Thermal In-Situ Scheme Progress Report for 2015
Japan Canada Oil Sands Limited Hangingstone

Approval No. 8788 (Demonstration Project)

Presented on February 23, 2016
1. **Background – Hangingstone Expansion Project**
   - Demonstration Enzo Pennacchioli
   - Expansion Enzo Pennacchioli

2. **Subsurface**
   - Geosciences Leigh Skinner
   - Well Design & Instrumentation Bob Park
   - Reservoir Performance Christian Canas

3. **Surface Operations**
   - Facility Design Bob Park
   - Measurement & Reporting “
   - Water “
     - Source “
     - Disposal “
   - Other Wastes Bob Park
   - Sulphur Emissions “
   - Environmental (included but not presented) Enzo Pennacchioli
   - Compliance Statements & Approvals Enzo Pennacchioli
   - Future Plans Enzo Pennacchioli

4. **Discussion**
Demo Scheme No. 8788 Background

**Plant 1**
- On original PCEJ CSS Site
- Startup 1999 – 2,000 bbl/day (320 m3/day)

**Plant 2**
- Phase 2 Facility, startup 2000 - 4,000 bbl/day (640 m3/day)
- Phase 3 Facility, startup in 2002 - 4,000 bbl/day (640 m3/day)

- Project located 50 km south of Fort McMurray
- Approved demonstration project area: 3.75 sections
- Approved production capacity: 11,000 bbl/day (1,760 m3/day)

**Wells & Pads**
- Pad 1: A,B (startup 1999)
- Pad 2: C,D,E (startup 2000)
- Pad 3: F,H,I (startup 2002)
- Pad 5: T (startup 2007); R,S (2008); U startup Nov 2010; V&W drilled in 2011; (W started circulation in May 2013 and put on SAGD in August 2013)
- Pad 6: X started in May 2010 (ESP started in Dec); Y started circulation Nov/11 (Y well ESP started in Feb 2013)
Subsurface
Geosciences
Hangingstone Demo Database
Hangingstone Demo Net Pay

Net Pay: 15-30 m
Porosity: 33%
Oil Saturation: 85%
Depth: 280 - 300 m
Permeability: Kv:5,132mD Kh:5,774mD
Initial Reservoir Temperature: 11°C
Initial reservoir pressure: 2,100kPa
Hangingstone Demo Top Reservoir Structure
Hangingstone Demo Composite Well
Hangingstone Demo Scheme Cross-Section
Cap Rock Integrity

- No change in conclusions - continue to observe no cap rock integrity issues through 2015
- Initial determination of injection pressures was based on mini-frac tests in 1980s
- 2010 Mini-frac test for Hangingstone Expansion (HE) Project Cap Rock Integrity Study shows consistent results
- HE Project Cap Rock Study concluded 5 MPa to be a safe operating pressure (80% of fracture pressure)
- Ongoing sand production in some wells, but manageable through:
  - Stable operation
  - Higher subcool
- Bottom pressure is regularly measured by purging the annulus with gas; utilizing it as a bubble tube and recording the pressure.

<table>
<thead>
<tr>
<th>Depth, m</th>
<th>Min. stress (MPa)</th>
<th>Min. stress (kPa/m)</th>
<th>Vert. stress (MPa)</th>
<th>Vert. stress (kPa/m)</th>
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</table>
Surface Heave Monitoring

Maximum heave in 2014-2015: 31.0 mm
vs. 2013 – 2014: 40.0 mm

• Modeling predicted max heave of 400mm over 10 years
  with max slope of 0.12%
  • within structural design tolerances for surface facilities
• Measured heave thus far within predictions
• No concerns observed

Network of 54 monuments

Cumulative Heave 1999-2015: 381 mm
Max Slope: 0.078% (increase of 0.006% from 2014)
Well Design and Instrumentation
Bottom Hole Pressure (BHP) Measurement

Startup Circulation mode on Injector and Producer:

- A small amount of gas is injected down the 7” inner annulus to displace liquids and eliminate possible buildup of a liquid column (similar to bubble tube testing) in the vertical section. This provides accurate continuous BHP measurement, and reduces heat transfer between the injected steam to the toe (4 ½” tubing) and the produced fluid (PF) returns from the outer annulus.

- Steam rates vary depending on PF return temperatures at the surface facilities.
Bottom Hole Pressure (BHP) Measurement

SAGD Mode: Injector
- Gas is injected intermittently down the 9-5/8” or outer annulus to displace liquids and eliminate possible buildup of a liquid column in the vertical section
- Surface steam injection pressure is a reliable proxy for downhole pressure.
- Small pressure drop between the surface and actual downhole pressure due to frictional losses does not vary significantly over time
- Some injectors with reliable instrument thermocouple points are used as a secondary data source
- Steam injection rates (toe or heel) vary depending on well conformance

SAGD Mode: Producer
- Heel BHP measurements are similar to the Injector wells whereby gas is injected intermittently down the outer annulus
- This allows operating delta T (Injector/Producer) set points to provide liner integrity and production optimization.
- Emulsion/Bitumen returns are produced either from the toe or heel sections, depending on temperature profile of the producer lateral
- ¾” instrument coil (thermocouples) are placed inside the producer 4 ½” toe strings
SAGD Well Layout

- 24 active well pairs
  - "oldest" wells A/B, started up in July 1999
  - "youngest" wells V and W, started up in July 2012 and May 2013 respectively
- F-Well abandoned 2014

