Suncor MacKay River Project
2013 AER Performance Presentation: Surface
Commercial Scheme Approval No. 8668

December 10, 2013
Reporting Period September 1, 2012 - August 31, 2013
AER Directive 054
2013 Performance Presentation

Section 3.1.2 – Surface Operations, Compliance, and Issues not related to Resource Evaluation and Recovery
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• Central Processing Facilities (CPF) Performance
• Measurement and Reporting
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MacKay River Project Overview

- Supplies bitumen to the Suncor’s Oil Sands Upgrader and sales to market

- Consists of a commercial Steam Assisted Gravity Drainage (SAGD) scheme

- Includes integrated central plant facilities, wellpads and gathering corridors

- Received AER approval for processing capacity of 11,600 m³/day (73 kbpd) of bitumen
MacKay River Project Site
Simplified CPF Process Block Diagram

- Fluids From Wells
- Produced Vapours
- Bitumen
- Fuel Gas to Steam Generators
- Pipeline to Market
- Produced Emulsion
- Pipeline Gas

- Water Treatment
  - Makeup Water
  - Solids to On-Site Landfill
  - Recovered Water

- Steam Generation
  - Boiler Feed Water
  - Blowdown Water
  - Salt Cake to On-Site Landfill

- Fuel Gas System
MacKay River Performance Presentation
Central Processing Facility Performance
CPF Performance (2012-2013 YTD)

- **The reliability of the facility has been excellent:**
  - Solid water treatment performance.
  - Much improved operations discipline through OEMS implementation

- **Major challenges:**
  - Extended turnaround due to WLS tank repairs (Sept. 2012)

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Average 91.2% (September 2012 to August 2013)
Historical Production (January 2003 – 2013 YTD)

MacKay River Sales

(m3/day)
Production (2012)

*Period Average: 4330.7 m$^3$/d*
Production (2013 YTD)

Period Average: 4583.2 m3/d

- Slowdown
- Cogen trip and high water inventory
- Duct burners down
- Unplanned Cogen Shutdown
- Steam gens and Cogen Outage
- Steam gens and Cogen Tripped
- Gen D Trip
- Cogen trip and high water inventory

(m3/day)

Jan-13 Feb-13 Apr-13 May-13 Jul-13 Sep-13
Warm Lime Softening (WLS) and Weak Acid Cation (WAC) softening for produced water

Zero Liquid Discharge (ZLD) System on blowdown slip stream:

- Evaporators: one steam and one mechanical driven
- Crystallizer: Steam driven
- Dryer: gas fired
- Filter press (2): back up for dryer
### Boiler Feed Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Avg. value (Sept 2012 – Aug 2013)</th>
<th>Max value during period</th>
<th>BFW Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, °C</td>
<td>148</td>
<td>175</td>
<td>140 – 170</td>
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<tr>
<td>Hardness (Dissolved), mg/L</td>
<td>0.226</td>
<td>1.44</td>
<td>&lt; 1.0</td>
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<tr>
<td>Total Dissolved Solids, mg/L</td>
<td>7666.9</td>
<td>11589</td>
<td>&lt; 8000</td>
</tr>
<tr>
<td>Silica, as SiO₂, mg/L</td>
<td>18.9</td>
<td>59.48</td>
<td>&lt; 50.0</td>
</tr>
</tbody>
</table>
The WLS performance has been steady:

- Reliability > 95.5%
- Consecutive days within spec: 128 days
  - Parameters: temperature, hardness, total dissolved solids, pH, silica, oil, free oxygen, total dissolved iron
- Reduced chemical dosage resulting in significant cost savings

Challenges:

- Reliability of Magox and Lime slurry feed system
  - Maintaining a consistent slurry feed to the WLS is a challenge due to the inherent nature of the slurries. The feed lines and pumps are frequently plugged due to deposition. A preventative maintenance strategy has been adopted to increase the reliability of the system.
Steam Generation (2012)

Steam Quality from Co-gen is maintained approximately 77% and OTSG is approximately 80%
Steam Generation (2013 YTD)

Steam Quality from Co-gen is maintained approximately 77% and OTSG is approximately 80%
Power Generation (2012)

Electricity Consumed (MWh)

- Consumption
- Imported

Turnaround
Power Generation (2013 YTD)
Gas Consumption (2013 YTD)
Energy Intensity

Energy Intensity Formula

• Energy Intensity (GJ/m³) = Total energy consumed by site / Sales bitumen volume

• Total energy consumed by site (GJ) = Energy used to make steam in Cogen + Natural Gas imported to *site + Solution gas from the wells + Electricity consumed by *site – Mixed gas to Cogen duct firing

• Energy used to make steam in Cogen (GJ) = BFW Mass Flow Rate to Cogen x Hourly average difference in enthalpy between steam and BFW

*Note: the term “site” does not include Cogeneration
Cogeneration Agreement with TransCanada Energy

Energy exchange: TransCanada Energy (TCE) provides steam and electricity to Suncor in exchange for BFW and a “fee”

- Fee calculated as GJ of fuel gas equivalent in compensation for steam and electricity (energy equivalent value based on contractual formula)
- Suncor provides on-spec BFW and fuel gas, maintains MacKay River facility within specified outage hours and takes a minimum steam requirement
- Mixed gas supplied by Suncor to TCE credited against total gas “fee” requirement
- TCE required to provide all other excess gas for the operation of the cogeneration facility
- TCE sells excess electric energy generated by the cogeneration facility to the market
Energy Intensity (2012)

Turnaround
Energy Intensity (2013 YTD)
MacKay River Performance Presentation
Measurement and Reporting
Measurement Accounting & Reporting Plan (MARP)

- Approved in April 2010
- Updated on Feb 28, 2013
- Details all the required data in Directive 42
Well Testing Strategy

Test Separators are used to test all wells for production allocation

Pad 20 and Pad 21 Well Testing Strategy
  • 12 active SAGD producers per pad, 4 hour tests (+ purge time)
  • Fully compliant with Directive 017

Pads 22/25 Well Testing Strategy
  • 23 active SAGD producers, 5.5 hour tests (+ purge time)
  • 36 hours of testing per well per month cannot be met due to number of wells

Pad 23 Well Testing Strategy
  • Currently 20 wells until Pad 25 is operational, then return to 14 wells

Pads 23/24 Well Testing Strategy
  • Prior to Phase 5B-1:
  • 14 active SAGD producers, 7 hour tests (+ purge time)
Well Testing Strategy

- Phase 5A wells (NN2-5, QQ4-5) are tested via Pad 22 test separator

- Phase 5B-1 wells (OO 4-9) are tested through Pad 23 test separator until Pad 25 facilities operational March/April 2014

- Pad 25 operational, Phase 5B-1 (OO 4-9) wells will be directed there

- Pad 23 returns to 14 wells testing through test separator
Well Testing Strategy

Since Phase 5B-1 start-up in June 2012:

- 20 SAGD producers to Pad 23 test separator

- Cannot meet 36 hours of test per well per month due to number of wells and required purge time per test

- Testing of Phase 5B-1 wells at Pad 23 has been approved until Pad 25 facility is commissioned and operational (March/April 2014)
Proration of Oil

- Year 2012: Oil Factor = 0.89  Water Factor = 0.97
- Year 2013 YTD: Oil Factor = 0.94  Water Factor = 1.12

Planned Maintenance Turnaround (Aug 18-Sep 29)
Pad 24 Multi-Phase Flow Meter Trial (Vx Meter)

Decision to Discontinue Multi-Phase Flow Meter (MPFM) Test

- Conducted technical evaluation of the trial which took place between Q3 2012 and Q1 2013
- Conclusion – Trial was not successful due to non-alignment between individual meter specifications and the operational environment of the well used for the trial
- Sizing of the MPFM meter was not suitable for current operational conditions and performance of the wells used for the trial
- High vapor to liquid ratio due to method of artificial lift at Mackay River made measurement more challenging for the MPFM meter

- Received approval to continue testing Phase 5B-1 wells (OO4-9) through Pad 23 test separator until April 30, 2014
- Suncor is still pursuing the MPFM technology for MacKay River. A redesigned trial may be implemented in 2014-2015
CPF Water Traffic

