Peace River In Situ Oil Sands Progress Report

Commercial Scheme Approval 8143

February 16th, 2017
TODAY’S AGENDA

**Introductions and Background**

- Ivan Gonzalez

**Subsurface Issues Related to Resource Evaluation and Recovery**

- Geology/Geoscience: Robyn Gooler
- Geophysics: Tam Pham
- Drilling and Completions: Dan Syrnyk
- Artificial Lift: Dan Syrnyk
- Instrumentation in Wells: Dan Syrnyk
- Well Integrity: Dan Syrnyk
- Scheme Performance: Laura Mislam
- Future Plans: Ivan Gonzalez

**Surface Operations, Performance and Compliance**

- Darcy Forman
- Located in Northwestern Alberta
- 100% Shell Share
- OBIP 239 Million m³ for the area in Approval 8143Z
- **Thickness**: 25-30 m
- **Depth**: 550-600 m TVD
- **NTG**: 0.8-1.0
- **API Gravity**: 6-11°
- **Porosity**: 0.25-0.30
- **Viscosity**: 10,000-1,000,000 cP (dead oil)
- **Initial pressure**: 3,800 kPa (sub-hydro)
- **Initial temperature**: 18°C
- **Horizontal permeability**: 0.1 – 10 D (air)
- **Kv/kh**: 0.3 – 0.9
- **Oil saturation ($S_o$)**: 0.70 – 0.80
Clifffield produced gas exported to Peace River. Most gas used in boilers to generate steam, excess gas stored in Three Creeks reservoir.
GAS INTEGRATION PEACE RIVER AND CLIFFDALE ASSETS

North Trans Canada Pipeline (Fuel Gas) To Seal Battery and Nipisi Terminal
Rainbow Pipeline

• 100% Shell / 27kbpd liquid capacity
• Current 8.2 kbpd oil production
• 180 active oil wells
• 1 Water Disposal Well

Peace River Complex

• 100% Shell / 13kbpd bitumen license
• Current 5.4 kbpd oil production
• 70 producing wells, 24 injectors
• 3 water disposal wells, 1 gas storage well (Three Creeks)

To Hage Lake Terminal and Plains Pipeline

TCPL (fuel gas)

Oil line
Condensate line
Gas line

Cliffdale Battery

To Seal Battery and Nipisi Terminal Rainbow Pipeline
PEACE RIVER PROJECT HISTORY

Experiment to Pilot to Demonstration to Commercial


- PR Leases Obtained

Experiments

- PRISP (PCSD)
- PREP (PCSD)
- SAGD
- Conv (CSS) → SD
- SR (CSS) → SD
- SR2000 (CSS) → SD
- Pad 32/33 (CSS)

- 20 Ph3 inf
- Pad 19 inf
- Pad 30i & 31i
- 22-04 inj
- CCP

PRISP = Peace River In Situ Pilot
PCSD = Pressure Cycle Steam Drive
PREP = Peace River Expansion Project
SAGD = Steam Assisted Gravity Drainage
CSS = Cyclic Steam Stimulation
SR = Soak Radial
SD = Steam Drive
CCP = Carmon Creek Project
2016 OVERVIEW

Key 2016 PRC updates:

- Improved field production and SOR as a result of plant debottlenecking, infill well projects (22-04, 30/31 injectors), and steam optimization. 2016 year-to-date average field production is 842 m³/d compared to 770 m³/d yearly average in 2015.
- Completed steam solvent pilot project on Pad 19 Sat 3 with positive production, SOR, and solvent recovery results.
- Obtained AER Approval for Directive 65 amendment application to increase maximum Three Creeks gas storage reservoir pressure to 5,000 KPa.
- Defined Carmon Creek Project suspension strategy.
- Increased Cliffdale produced gas utilization in all steam generators.
- Installed two power generators at PRC to further increase utilization of Cliffdale produced gas.
- Positive feedback from two AER DOI’s: Facility and Pipeline Inspections.
# TODAY’S AGENDA

## Introductions and Background
- Ivan Gonzalez

## Subsurface Issues Related to Resource Evaluation and Recovery

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## Surface Operations, Performance and Compliance
- Darcy Forman
- 7 Pads in current operation (outlined in pink)
- Suspended (outlined in green):
  - Pads 40 & 41
  - Pads 106 & 107
  - 6 Utility Wells (highlighted in green)
**Methodology:** Well tops, 3D seismic surfaces (where available) and properties modeled in a 3D cellular static reservoir model (cell size: 50x50x1m)

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<th>Units</th>
<th>Development Area*</th>
<th>Operating Area</th>
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<tr>
<td>Original Bitumen In Place</td>
<td>$10^6$m³</td>
<td>239</td>
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<tr>
<td>Area</td>
<td>$10^6$m²</td>
<td>42.6</td>
<td>10.5</td>
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<td>Average Net Pay</td>
<td>m</td>
<td>27</td>
<td>24</td>
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<tr>
<td>Average Porosity</td>
<td>1/1</td>
<td>0.27</td>
<td>0.28</td>
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<tr>
<td>Average Oil Saturation</td>
<td>1/1</td>
<td>0.81</td>
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<td>1/1</td>
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*Calculations are based on the 8143Z development scheme approval area

**OPERATING AREA NOTE:** Pad 40 & 41 are still included in the operating area as they are only suspended and Pad 106 and 107 have been excluded as they have not been completed.
• Ranges from 14-38m in the approved area
- Ranges from 70-86 m SS in the approved area
Ranges from 36-68 m SSTVD in approval area
Basal Water is a transitional zone of increasing water saturations in the Bluesky that is defined by a Sw > 0.31.
DATA ACQUISITION

- There have been no new wells drilled and no new data acquired this year
Cap rock: consists of the highly continuous Spirit River Formation (Wilrich/Falher/Notikewin) which has a minimum thickness of 240m over the approval area.

2012 Stress Testing:
- 12 in-situ cap rock stress tests, 3 wells @ 3 different depths in Wilrich, 1 depth top Bluesky
  - Measured Minimum Stress Wilrich = 19.6-22.7 kPa/m, avg 20.9 kPa/m
  - Calculated Minimum Stress Wilrich = 21.6-22.2 kPa/m
  - Measured Minimum Stress Bluesky = 14.7-20.2 kPa/m, avg 16.6 kPa/m
- 2 additional in-situ stress tests in 1 well in Notikewin and Fahler formations
  - Fahler Measured Breakdown Stress = 28.7 kPa/m
  - Fahler Measured Minimum Stress = 20.0 kPa/m
  - Fahler Calculated Minimum Stress = 21.3 kPa/m
  - Notikewin Measured Breakdown Stress = 29.1 kPa/m
  - Notikewin Measured Minimum Stress = 19.0 kPa/m
  - Notikewin Calculated Minimum Stress = 21.0 kPa/m
Q4 2014 Stress Testing:

- 3 tests were conducted on 3 of the Carmon Creek Utility Wells:
  - Nisku Formation In-situ stress test @ G180-80 (102/07-26-084-18W5/02)
    - Openhole test with 1.7m straddle packer used to obtain minimum horizontal stress (28.3MPa), Vertical stress (38.4MPa), Breakdown pressure (40.1MPa) at 1573m TVD
  - Leduc Formation In-situ stress test @ G180-81 (100/07-26-084-18W5/00)
    - Cased hole with 50m perforated zone (1694.9 - 1744.3m TVD) didn’t achieve fracture. Pressures reached 30.4MPa.
  - Leduc Formation Step rate test on G180-80 (102/07-26-084-18W5/02)
    - Cased hole with 50m perforated zone (1684.6 – 1734.4m TVD). Initial breakdown of 39MPa.
Relief on Debolt surface up to 35 meters - possible fault, or karst cliff

Legend:
- Wilrich Fm.
- Bluesky Fm.
- Gething Fm.
- Debolt Fm.

V.E. = 90:1
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CONTINUOUS REFLECTION MONITORING AT PAD 31

- Recording May 2014 – May 2016
- Time shifts are measurable and relate to production

Decommissioning underway:

Phase 1: Shutdown/Disconnection of electrical power (June 7-9)
Phase 2: All field equipment picked up and cached in piles along seismovie grid (completed Oct 12, 2016)
Phase 3: Pick up cached piles for recycle or landfill (~ early December)
Insar at Pad 31

- Cemented corner reflectors installation Feb 2015
- Data acquisition complete May 2016
- Surface deformations (measured with InSAR) correlate well with reservoir pressure changes

Near surface disturbances (thawing, precipitation)

Calendar Time

March '15 → September '15

Decommissioning Underway:
- Cabin attached artificial reflectors (6) to be removed December 2016
- Cemented Artificial Reflectors (18) to be left in place

Less stable

More stable
Microseismic monitoring is ongoing at Pad 30, 31, and 40 to monitor caprock and wellbore integrity, as well for out of zone injection.

- Microseismic receiver arrays installed in the Observation wells
- Microseismic monitoring provides an early alert/detection of event activities which might correspond to possible casing failures and/or out of zone injection

Any such event data is reported by the vendor and analyzed in-house to determine its significance for further follow-up action.

- Follow-up actions can range from data gathering through to well interventions
MICROSEISMIC EVENTS FROM THE PAST YEAR
(NOV 1 2015 - OCT 31 2016)

Pad 33 – Apr 2007
Pad 32 – June 2007
Pad 31
Pad 30
Pad 40 – May 2004
• Operations on Pad 32 and 33 started in 2006
• Downhole microseismic arrays active since Aug 2006
• Noise levels on Pad 32 and Pad 33 microseismic arrays have risen to levels where they are impacting the ability of the arrays to detect events
• Potential sources of noise:
  • Interference from unknown external source
  • Weak tool coupling
  • Downhole tool failures (some geophones on Pad 33 were damaged during 2006 installation as well)
• Suspended the microseismic monitoring on Pad 32 and Pad 33 until issues are resolved or alternative method of monitoring are in place
During the planned pad outage between June 8-9, the noise level decreased significantly which indicates some noise could be caused by an external source.
Two controlled well shut-down tests were conducted to determine which wells on Pad 32 are contributing to noise the most and if any actions can be performed to mitigate the noise to acceptable levels.

