal Liner, ~1250-1305 mMD to TD)

PCP or ESP

*All wells with either DTS or FBG Temperature Fiber*
## Summary of Alternate Completions

<table>
<thead>
<tr>
<th>System</th>
<th>Principle</th>
<th>Use in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam distribution control devices</td>
<td>Reduction of pressure gradient in the liner- better distribution of steam</td>
<td>AA02I, AB02I and AD02I</td>
</tr>
<tr>
<td>Inflow control devices Liner Based</td>
<td>Reservoir inflow equalization</td>
<td>AC01P and AD02P</td>
</tr>
<tr>
<td>Alternative sand control using Wire Wrap Screens (WWS)</td>
<td>Maximization of opened flow area to reduce completion drawdown</td>
<td>AE03P</td>
</tr>
<tr>
<td>Alternative sand control using Precision Punched Screens (PPS)</td>
<td>Improved filter media resistance to wearing using: better metallurgy and change of fluid momentum. Reduced tendency to plugging minimizing the thickness of the slots.</td>
<td>AH04P and AF02P</td>
</tr>
<tr>
<td>Tubing Deployed Inflow Control Devices (TDICD)</td>
<td>Adds back-pressure to regions of the well, at or near steam breakthrough conditions</td>
<td>AD03, and AA05</td>
</tr>
</tbody>
</table>

### Trial status to-date (March 2019):
- No specific advantages of using WWS on AE03P or PPS on AH04P have been observed thus far
- On the contrary, AF02P equipped with PPS has shown very good performance after conversion to SAGD
  - Constantly low drawdown (DP) of ~100 kPa (the lowest on the pad)
  - Highest normalized emulsion production rate on the pad
  - Highest normalized cumulative emulsion production on the pad
- The use of TDICDs is being trialed on wells with low liner drawdown, and where one or more controlling hot-spots limits the production from the well. Evaluation of this application is ongoing.
Steam Control Devices Test

- The injector wells that have steam control devices installed are: AA02I, AD02I and AB02I.

- These wells have a full fibre optic temperature sensor in the injector to allow better monitoring of the steam chamber growth.

Inflow Control Devices Test

- The liner deployed ICDs on AD02P and AC01P have performed well, yielding good overall conformance and production.

- Application of ICDs has been expanded to include tubing deployed systems. TDICDs have been installed at AD03P and AA05P, and are currently being evaluated.
Artificial Lift - Performance

• General ESP Designs:
  I. Emulsion flow: 120 m$^3$/d – 600+ m$^3$/d
  II. Max temp: 250°C (Typically operated <200°C)
  III. Max head: 600 m (surface pipe pressure rating limitation)
  IV. GOR: 2 – 8 m$^3$/m$^3$
  V. MTTF expectation: 24 mo. (min).
  VI. Current PCC MTTF not representative, since only 1 failure realized to date (18 mo. Run time).

• General PCP Designs:
  I. Emulsion flow: 70 m$^3$/d – 260+ m$^3$/d
  II. Max temp: 300°C (Typically operated <200°C)
  III. Max head: N/A (surface pipe protections in place)
  IV. Average 40% volume efficiency after 6 months of operation
  V. GOR: 2 – 8 m$^3$/m$^3$
  VI. MTTF: 16.4 mo. (includes DH mechanical failures)

Average PBHP – 1750 kPag,
Artificial Lift – Distribution of Lift Types

<table>
<thead>
<tr>
<th>Artificial Lift Distribution</th>
<th>AE PAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA PAD</td>
<td>AE01</td>
</tr>
<tr>
<td>AA01 (ESP)</td>
<td>AE02</td>
</tr>
<tr>
<td>AA02 (ESP)</td>
<td>AE03 (ESP)</td>
</tr>
<tr>
<td>AA03</td>
<td>AE04</td>
</tr>
<tr>
<td>AA04 (ESP)</td>
<td>AE05</td>
</tr>
<tr>
<td>AA05 (ESP)</td>
<td>AE06</td>
</tr>
<tr>
<td>AA06 (ESP)</td>
<td></td>
</tr>
<tr>
<td>AB PAD</td>
<td>AF PAD</td>
</tr>
<tr>
<td>AB01</td>
<td>AF01 (ESP)</td>
</tr>
<tr>
<td>AB02 (ESP)</td>
<td>AF02 (ESP)</td>
</tr>
<tr>
<td>AB03 (ESP)</td>
<td>AF03</td>
</tr>
<tr>
<td>AB04 (ESP)</td>
<td>AF04 (ESP)</td>
</tr>
<tr>
<td>AB05</td>
<td>AF05 (ESP)</td>
</tr>
<tr>
<td>AC PAD</td>
<td>AF06 (ESP)</td>
</tr>
<tr>
<td>AC01 (ESP)</td>
<td>AH PAD</td>
</tr>
<tr>
<td>AC02 (ESP)</td>
<td>AH01 (ESP)</td>
</tr>
<tr>
<td>AC03 (ESP)</td>
<td>AH02</td>
</tr>
<tr>
<td>AC04 (ESP)</td>
<td>AH03 (ESP)</td>
</tr>
<tr>
<td>AD PAD</td>
<td>AH04</td>
</tr>
<tr>
<td>AD01</td>
<td>AH05</td>
</tr>
<tr>
<td>AD02 (ESP)</td>
<td>AJ PAD</td>
</tr>
<tr>
<td>AD03 (ESP)</td>
<td>AJ01 (ESP)</td>
</tr>
<tr>
<td>AD04 (ESP)</td>
<td>AJ02</td>
</tr>
<tr>
<td>AD05</td>
<td>AJ03</td>
</tr>
<tr>
<td></td>
<td>AJ04</td>
</tr>
<tr>
<td></td>
<td>AJ05</td>
</tr>
</tbody>
</table>