N/C from 2014 PR
## SAGD Well Completions

### Approval Nos: 8788K (Demonstration)

#### N/C from 2014 PR

### Typical Injector
- 406 mm (16") Conductor Casing
- 245 mm (9 5/8") Intermediate Casing
- 177.8 mm (7") Tie-Back Casing
- 177.8 mm (7") Liner w/ Screens
- 114.3 mm (4 1/2") Tubing

### Typical Producer
- 406 mm (16") Conductor Casing
- 245 mm (9 5/8") Intermediate Casing
- 177.8 mm (7") Tie-Back Casing
- 177.8 mm (7") Liner w/ Screens
- 114.3 mm (4 1/2") Tubing

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### Well Completions Table

<table>
<thead>
<tr>
<th>Wellpair</th>
<th>Tie-Back</th>
<th>Liner Size</th>
<th>Screen Type</th>
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<td>I/P</td>
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<td>I/P</td>
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<td>P</td>
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<td>U</td>
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<td>I</td>
<td>I/P</td>
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<tr>
<td>V</td>
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<td>I/P</td>
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<tr>
<td>Y</td>
<td>Yes</td>
<td>I/P</td>
<td>Failed Liner - 5-1/2&quot;WWS</td>
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<tr>
<td>Z</td>
<td>No</td>
<td>P</td>
<td>SCVF - 7&quot; Cement to Surface</td>
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</table>

**Legend:**
- I = Injector Well
- P = Producer Well
SAGD Well Completions

- 1999-2004 MeshRite/wire wrap – Limited technology available for “SAGD” applications
  - Isolated cases of sand production

- 2005-2010 Slotted Liner – Commercial emergence of technology, lower cost alternative
  - Good sand control
  - High pressure drops
SAGD start-up in July 2012
Liner failure (sand production / plugged well off) June 2013
Well workover Aug – Oct 2013
Installed one 7” casing patch, issues with casing patch setting tool
Installed scab liner w/ 0.005” Wire-Wrapped-Screen
  • Restarted SAGD in June 2014
  • Replaced instrumentation coil - mechanical failure
  • Fluid recovery of calcium chloride/nitrate heavy brine solution before commingling with produced fluid returns to CPF
  • Well running at conservative rates, BS&W sampling show intermittent traces of solids, and bitumen slowly increasing
Contributing factors which resulted in “challenging” workovers

- JACOS DEMO operates at high injection pressures (≈4500kPa) resulting in downhole pressures higher than hydrostatic head
- Failed wells are in communication with adjacent wells making it difficult/impossible to de-pressure the reservoir
- Specialized brine (up to 1.6 density) is required to weight-up the column to perform workovers
  - Well control is difficult due to fluctuating downhole pressures; wells take kill fluids
  - Brine kill fluid returns have negative effect on plant water treatment systems; well produced fluid is trucked out until hardness/chlorides are at acceptable levels
HZXP/HZYP ESP trial was initiated to test downhole pumps.

The location of the wells was chosen due to the fact the wells are relatively isolated from the adjacent high pressure wells. The adjacent well (W) was the last well to be brought on stream.

Eventually when X/Y steam chamber coalesces with W-Well, X/Y will be converted to “natural lift” SAGD wells.
Demo Artificial Lift

HZXP – Schlumberger Hotline 550 (218°C)
1st ESP pump installed Dec/10 – April/12 (Run Time 487D, Surface Connector Failure).
2nd ESP system installed May/12- June/13 (Run Time 381D, Surface Connector / Electrical Cable Failure).
-3rd ESP pump installed July/13
  Operating Temperatures up to 210°C
  Intake Pump Pressure – 2000-2800kPa
  Production rate - 160-320 m³/D
  ISOR ≈ 2.5

HZYP – Schlumberger Hotline SA3 (250°C)
Pump installed Jan/13, online Feb/13
  Operating Temperatures up to 175°C
  Intake Pump Pressure – 2000-2800kPa
  Production rate - 100-150m³/D (Reduced rates due to high ΔP, temperature spikes)
  ISOR ≈ 4.3
Demo Thermocouple Placement

Instruments in Wells

Wells A, B
Injector

Wells C, H
Injector

Wells D, E, I
Injector

Wells J, K, L, M, N, O, P, Q, R, S, T
Injector

No Thermocouples

Well U, V, W, Y
Injector

No Thermocouples

N/C from 2014PR
Demo Instrumentation HZXP (ESP)

HZXI – 6 Thermocouples
HZXP – 40 Point LX-Data Temperature, LX-Data Pressure
ESP – Single Point LX-Data Temperature, LX-Data Pressure

Approval Nos. 8788K
N/C from 2014PR
Reservoir Performance
Currently producing 24 SAGD well pairs

2015 average bitumen rate ~ 5,284 bbl/day (840 m³/day)

Cumulative bitumen produced from project startup to 12/31/2015 ~ 34.58 million bbl (5.5 million m³)

Cumulative SOR to 12/31/2015 ~ 3.77 (wt/wt) (3.81 V/V)

OBIP for the developed area is 78 million bbl (12 million m³)

Recoverable bitumen is estimated at 48 million bbl (7.6 million m³) (61% Ultimate Recovery)
### Steam Injection (Temp, Pressure, Quality)

#### Annual Average Wellhead Pressures and Temperatures

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<thead>
<tr>
<th>Wells</th>
<th>Pressure (kPa)</th>
<th>Temperature (°C)</th>
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<tbody>
<tr>
<td>A Well</td>
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<td>257</td>
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<td>C Well</td>
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<td>P Well</td>
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<tr>
<td>Average</td>
<td>4466</td>
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**100% Steam Quality* @:**