- Shut-Down Test 1: Wells were sequentially turned off on Pad 32. Was able to pinpoint 5 wells contributing most to noise on the array.

- Shut-Down Test 2: Was able to further pinpoint 2 wells when off, noise levels are acceptable.

- Currently testing if well interventions on those wells alleviates the noise.
Pad 32/33 MS Array Issues Plan forward

- On Pad 32, currently investigating what is the source of noise from the two wells found in the controlled well shut-down tests. Once an understanding of what is happening on Pad 32 is achieved Pad 33 will also be investigated.

- Investigating alternatives for monitoring:
  - Potential installation of new downhole array in existing observation wells for Pad 32 if technically and economically feasible
  - Looking for technical and economically feasible options for Pad 33

- Continuing to perform SITS on an opportunity basis

- On injection wells, ongoing casing integrity alarms that can detect sudden drops in pressure which may be indicative of out of zone injection
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DRILLING AND COMPLETION OVERVIEW

- **PRISP & PREP (1979)**
  - 31 wells and 212 wells, 7 spot pattern

- **Disposal Wells (1978 & 2008)**
  - 3 brine disposal, 2 water disposal

- **Pad 19 (1996 and infills drilled in 2011)**
  - 1 test hole and 15 producers, “soak radial” design
  - Pad 19 infill wells: 10 new producers and 8 new injectors (vertical wells)

- **Pad 20/21 SAGD (1997 and phase 3 infills drilled in 2011)**
  - 5 well pairs, 5 dual wellbores, 9 observation wells
  - Pad 20 phase 3 injectors (4 new horizontal wells)

- **Pad 30/31/40/41 Multi Laterals (2000)**
  - 8 “haybob”, 25 “tuning fork”, 6 observation wells

- **Pad 20/21 Conversions, Infills, 19 SD (2004)**
  - Converted SAGD well to CCS, drilled 7 single lateral infills, 2 steam wells on pad 19

- **Pad 32/33 Horizontals (2005)**
  - 16 wells per pad, 3 obs wells

- **Pad 22 Steam Injectors (2006)**
  - 2 steam injectors running over pad 21 conversions, acting as steam drive

- **Pad 30 & 31 Steam Injectors (2014)**
  - 10 steam injectors 4 over Pad 30 & 6 over Pad 31

- **2 Carmon Creek Wells (2014)**
  - Brine disposal well (02/15-27-85-19W5)
  - Delineation well (AA/04-26-85-18W5, D&A)

- **Pad 22 Steam Injector (2015)**
  - Top down Steam Drive injector 22-04

- **Carmon Creek Wells 2015**
  - Pad F106
    - 46 wells + 1 Observation well
  - Pad F107
    - 46 wells + 1 Observation well
  - 2 Acid gas injection well & 1 monitoring well
  - 2 water back producers

- **No Drilling Activity in 2016**
WELL TYPE OVERVIEW

CSS 1996
- Soak Radial
  - 500m

CSS 2001
- Haybob
  - 1000m

CSS 2006
- H- and J- Wells
  - 1500m

CSS 2001
- Tuning Fork
  - 1500m

SAGD 1996
- 500-1000m
**Representative Well Spacing for Individual Pads**

- **Pad 19**
  - 100 m horizontal separation between injector and producer vertical wellbores
  - 150 m horizontal separation between producer vertical wellbores
  - Subsurface spacing variable due to soak radial geometry

- **Pad 20**
  - 5m vertical separation between SAGD injectors and producers
  - 100m horizontal separation between SAGD pairs and J-wells
  - 100m horizontal separation between new phase 3 infill injectors
  - 50m horizontal separation between a phase 3 injector and an original SAGD well pair
  - Vertical separation between a phase 3 injector and an original SAGD well pair is 3m to 15m

- **Pad 21/22**
  - 5m vertical separation between SAGD injectors and producers
  - 100m horizontal separation between SAGD pairs and J-wells

- **Pad 21/22 (continued)**
  - 90m horizontal spacing between pad 22 injectors
  - Pad 22 injectors are 10m to 17m above original SAGD producers

- **Pad 30**
  - Highly variable due to Haybob geometry
  - 2014 injector spacing – 150 – 250m

- **Pad 31**
  - 80 m horizontal separation between laterals
  - 2014 injector spacing 100m

- **Pad 32**
  - 150 m horizontal separation between horizontal wells

- **Pad 33**
  - 150 m horizontal separation between horizontal wells

- **Pad 40**
  - 80 m horizontal separation between laterals

- **Pad 41**
  - 80 m horizontal separation between laterals
Pads 30, 31, 40 & 41

9 5/8” Casing

7” Window sleeve

2 7/8” Liner

Thermal 40F cement

4.5” tubing

Insert pumps

550-700m laterals

During full steam cycles, the pump is removed and steam is injected down the tubing of the well.

For mini soaks (steam injection volumes 500-2000 t) the pump is unseated and steam is injected down the casing.
- Pads 32 & 33
- 7’’ Casing
- 4.5’’ perforated liner
- 4.5’’ Tubing
- Insert pumps
- Thermal 40M cement
- 500-700 m lateral

### Diagram

- 16” Conductor Casing
  - 55 kg/m
- 7” TN80SS Casing
  - 34.2 kg/m
- 4.5” EUE Tubing
  - 18.9 kg/m
- 1” DR-66 Corod

Bluesky @ 544 mTVD
PSN @ 548 mTVD

Cement: Thermal 40M Thix Mix

5 m liner overlap

4.5” perforated liner
K-55, LT&C, 17.3 kg/m

700 m

1600 m TD
**Producer Well Design**

**General Data:**
- Surface hole size: 374mm (14-3/4"), depth 250m – 310m
- Inclination in surface section 0° - 20°
- Main hole size: 273 mm (10-3/4"), TD 590m – 688m MD (~585m TVD)
- Inclination at TD 13° – 47°

**Casing Data:**
- Surface casing: 298.5mm (11-3/4") 62.5 kg/m (42 lb) H40 STC
- Production Casing: 219.1mm (8-5/8") 47.6 kg/m (32 lb) L80IRP TS3SB

**Cement:**
Both strings cemented to surface with RFC Thermal (thixotropic, ~40% silica, 1740 kg/m3)

**Tubing:**
88.9mm, 13.84kg/m, J55 EUE

**Injector Well Design**

**General Data:**
- Surface hole size: 311mm (12-1/4"), depth 250m – 310m
- Inclination in surface section 0° - 21°
- Main hole size: 216mm (8-1/2"), TD 599m – 646m MD (~585m TVD)
- Inclination at TD 29° – 45°

**Casing Data:**
- Surface casing: 244.5mm (9-5/8") 47.6 kg/m (32 lb) K55 TBlue
- Production Casing: 177.8mm (7") 34.2 kg/m (23 lb) L80IRP TBlue

**Cement:**
Both strings cemented to surface with RFC Thermal (thixotropic, ~40% silica, 1740 kg/m3)

**Tubing:**
73mm, 9.67kg/m, J55 EUE
PAD 30I INJECTOR COMPLETION – START UP JAN 2015

- Pads 30i
- 4 Single Laterals
- Instrumented coil tubing with thermocouples
- 30 -11 has DTS
- 8 5/8” Casing
- 2 7/8” tubing with 4 x ½” steam subs
- 5 ½” wire wrap liner
- 400-800 m lateral
PAD 31i INJECTOR COMPLETION – START UP NOV 2014

- Pads 31i
- 6 Single Laterals
- Instrumented coil tubing with thermocouples
- 31-10 & 31-13 have DTS
- 9 5/8” Casing
- 3 1/2” long string tubing
- 2 7/8” short string
- 7” wire wrap screen liner
- 950 m lateral
Well equipped with

- VIT from surface to 300 mKB
- 10 ICD subs at 4 Intervals
- 10 Type K thermocouples
CARMON CREEK PAD WELLS

- **Pad 106** production wells
  - 43 production wells, 3 surface holes
  - Drilled Sept 2014-Oct 2015
  - No completion
  - Standing, suspended

- **Pad 106-90 Observation well**
  - Drilled Sept 2014-Sept 2015
  - Two external pressure gauges @ 324 and 509 mMD
  - No completion
  - Standing, suspended

- **Pad 107** production wells
  - 46 production wells
  - Drilled Apr – Aug 2015
  - No completion
  - Standing, suspended

- **Pad 107-90 Observation well**
  - Drilled Apr 2015
  - Two external pressure gauges @ 310 and 510 mMD
  - No completion
  - Standing, suspended

- **Pad 101, 104, and 105**
  - Civil earthworks complete
  - Conductors installed

- **Pad 102 and 103**
  - Civil earthworks completed

- **Pad 108, 109 and 110**
  - Licensed, no field work executed
Softener regeneration waste water is currently disposed into the 16-27 well. 02/15-27 Standing back up brine disposal well.
TYPICAL PRODUCED WATER DISPOSAL WELL COMPLETION

02/16-23 & 02/14-25 dispose of produced water and boiler blowdown into the Leduc formation.