**Wells not indicating ESP lift, utilize Metal-Metal PCPs**

**General Comments**

- All 42 wellpairs utilize artificial lift for SAGD production.
- Two artificial lift types are utilized at MRCP: ESP and PCP.
- 16 ESP conversion were completed in the past year.
- Of the remaining 42 wellpairs 18 wells continue to utilize metal-metal PCPs.
- Conversion of wells from PCP lift to ESP is evaluated on an opportunity basis, when PCPs fail/lose lift capability, or when the well is worked over for other reasons.
### Summary of Downhole Instrumentation

#### Injection Well Instrumentation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type of Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down hole pressure</td>
<td>Blanket gas / Pressure Transmitter</td>
</tr>
<tr>
<td>Blanket gas injection rate</td>
<td>Coriolis meter</td>
</tr>
<tr>
<td>Toe string steam injection rate</td>
<td>Vortex meter</td>
</tr>
<tr>
<td>Toe string well head pressure</td>
<td>Pressure transmitter</td>
</tr>
<tr>
<td>Heel string steam injection rate</td>
<td>Vortex meter</td>
</tr>
<tr>
<td>Toe string well head pressure</td>
<td>Pressure transmitter</td>
</tr>
</tbody>
</table>

#### Producer Well Instrumentation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type of Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down hole pressure</td>
<td>Optic pressure sensor (phasing out)</td>
</tr>
<tr>
<td>Down hole pressure</td>
<td>Bubble Tube / Pressure transmitter</td>
</tr>
<tr>
<td>Blanket gas injection rate</td>
<td>Coriolis meter</td>
</tr>
<tr>
<td>Toe string steam rate (Circ)</td>
<td>Vortex meter</td>
</tr>
<tr>
<td>Toe string well head pressure</td>
<td>Pressure transmitter</td>
</tr>
<tr>
<td>Well bore temperature</td>
<td>DTS or FBG fibre optic system</td>
</tr>
<tr>
<td>Return well head pressure</td>
<td>Pressure transmitter</td>
</tr>
<tr>
<td>Return well head temperature</td>
<td>Temperature transmitters</td>
</tr>
<tr>
<td>Return rate</td>
<td>Coriolis meter</td>
</tr>
<tr>
<td>System</td>
<td>Type</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Pressure and temperature sensor at the heel</td>
<td>Optic sensor</td>
</tr>
<tr>
<td>Pressure and Temperature sensor at heel</td>
<td>Piezo meter</td>
</tr>
<tr>
<td>Heel Thermocouple</td>
<td>Thermocouple</td>
</tr>
<tr>
<td>DTS well bore temperature sensing system</td>
<td>Fibre optic DTS</td>
</tr>
<tr>
<td>LxData well bore temperature sensing system</td>
<td>Fibre optic FBG</td>
</tr>
<tr>
<td>Pressure sensor at the toe of the well</td>
<td>Fibre optic FBG</td>
</tr>
</tbody>
</table>
Well Production Testing

• Well production and injection volumes are estimated by the use of Coriolis meters (emulsion) and vortex meters (injection) for each well as the raw data check for the well tests

• MRCP utilizes one test separator per pad that automatically cycles through each well on the pad every 24 hours.
  • Typically each well will be in test for at least 120 hours per month
  • Well testing validations are completed once per week per pad within the Energy Components software

• This data is rolled up and balanced with the facility production and injection volumes to determine month end pro-rations prior to submission to Petrinex
MRCP – Update on Performance Prediction Methodology

- Actual performance has deviated from pre-steam forecasted performance
- Geological and reservoir models have been updated since first steam
- PCC has reviewed analog field performance and has developed its own methodology for performance predictions
  - Reservoir simulations are used to history match well pair, pad and field performance. The forecast is based on a history matched model of:
    - steam injection
    - produced oil and water
    - historical pressures
MRCP is continuing to ramp up production
Steam and thus SOR impacted by top gas zone effects and areas of thicker lower transition zone
Geological baffles (zones of higher mud bed frequency) impacting chamber growth and performance in areas of the reservoir
2018 monthly exit rate (1000 m3/d)
Late 2018 production primarily impacted by workovers, well testing and infill drilling activity
NCG Injection at 103/05-13 was started in September followed by additional co-injection in approved wells
• In a few areas, steam chamber interactions with top gas and losses to the lower transition zone has resulted in higher retention by the reservoir.
• Mitigation strategies in execution include gas cap pressurization (gas injection and co-injection), balancing operating pressures with multiple thief zones
### MRCP – Performance Indicators by Pad