UNIT 2
WATER DEOILING

UNIT 3
WATER TREATMENT

UNIT 1
BITUMEN TREATMENT

SOURCE WATER

PRODUCED WATER

DEOILED WATER

COOLING WATER

HEATING STEAM

VRU

CHEMICAL MAKEUP

STARTUP & SHUT DOWN WATER

LANDFILL LEACHATE & CONTAMINATED STORM WATER

UNITS 4 & 9
STEAM PLANT

BPW

RECOVERED CONDENSATE

UNITS 8
ZERO LIQUID DISCHARGE

VAPOUR/GAS

EMULSION

RESERVOIR

HP STEAM

LP STEAM

VAPOUR LOSSES

LP BLOWDOWN

ACCUMULATION

LOSSES
Fresh Water

Source Water Wells

• Water Act Licence No. 00188229-02-00 (511,000 m3/y) Birch Channel Aquifer (Renewal issued September 2012)

1. 13-05-093-12W4 (GD-SW-212-53; formerly WSW-1), max. rate 450 m3/day

2. 04-08-093-12W4 (GD-SW-213-86; formerly WSW-2), max. rate 1368 m3/day

3. 04-08-093-12W4 (GD-SW-215-91; formerly WSW-3), max. rate 1411 m3/day

Domestic Water Well

• Water Act Licence No. 00249470-01-00 (25,550 m3/y) Birch Channel Aquifer

4. 12-05-093-12W4 (CWSW-SW-218-55), max. rate 123 m3/day

• Monthly reporting done through Water Use Reporting System (WURS)
### Raw Water Source Wells

<table>
<thead>
<tr>
<th>Test</th>
<th>Water Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td></td>
</tr>
<tr>
<td>EC (us/cm)</td>
<td>864</td>
</tr>
<tr>
<td>pH (units)</td>
<td>8.21</td>
</tr>
<tr>
<td>Total Hard as CaCO2 (mg/L)</td>
<td>416</td>
</tr>
<tr>
<td>Total Alk as CaCO3 (mg/L)</td>
<td>402</td>
</tr>
<tr>
<td><strong>Indicators</strong></td>
<td></td>
</tr>
<tr>
<td>Chloride (mg/L)</td>
<td>0.53</td>
</tr>
<tr>
<td>Sulphate (mg/L)</td>
<td>108</td>
</tr>
<tr>
<td>Iron (mg/L)</td>
<td>&lt;0.030</td>
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<tr>
<td>Manganese (mg/L)</td>
<td>0.277</td>
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<tr>
<td>TDS-Calculated (mg/L)</td>
<td>535</td>
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<tr>
<td><strong>Cations, Anions, &amp; Ion Balance</strong></td>
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</tr>
<tr>
<td>Calcium (mg/L)</td>
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<tr>
<td>Magnesium (mg/L)</td>
<td>34.2</td>
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<tr>
<td>Potassium (mg/L)</td>
<td>5.18</td>
</tr>
<tr>
<td>Sodium (mg/L)</td>
<td>35.8</td>
</tr>
<tr>
<td>Bicarbonate (mg/L)</td>
<td>490</td>
</tr>
<tr>
<td>Carbonate (mg/L)</td>
<td>&lt;5.0</td>
</tr>
<tr>
<td>Hydroxide (mg/L)</td>
<td>&lt;5.0</td>
</tr>
<tr>
<td>Fluoride (mg/L)</td>
<td>0.23</td>
</tr>
<tr>
<td>Ion balance % (%)</td>
<td>---</td>
</tr>
</tbody>
</table>

#### Typical Water Quality Assessment Parameters

**Monitoring station GD-SW-212-53 (formerly WSW-1)**
Cumulative Raw Water – Source Wells (2012)

- Regulatory allowable limit from *Water Act* Licence No. 188229 is $1.4 \times 10^3$ m$^3$/day ($511 \times 10^3$ m$^3$ per year)
3.1.2 4 b) Regulatory allowable limit from Water Act Licence No. 188229 is $1.4 \times 10^3 \text{m}^3/\text{day}$ ($511 \times 10^3 \text{m}^3$ per year)
Cumulative Raw Water – Domestic Well (2013)

- Water well casing failure September 9, 2011; replacement well drilled July 2013. No water has been withdrawn (2013 YTD)
Water Balance

Steam:

- Present method:
  - Steam Injected = \( \sum \) All Meters to injection wells
  - Steam Injected = \( \sum \) (BFW * Steam Quality)

- MARP approved method: HP steam ultrasonic meter pending resolution on foaming issue (a new, longer wave guide was installed in the ultrasonic meter during September turnaround)

Raw Water = \( \sum \) Water Source wells (3 water source wells)

Produced Water:
- MARP approved method

Vapour losses are estimated:

- LP steam vent losses minimized by the installation of new exchanger
- ZLD has vapour loss to atmosphere

- Details of measurement and reporting procedures may be found in the MARP
Water Balance (2012)

Volume (m³/month)

- Steam Injected
- Produced Water
- Make-Up Water

Jan-12, Feb-12, Mar-12, Apr-12, May-12, Jun-12, Jul-12, Aug-12, Sep-12, Oct-12, Nov-12, Dec-12

Turnaround
Water Balance (2013 YTD)
Water Recycle (2012)

Recycle Rate (%) = (Steam Injected-Fresh Water)*100/Produced Water

Average for the year: 96.5% > Target 90%
Water Recycle (2013 YTD)

Average for Year-to-Date 95.8% > Target 90%
Low Pressure Blowdown Recycle (2012 & 2013 YTD)

**Blowdown Recycle** = 100%
- Blowdown treated in the Water Plant
  - YTD: 54,037 m³/month, 2012: 44,857 m³/month
- Blowdown treated in the Zero Liquid Discharge (ZLD) Plant
  - YTD: 41,563 m³/month, 2012: 31,850 m³/month

**Trucked volumes from Diversion Lagoon:**
- 36,004 m³ (January 1, 2012 – December 31, 2012)
- 31,038 m³ (January 1, 2013 – August 31, 2013)

**Note:** The diversion lagoon is filled by crystallizer concentrate during purges *and* by landfill leachate after periods of rain
MacKay River Landfill / Waste Management

AER Approval WM-072 Class II Oilfield Landfill

- Volumes of solids (salt/lime) to landfill
  - 2012: 22,690 m³
  - 2013 YTD: 18,234 m³*

- Total volume of landfill fluids to facility
  - 2012: 12,007 m³
  - 2013 YTD: 10,858 m³ *

- 2013 Waste Survey completed on June 30 and July 1, 2013 (Phases II&III)
  - Phase III: 7,164 m³
  - Phase II Cell (A&B): 74,002 m³ (approved for 86,000 m³)
  - Phase I of the MacKay River Landfill is closed and is in post-closure monitoring period

- Waste services contract in place
  - Addresses hazardous, scrap metal, domestic waste

- Waste Tracker software used to track and submit manifests to AER

* Volumes estimated in August 2013
Off-Site Brine Water Disposal

Location of disposal site:
- CCS Lindbergh (WPF, SFC)
- 05-26-056-05 W4M
- Application No: 1652609
- Approval No: WM061 (Amendment I)

- Brine water is disposed of off-site when the diversion tank and diversion lagoon reach capacity and the ZLD system cannot process the boiler blowdown from Unit 400.