- **Surface Casing:**
  - 339.7 mm, 81.1 kg/m, K-55, ST&C

- **Intermediate Casing:**
  - 244.5 mm, 59.5 kg/m, K-55, LT&C L-80 (429-719mKB)

- **Production Tubing:**
  - 177.8mm, 34.2 kg/m, L-80 LT&C
  - 177.8mm, 34.2 kg/m, L-80 buttress

- **Baker FB-1 194-60 Packer**
- **RN nipple**
- **Perforated pup joint**
- **Wireline re-entry guide**
- **Openhole**
The 8-11 sour gas injector was completed Nov 2009 as part of the Three Creeks Sour Gas Storage project.

Oct 2014 – Oct 2015:

- **C180-80** Brine Injection Well Completion
  - Drilled Mar/Apr 2014
  - Completed
  - Suspended

- **G180-80 and G180-81**, Two injectors
  - Drilled Sept-Dec 2014
  - G180-80 required acid wash, step rate test OK
  - Perforated (50m) liner across Middle Leduc
  - No completion hardware installed
  - Suspended

- **G180-90**, One monitor well
  - Drilled Sept-Dec 2014
  - TD in Winterburn Formation
  - No completion
  - Suspended

- **C170-70 and C170-71**, Water back producers
  - Drilled Dec 2014 – Jan 2015
  - Did not reach target depth on either well
    - C170-70 cemented intermediate casing @ 1603 mKB, called TD
    - C170-71 int casing @ 1610 mKB, drilled and open to TD @ 1776 mKB
  - No completion
  - Suspended
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ARTIFICIAL LIFT – ROD PUMPING EQUIPMENT

Pumping Units:
- Pumpjacks: 144” – 260” stroke
  - Lufkin/Legrand Pump Jacks
  - Rotaflex: 288” stroke

Max.Capacity:
- 280 m³/d
- 250 m³/d

Automation:
- Pump Off Controllers (POC): load cells, motor sensor, crank sensor, VFD
- XSPOC: Real-time pump cards
- LOWIS: Pilot deployed in August 2015

Pumps:
- Insert rod pumps, 2.0 – 3.25” barrel, 1” continuous rod, rod string designs
- Continuous improvement initiatives ongoing (improved rod-string designs, POC pump checks, dynagraph verification, fluid shots, etc.), POC fluid level verification

Stuffing Boxes:
- High temperature stuffing boxes are installed on every pumping well. The cone packing is used while pumping and it has rubber elements with brass supports.
- Packing Leak Containment devices (complete with high-level- shut-down switches) have been installed on all wells.
- There have been no offsite emulsion releases in 2016
ARTIFICIAL LIFT – ESP WELLS

**Pumping Units: Max.Capacity:**
- Schlumberger ESP D2400N SA-3 360 m³/d
- Schlumberger ESP D1800N SA-3 280 m³/d
- All ESP’s removed in 2016 due to economics

**Automation:**
- Downhole pressure and temperature monitoring to optimize subcool
- ESP’s equipped with VSD
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OBSERVATION WELLS - 19 Wells Over Existing Pads
## ACTIVE OBSERVATION WELLS

<table>
<thead>
<tr>
<th>Well Name</th>
<th>Type of observation well</th>
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<tr>
<td>TH33</td>
<td>Pressure and temperature</td>
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<tr>
<td>TH33A</td>
<td>Temperature and micro seismic</td>
</tr>
<tr>
<td>TH33B</td>
<td>Temperature</td>
</tr>
<tr>
<td>TH32A</td>
<td>Temperature and micro seismic</td>
</tr>
<tr>
<td>TH30A</td>
<td>Temperature and micro seismic</td>
</tr>
<tr>
<td>TH31A</td>
<td>Temperature and micro seismic</td>
</tr>
<tr>
<td>TH6</td>
<td>Temperature</td>
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<tr>
<td>TH7</td>
<td>Temperature</td>
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<td>TH8</td>
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<td>Temperature</td>
</tr>
<tr>
<td>TH12</td>
<td>Temperature</td>
</tr>
<tr>
<td>TH40A</td>
<td>Temperature and micro seismic</td>
</tr>
<tr>
<td>TH40B</td>
<td>Temperature</td>
</tr>
<tr>
<td>TH14</td>
<td>Temperature</td>
</tr>
<tr>
<td>TH41A</td>
<td>Temperature</td>
</tr>
<tr>
<td>D320 (5-19)</td>
<td>Temperature via DTS</td>
</tr>
<tr>
<td>D321 (11-19)</td>
<td>Temperature – via DTS</td>
</tr>
<tr>
<td>12-35</td>
<td>Pressure</td>
</tr>
</tbody>
</table>
Wilrich shale pressure and temperature are monitored. The Bluesky gauge failed in 2007.

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Diameter (mm)</th>
<th>Weight (kg/m)</th>
<th>Rock Type</th>
<th>Operation</th>
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<tbody>
<tr>
<td>Conductor Casing</td>
<td>340</td>
<td>48.1</td>
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<tr>
<td>Surface Casing</td>
<td>344.5</td>
<td>48.1</td>
<td>H-40</td>
<td>ST&amp;C</td>
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<tr>
<td>Intermediate Casing</td>
<td>177.8</td>
<td>34.2</td>
<td>K-55</td>
<td>LT&amp;C</td>
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<tr>
<td>Cement</td>
<td>483</td>
<td>Wilrich</td>
<td></td>
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<tr>
<td>Dual Tubing Strings: 60.3mm</td>
<td>60.3</td>
<td>48.1</td>
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<tr>
<td>Perforations</td>
<td>547-550</td>
<td>Bluesky</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD</td>
<td>592</td>
<td>Debolt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 60.3mm XN nipple
- Wireline Re-entry guide
- Perforations 498-503
- 60.3mm XN nipple
- 60.3mm XN nipple
- Baker Model 'DB' Packer
- 60.3mm XN nipple
- Wireline Re-entry guide
- Perforations 543
- 576
- Debolt
THREE CREEKS PRESSURE OBSERVATION WELL 12-35

Stage 1 (1600-1042mKB); 25.8 tonnes Class G cement. 3m3 cement returns.

Stage 2; 15.2 tonnes Class G cement (1042-650mKB)
10.8 tonnes Class G (650-400mKB).

219.1 mm, 35.7 kg/m, J-55. Cemented to surface with 26.7 tonnes Class G cement.
Cement Top from Bond log

73mm, 9.67 kg/m L-80 EUE tubing
0.1 % inhibited water in annulus
Retrievable Packer
Downhole Pressure Gauge
Bluesky Top. Bluesky Perfs 522.5-525 m KB

Lost Perf Gun

Bridge Plug
Perforations (550-555 m KB)

Bridge Plug
Perforations (586-591 m KB)

Bridge Plug
Perforations (656.5-661 m KB)

Bridge Plug
Perforations (988-1000 m KB)

Stage Tool

1600 m KB (TD)
139.7 mm, 23.1 kg/m, J-55 casing.
Thermocouples situated from the Wilrich to the Debolt formations to monitor steam chamber rise and temperature variations over cycle(s). The thermocouples are cemented in the well to surface.
Geophones located in Obs wells:
TH40A, TH30A, TH31A, TH32A, TH33A

Geophones placement

- Paddy/Cadotte
- Harmon Shale
- Notikewen
- Wilrich
- Bluesky
- Detrital
- Debolt
Before

- Wellhead Configuration
  - 7-1/16” 3K Master Valve w/DTS packoff
  - 2-1/16” 5K Casing Side Outlet Valve

- DTS Fiber Optic Line
  - (Landed @ 597.5mKB)

- Perf/Squeeze
  - (264.55-265.45mKB)
  - 2.9m³ into Perfs (No pressure squeeze)

- Perf/No Injection
  - (507.85-508.75mKB)
  - No Injectivity

- Perf/Squeeze
  - (520-520.9mKB)
  - 3.4m³ into Perfs (5MPa pressure squeeze)

- Sand
  - PBTĐ=605mKB
  - TRBP=610mKB

After

- Wellhead Configuration
  - 7-1/16” 3K Master Valve w/DTS packoff
  - 2-1/16” 5K Casing Side Outlet Valve

- DTS Fiber Optic Line
  - (Landed @ 597.5mKB)

- Perf/Squeeze
  - (264.55-265.45mKB)
  - 2.9m³ into Perfs (No pressure squeeze)

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  - TRBP=610mKB

- The 5-19 water disposal well was drilled and completed with the 11-19 well in 1978 as part of the PRISP (Peace River In Situ Pilot) disposal scheme.
- The well injected produced water until 1986, and then water softener backwash brine, until 2009, into the Debolt formation.
- Observed casing head pressures of around 16MPa, though a hydraulic pressure test later confirmed casing and bridge-plug integrity.
- Obtained cement, behind-casing fluid, and integrity data by means of caliper, ultrasonic, and saturation logs on the 5-19 well.
- Well perforated in the Wilrich (520 – 520.9 mKB) and cement squeezed with T-Mix thermal cement.
- Drilled out cement and logged to evaluate isolation – Confirmed isolation to the Bluesky however wanted to ensure we had better isolation above.
- Re-perfed 507.85 – 508.75 – obtained no injectivity – confirmed pressure integrity to 10 Mpa at perf face.
- As per the AER requirements we perfed 264.55 – 265.45 mKB and performed a cement squeeze (to isolate the Paddy Cadotte).
- Isolation was confirmed - Installed DTS Fiber
WELLHEAD CONFIGURATION

Before

After

- 7-1/16” 3K Valve, ½” termination port for DTS Line
- 2-1/16” 5K Valve, 2”LP crossover to ½” NPT needle and Pressure Gauge
- Junction Box
<table>
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Well Integrity: Monitoring Program