<table>
<thead>
<tr>
<th>Pad</th>
<th>OBIP (m³)</th>
<th>Cum. Oil to March 31 2018 (m³)</th>
<th>Recovery to March 31 2018 (%)</th>
<th>CSOR</th>
<th>ISOR</th>
<th>Ultimate Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>4,197,138</td>
<td>141,169</td>
<td>3.36</td>
<td>5.9</td>
<td>4.7</td>
<td>54</td>
</tr>
<tr>
<td>AB</td>
<td>3,465,819</td>
<td>119,350</td>
<td>3.44</td>
<td>7.5</td>
<td>9.2</td>
<td>57</td>
</tr>
<tr>
<td>AC</td>
<td>2,655,008</td>
<td>114,765</td>
<td>4.32</td>
<td>4.9</td>
<td>4.5</td>
<td>63</td>
</tr>
<tr>
<td>AD</td>
<td>2,957,075</td>
<td>81,757</td>
<td>2.76</td>
<td>9.2</td>
<td>7.4</td>
<td>54</td>
</tr>
<tr>
<td>AE</td>
<td>3,513,514</td>
<td>71,111</td>
<td>2.02</td>
<td>11.3</td>
<td>9.6</td>
<td>53</td>
</tr>
<tr>
<td>AF</td>
<td>4,149,444</td>
<td>160,052</td>
<td>3.86</td>
<td>5.4</td>
<td>4.5</td>
<td>62</td>
</tr>
<tr>
<td>AH</td>
<td>3,179,650</td>
<td>31,335</td>
<td>0.99</td>
<td>24.2</td>
<td>12.2</td>
<td>48</td>
</tr>
<tr>
<td>AJ</td>
<td>2,941,176</td>
<td>52,901</td>
<td>1.80</td>
<td>17.1</td>
<td>13.3</td>
<td>57</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>27,058,824</strong></td>
<td><strong>772,440</strong></td>
<td><strong>2.85</strong></td>
<td><strong>8.3</strong></td>
<td><strong>6.6</strong></td>
<td><strong>56</strong></td>
</tr>
</tbody>
</table>

- Higher SORs experienced on AE, AH, AJ and AB pads primarily due to gas cap contact and slightly larger lower transition zone leak off.
- Mitigations:
  - Operating pressure is balanced accordingly with the thief zones pressure
  - Gas cap pressurization with natural gas started in Sep 2018 in vertical well 05-13 (central DA)
  - Gas co-injection started in well pairs of pads AH, AE, AD in Jan 2019 to support gas cap pressurization in the Southern DA
MRCP – Pad AF: High Performance Example

![Graph showing Pad AF performance parameters over time. The graph includes lines for Steam Rate (m3/d), Oil Rate (m3/d), Water Rate (m3/d), cSOR, and iSOR. The dates range from December 2016 to March 2019. The graph illustrates trends and changes in the performance parameters over the specified period.]
5 Observation Wells in the Pad for steam chamber monitoring:
- Example: AF06E – 2.3 m from toe of AF06
- Design: Obs Well w/ thermocouples
- Steam Chamber conditions seen since 07/2017
- Sustained steam chamber growth observed during reporting period

Sustained steam chamber growth above injector level
MAX temp reflects operational pressure changes
MRCP – Observation Well Examples: Pad AF

5 Observation Wells in the Pad for steam chamber monitoring:

- Example: AF02E – 9.7 m from toe of AF02
- Design: Obs Well w/ thermocouples
- Steam Chamber conditions seen since 08/2018
- Steam chamber slowed down by geological baffles

Moved 1m Feb to early Mar 2019 @182m

Stalled @183m Nov 2018 – Jan 2019

Moved 6m up Aug to Nov 2018 (1.5m/month)

First steam @189m in Aug 2018
MRCP – Pad AD: Medium Performance Example

Pad AD

- Steam Rate (m³/d)
- Oil Rate (m³/d)
- Water Rate (m³/d)
- cSOR
- iSOR

Date:
- Dec-16
- Jan-17
- Feb-17
- Mar-17
- Apr-17
- May-17
- Jun-17
- Jul-17
- Aug-17
- Sep-17
- Oct-17
- Nov-17
- Dec-17
- Jan-18
- Feb-18
- Mar-18
- Apr-18
- May-18
- Jun-18
- Jul-18
- Aug-18
- Sep-18
- Oct-18
- Nov-18
- Dec-18
- Jan-19
- Feb-19
- Mar-19

Rate (m³/d):
- 0
- 200
- 400
- 600
- 800
- 1,000
- 1,200
- 1,400
- 1,600
- 1,800
- 2,000

SOR (m³/m³):
- 0
- 2
- 4
- 6
- 8
- 10
- 12
- 14
- 16
- 18
- 20
- 22
- 24
- 26
MRCP – Observation Well Examples: Pad AD

6 Observation Wells in the Pad for steam chamber monitoring:
- Example: AD02D – 5.59 m from toe of AD02
- Design: Obs Well w/ thermocouples
- Steam Chamber conditions seen since 11/2017
- Relevant geological baffles & barriers affecting steam chamber in this location

Steam Chamber stalled between injector and producer
Influenced by mud baffles & barriers present between injector and producer
MRCP – Observation Well Examples: Pad AD

6 Observation Wells in the Pad for steam chamber monitoring:
- Example: AD05C – 38.8 m from mid section of AD05
- Design: Obs Well w/ Thermocouples and external ERE pressure gauges
- Identified lateral event related to steam chamber contacting gas cap in AD05 and AD04
- ERE gauge #4 trend (WBSK) changed abruptly in mid Dec 2018
  - Pressure: reached 1,080 kPag (peak) before declining to ~1,022 kPag
  - Temperature: ERE temp increased to 12°C in Mar 2019