HZA, HZB, HZC, HZD, HZE

Average Steam quality for the remaining wells ~ 95%

* Steam Traps @ Phase 1&2 Wellheads
DEMO Field Performance

TOTAL FIELD PERFORMANCE
FROM START-UP TO DECEMBER 2015 (FINAL NUMBERS)
DEMO Field Cumulative Volumes
For bitumen production:

- SAGD well life consists of build up period, plateau period and decline period.
- Plateau rate is calculated as a function of effective net thickness.
Generic Production Curve

- **Buildup Period**
- **Plateau Period**
- **Decline Period**

**End of Plateau Period**

\[ \text{End of Plateau Period} = \frac{1}{2} \text{ of Reserves Recovered} \]

**Cumulative production = Reserves**
Methodology

- A linear trend is adopted to describe the SOR performance.
- The initial SOR in the demo area has been evaluated as a function of effective net thickness. The initial SOR is classified into four categories of net thickness.
  - 10, 15, 20, 25m
- The increasing ratio with time is from simulation results.
  - 0.025/month
- The actual trend is close to this prediction.
Linear Trend

- Buildup Period
- Plateau Period
- Decline Period

Instantaneous SOR vs. Production Period (Years)
Wells with History - 1

End of Plateau Period = \( \frac{1}{2} \) of Reserves Recovered

Cumulative production = Reserves
Wells with History - 2

Cumulative production = Reserves

Update decline based on actual trend
Wells with History - 3

Well Life is based on the Performance of Bitumen Rate

Instantaneous SOR

History ↔ Forecast

Linear Trend

Production Period (Years)
Decline Method

- Adapted to well groups (A to Q pairs) that have enough production history to estimate the decline
- The steam chambers from the well pairs in this group have merged or will merge in the future (Steam chamber between J well and O well have a communication since 2011.)
- A trend that reflects the stable operating period in both bitumen production and SOR is picked for the forecast with assumption that reservoir pressure will be relatively constant (fluctuation in pressure may exist due to marketing of bitumen and gas supply)
A-Q Production Forecast

Decline predicted from A – Q well pair production history
## DEMO Well Pairs Recovery Factor

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Well Pair</th>
<th>Original Bitumen in Place (Mm3)</th>
<th>Cum Produced Bitumen (Mm3)</th>
<th>Current Recovery (%)</th>
<th>Ultimate Recovery (%)</th>
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<tbody>
<tr>
<td>1999</td>
<td>A, B, C, D and E</td>
<td>3,113</td>
<td>1915</td>
<td></td>
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<td>2002</td>
<td>H, I, J and K</td>
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<td>L, M and N</td>
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<td>788</td>
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<td>Y and V</td>
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<td>W</td>
<td>585</td>
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Well Pair Performance Example

Recovery factor at the end of 2015: 67.4%

B-producer: Shut-in

B-producer: Restarted
A-B Well Pairs Highlights

- These wells have approximately 15 years history and were maintaining economic performance prior to price reductions.
- These two wells produced ~ 5.8 MMbbl (0.92 million m³) of bitumen and CSOR ~ 3.8
- The steam chambers for the A and B wells have been communicating since late 2001.
- The injection pressure of B is slightly higher than A, thereby sweeping bitumen from B to A. B well is a steam donor.
- Drainage west of A pair is beyond 50m. Most of the bitumen in this area is expected to be recovered through the sweep between M and A wells. (M at higher pressure)
- NCG co-injection on A and B well pairs was conducted in parts of 2012 and 2013. No NCG since 2014
Well Pair Performance Example - High

Recovery factor at the end of 2015: 51%
J Well Pair Highlights

- J pair has maintained good performance over the past year.
- The bitumen production profile appears to be following the typical build up, plateau, and decline periods.
- Well produced ~ 2.3 MMBBL and CSOR ~ 3.1
- The decline rate has moderated in the last 1-3 years.
- The J pair is in communication with the I pair to the south.
- The J pair started communication with the O pair in 2011 to the north and some steam is provided to the O well from J.
Well Pair Performance Example - Low

Recovery factor at the end of 2015: 39%
Actual bitumen production is lower than expected (150m3/d). Well produced ~ 0.85 MMBBL and CSOR ~ 4.3

Potential reasons for this low productivity are:

- The reservoir along the HZ well contains clast facies and these slow down the steam chamber growth. Thermocouple data in the producer indicate that steam chamber growth at the toe is poor; likely due to the previously mentioned clast facie.
- Steam coning induced sand production. This well has been controlled by production rate which prevents sand influx. This option enables the N well to produce steadily without sand issues.
- From April 2014 till Mid 2015 Steam was increased considerably in order to try and improve the drainage from N well. Additionally, we wanted to promote fluid mobilization to other wells in phase 3 by having N well act as a donor. The extra steam came from phase 5 resulting from the workover in that phase.
Well Pair Performance Example

Recovery factor at the end of 2014: 14.9%
X Well Pair Highlights

- First well with ESP test in the field.
- Well produced ~ 0.55 MMBBL & cSOR ~ 2.8
- X pair has maintained good performance since an ESP was installed to operate at low pressure (in December, 2010).
  - Maintained bitumen production
  - Reduced steam rate, which was free to be redeployed into other wells to maximize the total bitumen production from the facility.
  - Reduced SOR
- The second ESP failed in June 2013 (398 days in service) due to control line failure resulting in a short. The third ESP has been installed and running since July 2013.
  (Ref. : First ESP life : 487 days)
X Well Pair Highlights