- All pads part of Shell’s well integrity management program (WIMS).
- Risk based program that schedules preventative maintenance and associated repair times to the severity of the failure and AER regulations.
- All well histories being updated in eWIMS repository.
- Wellhead Integrity Tests (WITS) carried out on cycle basis:
  - Majority of surface components (casing heads, trees, stuffing boxes, valves, BOPs etc are pressure tested before steam injection)
- SCVF’s conducted on yearly basis
  - 17 non-serious SCVF being monitored at present as per ID2003-01 (includes wells drilled for Carmon Creek (see Table 1)
- Subsurface Integrity Tests (SITS)
  - Production casing inspections (deformation, wall thinning, corrosion logging, hydraulic integrity, packer isolation tests)
  - SITs begin on a sample of CSS wells (1 well per pad/10% wells) beginning at their 5th CSS cycle. Addition logs (CEL, Caliper, Pressure test etc) run on ad-hoc basis based on non-invasive triggers (eg passive seismic, opportunity)
## WELL INTEGRITY: SCVF Wells

### Table 1:

#### 2016 Results:

<table>
<thead>
<tr>
<th>UWI</th>
<th>LIC NUM</th>
<th>STATUS</th>
<th>COMMENT</th>
<th>WELL NAME/ALIAS</th>
<th>Date Checked</th>
<th>Results/Observations</th>
<th>24 Hour Build Up</th>
</tr>
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<tbody>
<tr>
<td>104/11-15-085-18W5/00</td>
<td>0310826</td>
<td>Open</td>
<td>Non Serious</td>
<td>SHELL P13 CADOTTE 11-15-85-18 (21-13)</td>
<td>12-Sep-16</td>
<td>No LEL/H2S, No vent flow observed - Could Close out - will monitor 1 more year</td>
<td>0 kPa</td>
</tr>
<tr>
<td>106/11-15-085-18W5/00</td>
<td>0361194</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL 22-01 CADOTTE 11-15-85-18</td>
<td>10-Sep-16</td>
<td>No LEL/H2S, Observed 60 bubbles/10 min</td>
<td>0 kPa</td>
</tr>
<tr>
<td>1F2/01-21-085-18W5/00</td>
<td>0411266</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL547-D CADOTTE 1-21-85-18</td>
<td>4-Oct-16</td>
<td>Water Obs well, Observed 21 bubbles/10 mins</td>
<td>28 kPa</td>
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<tr>
<td>100/16-27-085-19W5/00</td>
<td>0389349</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL C89-01 CADOTTE 16-27-85-19</td>
<td>4-Oct-16</td>
<td>No LEL/H2S, Observed 60 bubbles/10 min</td>
<td>51 kPa</td>
</tr>
<tr>
<td>104/06-20-085-18W5/00</td>
<td>0432193</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL HZ 20-20 CADOTTE 3-20-85-18</td>
<td>9-Sep-16</td>
<td>No LEL/H2S, Observed 100 bubbles/10 min</td>
<td>60 kPa</td>
</tr>
<tr>
<td>105/03-20-085-18W5/00</td>
<td>0432195</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL HZ 20-22 CADOTTE 3-20-83-18</td>
<td>9-Sep-16</td>
<td>No LEL/H2S, No vent flow observed - Could Close out - will monitor 1 more year</td>
<td>73 kPa</td>
</tr>
<tr>
<td>106/03-20-085-18W5/00</td>
<td>0432196</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL HZ 20-23 CADOTTE 3-20-83-18</td>
<td>9-Sep-16</td>
<td>No LEL/H2S, Observed 6 bubble/10 min</td>
<td>10 kPa</td>
</tr>
<tr>
<td>104/06-17-085-18W5/00</td>
<td>0464726</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL 31-13 CADOTTE 6-17-85-18</td>
<td>5-May-16</td>
<td>No LEL/H2S, No vent flow observed</td>
<td>0 kPa</td>
</tr>
<tr>
<td>105/06-17-085-18W5/00</td>
<td>0464727</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL 31-14 CADOTTE 6-17-85-18</td>
<td>5-May-16</td>
<td>No LEL/H2S, No vent flow observed - Could Close out - will monitor 1 more year</td>
<td>0 kPa</td>
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<tr>
<td>105/12-20-085-18W5/00</td>
<td>0464729</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL TH30C CADOTTE 12-20-85-18</td>
<td>11-Sep-16</td>
<td>No LEL/H2S, No vent flow observed - Could Close out - will monitor 1 more year</td>
<td>0 kPa</td>
</tr>
<tr>
<td>104/09-19-085-18W5/00</td>
<td>0464733</td>
<td>Open</td>
<td>Non Serious</td>
<td>SCL 30-11 CADOTTE 9-19-85-18</td>
<td>11-Sep-16</td>
<td>No LEL/H2S, Observed 6 bubbles/10 min</td>
<td>10 kPa</td>
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<tr>
<td>117/11-22-085-18W5/00</td>
<td>0459072</td>
<td>Open</td>
<td>Non Serious</td>
<td>F107-16</td>
<td>27-Aug-16</td>
<td>No LEL/H2S, 0 bubbles/10 mins</td>
<td>0 kPa</td>
</tr>
<tr>
<td>106/07-22-085-18W5/00</td>
<td>0463846</td>
<td>Open</td>
<td>Non Serious</td>
<td>F107-18</td>
<td>27-Aug-16</td>
<td>No LEL/H2S, 0 bubbles/10 mins</td>
<td>56 kPa</td>
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<tr>
<td>112/07-22-085-18W5/00</td>
<td>0459075</td>
<td>Open</td>
<td>Non Serious</td>
<td>F107-24</td>
<td>28-Aug-16</td>
<td>No LEL/H2S, 0 bubbles/10 mins</td>
<td>10 kPa</td>
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<tr>
<td>100/08-22-085-18W5/00</td>
<td>0459081</td>
<td>Open</td>
<td>Non Serious</td>
<td>F107-36</td>
<td>28-Aug-16</td>
<td>No LEL/H2S, 0 bubbles/10 mins</td>
<td>0 kPa</td>
</tr>
<tr>
<td>103/15-22-085-18W5/00</td>
<td>0459082</td>
<td>Open</td>
<td>Non Serious</td>
<td>F107-39</td>
<td>28-Aug-16</td>
<td>3% LEL, no H2S, 487 bubbles/10 mins</td>
<td>10 kPa</td>
</tr>
<tr>
<td>104/09-22-085-18W5/00</td>
<td>0459087</td>
<td>Open</td>
<td>Non Serious</td>
<td>F107-47</td>
<td>28-Aug-16</td>
<td>5% LEL, no H2S, 730 bubbles/10 mins</td>
<td>20 kPa</td>
</tr>
</tbody>
</table>
WELL INTEGRITY: HISTORICAL REMEDIATION/INVESTIGATION

- D320 (5-19) Suspended water disposal well
  - Converted to temperature monitoring well via DTS installation.

- D321 (11-19) Suspended water disposal well:
  - During CEL assessment (Flexural Attenuation), a small hole/puncture was discovered in the casing joint at approximately 527-528m MDKB
  - AER DDS submission (ID: 1328497) was entered on 13/7/12
  - Remediation matured. AER engagement on 29th Oct 2012
  - Conversion to permanent temperature monitoring well via DTS installation.

- 40-08 Suspended thermal well on steam-drive (Pad 40):
  - MFC investigation and SIT revealed casing leak at 609m MDKB across the Wilrich shale. Well suspended with TRBP at 620 mMDKB
  - AER DDS submission was entered November 2012.
  - Approval granted for low pressure (<6 Mpa) use.
100/03-28-85-18W5 (SR -12) Soak Radial – Pad 19 Satellite 4:
- Parted casing detected at 120 mKB depth via a calliper log. Appears to be a pin-box (straight tensile) pull.
- Retrievable bridge plug was installed (top of BP at 556 mKB) with 20 m of Thermal cement for subsurface isolation.
- Abandonment planned in 2017

107/15-21-85-18W5 (19-3-PH{15}) and 103/03-28-85-18W5 (19-3-PK{17}) Pad 19 Satellite 3:
- A collapsed/buckled casing section was detected via a downhole camera run performed on October, 2013. Failure depth is ≈ 276mKB on 19-3-PH{15} and 190.3 mKB on 19-3-PK{17}.
- Both wells abandoned Jan 2014 as per Directive 20

Pad 19 Satellite 3: Injectors (4) with casing collapse
- A collapsed/buckled casing section was detected via a downhole camera runs performed Nov 2013. AER DDS submissions Dec 2013.
- All 4 wells successfully abandoned Q-1 2015. Cut and cap completed 2015.
On February 25, 2015 gas emission detected with an infrared camera during routine monthly inspection. Gas is intermittent (flares up and dies off). Readings of 50 to 75 PPM of H2S have been recorded around the wellhead. No H2S can be detected outside of a radius of 2 ft from the wellhead.

On March 14, 2015 we commenced an investigative workover program to inspect the production casing. We detected a pin-collar straight tensile failure had occurred at ~94m.

On May 14, 2015 we ran noise-temperature and CHAT tools to further investigate the potential source of gas.

On July 12, 2015 Perforate and attempt to squeeze 545 – 545.9 mKB. Perfs would not take any fluid. July 13, 2015 perforate/acidize and attempt to squeeze 498 – 498.9 mKB - very limited injectivity (6-8 liters/min).

Vent Nanny installed to continuously monitor vent volumes and pressures.

May 17, 2016 Shell receives approval of program for non-routine abandonment.

June 27 - 30 Wellbore abandoned as per approved program.

Cut & cap will be executed after 2017 breakup to allow for monitoring.
January 2016 – micro-seismic event was recorded in the vicinity of the Shell Peace River Pad 31i wells.

Nitrogen purge investigation identified casing leak at 31-13.