Actions: Though minor concern, PCC is seriously following this type of case:
- D&C:
  - CBL/VDL check OK, cement looks normal.
  - Surface casing vent inspection was conducted. Good test, no bubbling detected.
- Reservoir:
  - Confirmed gauges consistency, no drifting, good match between external T ERE and thermocouples.
  - Permanent monitoring, temperature increase confirms the gauge has communicated with lower zone.
  - Preparing for remedial intervention in winter of 2019-2020
MRCP – Pad AH: Low Performance Example

Pad AH

- **Steam Rate (m3/d)**
- **Oil Rate (m3/d)**
- **Water Rate (m3/d)**
- **cSOR**
- **iSOR**

Date: Dec-16 to Mar-19

SOR (m3/m3) vs. Rate (m3/d)
5 Observation Wells in the Pad for steam chamber monitoring:

- Example: AH02A – 8.36 m from mid-section of AH02
- Design: Obs Well w/ thermocouples
- Steam Chamber conditions seen since 02/2018
- Competent F9 baffle halted steam chamber

**Facies F9 acting as baffles**

Steam chamber stalled by F9 mud beds since Sep 2018

Moved just above injector level until Sep 2018

Steam Chamber between injector and producer until Jul 2018

Steam chamber development is influenced by mud baffles present between injector and producer and higher Sw to the bottom of the reservoir
MRCP – Observation Well Examples: Off-Pad

7 Observation Wells are located outside the DA, far from direct influence of well pairs to monitor regional trends

- Example: 00-01 – 125 m from AE06
- Design: Perforated Obs Well w/ Thermocouples and ERE pressure gauges (Multi Zone)
- Temperature response: Virgin reservoir temperature, as expected
- This well has been instrumental in understanding regional pressure trends of the top gas and bottom transition zone
  - Pressure build up first observed in the BTZ as start-up and ramp-up of SAGD wells influenced the pressure in the bottom of the reservoir
  - Pressure response in the top gas shown from Q3, 2018 as the top gas is pressurized by gas injection and interactions with steam chambers

No TEMP response

Pressure in BTZ indicating ~ 1500 kpag

Pressure in Top Gas increasing (accelerated after gas injection started in 05-13)

05-13 started gas injection in late Sep 2018
MRCP – Observation Well Examples: Pad AA

4 Observation Wells experienced water or methanol vapor refluxing in 2018 and were repaired in Mar 2019

- Example: AA01E – 3.1 m from AA01 toe
- Design: Obs Well w/ thermocouples
- Temperature response: Steam chamber being tracked since Dec 2017
- Temperature alignment caused by presence of methanol (or water) inside wellbores.
  - Methanol refluxing showed up in May 2018, prevented valid temperature record until Mar 2019

Steam chamber at 174m when refluxing was removed after well clean-up

Methanol Vapor refluxing @ 65°C (water @ 100°C)

Steam chamber at 182m when refluxing started
Key Learnings To-Date

• SAGD

  o Continuing to ramp-up production through optimization efforts and mitigating the effects of:

    ▪ Top gas and thicker lower transition zones
    ▪ Operational pressure strategies tied to “thief” zones
    ▪ Effects of baffles and barriers
    ▪ Fines migration

  o The use of PCP was the best low cost conversion solution

    ▪ Some design considerations need optimization to extend run life

  o Differences in wellbore horizontal temperature fibre vendors are evident in data accuracy

    ▪ Observations indicate that FBG may show signs of degrade
Future Initiatives

- Winter Appraisal Program:
  - Annually review MLE requirements
  - Plan to shoot a 4D seismic monitor survey in 2019/2020

- Potential Commercial Amendment Applications in 2019/2020:
  - Steam Stimulation Process – additional wells may be requested
  - Pressure maintenance in bottom transition zone is being investigated
  - Solvent co-injection or solvent soaking under consideration

- Infill Well Project:
  - MacKay Phase 1A – down spaced 17 well pairs utilizing well design enhancements approved:
    - Drilling 4 well pairs on Pad AA – steam to start Q4 2019
    - Drilling of the remaining 13 well pairs will follow a staged approach to incorporate learnings from initial infill well pairs

- Sustaining Wells
  - Continue the internal project development process for the first group of sustaining well pairs
  - Potentially submit an application in early 2020

- Pad/Well Abandonments:
  - There are no pad or well abandonments planned in the next reporting cycle
3.1.2 SURFACE OPERATIONS, COMPLIANCE AND ISSUES NOT RELATED TO RESOURCE EVALUATION

Facility Performance, measurement and reporting
Parts (1), (2), (3)
• Phase 1 has a bitumen capacity of 35,000 bpd

• The MRCP averaged 7130 bpd of bitumen during the reporting period
MRCP Central Processing Facility – Aerial View
MRCP CPF General Block Flow Diagram
Bitumen Production

<table>
<thead>
<tr>
<th>Month</th>
<th>Production (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-18</td>
<td>37.61322903</td>
</tr>
<tr>
<td>May-18</td>
<td>35.60224194</td>
</tr>
<tr>
<td>Jun-18</td>
<td>34.49196954</td>
</tr>
<tr>
<td>Jul-18</td>
<td>34.50676575</td>
</tr>
<tr>
<td>Aug-18</td>
<td>33.46890824</td>
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<td>Sep-18</td>
<td>36.00612556</td>
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<td>Oct-18</td>
<td>32.53943014</td>
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<tr>
<td>Nov-18</td>
<td>31.37524184</td>
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<tr>
<td>Dec-18</td>
<td>36.4428953</td>
</tr>
<tr>
<td>Jan-19</td>
<td>32.32768293</td>
</tr>
<tr>
<td>Feb-19</td>
<td>37.55398821</td>
</tr>
<tr>
<td>Mar-19</td>
<td></td>
</tr>
</tbody>
</table>
Water Treatment Technology