- Water sources in the diversion lagoon include: precipitation, leachate from the MacKay River Landfill and excess boiler blowdown water during upset conditions.
Off-Site Brine Water Disposal (2012)

- Volumes reported via Petrinex
Off-Site Brine Water Disposal (2013 YTD)

- Volume trucked (m³)

- Volumes reported via Petrinex
MacKay River Performance Presentation

Sulphur Production
Currently there are no sulphur recovery facilities at the MacKay River Project
• S0₂ emissions are calculated from monthly produced gas samples
Sulphur Dioxide Emissions (2013 YTD)

- S0₂ emissions are calculated from monthly produced gas samples
• H$_2$S concentrations are measured in monthly produced gas samples
• Historic average for MacKay River is around 750 ppm; concentrations recorded in April, May and June 2012 are similar to levels reported in July 2005 and March 2006; increased levels are caused by introduction of steam to new reservoir areas and to inconsistent sampling methods
• Outage kept samples from being taken in August and September
H$_2$S Concentration (2013 YTD)

- H$_2$S concentrations are measured in semi-monthly produced gas samples. Suncor increased sampling frequency in 2013 to reduce chance of sampling error and to improve consistency.
Solution Gas Flared (2012)
Solution Gas Flared (2013 YTD)

![Bar chart showing solution gas flared from January to August 2013. The values range from 0 to 2,000 m³. In January, February, July, and August, the values are around 200 m³. In March and April, the values are around 100 m³. In May and June, the values are around 400 m³.](chart.png)
Solution Gas Recovery (2012)

Chart showing the solution gas recovery percentages for each month from January to December.
Solution Gas Recovery (2013 YTD)
Reduced Liquid Discharge Pilot

- Regulatory application for technology pilot approved by AER December 17, 2012
- Pilot designed to test reduced liquid discharge as a viable alternative to the current zero liquid discharge technology
- Pilot delivery and installation complete June 2013; commissioning and start up complete July 2013; piloting from July 19 to August 1, 2013; pilot decommissioning underway as of August 31, 2013
- Pilot testing completed as planned by Suncor in partnership with COSIA companies using an Alberta technology provider
- No impact on water recycle and disposal rates at the MacKay River Project
Greenhouse Gas Emissions (GHG)

Submitted the annual SGER report to ESRD and NPRI GHG report to Environment Canada
  • GHG calculation methodology developed to improve transparency

Total direct emissions for 2012:
  • 151,921 tonnes of CO$_2$equiv
  • Total emissions have been reported to ESRD

Total direct emissions for 2013 (YTD):
  • 143,094 tonnes of CO$_2$equiv
  • Total emissions will be reported to ESRD

Approved baseline emissions intensity:
  • 0.1173 tCO$_2$e/m$^3$

- 2012 total direct emissions verified in March 2013
Greenhouse Gas Emissions (2013 YTD)

- 2013 total direct emissions will be verified in March 2014
Ambient Air Monitoring

- 4 passive air monitoring stations at MacKay River

- Monthly ambient air quality monitoring performed by a site representative and sample analysis reports submitted to ESRD by Suncor site personnel for $\text{H}_2\text{S}$, $\text{NO}_2$, $\text{O}_3$, and $\text{SO}_2$

- Ambient air quality data available for viewing on WBEA website

- No air quality exceedances at MacKay River

- In 2012 average $\text{H}_2\text{S}$ concentration was 0.11 ppb and $\text{SO}_2$ concentration was 0.50 ppb collected from the passive stations

- In 2013 (as of August 31) average $\text{H}_2\text{S}$ concentration was 0.10 ppb and $\text{SO}_2$ was 0.79 ppb collected from the passive stations
Total Flared Gas (2012)

- TFG includes purchase gas
Total Flared Gas (2013 YTD)

- TFG includes purchase gas
Regulatory Compliance (2012)

**AER Surveillance Inspection (Calgary Office)**
- **April 2, 2012**
  - Discussion of MARP, ZLD Operation, water imbalance, flow nozzles on Pads 20 and 21, steam measurement, PRA reporting issues
  - Site tour of facility
  - Tour of ZLD unit

**AER Inspection (Bonnyville Field Office)**
- **August 15, 2012**
  - Release investigation, August 5, 2012 PSV collection tank overflow

**ESRD Site Visit**
- **June 21, 2012**

**ESRD Site Visit**
- **August 14, 2012**
  - Site visit to evaluate wildlife mitigation at MacKay River
Regulatory Compliance (2013 YTD)

**ESRD Site Visit**
- June 4, 2013
  - Site visit to evaluate reclamation piles/borrow pits at MacKay River/Dover projects

**AER Site Visit**
- June 16, 2013
  - Site visit to view spill on Pad 22
Release Management – Reportable Releases

AER Reportable Releases for 2012
- Seven AER reportable releases for 2012
- Five spills and two overflows

AER Reportable Releases for 2013 (YTD)
- Six AER reportable releases for 2013
- Four spills and two overflows

Environmental Awareness Training
- Core training requirement
- Highlights Spill Awareness, Waste Management, Flaring etc.
AER Approval No. 8668

- Amendment 8668Q
  - Water Treatment Pilot approval issued December 11, 2012

- Amendment 8668R
  - Well Abandonment (G1I) approval issued May 9, 2013

- Amendment 8668S
  - Chemical Injection Test (Pad 21 D-Pattern) approval issued September 5, 2013

- Application 1724610
  - Maximum Operating Pressure Strategy Category 2 application submitted April 10, 2012; SIR 2 response submitted July 16, 2013

- Application 1757021
  - Pad 819 Development Category 2 application submitted March 6, 2013; SIR response submitted September 20, 2013
Current Amendments / Applications

AER Landfill Approval WM072
• Landfill Barrier Wall Pilot application submitted August 22, 2013

AER Facility Licenses
• F43159 for Pad 25 amended July 22, 2013

ESRD Water Act Licences
• Licence No. 00289164-00-00 for MR2 diversion of water issued January 11, 2013; expiry January 10, 2015
• Licence No. 00307934-00-00 for dust suppression on AOSTRA road issued June 13, 2013; expiry June 12, 2023
• Licence No. 00249470-01-00 for diversion of water (domestic uses) issued July 29, 2013; expiry July 28, 2038
Current Amendments / Applications

**EPEA Approval**
- EPEA renewal approval 48408-01-00 issued August 10, 2012; expiry July 31, 2022

**AER Pipeline Licences**
- Suncor continues its work at the MacKay River site with the In-Situ Pipeline Compliance Rapid Response Team to address any licencing inconsistencies, and to assess and ensure pipelines are in compliance with Directive 056

**ESRD**
- New Wildlife Research Permit (54161) and Collection License (54202) received from ESRD – April 30, 2013
Environmental Initiatives

Suncor is an active member of:

- Cumulative Environmental Management Association (CEMA)
- Regional Aquatics Monitoring Program (RAMP)
- Wood Buffalo Environmental Association (WBEA)
- Alberta Biodiversity Monitoring Institute (ABMI)
- Alberta Water Council (Watershed Planning Advisory Council)
- Canada’s Oil Sands Innovation Alliance (COSIA)
- Oil Sands Spill Coop Area Y

Suncor is in ongoing consultation with:

- Regional stakeholders
- Aboriginal Communities and the local Municipality
Reclamation

2012 Conservation & Reclamation report was submitted to ESRD in March 2013. No reclamation activities are underway at MacKay River.

- **Total area of land cleared in 2012 was 21.9 ha:**
  - Pad 25 extension – 0.8
  - Pad 751 – 18.5
  - Remote Sump – 2.6

- **Estimated total area of land to be cleared in 2013 is 21.7 ha:**
  - Pad 750 – 20.0
  - BEST Fuel Gas Line ROW – 1.7

*Note: Estimated numbers do not include exploration programs*
Regulatory Compliance

- Suncor Energy Inc. is in compliance with all regulatory approvals, decisions, regulations and conditions as described in Decision Report 2000-50; specifically pertaining to:
  - Plant and waste management facility location,
  - Ground level ozone and VOC monitoring,
  - Groundwater monitoring wells,
  - Surface water quality monitoring, and
  - Participation in Regional Initiatives.
Summary of Key Learnings (Operations)

- Under insulation corrosion presented challenges in previous years. Program in place to inspect / overhaul all tanks by end of 2014

- Improved reliability of group transfer pumps - operations and maintenance procedures

- Rifled tubes installed on 1 of 4 OTSG’s to improve steam quality and lower fouling rates

- Desand drum: Erosion of internal components and pressure boundary is highly variable. Metallurgy upgrades will be implemented.