- X well was shut-in from November 2014 to April 2015 due to hot toe

  - Hot toe was mitigated by shutting steam injection allowing the injector to cool down
  - 75 C water was injected into the injector well. This cooled down both the injector and the producer’s toe.
  - After this, steam resumed at trickle rates and production restarted at reduced rates
  - Chamber Pressure has been declining and the interruption of steam is also allowing the temperature to dissipate so that water flashing in the producer liner is prevented.
Y Well Pair Highlights

- SAGD start-up in Feb 2012
- Sand production observed early in production life
- Liner failure (sand production / plugged well off) Nov 2012, well workover
- Rate control to minimize sand production
- Slowly ramping up production from the well considering past experiences with hot toe

Recovery factor at the end of 2015: **11%**

![Graphs showing production rates and steam injection pressure over time.](chart)
Received AER approval to co-inject NCG in H-Q
  • No NCG co-injection happened in 2015 because we had excess of steam
  • A-Q NCG Co-Injection start date still to be determined. This will be subject to steam requirement/availability

Long Term Plan
  • Target NCG rate for Phases 1&2 as per approval
  • Target NCG rate for Phases 3&4 as per approval
Fluid Communication

- A & B in December 2001
- D & E in April 2005
- H & I in May 2004
- H & K in January 2005
- J & O in January 2011
- S & T in January 2012
- P & O in July 2011
Fluid Communication

- Well Pads 3 & 4 are thermally mature
  - Production from well pad 3 started in December 2001
  - Production from the last wells in well pad 4 started in August 2005
  - Temperature observation wells show full steam chamber development in the clean sand
  - Fluid communication between the wells observed between the Well Pads 3 & 4 and presented below.
Future Development Options

- Lower pressure operation
- NCG Co-injection for A-E and H-Q wells. The timing to start will be determined based on steam requirement/availability.
- Blowdown
Surface Operations
Facility Design
Site Plan Update
Plant Schematic – Plant 1

Plant 1 was shut down in June, 2015.

- Fuel gas goes to Plant 1 for glycol heater – to be deactivated in 2016
- Concentrated blowdown (brine) for disposal returns from Plant 2 to Plant 1 due to the location of the disposal equipment & pipeline
- No Production Treatment, Bitumen Trucking, Water De-Oiling, Water Treatment, or Steam Generation are occurring at Plant 1
Plant Schematic – Plant 2
Fall 2016 turn-around avoided
MVR Evaporator start-up July, 2015
Heat and water recovery improved
Improved water quality
Chemical savings on water treatment
Gas savings on steam generation
Increased electrical cost
New Inlet Fuel Gas Compressor

Existing Inlet Natural Gas Configuration

- TCPL Gas Meter House
  - PSV
  - HP Flare
  - Demo Plant 2 Multiple Services, incl. Flare
    - Wellpads Phases 5/6 Wells & Building Heaters
    - Demo Plant 1 Glycol Heater
    - Wellpads Phases 2-4 Wells & Building Heaters
    - Wellpads Phase 1 Wells & Building Heaters

Planned Inlet Natural Gas Configuration

- TCPL Gas Meter House
  - PSV
  - HP Flare
  - Demo Plant 2 Multiple Services, incl. Flare
    - Inlet Gas Compressor
    - Wellpads Phases 5/6 Wells & Building Heaters
    - Demo Plant 1 Glycol Heater
    - Wellpads Phases 2-4 Wells & Building Heaters
    - Wellpads Phase 1 Wells & Building Heaters
New Inlet Compressor Location
Facility Performance
Plant 1 – Shutdown June 2015

- Why Plant 1 is Shutdown?
  - Demo Steam Requirements Decreasing
  - New MVR Evaporator shifted Water Treating to Plant 2

- Plant 1 Components Still Operating:
  - Brine Disposal (historically used for both Plant 1 and 2)
  - Glycol (Utility) Boiler – hope to shut down before winter 2016/17
  - All Secondary Containment monitoring programs remain in effect

- Decommissioning and Clean-Out is ongoing
2015 Service Factor – 94%

- Operations interruptions are described in two categories
- Planned Plant Turnarounds
  - Major – May-June 2015
    - Vessel inspections, PSV maintenance, process equipment cleaning, meter calibration/checks, boiler pigging, various repairs
    - TCPL tie-in
  - Contributed ~5% of downtime
- Transportation/Utility Restrictions
  - Limitations in the following
    - Markets
    - Road access
    - Rail limitation
  - Contributed <1% of downtime
Steam Generation 2015

- Plant 1
  - B-201A/B – 50 MMBtu/h Boilers
- Plant 2
  - B510/520 – 180 MMBtu/h Boilers
  - B540 – 50 MMBtu/h Boiler

<table>
<thead>
<tr>
<th></th>
<th>Plant 1 (m$^3$)</th>
<th>Plant 2 (m$^3$)</th>
<th>Total (m$^3$)</th>
<th>Plant 1 Quality</th>
<th>Plant 2 Quality</th>
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<td>128,902</td>
<td>-</td>
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<td>127,925</td>
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<td>75%</td>
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# Power & Energy Intensity 2015