A Magnetic Thickness Detector (MTD) and a 56-finger caliper log was performed which showed pitting corrosion in the casing from 86 -186 m KB; and a series of packer isolation tests confirmed the presence of a single point leak at a casing connection at ~128 mKB.

Micro-seismic Events
• April 5, 2016 – AER repair extension granted to investigate cause of pitting and casing failure.

• Root cause investigation potential sources of failure:
  
  • **Mechanical weakening of connecting integrity** due to tong slippage (abnormal make-up torque)
  • **Thermal Stresses of expansion and contraction** (seismic event detected 8 days after steam was stopped on well – during cooling period)
  • **Incorrect Pipe Dope (Thread Lubricant) used** – drilling program was not followed and the pipe dope used was not developed for thermal use

• Shell evaluating remediation plans for the wellbore – will comply to the timeline as per extension approval

**MFC Log**

**Enlargement of Pitted Joint 86-100 mKB**
In 2016 Shell abandoned 7 wells in the approval no. 8143Z area.
PREVIOUSLY ABANDONED WELLS

Update required as per AER approval no. 8143Z

Oct 2015 – Oct 2016:

- 1AA052708518W500
  - Pad 106 wells drilled 400m to south – no production
  - Closest production wells on Pad 19 > 1000m
- 1AA131508518W500
  - Low pressure injection on Pad 21/22
  - New steam injector well 22-04 (green) drilled
  - No changes observed

21-14 Injection Casing Head Pressure

October 2015 - October 2016
**TODAY’S AGENDA**

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### SCHEME PERFORMANCE PREDICTION

- The basis for Scheme performance prediction estimation based on historical cSOR increase for steam drive pads, and water cut increase with recovery factor for blow down pads.

<table>
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<tr>
<th>Pad</th>
<th>Recovery Process</th>
<th>Date of Conversion</th>
</tr>
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<tbody>
<tr>
<td>19 Sat 1 and 2</td>
<td>Lateral Steam Drive</td>
<td>Oct 2012</td>
</tr>
<tr>
<td>19 Infills</td>
<td>Vertical Well Steam Drive</td>
<td>July 2013</td>
</tr>
<tr>
<td>20 Conv</td>
<td>Top-Down Steam Drive</td>
<td>July 2012</td>
</tr>
<tr>
<td>20 Infills</td>
<td>Lateral Steam Drive</td>
<td>June 2012</td>
</tr>
<tr>
<td>21 Conv</td>
<td>Top-Down Steam Drive</td>
<td>Jan 2009</td>
</tr>
<tr>
<td>21 Infills</td>
<td>Lateral Steam Drive</td>
<td>Nov 2011</td>
</tr>
<tr>
<td>30</td>
<td>Top-Down Steam Drive</td>
<td>Dec 2014</td>
</tr>
<tr>
<td>31</td>
<td>Top-Down Steam Drive</td>
<td>Nov 2014</td>
</tr>
<tr>
<td>40</td>
<td>Suspended</td>
<td>Converted to LSD June 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blowdown June 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspended October 2015</td>
</tr>
<tr>
<td>41</td>
<td>Suspended</td>
<td>Converted to LSD June 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blowdown June 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspended October 2015</td>
</tr>
<tr>
<td>32/33</td>
<td>Cyclic Steam Stimulation (CSS)</td>
<td>Converted to LSD December 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Converted to CSS August 2014</td>
</tr>
</tbody>
</table>
PEACE RIVER PRODUCTION HISTORY

Cumulative SOR has been increasing, though if TDSD and CSS on pads 32/33 continue to perform favourably this may plateau before continuing to increase.

- Cumulative SOR = 4.38
- Cumulative WSR = 0.77
- Cum Oil: 7,055 Mm3
- Cum Wtr: 23,754 Mm3
- Cum Stm: 30,867 Mm3

All data current as of Oct 2016
2016 YTD average as of Oct. 31, 2016:
- Oil rate = 842 m³/d
- Injection rate = 4436 t/d

2015 Average was 770 m³/d, improvement due to infill well projects (22-04, 30/31 injectors), plant debottlenecking and steam optimization
Production capacity limit raised to 2000 m³/d (from 1900 m³/d) annualized average on April 30, 2002 as part of Amendment F to 8143 approval.

Bitumen production has decreased from peak rates in Nov/Dec 2007 due to maturing pads.

2013 - 2015 production were also impacted by produced water scaling issues, gas injection compressor issues and multiphase pump reliability issues. June 2013 water processing lines were mechanically cleaned, 2015 the skim and surge tank were cleaned, and in mid 2015 new chemical treatment was introduced, increasing gross emulsion processing capacity.
AREA FOR VOLUMETRICS

Legend
- Township
- Range
- Section
- Shell Land
- Approval 8143
- Operating Area
## PAD OBIP VALUES

<table>
<thead>
<tr>
<th>Pad</th>
<th>Area (m²)</th>
<th>Height (m)</th>
<th>NTG (frac)</th>
<th>Porosity (frac)</th>
<th>So (frac)</th>
<th>Bo (m³/m³)</th>
<th>PV (m³)</th>
<th>OBIP (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR 1-3</td>
<td>199,482</td>
<td>23</td>
<td>1.00</td>
<td>0.290</td>
<td>0.83</td>
<td>1.01</td>
<td>1,330,545</td>
<td>1,093,418</td>
</tr>
<tr>
<td>SR 4-7</td>
<td>359,361</td>
<td>16</td>
<td>1.00</td>
<td>0.290</td>
<td>0.83</td>
<td>1.01</td>
<td>1,667,435</td>
<td>1,370,268</td>
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<tr>
<td>SR 8-11</td>
<td>256,081</td>
<td>22</td>
<td>1.00</td>
<td>0.290</td>
<td>0.83</td>
<td>1.01</td>
<td>1,612,254</td>
<td>1,306,774</td>
</tr>
<tr>
<td>SR 12-15</td>
<td>249,546</td>
<td>19</td>
<td>1.00</td>
<td>0.290</td>
<td>0.83</td>
<td>1.01</td>
<td>1,374,998</td>
<td>1,129,949</td>
</tr>
<tr>
<td>Pad 20 Infills</td>
<td>373,386</td>
<td>21</td>
<td>1.00</td>
<td>0.280</td>
<td>0.82</td>
<td>1.01</td>
<td>2,195,510</td>
<td>1,782,493</td>
</tr>
<tr>
<td>Pad 20 Conv</td>
<td>410,545</td>
<td>22</td>
<td>1.00</td>
<td>0.280</td>
<td>0.82</td>
<td>1.01</td>
<td>2,528,957</td>
<td>2,053,213</td>
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<tr>
<td>Pad 21 Infills</td>
<td>279,163</td>
<td>25</td>
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<td>0.280</td>
<td>0.82</td>
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<tr>
<td>Pad 21 Conv</td>
<td>427,746</td>
<td>25</td>
<td>1.00</td>
<td>0.280</td>
<td>0.82</td>
<td>1.01</td>
<td>2,994,222</td>
<td>2,430,953</td>
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<td>Pad30</td>
<td>758,773</td>
<td>24</td>
<td>1.00</td>
<td>0.290</td>
<td>0.82</td>
<td>1.01</td>
<td>5,281,060</td>
<td>4,287,593</td>
</tr>
<tr>
<td>Pad31</td>
<td>1,239,870</td>
<td>23</td>
<td>1.00</td>
<td>0.285</td>
<td>0.82</td>
<td>1.01</td>
<td>8,127,348</td>
<td>6,598,441</td>
</tr>
<tr>
<td>Pad40</td>
<td>1,626,190</td>
<td>25</td>
<td>1.00</td>
<td>0.265</td>
<td>0.80</td>
<td>1.01</td>
<td>10,773,509</td>
<td>8,533,472</td>
</tr>
<tr>
<td>Pad41</td>
<td>1,077,660</td>
<td>24</td>
<td>1.00</td>
<td>0.265</td>
<td>0.80</td>
<td>1.01</td>
<td>6,853,918</td>
<td>5,428,846</td>
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<tr>
<td>Pad 32</td>
<td>1,725,020</td>
<td>24</td>
<td>1.00</td>
<td>0.275</td>
<td>0.78</td>
<td>1.01</td>
<td>11,385,133</td>
<td>8,792,479</td>
</tr>
<tr>
<td>Pad 33</td>
<td>1,805,980</td>
<td>24</td>
<td>1.00</td>
<td>0.275</td>
<td>0.78</td>
<td>1.01</td>
<td>11,919,467</td>
<td>9,205,133</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>55,599,562</strong></td>
<td></td>
</tr>
</tbody>
</table>

- Net pay calculated based on the net pay map (shown in the Geology section)
- Area and OBIP for Pad 19 Sat 3 (SR8-11) have been modified to reflect new Pad 19 Infill wells
## PAD RECOVERY FACTORS