- Successfully replaced warm lime softener gearbox online. Minimal disruption to process
## Future Plans

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Comments</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion of Phase 5 development</td>
<td>Installation of new facility at Pad 25 and tie-in of Pad 24/25 wells to MR1 via above ground distribution/gathering pipeline system.</td>
<td>Facility construction work underway. Completion spring 2014</td>
</tr>
<tr>
<td>MR2 Pad Development Project</td>
<td>Construction and development of Pads 750, 751 and 28</td>
<td>Drilling and completions underway</td>
</tr>
<tr>
<td>Pad 819 Pad Development Project</td>
<td>Construction and development of sustaining production from JK drilling pattern</td>
<td>Application submitted March 2013</td>
</tr>
<tr>
<td>MR2 Central Processing Facility Amendment</td>
<td>Amendment to approved MR2 CPF due to equipment modifications.</td>
<td>Application planned for October 2013.</td>
</tr>
<tr>
<td>North Arm Pad Development</td>
<td>North Arm is a future development area north of existing pads within the MacKay River PA</td>
<td>Application planned for August 2014</td>
</tr>
<tr>
<td>MR1 Debottlenecking/Optimization</td>
<td>Series of equipment modifications/improvements building towards an increase in MR1 production capacity</td>
<td>Series of submissions over the next three to four years</td>
</tr>
<tr>
<td>Redirection of process water to Suncor base plant operations</td>
<td>Potential to further recycle upset or turnaround production water at base plant operations.</td>
<td>Internal assessment underway. Feasibility and timeline to be determined.</td>
</tr>
</tbody>
</table>
Suncor MacKay River
2013 AER Performance Presentation - Subsurface Commercial Scheme Approval No. 8668

December 10, 2013
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The Suncor Strategy

To provide greater reliability and flexibility to our feedstock supplies, we produce bitumen through mining and in-situ recovery technologies and supplement that supply through third-party agreements.

A staged approach to increasing crude oil production capacity allows Suncor to better manage capital costs and incorporate new ideas and new technologies into our facilities.

We produce natural gas as a natural price hedge against the cost of energy consumption at Suncor’s oil sands operation.

Suncor takes an active role in connecting supply to consumer demand with a diverse portfolio of products, downstream assets and markets.

International and offshore assets are a source of steady cashflow to fund our oil sands growth.

Our investments in renewable wind energy and biofuels are a key part of Suncor’s climate change action plan.
Suncor has high quality leases in close proximity
2013 AER Performance Presentation

Section 3.1.1 – Subsurface Issues Related to Resource Evaluation and Recovery
Table of Contents

• Introduction
• Geoscience
• Well Operations
• Scheme Performance
• Caprock Integrity
• Future Plans
MacKay River Overview

- Company’s first operated SAGD facility - located 60 km NW of Ft. McMurray
- Current Approved Bitumen Production Rate 11,600 m³/d (73 kbpd)
- Adjacent to Suncor Dover (UTF/AOSTRA) project
- Horizontal production wells are placed in the McMurray Formation at a depth of 98 – 145m from surface
- No extensive underlying water or gas over bitumen issues in current development areas
- Initial development had 25 well pairs with first steam in September 2002 and first production in November 2002
- 55 well pairs have been subsequently added
  - Section 16 (Pad 40 – 2 well pairs) first steam October 2005
  - Phase 2 (Pad 22 – 14 well pairs) first steam January 2006
  - Phase 3 (Pad 23 – 7 well pairs) first steam September 2007
  - Phase 4 (Pads 24 & 25 – 10 well pairs) first steam 2008
  - Phase 5A (Pad 25 – 6 well pairs) first steam June 2011
  - Phase 5B-1 (Pad 24 – 6 well pairs) first steam February 2012
  - Phase 5B-2 (Pad 25 – 10 well pairs) first steam January 2013
Project Area and Project Site

- Current Project Area (PA) approximately 24 ½ sections
Wellpads and Subsurface Patterns

- 78 producing well pairs at MacKay River (up to Phase 5B-2)
- 23 well pairs and 2 single producers were drilled from Sept 2012 – Aug 2013
- 10 Phase 5B-2 well pairs started steaming Q1 2013
Historical Approval Amendments

- **Amendment 8668A**
  - Changed annual average volume to 33,000 bpd (5,250 m³/d)

- **Amendment 8668B**
  - Increase to project area

- **Amendment 8668C**
  - Additional project area
  - Approval to inject non-condensable gas

- **Amendment 8668D**
  - Additions to project area
  - Increase to annual average volume to 72,964 bpd (11,600 m³/d)

- **Amendment 8668E**
  - Approval to drill four well pairs

- **Amendment 8668F**
  - Approval to change approval holder from Petro-Canada to Suncor

- **Amendment 8668G**
  - Approval to undertake amendments & modifications to CPF systems
  - Approval tie-in 6 well pairs to well testing facilities

- **Amendment 8668H**
  - Approval to conduct non-condensable gas injection test on Pad 21 wells

- **Amendment 8668I**
  - Approval to conduct non-condensable gas injection at the Section 16 Test Project

- **Amendment 8668J**
  - Approval to transfer portions of the Dover project area into the MacKay River project area

- **Amendment 8668K**
  - Approval to tie-in 16 well pairs to well testing facilities

- **Amendment 8668L**
  - Approval to remove the limiting factor of a mole percent restriction for the B Pattern non-condensable gas injection test on Pad 21

- **Amendment 8668M**
  - Approval to inject chemical into Pad 22 wells

- **Amendment 8668N**
  - Approval to abandon 3 wells and suspend 1 well on Pad 20

- **Amendment 8668O**
  - Approval to change Phase 5F well trajectories

- **Amendment 8668P**
  - Approval to develop Pads 750/751/28 and add 2 sections to project area
Current Approval Amendments / Applications

- **Amendment 8668Q**
  - Water Treatment Pilot approval issued December 11, 2012

- **Amendment 8668R**
  - Well Abandonment (G1I) approval issued May 9, 2013

- **Amendment 8668S**
  - Chemical Injection Test (Pad 21 D-Pattern) approval issued September 5, 2013

- **Application 1724610**
  - Maximum Operating Pressure Strategy Category 2 application submitted April 10, 2012; SIR 2 response submitted July 16, 2013

- **Application 1757021**
  - Pad 819 Development Category 2 application submitted March 6, 2013; SIR response submitted September 19, 2013
MacKay River Performance Presentation

Geoscience
MacKay River Stratigraphy

- Upper Clearwater
- Clearwater Shale
- Wabiskaw A Shale
- Wabiskaw C Sand
- Wabiskaw D
- McMurray Formation
- Beaverhill Lake

2013 MacKay Bitumen Pay
Contour Interval = 5m

Approved PA
2012-13 Activities – Vertical & SAGD Drilling

- No vertical wells drilled or special core analyses conducted in PA
- 23 SAGD well pairs + 2 single producers drilled in DA, DB & DC patterns
- New SAGD wells*:
  - 751WP14 to 751WP19
  - 751P13 and 751P20
  - 750WP1 to 750WP17
- Upcoming SAGD wells:
  - 751WP1 to 751WP12

* As of Sept 24, 2013
2012-13 Activities - Seismic

- Acquired 15.9 km² of high resolution 3D seismic shot over the MacKay River PA
- Purposes:
  - 4D baseline
  - Reservoir management
  - Caprock integrity
  - Optimized well trajectories

Legend
- Approved PA Boundary
- 2012/2013 3D seismic
- 2011/2012 3D seismic
- 2012 Birch Channel Test Line
2012-13 Activities – Preliminary Seismic Interpretation

• Caprock has not been incised by Quaternary Birch Channel
Bitumen Pay Isopach

10 Weight Percent
Bitumen cutoff

Legend
- Approved PA Boundary

2013 MacKay Bitumen Pay
Contour Interval = 5m
Base of Pay Structure Map

Legend
- Approved PA Boundary

Contour Interval = 5m
Top of Pay Structure Map

Legend
- Approved PA Boundary
- Contour Interval = 2m
Oil Sands Facies and Gross Bitumen Pay

Facies:
Defined by visual mud index (VMI)

Cutoffs:
F1 (Sandstone) = 0-5% VMI
F2 (Sandy IHS*) = 5-15% VMI
F3 (IHS*) = 15-30% VMI
F4 (Muddy IHS*) = 30-70% VMI
F5 (Mudstone) = 70-100% VMI
F10 (Breccia) = variable