## Power (kWh&MW) & Intensity [Natural Gas (m³ & GJ)/Bitumen (m³)]

<table>
<thead>
<tr>
<th></th>
<th>Power (kWh)</th>
<th>Power (MW)</th>
<th>Natural Gas* (e³ m³)</th>
<th>Bitumen (m³)</th>
<th>Intensity (m³/m³)</th>
<th>Nat gas heating value (GJ/e³m³)</th>
<th>Intensity** (GJ/m³)</th>
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<tbody>
<tr>
<td>Jan</td>
<td>2,491,929</td>
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<td>9,376</td>
<td>28,169</td>
<td>333</td>
<td>40.24</td>
<td>13.4</td>
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<td>3.3</td>
<td>7,950</td>
<td>24,529</td>
<td>324</td>
<td>40.16</td>
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<td>3.2</td>
<td>8,344</td>
<td>26,647</td>
<td>313</td>
<td>40.16</td>
<td>12.6</td>
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<td>2,272,495</td>
<td>3.2</td>
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<td>25,910</td>
<td>320</td>
<td>40.09</td>
<td>12.8</td>
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<td>7,598</td>
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<td>39.64</td>
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<td>299</td>
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<td>27,603</td>
<td>307</td>
<td>40.61</td>
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<td>7,554</td>
<td>24,826</td>
<td>304</td>
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<td>2,974,704</td>
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<td>40.42</td>
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<td>27,858</td>
<td>296</td>
<td>40.42</td>
<td>11.9</td>
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<tr>
<td>Dec</td>
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<td>4.1</td>
<td>8,104</td>
<td>28,299</td>
<td>286</td>
<td>40.32</td>
<td>11.5</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>29,915,816</strong></td>
<td><strong>3.4</strong></td>
<td><strong>95,189</strong></td>
<td><strong>306,373</strong></td>
<td><strong>311</strong></td>
<td><strong>40.30</strong></td>
<td><strong>12.5</strong></td>
</tr>
</tbody>
</table>

* - Total natural gas to plant  
** - Using monthly nat gas heating values
<table>
<thead>
<tr>
<th></th>
<th>Purchased Gas</th>
<th>Produced Gas</th>
<th>Flared Gas</th>
<th>Produced Gas Recovery</th>
</tr>
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<tbody>
<tr>
<td>January</td>
<td>9,376</td>
<td>346.1</td>
<td>30.4</td>
<td>91.2%</td>
</tr>
<tr>
<td>February</td>
<td>7,950</td>
<td>309.8</td>
<td>23.9</td>
<td>92.3%</td>
</tr>
<tr>
<td>March</td>
<td>8,344</td>
<td>366.5</td>
<td>25.4</td>
<td>93.1%</td>
</tr>
<tr>
<td>April</td>
<td>8,286</td>
<td>300.3</td>
<td>14.1</td>
<td>95.3%</td>
</tr>
<tr>
<td>May</td>
<td>7,598</td>
<td>280.1</td>
<td>21.1</td>
<td>92.5%</td>
</tr>
<tr>
<td>June</td>
<td>4,597</td>
<td>163.3</td>
<td>7.6</td>
<td>95.3%</td>
</tr>
<tr>
<td>July</td>
<td>8,277</td>
<td>376.0</td>
<td>4.1</td>
<td>98.9%</td>
</tr>
<tr>
<td>August</td>
<td>8,487</td>
<td>295.1</td>
<td>9.8</td>
<td>96.7%</td>
</tr>
<tr>
<td>September</td>
<td>7,554</td>
<td>266.0</td>
<td>1.7</td>
<td>99.4%</td>
</tr>
<tr>
<td>October</td>
<td>8,382</td>
<td>335.5</td>
<td>3.4</td>
<td>99.0%</td>
</tr>
<tr>
<td>November</td>
<td>8,234</td>
<td>350.5</td>
<td>1.4</td>
<td>99.6%</td>
</tr>
<tr>
<td>December</td>
<td>8,104</td>
<td>398.8</td>
<td>0.2</td>
<td>99.9%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>95,189</td>
<td>3,788</td>
<td>143</td>
<td>96.2%</td>
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</table>
Measurement & Reporting
Facility Codes
15 out 24 SAGD well pairs have individual metered wellhead separators; produced fluid rates are continuously measured and recorded.

Two Group/Test separators
- P / Q / Z Wells
- R / S / T / U / V / W Wells

Bitumen cut determined as follows
- Phase 5 Wells (R→W) – Online Cut Meter (Phase Dynamics)
- All other wells – Manual bitumen cut measurement (twice a month)

Steam injection rates are continuously measured at each and every wellhead and prorated to high-pressure steam meters.
Total daily bitumen production is determined with metered truck-out volumes and inventory levels in sales tanks. The trucked volume is prorated to the custody transfer meter from the receivers trucking terminals.

Σ Individual wellhead bitumen is measured/calculated and prorated to the plant production.

Produced water from each well is calculated with the following formula:

- \( PW = \text{Produced Fluid} - \text{Bitumen} \)
- Produced water from all the wells is then prorated to the total metered de-oiled produced water
  - (This volume includes all condensed produced steam which is not measured off the liquid leg of the well head separators)
The average 2015 proration factor for bitumen was 0.992, steam was 1.075, and water was 1.061
Water Balance