<table>
<thead>
<tr>
<th>Pad</th>
<th>OBIP (e3m³)</th>
<th>Cum Produced 30.09.2016 (e3m³)</th>
<th>Expected Ultimate Recovery (e3m³)</th>
<th>Actual RF at 30.09.2016 (%)</th>
<th>Estimated RF* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR 1-3&lt;sup&gt;1,4&lt;/sup&gt;</td>
<td>1,093</td>
<td>272</td>
<td>272</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>SR 4-7&lt;sup&gt;4&lt;/sup&gt;</td>
<td>1,370</td>
<td>234</td>
<td>232</td>
<td>17%</td>
<td>17%</td>
</tr>
<tr>
<td>SR 8-11&lt;sup&gt;4&lt;/sup&gt;</td>
<td>1,307</td>
<td>269</td>
<td>352</td>
<td>21%</td>
<td>27%</td>
</tr>
<tr>
<td>SR 12-15&lt;sup&gt;4&lt;/sup&gt;</td>
<td>1,130</td>
<td>223</td>
<td>223</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Pad 20 Infills</td>
<td>1,782</td>
<td>195</td>
<td>231</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>Pad 20 Conv&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2,053</td>
<td>606</td>
<td>1050</td>
<td>30%</td>
<td>51%</td>
</tr>
<tr>
<td>Pad 21 Infills</td>
<td>1,587</td>
<td>226</td>
<td>354</td>
<td>14%</td>
<td>22%</td>
</tr>
<tr>
<td>Pad 21 Conv&lt;sup&gt;3&lt;/sup&gt;</td>
<td>2,431</td>
<td>571</td>
<td>948</td>
<td>24%</td>
<td>38%</td>
</tr>
<tr>
<td>Pad30&lt;sup&gt;5&lt;/sup&gt;</td>
<td>4,288</td>
<td>799</td>
<td>1,145</td>
<td>19%</td>
<td>27%</td>
</tr>
<tr>
<td>Pad31&lt;sup&gt;5&lt;/sup&gt;</td>
<td>6,598</td>
<td>730</td>
<td>1,112</td>
<td>11%</td>
<td>17%</td>
</tr>
<tr>
<td>Pad40&lt;sup&gt;6&lt;/sup&gt;</td>
<td>8,533</td>
<td>847</td>
<td>847</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Pad41&lt;sup&gt;6&lt;/sup&gt;</td>
<td>5,429</td>
<td>483</td>
<td>483</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>Pad 32</td>
<td>8,792</td>
<td>821</td>
<td>1192</td>
<td>9%</td>
<td>14%</td>
</tr>
<tr>
<td>Pad 33</td>
<td>9,205</td>
<td>774</td>
<td>1083</td>
<td>8%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>55,598</strong></td>
<td><strong>7,055</strong></td>
<td><strong>9,524</strong></td>
<td><strong>13%</strong></td>
<td><strong>17%</strong></td>
</tr>
</tbody>
</table>

### NOTES:

1. SR 1-3: 17% recovery from CSS, additional recovery from steam drive from wells SR-16+17
2. Pad 20 Conv wells: 14% recovery from SAGD operations, 8% recovery from CSS, remaining RF from Top down Steam Drive
3. Pad 21 Conv wells: 6% recovery from SAGD operations, 4% recovery from CSS, remaining RF from Top-down Steam Drive
4. Pad 19 SR 1-3, 12-15 currently shut in due to poor economics and high watercut. SR 6 is producing, SR 8-10 are part of the Pad 19 Infills
5. Pad 30 and 31 had injectors added in 2014, will see remaining RF recovered via Top down Steam Drive.
6. Pad 40 and 41 suspended. Remaining OBIP to be recovered via future project
- Pads 40/41 – Low performing CSS / lateral steam drive pads, suspended Oct 2015
- Pad 19 – Overall medium recovery with CSS and vertical steam drive
- Pads 20, 21/22 – High performing TDSD pads
- Pad 20/21 infills – Medium-performing LSD pads
RECOVERY EXAMPLES

Cyclic Steam Followed by Vertical Steam Drive Pad19

Top Down Steam Drive Pad21

Lateral Steam Drive Pad 21 Infills
RECOVERY EXAMPLE – PAD 19: CSS AND VSD

- Originally 15 Soak radial wells, 2 vertical injectors
- 8 CSS cycles completed on SR1-3; converted to steam drive Feb 2003. Restarted 2011, shut in Dec 2014 due to high watercut
- 6 CSS cycles completed on SR 4-7; SR6 restarted 2011 – supported by pad 20 injection
- 8 CSS cycles completed on SR 8-15; restarted 2011 with additional 7 infill wells and 4 infill injectors. Steam drive ongoing
- VSD post CSS increases recovery factor

<table>
<thead>
<tr>
<th>As of 30.09.2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative Oil</td>
</tr>
<tr>
<td>Current RF</td>
</tr>
<tr>
<td>cSOR</td>
</tr>
</tbody>
</table>

[Graph showing oil and water rates over time]
**RECOVERY EXAMPLE PAD 21/22 TDSD**

- **Pad 21 SAGD pairs [21-08 to 21-12]**
  - Injector legs 5 m above producer legs
  - SAGD operation from 1997 - 2003
  - CSS operation from 2003 - 2008
    - Steam injection through injection legs
    - Production from production legs
  - Steam drive from 2008 onwards
    - Steam injection through pad 22 injectors
    - Production from 21-8-12 production legs

- **Pad 22 wells [22-01, 22-02, 22-04]**
  - Two single laterals drilled perpendicular to existing wells higher in the reservoir
  - Initial cold production test in February 2007
  - Cold produced October 2007 to August 2008
  - Steam drive to Pad 21 conversion wells below since November 2008
    - Top-down steam drive was pursued for Pads 20 and 21 as a follow-up process to CSS, as CSS performance was worsening in subsequent cycles
    - Well configuration on Pads 20 and 21 was appropriate for TDSD as these wells were drilled as SAGD well pairs

---

**SD performance As of 30.09.2016**

<table>
<thead>
<tr>
<th></th>
<th>Cumulative Oil</th>
<th>Cumulative Steam</th>
<th>Cumulative SOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>574 e3m3</td>
<td>2599 e3m3</td>
<td>4.53</td>
</tr>
</tbody>
</table>

---

**Graph**

- **Water Rate (bbl/day)**
  - Range: 0 to 3000 bbl/day
- **Steam Inj Rate (bbl/day)**
  - Range: 0 to 3000 bbl/day
- **Date**
  - From 1997 to 2016

---

**Map**

- **Pad 21**
- **Pad 22**

---

**Legend**

- Oil Rate (bbl/day)
- Steam Inj Rate (bbl/day)
RECOVERY EXAMPLE PAD 21 INFILLS LSD

- Pad 21 Infills [21-13, 21-14, 21-15]
  - 3 J-wells, drilled 2004
  - CSS operation, 4 cycles completed
  - Converted to lateral SD in November 2011
    - 21-14 converted to dedicated injector
    - TDSD was not pursued on Pad 20 Infills or Pad 21 Infills due to the J-well producer configuration (vertical spacing of infill injectors and producers is suboptimal)
  - Significant improvement in SOR performance once communication between injector and producer established

SD performance As of 30.09.2016

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative Oil</td>
<td>226 e3m3</td>
</tr>
<tr>
<td>Cumulative Steam</td>
<td>724 e3m3</td>
</tr>
<tr>
<td>Cumulative SOR</td>
<td>3.21</td>
</tr>
</tbody>
</table>
KEY LEARNINGS OF RECOVERY MECHANISMS IN PR

- **Pressure Cycle Steam Drive (PCSD)** 1979-2001
  - Approximate reservoir pressure range: 1-12 MPa
  - Need steam to rise and gravity to drain oil
  - Performance hindered if pressure interference exists
  - Demonstrated vertical well steam drive to be feasible

- **Steam Assisted Gravity Drainage (SAGD)** 1997-2003
  - Approximate reservoir pressure range: 2-6 MPa
  - Uneconomic due to wellpairs placed low in reservoir (high Sw), and difficult to operate due to well completion

- **Cyclic Steam Stimulation (CSS)** 1997 - present
  - Approximate reservoir pressure range: 1-12 MPa
  - Steam growth for horizontal wells limited by poor steam quality and reservoir heterogeneities
  - Works well with vertical wells if reservoir is conditioned properly

- **Horizontal Well Steam Drive (SD)** 2005 - present
  - Approximate reservoir pressure range: 2-6 MPa
  - Need established fluid pathways between wells
  - Maintain low pressure operation
  - Horizontal well steam drive demonstrated feasible in mature areas
**KEY LEARNINGS OF TOP-DOWN STEAM DRIVE IN PR**

- **Top-Down Steam Drive (TDSD)**
  - Approximate reservoir pressure range: 1.5 – 6 MPa
  - Dedicated injectors target unswept oil and reduce SOR and WC
  - Performance hindered by inconsistent steam delivery and well completion – old producers have single tubing string and in pads 30/31, suspected liner collapse.
  - Best performers: Pads 20 and 21/22, Worst performers Pads 30 and 31
FACTORS IMPACTING RECOVERY

■ Well design
  ■ Multi and single lateral J wells have no clear performance advantage
  ■ Difficult to control subsurface steam movement in multilaterals

■ Inter-well or Inter-pad Communication
  ■ Examples include: pad 40-41, pad 32-30, pad 32-33, pad 20 infills-conv, pad 21 infills-conv)
  ■ If evidence of well established communication exists:
    ■ Temporarily shut in well adjacent to steaming if necessary
    ■ Production may not require additional steam (ex SR6 supported by 20-18)
  ■ If not well established
    ■ Monitor pressure and temperatures

■ Steam Drive
  ■ Well completion design limits ability to target unswept reservoir areas

■ Geology
  ■ The presence of shale layers is variable across the leasehold and shows some impact
to injector / producer communication. However, good communication has been established in top-down steam drive pads which suggests that these shales act as baffles not barriers.
FACTORS IMPACTING RECOVERY

- Low Recovery factors:
  - Seismic from 2009 indicates that the well completions for the multilateral wells in Peace River were inefficient. Several legs were unlined and may have collapsed – steam did not go to all legs equally.
  - Example Pad 31 to the right. Warm colors indicate steam affected zones.