• High pH Vertical Tube Falling Film Mechanical Vapor Compression (MVC) Evaporators for produced water treating:
  ▪ First Stage Evaporators x (2)
  ▪ Second Stage Evaporator x (1)

• Forced Circulation MVC driven Concentrator for further concentrating of evaporator blowdown to Reduced Liquid Discharge (RLD)
Water Treatment Successes and Challenges

• Successes:
  - The performance of evaporators and concentrator are meeting design expectations in general

• Challenges:
  - Equipment scaling due to hard non saline water as service water, plan in place to mitigate.
  - H$_2$S unexpectedly concentrating in water treatment foul gas (see slide No. 87 for future plans regarding sulphur recovery).
Steam Generation Technology

• Natural circulation elevated drum steam generators designed for sub-ASME feed water quality
  ▪ (4) x steam generators
  ▪ Low NOx combustion system

• Steam Generation Success:
  ▪ Boilers are successfully commissioned and operating. The steam generated is meeting the field steam demands.

• Steam Generation Challenge:
  ▪ Low produced water return rate from field forced high rate of cold source water as make-up. As a result, boiler feed water temperatures are low which condenses Sulphur compounds on the boiler economizers.
Steam Produced

![Bar Chart]

- **X-axis**: Months from April 2018 to March 2019
- **Y-axis**: Se$^3$m$^3$ (CWE)
- **Legend**: PetroChina Canada
Total Purchased and Produced Gas Consumed

100% of solution gas is recovered at the MRCP
Measurement Accounting & Reporting Plan (MARP)

- Mackay River Report Codes:
  - Production Battery AB BT 0142085
  - Injection Facility AB IF 0142086
  - Meter Station (Fuel Gas) AB MS 0136386
  - Custody Transfer Point (Diluent) AB PL 0142114
  - Custody Transfer Point (Product) AB PL 0144307
Proration Factors

<table>
<thead>
<tr>
<th>Month</th>
<th>Water Proration Factor</th>
<th>Oil Proration Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>May-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Jun-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Jul-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Aug-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Sep-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Oct-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Nov-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Dec-18</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Jan-19</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Feb-19</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Mar-19</td>
<td>1.1</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Upper Proration Limit: 1.2
Lower Proration Limit: 0.8
3.1.2 SURFACE OPERATIONS, COMPLIANCE
AND ISSUES NOT RELATED TO RESOURCE EVALUATION

DISCUSSION OF WATER PRODUCTION, INJECTION, AND USES
Part (4)
Non-Saline Water

Source Water Wells

• **Water Act Licence No. 00266369-01-03:**
  - Approved Annual Withdrawal Volume = 2,116,964 m$^3$/year from the Empress Channel
    - 13-10-90-15W4, max rate 2,930 m$^3$/d
    - 14-11-90-15W4M, max rate 3,000 m$^3$/d
    - 02-13-90-15W4M, max rate 2,900 m$^3$/d
    - 08-13-90-15W4M, max rate 3,100 m$^3$/d

Domestic Water Wells

• **Water Act Licence No. 00316276-00-00:**
  - Approved Annual Withdrawal Volume = 82,125 m$^3$/yr from the Grand Rapids 4
    - 16-02-90-14W4M North, max rate 400 m$^3$/d
    - 16-02-90-14W4M South, max rate 360 m$^3$/d
Raw Water Withdrawal – Source Wells

Yearly Cumulative Withdrawal Limit

Monthly Water Withdrawal

Annual Cumulative Water Withdrawal

<table>
<thead>
<tr>
<th>Month</th>
<th>Withdrawal (CWE)</th>
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</thead>
<tbody>
<tr>
<td>Apr-18</td>
<td>0</td>
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<td>Jun-18</td>
<td>0</td>
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<td>Jul-18</td>
<td>0</td>
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<tr>
<td>Aug-18</td>
<td>0</td>
</tr>
<tr>
<td>Sep-18</td>
<td>0</td>
</tr>
<tr>
<td>Oct-18</td>
<td>0</td>
</tr>
<tr>
<td>Nov-18</td>
<td>0</td>
</tr>
<tr>
<td>Dec-18</td>
<td>0</td>
</tr>
<tr>
<td>Jan-19</td>
<td>0</td>
</tr>
<tr>
<td>Feb-19</td>
<td>0</td>
</tr>
<tr>
<td>Mar-19</td>
<td>0</td>
</tr>
</tbody>
</table>
Produced Water

Se$^3$m$^3$ (CWE)

Steam Injected

- April to July 2018 show a peak in steam injected.
- A gradual decline from August to March 2019 is observed.

Units: Se$^3$m$^3$ (CWE)
Blowdown, Waste and Disposal Wells

Blowdown Recycle

- Continuous blowdown from boilers is injected into the HP steam line.
- Intermittent blowdown from boilers is recycled to Water Treatment.