The chart below summarizes the water balance for 2015

<table>
<thead>
<tr>
<th>(m³)</th>
<th>IN</th>
<th>OUT</th>
<th>(ABS) Δ(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Produced Water</td>
<td>Raw Water</td>
<td>Total</td>
</tr>
<tr>
<td>January</td>
<td>132,372</td>
<td>22,967</td>
<td>155,339</td>
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<tr>
<td>February</td>
<td>113,150</td>
<td>16,885</td>
<td>130,035</td>
</tr>
<tr>
<td>March</td>
<td>123,108</td>
<td>14,713</td>
<td>137,821</td>
</tr>
<tr>
<td>April</td>
<td>121,208</td>
<td>17,197</td>
<td>138,405</td>
</tr>
<tr>
<td>May</td>
<td>114,967</td>
<td>14,145</td>
<td>129,112</td>
</tr>
<tr>
<td>June</td>
<td>59,666</td>
<td>10,157</td>
<td>69,823</td>
</tr>
<tr>
<td>July</td>
<td>124,925</td>
<td>7,000</td>
<td>131,926</td>
</tr>
<tr>
<td>August</td>
<td>124,006</td>
<td>6,892</td>
<td>130,898</td>
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<tr>
<td>September</td>
<td>108,165</td>
<td>10,552</td>
<td>118,716</td>
</tr>
<tr>
<td>October</td>
<td>122,953</td>
<td>8,493</td>
<td>131,446</td>
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<tr>
<td>November</td>
<td>123,667</td>
<td>7,097</td>
<td>130,764</td>
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<tr>
<td>December</td>
<td>123,411</td>
<td>6,365</td>
<td>129,776</td>
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<tr>
<td>Total</td>
<td>1,391,599</td>
<td>142,463</td>
<td>1,534,062</td>
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</table>
Optimization of Test Duration

- Optimization of test duration
  - Achieve the minimum test period and frequency for each well
  - Maximize time & frequency for wells with weak returning pressure and/or unstable operation

- Minimum test period: 2 days per month
- Minimum test frequency: Target 1 per month
- Minimum BS&W tests: 2 cuts per month
MARP Updates 2015

- New to JACOS 2015 MARP
  - General updates associated with Plant 1 shutdown
  - Update of flow diagrams
  - Inactive meters highlighted in meter list
  - Evaporation calculation/diagram updates

- MVR Evaporator updates
  - Updated flow diagrams
  - Evaporation calculation/diagram updates
Directive 81 – Water Disposal Limits

Directive 81: Water Disposal Limits and Reporting Requirements for Thermal In Situ Oil Sands Schemes

![Graphs showing water balance and disposal limits for JACOS Hangingstone DEMO]
Water
Water Sources and Uses

Wells

DQ02-2, DQ06-7:
Loc: SE 11-084-11W4M
WA Licence: 00229371-02-00
Aquifer: Muriel Lake Formation

Water Source – fresh groundwater, no brackish water use; no surface water

Licensed withdrawal - 438,000 m³/yr
2015 withdrawal - 142,463 m³/yr

Max pumping rate - 1350 m³/day
2015 max day - 865 m³/day
2015 average - 390 m³/day

Source water is required to makeup for reservoir loss, evaporation & disposal at the demo.

All makeup used for steam generation – introduced at wellheads and plant as “quench” water

Additionally, source water is used for construction & drilling of expansion project

<table>
<thead>
<tr>
<th>Month</th>
<th>DQ02-2</th>
<th>DQ06-7</th>
<th>Total</th>
<th>HE Use</th>
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<td>16,885</td>
<td>16,885</td>
<td>1,149</td>
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<td>8,876</td>
<td>5,837</td>
<td>14,713</td>
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<td>17,197</td>
<td>17,197</td>
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<td>6,629</td>
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<td>June</td>
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<td>10,157</td>
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<td>4,649</td>
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<td>October</td>
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<td>8,493</td>
<td>456</td>
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<td>3,303</td>
<td>3,793</td>
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<td>222</td>
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<td>142,463</td>
<td>11,145</td>
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</table>

(m³)
Disposal Limit and Actual

\[
Disposal \ Limit \ (\%) = \frac{(Produced \ Water \times \ Produced \ Factor) + (Fresh \ water \times \ Fresh \ Factor)}{Produced \ Water + Fresh \ Water} \times 100\%
\]

\[
Disposal \ Actual \ (\%) = \frac{Well \ Disposal + Brine \ Trucking}{Produced \ Water + Fresh \ Water} \times 100\%
\]

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<th>Produced Water (m³)</th>
<th>Fresh Water (m³)</th>
<th>Disposal Limit, %</th>
<th>Disposal (m³)</th>
<th>Brine Trucked (m³)</th>
<th>Disposal Actual, %</th>
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<td>Feb-15</td>
<td>113150</td>
<td>16885</td>
<td>9.09%</td>
<td>2110</td>
<td>0</td>
<td>1.62%</td>
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<tr>
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<td>123108</td>
<td>14713</td>
<td>9.25%</td>
<td>2322</td>
<td>0</td>
<td>1.68%</td>
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<td>121208</td>
<td>17197</td>
<td>9.13%</td>
<td>2190</td>
<td>0</td>
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<td>114967</td>
<td>14145</td>
<td>9.23%</td>
<td>2083</td>
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<td>40</td>
<td>1.65%</td>
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<td>Oct-15</td>
<td>122953</td>
<td>8493</td>
<td>9.55%</td>
<td>2077</td>
<td>0</td>
<td>1.58%</td>
</tr>
<tr>
<td>Nov-15</td>
<td>123667</td>
<td>7097</td>
<td>9.62%</td>
<td>2179</td>
<td>0</td>
<td>1.67%</td>
</tr>
<tr>
<td>Dec-15</td>
<td>123411</td>
<td>6365</td>
<td>9.66%</td>
<td>2129</td>
<td>0</td>
<td>1.64%</td>
</tr>
<tr>
<td>Average</td>
<td>115967</td>
<td>11872</td>
<td>9.34%</td>
<td>2075</td>
<td>10</td>
<td>1.62%</td>
</tr>
<tr>
<td>Total</td>
<td>1391599</td>
<td>142463</td>
<td>9.35%</td>
<td>24905</td>
<td>120</td>
<td>1.63%</td>
</tr>
</tbody>
</table>