- The completion assembly had large openings near the well center where legs met the central well, steam preferentially flowed into the reservoir at the center vs the legs.
Field: Brownfield, previously CSS’ed, infill wells to increase recovery

Technology: Solvent (diluent) is co-injected with the steam into the reservoir

Pilot: 4 inverse 5 spot patterns (2 steam-only, 2 steam-solvent)

Steam-solvent patterns: 2 month SD → 4 month solvent injection (15 wt%) → followed by SD and surveillance for solvent recovery

Measurement: Pad facilities, all streams (CVG and tubing) metered and sampled (auto-samplers)

Objectives: Oil production uplift over steam, Solvent recovery, Model validation, Operational experience
**PILOT INTERPRETATION**

**Heavy Oil Uplift:**
- OSR improved by 38% due to solvent injection, estimated uplift 2520 m³. Solvent efficiency (uplift/injected solvent) at 0.49 m³/m³.
- Data accurately history matched with reservoir model.

**Solvent Recovery:**
- Recovery after 13 months is 63%.
- Model history matched to first 8 months of solvent production. Model predicted solvent recovery of 62% after 13 months.
- Solvent recovery forecast after 3 years is 90%.
SOLVENT PILOT LEARNINGS AND CONCLUSIONS

- Intense and redundant metering and well testing checking were key on reducing data uncertainty and achieving confidence in the pilot results
- Frequent sampling was required to generate a conclusive interpretation of the pilot
- A single hydrocarbon splitting method (developed internally) was screened in for robustness on assumptions
- The Solvent Enhanced Steam Drive pilot results demonstrated a successful technology and the benefits of using solvent in a steam-drive application

Future Development:
- Technology is ready for deployment and is selectable for future steam-drive developments in Peace River area

Publications:
- SPE185014, SPE179815, SPE175414, SPE169070
STEAM SCHEDULE

MONTHLY STEAM RATES PER PAD, 2017

- Pad 19 SAT1: Blowdown (No further steam injection)
- Pad 19 Infills: Steam Drive
- Pad 20 Phase 3: Top-Down Steam Drive
- Pad 20 Infills: Lateral Steam Drive
- Pad 21 Conv/Pad22: Top-Down Steam Drive
- Pad 21 Infills: Lateral Steam Drive
- Pad 30: Top-Down Steam Drive
- Pads 31: Top-Down Steam Drive
- Pad 32/33: CSS
Plan to abandon 6 wells in 2017

Any future uneconomic wells will be suspended as per Directive 13

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
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<tbody>
<tr>
<td># Wells Abandoned</td>
<td>6</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
# TODAY’S AGENDA

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
</tr>
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<tbody>
<tr>
<td>Introductions and Background</td>
<td>Ivan Gonzalez</td>
</tr>
<tr>
<td><strong>Subsurface Issues Related to Resource Evaluation and Recovery</strong></td>
<td></td>
</tr>
<tr>
<td>Geology/Geoscience</td>
<td>Robyn Gooler</td>
</tr>
<tr>
<td>Geophysics</td>
<td>Tam Pham</td>
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<tr>
<td>Drilling and Completions</td>
<td>Dan Syrnyk</td>
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<tr>
<td>Artificial Lift</td>
<td>Dan Syrnyk</td>
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<tr>
<td>Instrumentation in Wells</td>
<td>Dan Syrnyk</td>
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<tr>
<td>Well Integrity</td>
<td>Dan Syrnyk</td>
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<tr>
<td>Scheme Performance</td>
<td>Laura Mislans</td>
</tr>
<tr>
<td><strong>Future Plans</strong></td>
<td>Ivan Gonzalez</td>
</tr>
<tr>
<td><strong>Surface Operations, Performance and Compliance</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Darcy Forman</td>
</tr>
</tbody>
</table>
SAGD Pilot Project

- Shell is currently progressing a two SAGD well-pair pilot project north of Pad 32 to prove SAGD feasibility in an important area of the Peace River lease. Expected spud date in Q3 2017 pending final investment decision.

100% Steam Quality

- Re-instate existing Steam Separator (PV5.01)
  - Supports SAGD pilot project and production improvement of existing top-down steam drive pads
  - Support produced water treatment plant (D81 compliance)
- To be implemented during June 2017 turnaround
FUTURE PLANS: Water treatment Demo Unit

Water Treatment Commercial Demonstration Unit (CDU)

- A CDU will be implemented in 2017 to better understand the operational implications of the Electrocoagulation (EC) + Dissolved Gas Flotation (DGF) water treatment process
- Tie-ins planned for June 2017 turnaround
- Installation in Q4 2017 and startup in Q1 2018 (operate 6 months)
Full Scale Commercial Produced Water Treatment System

- Once CDU is complete, final process selection can be made
  - Alternative include Zero Lime Softening (ZLS) and ceramic Nanofiltration (NF)
- Switch to 100% steam quality for removal of TDS from the produced water circuit
- Heat integration will be a significant component of any water treatment efforts
TODAY’S AGENDA

Introductions and Background
Ivan Gonzalez

Subsurface Issues Related to Resource Evaluation and Recovery

Geology/Geoscience
Robyn Gooler

Geophysics
Tam Pham

Drilling and Completions
Dan Syrnyk

Artificial Lift
Dan Syrnyk

Instrumentation in Wells
Dan Syrnyk

Well Integrity
Dan Syrnyk

Scheme Performance
Laura Mislans

Future Plans
Ivan Gonzalez

Surface Operations, Performance and Compliance
Darcy Forman
No modifications in 2016
PEACE RIVER PLANT
PR is a thermal facility

Recovery mechanism is a combination of steam drive and cyclical steaming.

- In cyclical steaming, the wells are left shut-in for a period of time to soak. Subsequently the wells are flowed back until they reach flowline pressure (1,300 kPa) at which point pumps are installed.
- In steam drive, steam is injected through dedicated injectors and water and bitumen are produced through dedicated producers at some distance from the injectors.

Production is pumped into the production pipeline. The casings are vented into a casing vent line that runs on plant line pack (250 kPa). Pad 32/33 have multiphase pumps that compress the casing gas back into the production line.

Emulsion enters the plant for oil, water, and gas separation.

Bitumen treating consists of degassing, separating & treating. The separation process is enhanced by controlled heat exchange and addition of demulsifier & diluent.

The produced gas is compressed and injected into a formation for future usage.

Production averages around 40% of 2,000 m³/day licensed capacity.
Produced water is treated & disposed into two injection wells completed in the Leduc Zone.

Produced water is:
- Taken off the separators and treaters
- Cooled using exchangers with boiler feedwater as the cooling medium
- Sent to the skim tank and surge tank for additional retention time and oil separation
- Passed through the sand filters
- Sent to disposal tank
- Sent to Leduc injection wells

Produced water recycle percent = 0%

Typical water quality:
- Produced water TSS 30 mg/L, Oil and Grease 75 ppm, Total Hardness 374 mg/L, Chlorides 3190 mg/L

Solids are periodically disposed of through approved waste stream treating companies.

Designed produced water handling and injection capacity is 7977 m3/day.
PRC pulls water from the Peace River on a continuous basis. Shell has a source water treatment facility located on the east bank of the Peace River.

PRC is licensed to withdraw 4.3 $\times 10^6$ m$^3$ of water from the Peace River per year (11,813 m$^3$/day).

Historical water usage range is 5,000 m$^3$/day to 11,000 m$^3$/day.

- YTD fresh water withdrawal (as of Sep 30th) is 1.6 $\times 10^6$ m$^3$ or an average of 4,512 m$^3$/day.

Before being sent to the main complex, fresh water from source water is treated to:

- less than 5 ntu, and less than 0 ppm oxygen.

Water is clarified in a reaction clarifier. After passing through gravity sand filters, the water is vacuum deaerated.

The water is pumped to the main complex through a 20 km pipeline.

Main PRC water treatment consists of water softening using the sodium zeolite resin exchange process to remove calcium and magnesium.

The water softeners were converted to shallow shell technology in 2016.

Waste brine is disposed down a disposal well (16-27) in the Leduc formation.
Peace River Complex pulls water from the Peace River through our source water facility

The removal of water is covered under three Water Act Licences:

- 00030033-00-00
- 00030034-00-00
- 00030035-00-00

Each of the licences have been amended three times
2016 Water Treatment

Electrocoagulation (EC) Pilot Trial
- Small (20 gpm) pilot trial conducted in Q1 2016
- Proof of Concept achieved
- Some uncertainties remain around operational/economic aspects of the EC process → commercial demonstration unit recommended

Directive 81 (D81) Compliance
- Application submitted Q2 2016
- Waiver extension granted Q3 2016
- Approval subject to construction of a commercial produced water treatment and recycling facility before end of 2020
PRC generates 80% steam quality from four once through steam generators. The four steam generators have a total capacity of approximately 8,000 tons of 80% quality per day. Steam pressures of 14 MPa and 335 °C.

The main complex takes formation steam off the high pressure injection line and utilizes it in the utility steam system. The utility steam uses 700 to 1,500 t/d based on seasonal requirements.

PRC has a 100% utility steam system blowdown recycle back in to the plant steam condensate recovery system.

All Steam Generators can now use a mixture of up to 75% Cliffdale and 25% Natural Gas by volume as their fuel source. The original design called for 60% Cliffdale and 40% Natural Gas and this change was made in June of 2016.