Waste and Disposal Wells

- Waste Tracker software and AER manifests are used to track and submit data to AER.
- No disposal wells are associated with MRCP Phase 1.
Off-Site Waste Water Disposal

• Concentrated brine reject, emulsified slop oil, and desand slurry water streams are disposed of off-site.

• Location of disposal sites:
  ▪ Tervita Lindbergh – AB WP 0000557 (For evaporator/concentrator brine water)
  ▪ Tervita Fort McMurray - AB WP 0133414 (For emulsified slop oil water and desand slurry water)
  ▪ Secure Energy Tulliby Lake– AB IF 0139713 (For emulsified slop oil water and desand slurry water)

• Sources of disposal water:
  ▪ Evaporator Waste Water Tanks
  ▪ Concentrator Feed/Waste Tanks
  ▪ Slop Oil and Desand/Decant Tanks
Off-Site Waste Water Disposal

- e³m³ (Brine)


- Values range from 0.2 to 1.6
Sulphur

Graph showing the inlet sulphur limit and the sulphur levels from April 2018 to March 2019.
Future Plans – Sulphur Recovery

• PCC’s initial sulphur recovery design will focus on sequestration of the sulphur within the caustic waste brine destined for disposal. Since the majority of the hydrogen sulphide is concentrating preferentially in the foul vent system of the water treatment plant, this highly concentrated/low flow stream can easily be sequestered by means of injecting additional caustic into the produced water (upstream of de-aeration) whereby the acidic sulphur species can be quickly sequestered in bisulphide format.
Summary of actual calendar quarter-year sulphur emissions

Overview of peak and average sulphur emissions

<table>
<thead>
<tr>
<th></th>
<th>Sulphur Emissions (tonnes)</th>
<th>Peak Daily Sulphur Emission (tonnes)</th>
<th>Average Daily Sulphur Emissions (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018 Q2</td>
<td>52.44</td>
<td>0.75</td>
<td>0.58</td>
</tr>
<tr>
<td>2018 Q3</td>
<td>59.7</td>
<td>0.93</td>
<td>0.65</td>
</tr>
<tr>
<td>2018 Q4</td>
<td>43.74</td>
<td>0.61</td>
<td>0.48</td>
</tr>
<tr>
<td>2019 Q1</td>
<td>50.72</td>
<td>0.83</td>
<td>0.56</td>
</tr>
</tbody>
</table>
Comparison of actual peak daily and rolling average sulphur dioxide (SO$_2$) emissions with conditions of Alberta EPEA approvals

April 2018 - March 2019 SO2 Emissions (tonnes per day)
## Sulphur / SO2 emission compared to limits

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Daily Average (Sulphur t)</th>
<th>Calendar Quarter Average (Sulphur t)</th>
<th>Combined Sources Daily Maximum (SO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limit 1 tonne</td>
<td>Limit 1.98 tonne</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>0.617</td>
<td>0.587</td>
<td>1.233</td>
</tr>
<tr>
<td>May</td>
<td>0.455</td>
<td>0.910</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>0.661</td>
<td>1.322</td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>0.446</td>
<td>0.892</td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>0.657</td>
<td>0.651</td>
<td>1.313</td>
</tr>
<tr>
<td>September</td>
<td>0.851</td>
<td>1.702</td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>0.412</td>
<td>0.823</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>0.543</td>
<td>0.476</td>
<td>1.087</td>
</tr>
<tr>
<td>December</td>
<td>0.473</td>
<td>0.947</td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>0.492</td>
<td>0.985</td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>0.492</td>
<td>0.983</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>0.700</td>
<td>1.399</td>
<td></td>
</tr>
</tbody>
</table>
NOx Emission Rate – Continuous Emission Monitoring System

April 2018 - April 2019 NOx Emissions (kg/hr)
## Regulatory Compliance

<table>
<thead>
<tr>
<th>Notification Date</th>
<th>Non-Compliance</th>
<th>Description</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-Jul-18</td>
<td>Noncompliance with clause 16e of scheme approval 11715J</td>
<td>SSP duration of injection above limit</td>
<td>Incorporate learnings into potential future tests</td>
</tr>
<tr>
<td>4-Sep-18</td>
<td>Directive 017 s. 12.3.9: Well production Measurement</td>
<td>In July 2018, no valid well tests were completed for production well AE06. The reason was that the flow was too low and therefore directed to the multiphase pump package (MPP) to increase pressure differential in order to lift more fluid</td>
<td>An alternative measurement method allowed collection of necessary data in July. For production measurement, AE-FIT-0650 flow was used. Bottom Sediment and Water was assumed from last sample June 18, 2018</td>
</tr>
<tr>
<td>19-Oct-18</td>
<td>Wells have been operating since approximately December 2016 under a “suspended” well status</td>
<td>Wells were suspended due to delayed construction schedule however we never activated once operation started</td>
<td>All wells have been re-activated</td>
</tr>
<tr>
<td>8-Jan-19</td>
<td>Noncompliance with clause 16e of scheme approval 11715J</td>
<td>Despite the DCS showing the valves as closed, some of the valves were passing. This resulted approximately 1.0 m3/ hr of steam being injected during the pressure falloff portion of the test, when there should have been no injection.</td>
<td>The steam control valve had an actuator that was out of spec and may not have had the ability to fully close. The actuator was replaced at the end of January, 2019</td>
</tr>
<tr>
<td>12-Dec-2018</td>
<td>EPEA</td>
<td>Voluntary Self-Disclosure - Equipment Failure Installation leak resulting in steam release</td>
<td>Repair plan put in place</td>
</tr>
<tr>
<td>14-Dec-2018</td>
<td>EPEA</td>
<td>Release Report - Equipment Failure – Valve leak resulting in steam condensate release</td>
<td>Condensate was vacuumed up. Procedures modified to incorporate inspections prior to returning wellheads to service</td>
</tr>
<tr>
<td>21-Dec-2018</td>
<td>Water Act</td>
<td>Voluntary Self-Disclosure (x2) Missed WURS data submission deadlines</td>
<td>Closed gaps in reporting process</td>
</tr>
<tr>
<td>22-Jan-2019</td>
<td>EPEA</td>
<td>Voluntary Self-Disclosure – Diesel spill at well pad AI</td>
<td>Site cleaned up with vacuum truck</td>
</tr>
<tr>
<td>27-Feb-2019</td>
<td>EPEA</td>
<td>Steam release at well AJ05I</td>
<td>Implementation of a check program at all shut in wells to assure winterization has occurred</td>
</tr>
</tbody>
</table>