* IHS = inclined, interbedded, sand and shale

Pay:
Includes Facies F1, F2, and F10
Can include F3-F5, if < 2m thick

Weight percent bitumen > 10%

Generally > 30% Porosity
- PA averages 31.1% in clean sands

Permeability = 1 to 5 Darcies

> 15m for OBIP volumetrics
Gross Pay Volume (GRV) = total rock volume derived from Continuous Pay map

Net Pay Volume (NRV) = product of Continuous Pay gross rock volume multiplied by the average Net Sand Ratio for each area

Net Sand Ratio (NSR) = a net-to-gross adjustment used to account for pay mapping being done on a continuous (gross) basis
  ➢ 15% VMI (visual mud index) cutoff plus the sand component of breccia intervals

Original Bitumen in Place = product of the Net Pay volume multiplied by the average Porosity, and the average Oil Saturation

$$GRV \times NSR = NRV \times So \times Por = OBIP$$

New net-to-gross adjustment using Net Sand Ratio map allows for consistent application of a mudstone cutoff while: a) avoiding adjustments based on pattern averages, and b) allowing the differential treatment of sand- versus mud-rich breccias.
### Reservoir Properties and Base Case OBIP

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Net Sand Ratio</th>
<th>$S_0$</th>
<th>Phi</th>
<th>$S_0$-Phi</th>
<th>Volumes (e$^3$m$^3$)</th>
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<tbody>
<tr>
<td>A</td>
<td>91%</td>
<td>82%</td>
<td>31%</td>
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<tr>
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<td>86%</td>
<td>32%</td>
<td>27%</td>
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<tr>
<td>D</td>
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<td>91%</td>
<td>31%</td>
<td>28%</td>
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<td>E</td>
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<td>89%</td>
<td>32%</td>
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<td>Section 16</td>
<td>81%</td>
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<td><strong>Subtotal</strong></td>
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<td><strong>37,959</strong></td>
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<tr>
<td>Total PA</td>
<td>90%</td>
<td>84%</td>
<td>31%</td>
<td>26%</td>
<td><strong>172,190</strong></td>
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</table>
Phase 1

Pad 20

Pad 21

2013 MacKay Bitumen Pay
Contour Interval = 5m

Clearwater
Wabiskaw C
Wabiskaw D
Top of Pay
Devonian
Beaverhill Lake

A Pattern
B Pattern
C Pattern
D Pattern
Phases 2, 3 and 4

2013 MacKay Bitumen Pay
Contour Interval = 5m
Phase 5

Clearwater
Wabiskaw C
Wabiskaw D
Top of Pay
Devonian
Beaverhill Lake

Pad 24
Pad 25

2013 MacKay Bitumen Pay
Contour Interval = 5m
Pad 750/751

2013 MacKay Bitumen Pay
Contour Interval = 5m

Clearwater
Wabiskaw C
Wabiskaw D
Top of Pay
Devonian
Beaverhill Lake
Preliminary Estimated Edge of Steam Chamber

Key Observations from preliminary 2012/2013 3D seismic interpretation

- Edge of the steam chamber growth can be estimated in current operating areas
- Warm colours are time delays indicative of steam
2012/2013 Geoscience Key Learnings

• **3D over MacKay PA**
  • Refined seismic source and line spacing to acquire 15.9 km² of high quality data over a relatively shallow reservoir
  • Provided a 4D baseline for upcoming development, estimated edges of current steam chamber growth, optimization of undrilled SAGD trajectories and further input into the MacKay River caprock integrity dataset

• **SAGD Drilling at Pad 750/751**
  • Optimized placement of SAGD trajectories while drilling to reduce standoff between producer and Base of Continuous Pay
Typical Well Completions – Phase 1 Type

Injector

Producer
Typical Well Completions – Phase 5 Type

Injector

- 473 mm surface casing @ mKB
- SHORT STRING 114 mm tubing @ mKB
- HS-HT packer
- Instrumentation guide string
- 114 mm Long Tubing String
- TD @ mKB (128.8 mTVD)

Producer

- 473.0 mm Surface Casing
- 44.5 mm gas lift
- 114.3 mm Short String Last Joint Perforated
- HS-HT packer
- Instrumentation guide string
- Instrument String
- Bubble Tube
- 244.5 mm Slotted Liner
- TD @ mKB (133.1 mTVD)
Well Downhole Instrumentation

- **Phase 1** (25 well pairs)
  - Temperature optic fibre in every producer
  - All failed early on; 5 have been replaced and are functional today (A5, B2, B4, C1, and C2)
- **Phase 2** (14 well pairs)
  - Three producers equipped with temperature optic fibre (E1, E4 and E6)
  - Four producers equipped with 3 x P/T gauges (E3, G2, G3 and G6)
- **Phase 3** (7 well pairs)
  - No instrumentation
- **Phase 4** (10 well pairs)
  - No instrumentation except temperature fibre optics in OO3 I & P
  - Temperature fibre optic installed in NN1P after 2nd liner failure
- **Phase 5A** (6 well pairs, NN2-5, QQ4-5) (SAGD Q4 2011)
  - Pressure - bubble tube to the toe in every producer
  - Two producers equipped with 6 point thermocouple bundle to the toe (QQ5, NN5)
- **Phase 5B-1** (6 well pairs, OO4-9) (SAGD Q2/3 2012)
  - Pressure - bubble tube to the toe in every producer
  - All producers equipped with 6 point thermocouple bundle to the toe
Well Downhole Instrumentation

- **Phase 5B-2** (10 well pairs; NN6-10, QQ 6-10) (Start-up Q1 2013)
  - Pressure - bubble tube to the toe in every producer
  - All producers equipped with 6 point thermocouple bundle to the toe

- **Phase 5D&F** (18 well pairs, NN11-16, OO10-15, QQ11-16) (September 2013 wells completed; start-up planned to begin Q1 2014)
  - Pressure - bubble tube to the toe in every producer
  - All producers equipped with fibre optic to the toe
Workovers

- Pad 20 A3P well suspension/abandonment (pending decision)
- Pad 20 C2P steam trial ended (abandonment, observation well, suspension decision pending)
- Pad 22 E1I surface casing vent flow repair attempted (no H₂S, some bubbles; monitoring)
- Pad 21 D1I & Pad 22 G2I surface casing vent flow repair (no flow, monitoring)
- Pad 40 wells abandonment (not completed)
- Pad 22 G1I well abandonment (in progress)
- Pad 22 G6P liner repair/re-drill (decision pending investigation results, in progress)
- Well workovers to diagnose and address wellbore integrity issues
Workover - Wellbore Integrity Repair

SUNCOR MACKAY RIVER
PC OO(P) - 9 DOVER 16-8-93-12

Hole found ~468 mKB
15m liner patch
Workovers

Pad 40 Wells Abandonment

- 16P2, 16P1 and 16I1 all developed sour SCVFs
- All SCVFs stopped when the wells were killed
- Received extension to repair these wells (16P1 and 16P2) by June 30, 2014
Surface Casing Vent Flow Update

- A3I, F6I – On injection and being monitored
  - $\text{H}_2\text{S}$ level below 10ppm
  - Continue to monitor and inject steam to keep the well warm
- E1I, D1I, G2I – Remedial work done, only E1I has intermittent bubbles
  - No $\text{H}_2\text{S}$, there is no venting on D1I or G2I
  - Continue to monitor, no plan to resume steam injection
- 16I1, 16P1, 16P2 – Vent stopped when steam ceased, and well was killed
- G1I – Have completed two squeezes, third squeeze to be completed before October 31, 2013
  - Plan to complete SCVF repair, monitor, and abandon the well
Artificial Lift

- All SAGD production wells designed for gas lift
  - Low cost completion
  - Recover gas
  - No downhole moving parts

- Wells with downhole pumps:
  - F1P, ESP since February 2009, failed in December 2010 and was replaced
  - OO3P, ESP since October 2009, replaced before failure in June 2011 & March 2012
  - QQ2P, ESP from October 2009 to October 2011 when it was converted to gas lift

- 76 of 78 well pairs on gas lift (completed wells excludes Phase 5D&F) because it is the most economical method where the gas is recovered then used to create steam
  - The two wells with mechanical lift (ESPs) have MOPs at wellhead of 1680 kPag (OO3P) and 1510 kPa (F1P)

- The current wellhead operating pressure range is from 1320 kPag to 1980 kPag
Well Operations – Key Learnings

- **Wellbore stimulations** (4 wells) have been successful in lowering differential pressure (dP) across the slotted liner and help with wellbore conformance in the producers.