*Produced water factor: 0.1 ; Fresh water factor: 0.03
Produced Water Recycle = \( \frac{\text{Steam Injection} - \text{Fresh Water}}{\text{Produced Water}} \)

Reservoir Loss = 1 – (Produced Water / Steam Injection)

<table>
<thead>
<tr>
<th></th>
<th>Fresh Water to Demo (m(^3))</th>
<th>Produced Water Volume (m(^3))</th>
<th>Steam Injection Volume (m(^3))</th>
<th>Produced Water Recycle (%)</th>
<th>Reservoir Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>19,759</td>
<td>132,372</td>
<td>140,266</td>
<td>91</td>
<td>5.6</td>
</tr>
<tr>
<td>February</td>
<td>15,736</td>
<td>113,150</td>
<td>119,859</td>
<td>92</td>
<td>5.6</td>
</tr>
<tr>
<td>March</td>
<td>14,067</td>
<td>123,108</td>
<td>126,935</td>
<td>92</td>
<td>3.0</td>
</tr>
<tr>
<td>April</td>
<td>15,940</td>
<td>121,208</td>
<td>126,277</td>
<td>91</td>
<td>4.0</td>
</tr>
<tr>
<td>May</td>
<td>13,175</td>
<td>114,967</td>
<td>117,767</td>
<td>91</td>
<td>2.4</td>
</tr>
<tr>
<td>June</td>
<td>9,243</td>
<td>59,666</td>
<td>65,500</td>
<td>94</td>
<td>8.9</td>
</tr>
<tr>
<td>July</td>
<td>5,782</td>
<td>124,925</td>
<td>128,365</td>
<td>98</td>
<td>2.7</td>
</tr>
<tr>
<td>August</td>
<td>6,117</td>
<td>124,006</td>
<td>127,684</td>
<td>98</td>
<td>2.9</td>
</tr>
<tr>
<td>September</td>
<td>10,372</td>
<td>108,165</td>
<td>116,411</td>
<td>98</td>
<td>7.1</td>
</tr>
<tr>
<td>October</td>
<td>8,037</td>
<td>122,953</td>
<td>129,948</td>
<td>99</td>
<td>5.4</td>
</tr>
<tr>
<td>November</td>
<td>6,875</td>
<td>123,667</td>
<td>128,639</td>
<td>98</td>
<td>3.9</td>
</tr>
<tr>
<td>December</td>
<td>6,214</td>
<td>123,411</td>
<td>127,653</td>
<td>98</td>
<td>3.3</td>
</tr>
<tr>
<td>Total</td>
<td>131,318</td>
<td>1,391,599</td>
<td>1,455,303</td>
<td>95</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Waste Water Disposal 2015

Disposal Well Injection Pressures / Limits & Temperature

<table>
<thead>
<tr>
<th>JACOS CLASS 1b WELLS – McMurray Fm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS2-23 F1/02-23-084-11W4/0</td>
</tr>
<tr>
<td>WD-3 00/15-14-084-11W4/0</td>
</tr>
</tbody>
</table>

OFFSITE BRINE DISPOSAL
Absolute 10-17-053-23W4
Worthington Business Park
Edmonton

Rate Summary
<table>
<thead>
<tr>
<th>Rate Summary</th>
<th>2015 Avg Rate (m³/D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WD-3</td>
<td>4</td>
</tr>
<tr>
<td>WS2-23</td>
<td>64</td>
</tr>
<tr>
<td>Total disposal to JACOS wells</td>
<td>69</td>
</tr>
<tr>
<td>Brine to offsite disposal well</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL DISPOSAL</td>
<td>69</td>
</tr>
</tbody>
</table>
# Waste Water Disposal Volumes 2015

### Monthly Disposal Volumes

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucked Out</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WD-3</td>
<td>424</td>
<td>330</td>
<td>359</td>
<td>275</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>215</td>
</tr>
<tr>
<td>WS2-23</td>
<td>2,286</td>
<td>1,798</td>
<td>1,970</td>
<td>1,879</td>
<td>2,066</td>
<td>961</td>
<td>2,184</td>
<td>2,155</td>
<td>1,976</td>
<td>2,114</td>
<td>2,137</td>
<td>1,863</td>
</tr>
</tbody>
</table>
Other Wastes
Solid Waste Disposal

Types of Solid Waste
- Lime Sludge
- Sand
- Spent filter media

SOLID WASTE DISPOSAL
12.5 tonne/day
Class II Oilfield Landfills:
Tervita Janvier SE-03-081-06W4M
Sulphur Emissions
Sulphur Dioxide Emissions

2015 Sulphur Dioxide Emissions

SO₂ (tonnes/day)


Approval Limit
SO₂ Emissions
Quarterly Sulphur Dioxide Emissions

2015 Sulphur Dioxide Emissions

Sulphur Inlet Rate (t/d)

Q1 | Q2 | Q3 | Q4

0.00 0.20 0.40 1.20
Environmental
Environmental Monitoring Programs

- **Active Ambient air monitoring program:**
  - Data collected from January 1st to July 31st, 2015 (6 months in 2015) as per approval; in compliance with all AAAQO.