AER release reporting requirements were followed for all EPEA non-compliances
Industrial Wastewater and Industrial Runoff Management and Disposal

• Between April 1 2018 and March 31 2019:
  • A total of 17,240 m$^3$ of wastewater and waste emulsion was trucked off-site for disposal;
  • 397,368 m$^3$ of industrial runoff was released from the storm water pond of the Industrial Runoff Control System;
  • 45,735 m$^3$ of industrial runoff was released from the eight SAGD well pads

• Summary of Non-Compliances:
  • In 2018, pre-release testing and volume measurement was not obtained for six storm water pond release dates and eight well pad release dates. Discharge analysis was not obtained for one storm water pond discharge and two well pad discharges.
  • In 2019 volume measurements and discharge testing was not obtained for nine well pad release dates. All releases had pre-release analysis conducted.

• Contravention report was submitted for all non-compliances related to industrial runoff
EPEA and Water Act Amendments

- There have been no amendments to EPEA approval No. 254465-00-02 since the last performance presentation.

- Water Act approval No. 00266369-01-04 was amended to reflect the corporate name change from Brion Energy Corporation to PetroChina Canada Ltd. It is now approval No. 00266369-01-05.
Compliance Statement

To the best of our knowledge, PCC’s MRCP is compliant with all conditions of its approvals and associated regulations with the exception of items disclosed in previous slides.
## EPEA Monitoring Programs

### Monitoring Programs Required under EPEA Approval

<table>
<thead>
<tr>
<th>Program</th>
<th>Progress and Results</th>
</tr>
</thead>
</table>
| Groundwater Monitoring                       | • Groundwater monitoring was conducted in June and October 2018 at the MCP and Pad AJ, and in October at Pad AH. Groundwater quality in the shallow glacial till and Grand Rapids 4 and 5 aquifers were relatively stable in 2018 and consistent with historical conditions  
  • Thermal effects are being monitored and will be compared to the Thermal Directive |
| Wetland Monitoring                           | • The comprehensive wetland monitoring report was submitted to the AER on September 27, 2018  
  • Based on data collected from focal plots, there were no definitive impacts from the MRCP activities on surrounding wetlands identified in the five years of monitoring data. |
| Annual Conservation and Reclamation Report   | • Schedule II, Condition 7, and Schedule IX, Conditions 52 and 53 of the EPEA Approval require PCC to prepare an Annual Conservation and Reclamation Report (Annual C&R Report) for submission to the Alberta Energy Regulator.  
  • The approved Wetland Reclamation Trial Program prepared by Acden Navus Limited Partnership (2014a) contained two trials: Small-Scale Trial #1: Alternative Storage Technique of Peat Material and Peatland Reclamation of a Borrow Area and Small-Scale Trial #2: Effects of Padding over Reclamation Material (hereafter referred to as “Trial #2”).  
  • Trial #2 involved collection of samples from the unsalvaged soil beneath the pad, stockpiled soil and undisturbed soil and comparing properties of these soils at 2, 3, 5, 10 and 20 years post construction of Pad AH. Samples have been collected for years 2 (2015), 3 (2016) and 5 (2018).  
  • After five years, placement of fill material (padded) over unsalvaged organic and transitional soils has not resulted in a greater loss of soil quality in comparison to salvaging and stockpiling soil.  
  • Reclamation Monitoring Program currently being implemented on reclaimed portions of Borrow Areas 12, 38, and 118. Monitoring will continue until the AER issues the requisite reclamation certificates |
| 2019 Operational Soil Monitoring Program Proposal | • The Operational Soil Monitoring Program will be implemented following authorization in writing by the Director per Schedule VII(4) of the EPEA Approval with the soil Monitoring Program report submitted on or before January 31, 2020, contingent upon receiving approval prior to winter 2019 (frozen conditions).  
  • The Program Proposal was approved by the AER on March 26, 2019. |
| Wildlife and Woodland Caribou Monitoring     | • The comprehensive wildlife report was submitted to the AER on May 30, 2018  
  • A large component of the mitigation monitoring plan was the implementation and monitoring of caribou habitat restoration treatments and access management trials. Preliminary results indicate some success of restoration trials, particularly in supporting the establishment and growth of planted black spruce, and naturally established tamarack seedlings.  
  • For the most part, monitoring results were similar to those observed during baseline surveys, and in some cases winter track count densities recorded during monitoring surveys were higher than those recorded during baseline. Monitoring results appear to be in line with impact predictions from the EIA. |
| Annual Air Emission Summary and Evaluation Report | • No issues with operations or pollution control equipment where identified in 2018.  
  • In 2018 there were no expansions or modifications to the operations at the Mackay River Commercial Project that would affect atmospheric emissions from this facility.  
  • In 2018 there were no changes to monitoring methods. |
| Annual Industrial Wastewater and Industrial Runoff Report | • A total of 17,408.10 m3 of wastewater was removed from site  
  • 359,928 m3 of industrial runoff was released from the Storm Water Pond of the MCP Industrial Runoff Control System  
  • 29,251 m3 of industrial runoff was released from the eight SAGD well pads |
### Summary of ambient air quality monitoring results required under EPEA approvals