- **Wellbore integrity management** is a high priority focused on wellbore containment over wells full life cycle:
  - Continuous improvement plan developed for long term well integrity with focus on monitoring/surveillance, prevention, best practices, and data management.
Observation Wells
Observation Wells

• Total of 125 licensed observation wells at MacKay River

• Observation wells at MacKay River serve three main purposes:
  1. Reservoir optimization (steam chamber monitoring)
     • 44 wells with fibre optic cable from surface to TD
     • 23 wells with thermocouple bundles and pressure sensors
     • 2 heave monitoring wells (extensometers downhole)
  2. Wabiskaw C pressure monitoring
     • 49 wells with a single pressure / temperature sensor
  3. Risk mitigation
     • 10 wells with thermocouple bundles and pressure sensors
     • 2 wells with a single pressure / temperature sensor
     • 5 piezometer wells

• Current observation well design incorporates thermocouple measurement as this provides sufficient resolution for steam chamber monitoring and is preferred for remote well locations.

Note: some wells serve more than one purpose
Observation Well Instrumentation

McMurray Observation Well (Type 1):
• Capillary line loop cemented outside casing
• Fibre optic cable pumped into capillary line loop to provide temperature profile along entire vertical well depth
• Allows for close monitoring of steam chamber development

McMurray Observation Well (Type 2):
• Coiled tubing instrument string containing 14 thermocouples and 1 P/T gauge run inside 114 mm intermediate casing
• Perforated near the top of the McMurray oil sands zone
• Pressure / temp gauge positioned at MPP
• 14 point thermocouple bundle collects temperature data across the McMurray
Observation Well Instrumentation

**Wabiskaw C Observation Well:**
- Open hole into Wabiskaw C sand
- Wellbore does not penetrate Wabiskaw D mudstone or McMurray sand
- Pressure / temp gauge landed inside tubing
## Summary of Operating Wells

<table>
<thead>
<tr>
<th>Pad</th>
<th>Pattern</th>
<th>Phase</th>
<th># Well pairs</th>
<th>Start-up</th>
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<td>A</td>
<td>1</td>
<td>7</td>
<td>Sept 2002</td>
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<td></td>
<td>C</td>
<td></td>
<td>6</td>
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<tr>
<td>21</td>
<td>B</td>
<td></td>
<td>7</td>
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</tr>
<tr>
<td></td>
<td>D</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>22</td>
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<td>Jan 2006</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>F</td>
<td>3</td>
<td>7</td>
<td>Sept 2007</td>
</tr>
<tr>
<td>24</td>
<td>OO</td>
<td>4</td>
<td>3</td>
<td>Oct 2008 - Apr 2009</td>
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<td></td>
<td></td>
<td>5B-1</td>
<td>Feb 2012</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>4</td>
<td>4</td>
<td>Feb 2009 - Jun 2010</td>
</tr>
<tr>
<td>25</td>
<td>QQ</td>
<td>4</td>
<td>2</td>
<td>Nov 2008</td>
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<td></td>
<td>5A</td>
<td>Jul 2011</td>
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<td></td>
<td>5B-2</td>
<td>Jan - May 2013</td>
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<td>NN</td>
<td>4</td>
<td>1</td>
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<td></td>
<td>5A</td>
<td>Jun - Jul 2011</td>
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<td></td>
<td>5B-2</td>
<td>Jan - Feb 2013</td>
</tr>
</tbody>
</table>
MacKay River Fluid Rates

Events 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Rate (m³/d)

Steam Oil Ratio (m³/m³)

MacKay River Fluid Rates

3.1.1 7 a) ii, iii
### Major Outage Events

<table>
<thead>
<tr>
<th>No.</th>
<th>Month</th>
<th>Major Events</th>
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<tr>
<td>1</td>
<td>May 2003</td>
<td>Steam gen outage</td>
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<tr>
<td>2</td>
<td>May 2004</td>
<td>Warm lime softener repair</td>
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<td>3</td>
<td>Sept 2004</td>
<td>Plant turnaround</td>
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<td>4</td>
<td>May 2006</td>
<td>Warm lime softener repair</td>
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<td>5</td>
<td>Oct 2006</td>
<td>Plant turnaround</td>
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<td>6</td>
<td>May 2007</td>
<td>Transformer maintenance</td>
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<tr>
<td>7</td>
<td>Nov 2007</td>
<td>Plant outage</td>
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<td>8</td>
<td>May 2008</td>
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<td>July 2009</td>
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<td>14</td>
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<td>15</td>
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<td>Cogen outage</td>
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<tr>
<td>16</td>
<td>Jun 2013</td>
<td>Cogen maintenance</td>
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</table>
MacKay River Producing Well Count

- Phase 1
  - Section 16
  - Phase 2
  - Phase 3
  - Phase 4
  - Phase 5A
  - Phase 5B-1
  - Phase 5B-2

Well Pair Count

Oil Rate [m³/d]

- Well Count
- Oil Rate

Suncor

3.1.1 7 a) ii, iii
MacKay River Cumulative Fluid Volumes

As of August 2013
Cum Oil  14.8 million m³
Cum Steam  34.9 million m³
Cum Water  35.2 million m³
CSOR  2.4
CSOR by Pattern

- QQ wells have the lowest CSOR
- H and OO wells have a mid range CSOR
- A Pattern has the highest CSOR
### Performance Summary by Pattern

<table>
<thead>
<tr>
<th>Pattern</th>
<th>OBIP [e³ m³]</th>
<th>Cum. Oil [e³ m³]</th>
<th>Recovery up to August 2013 [%]</th>
<th>CSOR [m³/m³]</th>
<th>ISOR (Aug. 2013) [m³/m³]</th>
<th>Ultimate Recovery [%]</th>
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<tbody>
<tr>
<td>Pattern A</td>
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<td>37.8</td>
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<td>Pattern B</td>
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<td>Pattern D</td>
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<td>3.5</td>
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<td>50.6</td>
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<td>Total</td>
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<td>38.9</td>
<td>2.4</td>
<td>2.6</td>
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</table>
### Pattern Examples Based on Recovery

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<th>Pattern</th>
<th>ISOR $[\text{m}^3/\text{m}^3]$</th>
<th>CSOR $[\text{m}^3/\text{m}^3]$</th>
<th>Cum Oil $[10^3 \text{m}^3]$</th>
<th>Peak Oil Rate $[\text{m}^3/\text{d}/\text{well pair}]$</th>
<th>Current Oil Rate $[\text{m}^3/\text{d}/\text{well pair}]$</th>
<th>Comments</th>
</tr>
</thead>
</table>
| A Pattern | 4.2                           | 4.3                           | 904                         | 73-149                          | 15-39                           | - 79% Facies 1  
- 38% recovery to date  
- Producing for more than 10 years |
| Low Recovery |                               |                               |                             |                                 |                                 |          |
| E Pattern | 2.1                           | 1.9                           | 1886                        | 125-235                         | 15-95                           | - 79% Facies 1  
- 51% recovery to date  
- E1I is shut-in  
- Producing for about 7 years |
| Medium Recovery |                               |                               |                             |                                 |                                 |          |
| C Pattern | 4.3                           | 2.2                           | 3091                        | 179-299                         | 74-172                          | - 95% Facies 1  
- 73% recovery to date  
- C1I, C2I, C2P are shut-in  
- Producing for more than 10 years |
| High Recovery |                               |                               |                             |                                 |                                 |          |
A Pattern – Low Recovery
E Pattern – Medium Recovery
C Pattern – High Recovery
Steam Chamber Development

Areas of Interest

- Chamber conformance along horizontal section
  - OO3 before and after turnaround Aug 2013
- Overall pattern & field chamber growth

Methods of Investigation

- Temperature Logs
- Surface heave monitoring
Steam Chamber Development: OO3P Temperature Fall-off