- **Routine Annual monitoring programs:**
  - Six passive ambient air monitoring stations collected SO2 and H2S data during 2015 – no exceedances were noted.
  - Groundwater - spring/fall sampling results were largely comparable to previous years. Increasing trends in parameters were still noted at ENV98-1A. A soil delineation program was undertaken in 2015 to investigate the exceedance.
  - Fugitive emission survey (LDAR) results were in compliance with CCME guidelines. Each year ongoing minor repairs continue to be made.
  - Water Use - report in draft; updates to AESRD Water Use Reporting registry ongoing.
  - Soil Management – from the previous Soil Monitoring Program, in 2015 mitigation measures were developed as part of the Soil Management Program.
  - Stack survey results were in alignment with previous years and in compliance with approved limits.
  - Heave Monument survey – annual work completed in Q1 of 2015.
  - Vegetation management – work undertaken throughout 2015.
  - All other annual compliance initiatives completed were comparable with findings from previous years.
Ambient Air Quality 2015 – SO$_2$

2015 Ambient Air Quality from Passive Monitoring Stations
Total Sulphur Dioxide

Limit = 11 ppb (30-day average)
Ambient Air Quality 2015 – H$_2$S

Limit = 3 ppb (24-hour average)
Ambient Air Quality 2015 – SO$_2$

2015 Ambient Air Quality from Active Monitoring Station
Sulphur Dioxide (SO$_2$)

Limit = 172 ppb (1-hour average)

Limit = 48 ppb (24-hour average)
Ambient Air Quality 2015 – H$_2$S

Limit = 10 ppb (1-hour average)

Limit = 3 ppb (24-hour average)
Regional Initiative Involvement

<table>
<thead>
<tr>
<th>CAPP</th>
<th>CEMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>iFROG – COSIA JIP</td>
<td>JOSM/AEMERA</td>
</tr>
<tr>
<td>(wetland monitoring research group)</td>
<td></td>
</tr>
</tbody>
</table>
In 2015 remediation work continued on the 5 remaining OSE programs.

Vegetation management continued at former remote sumps 16-14 and 14-21.

A Supplemental Phase 2 ESA was conducted at 04-35-84-11.

The 2009 and 2010 OSE programs received reclamation certificates (34.77 ha).

Remediation work was undertaken at three historical remote sumps, 03-27, 05-27, and 13-21-84-11. Drilling waste and contaminated material removed from sites.

Throughout 2015 JACOS maintained its involvement in iFROG (COSIA-JIP)
Compliance Statements & Approvals
Demo Compliance Statement

JACOS is in compliance with conditions of their approval and regulatory requirements, subject to the following:

- AER Detailed Operational Inspection (ID 442672) completed August 24-26, 2015. Ongoing or Follow Up Items:
  - Plant 2 - Alternate storage approval received for lime slurry tank secondary containment system (TK-417)
  - Plant 2 – Proposed design for centrifuged sludge secondary containment upgrades presented to AER
  - Plant 2 - tank farm clay compaction testing completed and compliance with D55 confirmed
  - Plant 1 - process pond has been emptied of fluid. Remaining solids to be removed in spring 2016
  - Plant 1 – storage tank, piping and vessel emptying and cleaning work is progressing
  - Some minor D56 licensing issues are being resolved

- AER Pipeline Operations Inspection (IDs 445-598,601,603,660,684) completed December 15, 2015. All inspections ‘satisfactory’, with some follow up items:
  - Signage to be installed on new pipeline installations
  - Signage corrections to be done on existing pipeline watercourse crossing
October 19, 2014 - small volume steam leak was observed on injector well head.

Steam injection immediately shut-in and wellhead gas blanketed.

- Leak stopped.

Due to discontinuation of wellhead components, repair was delayed.

June 12, 2015 wellhead was frozen and repaired successfully.

- No internal corrosion found.
JACOS was required to bring 20% (7 wells) of its IWCP wells into compliance by March 31, 2016.

To date:
- Ten (10) wells brought into compliance
- JACOS has established a Well Compliance Working Group to manage compliance related to Directives 6, 13 and 20.
SGER Compliance Report for 2014 submitted

Restated baseline emission intensity and 2010 to 2014 reports after discovery of error that overstated emissions

Received reimbursement for overpaid GHG credits for 2010 – 2013 in 2015.

NPRI & Federal GHG reports for 2014 – submitted June 1, 2015

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution Gas Recovery</td>
<td>&gt; 90%</td>
<td>90.4%</td>
</tr>
<tr>
<td>SO₂ Emissions</td>
<td>&lt; 1.63 T/d</td>
<td>0.46 T/d</td>
</tr>
<tr>
<td>D81 Disposal Limit</td>
<td>&lt; 9.04%</td>
<td>1.83%</td>
</tr>
<tr>
<td>Plant 2 B-520 NOₓ</td>
<td>&lt; 7.60 kg/hr</td>
<td>3.15 kg/hr</td>
</tr>
</tbody>
</table>
Future Plans
Potential Suspension of DEMO Operations

- Due to current economic conditions, DEMO operations is not economically feasible. If low prices continue for the foreseeable future, DEMO operations will be suspended in Q2 2016 and possibly restarted when economics are positive.

- Plant will be shut down and safely preserved.

- Wells will be shut-in and wellheads winterized.

- Reservoir maintenance (gas/steam injection) is being investigated to assist with re-start of SAGD well pairs.

- A shut-down surveillance and monitoring program will be established to ensure equipment and facilities are safe and the environment is protected.
Discussion