#### 2018 Q2 1-hour Averages

<table>
<thead>
<tr>
<th></th>
<th>H$_2$S (ppb)</th>
<th>NO$_2$ (ppb)</th>
<th>SO$_2$ (ppb)</th>
<th>THC (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>5</td>
<td>22.6</td>
<td>18</td>
<td>2.7</td>
</tr>
<tr>
<td>Average</td>
<td>0.13</td>
<td>1.45</td>
<td>0.54</td>
<td>2.2</td>
</tr>
<tr>
<td>AAAQO Limit</td>
<td>10</td>
<td>159</td>
<td>172</td>
<td>N/A</td>
</tr>
</tbody>
</table>

#### 2018 Q3 1-hour Averages

<table>
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<th>H$_2$S (ppb)</th>
<th>NO$_2$ (ppb)</th>
<th>SO$_2$ (ppb)</th>
<th>THC (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>21</td>
<td>25.5</td>
<td>16</td>
<td>2.8</td>
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<tr>
<td>Average</td>
<td>0.06</td>
<td>1.22</td>
<td>0.46</td>
<td>2.17</td>
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<td>AAAQO Limit</td>
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<td>159</td>
<td>172</td>
<td>N/A</td>
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#### 2018 Q4 1-hour Averages

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<th>H$_2$S (ppb)</th>
<th>NO$_2$ (ppb)</th>
<th>SO$_2$ (ppb)</th>
<th>THC (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>2</td>
<td>82.1</td>
<td>34</td>
<td>3.5</td>
</tr>
<tr>
<td>Average</td>
<td>0.05</td>
<td>3.99</td>
<td>0.60</td>
<td>2.25</td>
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<tr>
<td>AAAQO Limit</td>
<td>10</td>
<td>159</td>
<td>172</td>
<td>N/A</td>
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#### 2019 Q1 1-hour Averages

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<th>H$_2$S (ppb)</th>
<th>NO$_2$ (ppb)</th>
<th>SO$_2$ (ppb)</th>
<th>THC (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>2</td>
<td>72.7</td>
<td>25</td>
<td>3.3</td>
</tr>
<tr>
<td>Average</td>
<td>0.06</td>
<td>4.89</td>
<td>0.87</td>
<td>2.28</td>
</tr>
<tr>
<td>AAAQO Limit</td>
<td>10</td>
<td>159</td>
<td>172</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Progress and results of reclamation programs

• Reclamation continues at Borrow Pits 12, 38 and 118.

• Borrow Pit is 118 nearly reclaimed and PPC could potentially apply for a reclamation certificate fall 2019.

• PCC is evaluating future reclamation candidates.
Greenhouse Gas Emissions

2018 GHG Emissions

2018 Cumulative Total CO$_2$eq = 518,482 tonnes

January: 43076
February: 30822
March: 40645
April: 46076
May: 44323
June: 45846
July: 49443
August: 47071
September: 45452
October: 46354
November: 43131
December: 36244

Tonnes CO$_2$eq
Flaring and Venting at the MRCP

Flaring and venting occurs at the MRCP as a result of process upsets. For example: plant trips or power outages.

Three separate events in February 2018 contributed to the total vent volume shown. The largest release, which accounts for 2 e³m³ of the overall volume was the result of the foul vent compressor tripping, and operators being unable to start the second foul vent compressor resulting in venting from one evaporator.
Regional Monitoring and Initiatives

PCC continues to participate in and/or fund the following initiatives:

• Oil Sands Environmental Monitoring Program (OSEMP)
• Canada’s Oil Sands innovation Alliance (COSIA) Monitoring Working Group
• Wood Buffalo Environmental Association (WBEA)
• Alberta Biodiversity Monitoring Institute (ABMI)
• Black Bear Partnership Project
• Alberta Upstream Petroleum Research Fund (AUPRF)
Future Plans – Surface Facilities and Regulatory Applications

• No additional EPEA or Water Act Licence amendments are proposed for the remainder of 2019

• Currently focused on optimization and efficiency gains to support further production growth. No major changes to surface facilities are proposed at this time.
  - Routine maintenance may require temporary shutdowns of equipment.

• Infill Well Project:
  - Drilling 4 well pairs on Pad AA – steam to start Q4 2019
  - Next 13 well pairs are under internal review – design may depend on results of the AA wells

• Sustaining Well Pairs
  - Continue the internal project development process for the first group of sustaining well pairs
  - Potentially submit an application in early 2020
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