- Temperature fall offs were performed Mar 2012 and Sept 2012 (during turnaround)
- Acid wash performed in March 2012 – after initial temp log
- Observed improved conformance and production
  - Cold spots warmed up, hot spot at the toe continues to the warmest section of the well
Steam Chamber Development: Surface Heave Monitoring

- 372 monuments exist over MacKay River for heave measurement and monitoring
- Survey History
  - 1st: Fall 2002
  - 2nd: Dec 2006
  - 3rd: Fall/Winter 2007/08
  - 4th: Nov 2008
  - 5th: Jan/Feb 2010
  - 6th: Nov. 2010
  - 7th: Dec. 2011
- Maximum surface heave gradient observed on the southern edge of Phase 1 Patterns:
  - A: 0.0017 m/m
  - B: 0.0023 m/m
  - C: 0.0018 m/m
  - D: 0.0041 m/m
2D Surface Heave: Change from Baseline to December 2012

- The maximum displacement from baseline is 63 cm over 12 years
  - Overlying the heel of B5/B6 and the heel of C5/C6
  - Areas close to wells with high recoveries
- Heave above active steam chambers continue to increase at rates between 3.5-5 cm annually
### Surface Heave Monitoring Cross Section

<table>
<thead>
<tr>
<th>Start of SAGD</th>
<th>Position of Monument Along Hz</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4</td>
<td>Sept 2002</td>
<td>2/3</td>
</tr>
<tr>
<td>B4</td>
<td>Sept 2002</td>
<td>Heel</td>
</tr>
<tr>
<td>C5</td>
<td>Sept 2002</td>
<td>1/3</td>
</tr>
<tr>
<td>D5</td>
<td>Sept 2002</td>
<td>1/2</td>
</tr>
<tr>
<td>F4</td>
<td>Sept 2007</td>
<td>2/3</td>
</tr>
<tr>
<td>G4</td>
<td>Jan 2006</td>
<td>2/3</td>
</tr>
<tr>
<td>NN1</td>
<td>Dec 2008</td>
<td>Heel</td>
</tr>
<tr>
<td>QQ2</td>
<td>Nov 2008</td>
<td>Heel</td>
</tr>
</tbody>
</table>
Key Learnings: Subsurface Instrumentation

Phase 5A (QQ4 & QQ5, NN2 – NN5)
• SAGD conversion readiness of the un-instrumented wells can be benchmarked against the appropriate instrumented wells (NN5 and QQ5)

Phase 5B-1 (OO4 – OO9) and 5B-2 (QQ6 – QQ10, NN6 – NN10)
• Thermocouple orders can be verified using steam movement during start-up
• Thermocouples allow for the detection of steam-to-toe
Key Learnings: Subsurface Instrumentation Cont.

- Thermocouples help to describe down hole behaviour
  - Assist in managing temperature conformance
  - Can help in evaluation of initial reservoir conditions
  - Aids in understanding impact of our operating process
  - Thermocouples show that surface measurement may not fully explain downhole behaviour
Key Learnings: Subsurface Instrumentation Cont.

- Temperature fall-off tests are conducted prior to converting from circulation to SAGD using 6-point thermocouple in producer horizontal.
- Testing involves stopping steam injection for 18-20 hours allowing estimation of the near wellbore temperatures.
- Ultimate fall-off temperatures are used as SAGD conversion readiness indicators.

![Temperature Fall-Off Test diagram]

- Actual data
- Best fit
Key Learnings: Revised Start-up Strategy for Phase 5B-2

Phase 5B-2 circulation strategy remains consistent with Phase 5A and 5B-1

**Historical Circulation Methodology**
- Emphasis on short circulation duration and quick ramp up
- Utilized higher rates to achieve heating
- Utilized delta P between injector and producer after 30 days

**Phase 5B-2 Circulation Methodology**
- Emphasis on conformance and uniform heating versus duration
- Target lower rates (2-3 m³/hr) while maintaining steam-to-toe
- Target of 0-50 kPag delta P between injector and producer
  - Daily adjustments based on flowing bottom hole pressure (FBHP)
- Use downhole instrumentation and production testing data (oil rate) to estimate conversion timing
Steam Injection Conditions

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Current Maximum Injection Pressure at WH (kPag)</th>
<th>Proposed Maximum Surface Operating Pressure (kPag)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1650</td>
<td>1910</td>
</tr>
<tr>
<td>B</td>
<td>1650</td>
<td>1810</td>
</tr>
<tr>
<td>C</td>
<td>1550</td>
<td>1570</td>
</tr>
<tr>
<td>D</td>
<td>1380</td>
<td>1400</td>
</tr>
<tr>
<td>E</td>
<td>1410</td>
<td>1430</td>
</tr>
<tr>
<td>F</td>
<td>1490</td>
<td>1510</td>
</tr>
<tr>
<td>G</td>
<td>1710</td>
<td>1730</td>
</tr>
<tr>
<td>H</td>
<td>1980</td>
<td>2010</td>
</tr>
<tr>
<td>NN1-5</td>
<td>1870</td>
<td>1890</td>
</tr>
<tr>
<td>NN6-10</td>
<td>1920</td>
<td>1970</td>
</tr>
<tr>
<td>QQ2-5</td>
<td>1350</td>
<td>1370</td>
</tr>
<tr>
<td>QQ6-10</td>
<td>1320</td>
<td>1350</td>
</tr>
<tr>
<td>OO1-3</td>
<td>1660</td>
<td>1680</td>
</tr>
<tr>
<td>OO4-9</td>
<td>1690</td>
<td>1710</td>
</tr>
</tbody>
</table>

*requested in application 1724610 currently under review

- Proposed MOPs based on the methodology detailed in Application 1724610
- MOPs are set by shallowest point in each pattern to allow for intra-pattern communication.
- Steam injection pressure is reduced as required to maintain estimated bottomhole pressure below MOP for neighbouring patterns in communication.
- Steam injection pressure limits are enforced at wellhead on tubing and annulus via pressure transmitters. Phase 1 wells are monitored via manual pressure measurement at the wellhead every second day.
- As of end of reporting period there have been no exceedances of downhole MOP.
- Design steam quality at the injection wellheads is 95% or greater. Due to complexity and safety concerns with sampling, steam quality is not measured at this point.
Methodology for Predicting Scheme Performance

- Methodology for production forecasting has not changed from last year
- Evaluating the use of historical analog data to better forecast future decline behaviour of wells with mature steam chambers

Phases 1 - 5
- Oil forecast is based on the following:
  - The SAGD theoretical flow equations for the rising and spreading of the steam chamber (Butler) are used to describe the profile trend
  - Production history matching is used to calibrate the analytical model
  - Water & steam forecasts are based on historical performance trends

Future Phases
- Production profile predicted using a combination of numerical flow simulation and analytical forecast
Analytical model used to match performance history of wells in SAGD mode
Focus on trend fitting current phase of well’s life, not individual points
Forecast describes reservoir deliverability only
Pad Abandonment Outlook

• The strategy for future well and pad (including surface equipment) abandonments is under development
• Wellbore integrity concerns will be addressed prior to abandonment
• Do not anticipate abandonment of Pads 20, 21, 22, 23, 24 or 25 during the next 4 years
  • Pads 20 and 21 (A/C and B/D patterns) are the most mature and are expected to be under pressure maintenance within 5 years.
  • Individual wells may be suspended or abandoned but some wells may be required to remain operational
  • B pattern NCG injection results may impact wind-down and pressure maintenance strategies, but not expected to accelerate timing of pad abandonment
  • Pad 20/21 facilities may be utilized for future development (e.g. J/K)
• Pad 40 expected to be abandoned within the next 4 years
  • Wells have historically performed poorly
  • Considerations for surface equipment are under review
SAGD Wind-down Strategy Development

B-Pattern Non-Condensable Gas (NCG) Co-injection Pilot

- Fuel gas (methane) co-injection with steam into B3, B4, and B5
- Cumulative gas injection to August 31, 2013 is 9,823,300 sm³
  - Average injection rate of 5,735 sm³/d/well since beginning of pilot (maximum injection approval of 10,000 Sm³/d/well)
- Volume Percentage of Total attributed to NCG (sm³ NCG / [sm³ NCG + sm³ STEAM]):
  - 4% of B3, B4, and B5 injection and 2% of total B pattern injection
- No significant impact to oil production
- Noticeable decrease in SOR
SAGD Wind-down Strategy Development

- Some evidence of localized partial pressure cooling effects at both toe and heel
- Evidence of stable or slightly elevated chamber pressure within B pattern

Path Forward
- Plan to continue optimization of NCG and steam injection
- Monitor impact on chamber pressure and production
- Plan for expansion of wind-down to all of Phase 1
Chemical Additive Co-Injection Pilot

- Pilot consists of three well pairs (E3, E4, & E5) on Pad 22 at MacKay River
- Started injecting chemical additive (SAW7965) in June 2012
- Additive concentration ranged between 250ppm to 1000ppm throughout the duration of the pilot
- Chemical injection ended in July 2013
- Encouraging results were obtained in regards to bitumen production trends
- A second pilot is planned for D-pattern using a new chemical
Caprock Integrity

- Geology
  - Natural fractures analysis/modeling (no changes to last year’s information)
  - Caprock characterization from preliminary 3D seismic interpretation

- Monitoring
  - Wabiskaw C pressure / temperature monitoring

- Geomechanics
  - Mini-frac testing (no changes to last year’s information)
  - Geomechanical simulation studies
  - Ongoing and future workplans
Dataset for Characterization of Natural Fractures

2005/06:
• Image logs for 15 wells

2007/09:
• Cores and/or image logs for 17 wells

2010/11:
• 17 wells with cores and image logs,
  • 11 wells with only image logs

2011/12:
• Cored 6 wells
  • FMI logs for 34 wells

2012/13:
• No wells were drilled
Geology - Observations of Natural Fractures

Dataset
- Over 700 individual fracture observations have been assessed, measured, and classified
- 3rd party currently running fracture analysis of 2011/12 core
  - Caprock core logging & fracture identification of 6 high cores (OB-OO-2, OB-QQ-9, OB-QQ-1, STUV-11, STUV-22, SD-48)
  - Analysis and integration of 34 image logs into MacKay River caprock dataset

Fracture Frequency
- Fracture frequency higher for the lower part of the Clearwater Shale and the Wabiskaw A Shale than for the Wabiskaw D Mudstone.
- No observed correlation between natural fracture frequency and proximity to SAGD operations

Fracture Orientations
- Orientations are random in azimuth. Summaries of the Wabiskaw A Shale fracture orientations are shown below (does not include 2011/12 core data):
• The Birch Channel does not affect the integrity of the Clearwater Caprock in the MacKay River Development Area
Monitoring: WabC Pressure & Temperature

Average pressure increase of 15 kPa from October 2012 to September 2013

- Pressures are well below hydrostatic and fracture pressures

8 WabC wells with elevated temperatures directly above mature SAGD operations

- 3 wells between 100°C and 90°C - 5 wells between 30°C and 90°C
- Elevated temperatures are within the expected range as depicted by heat conduction calculations
- Ongoing analysis and simulation efforts are continuing to further understand underlying mechanisms
Geo-Mechanics: Minifrac Test

• No minifrac tests were conducted in the reporting period

• Most recent 2 minifrac tests were reinterpreted by third party (05-34-092-12W/00 and 09-06-093-12W4)
  • Results agree with previous findings that vertical stress is the minimum principle stress

• The MacKay River asset team is reviewing the potential to run another minifrac test in the current project area during the 2013/14 winter program
**Geo-Mechanics: Geomechanical Simulation Studies**

### Sensitivity Study and Continued Calibration to Field Data

- Studies performed in conjunction with MOP Application (1724610) SIR #2 sent to the AER July 16, 2013
- Evaluated stress unloading/relaxation effect of the caprock and the implications for a safe maximum operating pressure (MOP) design
- Investigated both single well pair and pad models to review the edge effects around large development areas
- Re-calibrated the MacKay River geo-mechanical model utilizing the most recent surface heave data and pressure measurements in the McMurray

### Results

- Reduction in the minimum horizontal caprock stress occurs above the well pairs, but showed a low risk of tensile failure in both the well pair and pad simulations
- Risk of elevated shear stress at the edge of well pads was shown to be low based on the designed MOP’s
- Vertical pressure transmission was calibrated and shown to be important in evaluating the shear strength of the caprock
- Shear strength of the Wabiskaw D Mudstones continues to be an important variable in limiting the MOP of the MacKay River operating area
Geo-Mechanics: Ongoing Work/Future Plans

**Geo-Science**
1. Geomechanical lab testing on cores collected in 2011/12 winter program
2. Evaluation of another mini-frac data point to improve the caprock integrity database
3. Ongoing characterization of natural fractures, future fracture modeling of caprock units
4. Ongoing interpretation and geo-mechanical analysis of new seismic

**Monitoring**
1. Continuous monitoring and analysis of Wabiskaw C pressure and temperature data
2. Designing options for Wabiskaw C production test
3. Addition of more heave monuments over new phases
4. Continued effort required to keep observation well instrumentation in working condition

**Geo-Mechanical Interpretation**
1. Continually tuning the geo-mechanical simulation model to safely operate the asset and identify opportunities for improving understanding of caprock behavior above MR operations
MacKay River Coupled Geo-Mechanics/Reservoir Workflow

1 - Data Gathering
- Well Operations (Rate/Pressure)
- Pressure (Piezometer)
- Temperature (Thermocouple/Fiber)
- Stress (minifracs)
- Geomechanical (core tests)
- Surface Heave (monuments)
- Dilation (Extensometers)

2 – Data Interpretation
Reservoir Physics
- Well performance
- Vertical Pressure Leak-off
- Lateral Pressure Leak-off
- Vertical heat conduction
Geo-Science
- Initial stress state
- Material behavior
  - shear strength
  - dilation
  - perm enhancement
  - fractures
- Surface Heave
- Reservoir level deformations

3 - Coupled Reservoir Geo-Mechanics
- Update material properties
- Update pressures and stress state
- Recalibrate field history match
- Truth test model
- Forecast/Design for all developments

4 - Learnings
- Sensitize key variables within uncertainty range
- Quantify geomechanical risks
- Verify and update MOP
- Recommend further measurements
- Design lab tests

Geo-Mechanical analysis for safe optimal MacKay River operations
MacKay River Performance Presentation

Future Plans
Phase 5 Development

- Pad 25 south, 6 well pairs (Phase 5A): 1st steam June 2011
- Pad 24 south, 6 well pairs (Phase 5B-1): 1st steam Feb 2012
- Pad 25, 10 well pairs (Phase 5B-2): 1st steam Q1 2013
- Pad 24 & 25 north, 18 well pairs (Phase 5D/F): 1st steam Q2 2014
  - 18 well pairs - drilling finished Q3 2012
  - Completions finished Q3 2013
  - Pad facilities construction commenced early 2013
- All Phase 5 wells will produce to existing MR1 central processing facilities
- Sufficient steam capacity available to satisfy Phase 5 steam requirements
- AER D51 approval received August 2013 for Pad 25, 10 well pairs (Phase 5B-2) D51
  - No outstanding approvals
**Future Development: Pads 750/751**

- To provide sustaining production for the existing MR1 central processing facility (CPF), as well as support potential growth for a future MR2 CPF
  - Approval received August 7, 2012
  - Approved Pads 28, 750 & 751, 38 well pairs, 2 single producers
    - Note that Pads 50 and 51 have been renamed to 750 and 751, respectively
  - Pad 751 West drilling completed March 2013
  - Pad 750 drilling forecast completion September 2013
  - Pad 751 drilling forecast start Q4 2013
  - Completions activity planned for 2014
  - Vintage/orphan well review complete, abandonment program approval submission planned Q3 2014
Future Development: Pad 819 (JK pattern)

- JK pattern is the next proposed phase of horizontal wells to the south of existing infrastructure
- D78 amendment submitted March 2013; SIR response submitted in September 2013
- Currently evaluating new facility requirements
Future Development: North Arm

- North Arm region is a future area of development within the MacKay River PA
- D78 amendment currently targeted for August 2014