Currently doing detailed engineering work to convert the Peace River steam system back to 100% steam quality to the field. Targeting an implementation date of mid 2017.
- Four PREP boilers at 2000 tons/d capacity each

![Steam Quality Graph](image-url)

- Steam Quality
- Facility Design

<table>
<thead>
<tr>
<th>Month</th>
<th>Steam Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct-15</td>
<td>80</td>
</tr>
<tr>
<td>Nov-15</td>
<td>80</td>
</tr>
<tr>
<td>Dec-15</td>
<td>80</td>
</tr>
<tr>
<td>Jan-16</td>
<td>80</td>
</tr>
<tr>
<td>Feb-16</td>
<td>80</td>
</tr>
<tr>
<td>Mar-16</td>
<td>80</td>
</tr>
<tr>
<td>Apr-16</td>
<td>80</td>
</tr>
<tr>
<td>May-16</td>
<td>80</td>
</tr>
<tr>
<td>Jun-16</td>
<td>80</td>
</tr>
<tr>
<td>Jul-16</td>
<td>80</td>
</tr>
<tr>
<td>Aug-16</td>
<td>80</td>
</tr>
<tr>
<td>Sep-16</td>
<td>80</td>
</tr>
</tbody>
</table>
Natural gas is purchased from TransCanada for use as fuel.

Since June 2010, CVG from the Cliffdale field is being imported to PRC as a fuel source to the boilers.

EPEA licence restrictions limit using sour fuel in the boilers to events less than 72 hours in duration. While Peace River has the capability to burn sour mixed gas it has not been done since 2010.
FACILITY PERFORMANCE: Three Creeks Compressor

- Three Creeks Gas injection facility has been operational for six years.
- Gas is currently analyzed once per month at the Three Creeks dehydration outlet to the Three Creeks gas injection pipeline. Analysis done by an outside lab.
- Compressor turnaround completed June 2016
- 2016 Injection facility reliability is currently 99%. This includes planned maintenance shutdowns.
- PRC produced gas is no longer consumed in boilers but injected into the Three Creeks reservoir since September 2010
Data as per Three Creeks annual progress report submitted Nov 2016

- Obtain D65 approval in October 2016 to store gas up to 5,000 kPa(a) static reservoir pressure.
THREE CREEKS SUBSURFACE INFORMATION

Cumulative Volume Of Gas Injected

Q3 2016
History

Cum Gas Stored @ 30-Sep-2016:
236 e6m3
THREE CREEKS SUBSURFACE INFORMATION

- Injected gas stream is analyzed once each month. The graph below presents the gas analysis from January to October.

Gas Composition 2016

<table>
<thead>
<tr>
<th>Month</th>
<th>Mole Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>0.00 - 0.10</td>
</tr>
<tr>
<td>Feb</td>
<td>0.20 - 0.30</td>
</tr>
<tr>
<td>Mar</td>
<td>0.40 - 0.50</td>
</tr>
<tr>
<td>Apr</td>
<td>0.60 - 0.70</td>
</tr>
<tr>
<td>May</td>
<td>0.80 - 0.90</td>
</tr>
<tr>
<td>Jun</td>
<td>1.00</td>
</tr>
<tr>
<td>July</td>
<td>0.00 - 0.10</td>
</tr>
<tr>
<td>Aug</td>
<td>0.20 - 0.30</td>
</tr>
<tr>
<td>Sept</td>
<td>0.40 - 0.50</td>
</tr>
<tr>
<td>Oct</td>
<td>0.60 - 0.70</td>
</tr>
</tbody>
</table>

- Hydrogen Sulfide
- Carbon Dioxide
- Nitrogen
- Hydrogen
- Helium
- Methane
- Ethane
- Propane
- Isobutane
- n-Butane
- Isopentane
- n-Pentane
- Hexanes
- Heptanes+
Injected gas stream is analyzed once every month. The table below presents the gas analysis for July, August and September 2016.

<table>
<thead>
<tr>
<th>Component</th>
<th>July 2016</th>
<th>August 2016</th>
<th>September 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole Fraction (As Received)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0.01024</td>
<td>0.00582</td>
<td>0.00731</td>
</tr>
<tr>
<td>Helium</td>
<td>0.00003</td>
<td>0.00003</td>
<td>0.00005</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.00349</td>
<td>0.00295</td>
<td>0.00358</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>0.49703</td>
<td>0.39319</td>
<td>0.47969</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.01404</td>
<td>0.01270</td>
<td>0.01650</td>
</tr>
<tr>
<td>Methane</td>
<td>0.44075</td>
<td>0.55792</td>
<td>0.45377</td>
</tr>
<tr>
<td>Ethane</td>
<td>0.01154</td>
<td>0.00787</td>
<td>0.01308</td>
</tr>
<tr>
<td>Propane</td>
<td>0.00966</td>
<td>0.00575</td>
<td>0.01042</td>
</tr>
<tr>
<td>Isobutane</td>
<td>0.00283</td>
<td>0.00269</td>
<td>0.00332</td>
</tr>
<tr>
<td>n-Butane</td>
<td>0.00422</td>
<td>0.00380</td>
<td>0.00550</td>
</tr>
<tr>
<td>Isopentane</td>
<td>0.00240</td>
<td>0.00249</td>
<td>0.00272</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>0.00205</td>
<td>0.00205</td>
<td>0.00239</td>
</tr>
<tr>
<td>Hexanes</td>
<td>0.00118</td>
<td>0.00141</td>
<td>0.00119</td>
</tr>
<tr>
<td>Heptanes+</td>
<td>0.00054</td>
<td>0.00133</td>
<td>0.00048</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1.00000</strong></td>
<td><strong>1.00000</strong></td>
<td><strong>1.00000</strong></td>
</tr>
</tbody>
</table>
A MARP was approved in July 2009. Most recent MARP update was submitted on February 25, 2016.

The following changes to the Measurement, Accounting and Reporting Plan were included in the last submission:

- Removed Pad 40 wells (suspended)
- Removed the Temporary Approval #1812468
- Added the Chemical Dilution Fresh Water to (Floc Skid, Reverse Emulsion Breaker & Clarifier)
- Added the Boiler Winterization Steam
PRODUCTION WELL TESTING

- Each well is directed to a test vessel on the pad, except pad 19 sat 1, 2, 4 & 20
- Well test duration/frequency largely dependent on purge time & number of wells tied into each test separator:

<table>
<thead>
<tr>
<th>Pad</th>
<th>Separator</th>
<th>Purge time*</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>2 phase</td>
<td>~3-8 hrs</td>
<td>~24 hrs</td>
<td>3-4x/month</td>
</tr>
<tr>
<td>19 sat 1-2-4 &amp; 20</td>
<td>3 phase</td>
<td>~1 to 8 hrs</td>
<td>~10 hrs</td>
<td>3-4x/month</td>
</tr>
<tr>
<td>19 sat 3</td>
<td>2 phase</td>
<td>~0.5 hrs</td>
<td>~24 hrs</td>
<td>3-4x/month</td>
</tr>
<tr>
<td>30, 31</td>
<td>2 phase</td>
<td>~0.5 hrs</td>
<td>~10 hrs</td>
<td>4-5x/month</td>
</tr>
<tr>
<td>32, 33</td>
<td>2 phase</td>
<td>~0.5 hr</td>
<td>~10 hrs</td>
<td>4-5x/month</td>
</tr>
</tbody>
</table>

* Purge time varies for each test, as it is dependent on the production rate of the well. A pre-determined purge volume is applied to each vessel

- Flow rates are measured by a Coriolis meter
- Water/bitumen cuts are determined by inline BS&W analyser
- Reported volumes are prorated based on measured total volumes at the plant
- Details of measurement and reporting procedures can be found in the Peace River MARP
WELL TESTING

- Reliability
  - 100% compliance was not achieved for the year. June, July Sept and Oct 2016 were not compliant.
  - Test compliance issues:
    - June – Steam system repair on Pad 19-3. Steam is required for pressure makeup in the test separator
    - July – faulty watercut meter. Found debris on the probe.
    - Sept & Oct – Blocked flow in Pad 32 test separator

- Year To Date Activities
  - Implemented new steam pressure make up control on 19-3 for improved level control.
  - Conducted investigation of blocked flow in Pad 32 test separator piping, valves, and vessel.
  - Field wide AGAR calibration campaign conducted in Oct and Nov. Samples were obtained to implement new watercut curves.
**STEAM PRORATION**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>1.07 – 1.18</td>
<td>1.12</td>
</tr>
</tbody>
</table>

![Proration Chart]

**Proration Factor**

- **Oct-15**: 1.08
- **Nov-15**: 1.06
- **Dec-15**: 1.08
- **Jan-16**: 1.06
- **Feb-16**: 1.08
- **Mar-16**: 1.08
- **Apr-16**: 1.12
- **May-16**: 1.20
- **Jun-16**: 1.20
- **Jul-16**: 1.14
- **Aug-16**: 1.20
- **Sep-16**: 1.14
In October 2016 we completed a field wide well sampling and AGAR meter calibration program.
Battery Level GOR x Prorated Well Oil Volume used for reporting PRC Produced Well Gas Volumes. Implemented the steam volumes used for winterization and test separator pressure into the water recycle calculation to correct the produced water volume.
STEAM INJECTED & PRODUCED WATER

Water (Steam) Injected vs Water Recovered

- **X-axis**: Months from Oct-15 to Sep-16
- **Y-axis**: Thousands of M3
- **Legend**:
  - Injected Steam
  - Recovered Water

- October-15: 150
- November-15: 110
- December-15: 180
- January-16: 200
- February-16: 130
- March-16: 160
- April-16: 170
- May-16: 140
- June-16: 120
- July-16: 130
- August-16: 110
- September-16: 140
WATER DISPOSAL

- **Brine Water Disposal Well** (100/16-27-85-19W5)
  - Disposing into the Leduc formation
  - Used for boiler feed water softener regeneration waste
  - Average Disposal Volume/Day = 53.5 m³/d
  - Average Upstream Pressure = 2,780 kPa
  - Max Wellhead Pressure = 3602 kPa (Approved pressure = 4,500 kPa)
  - Typical Total Dissolved Solids (TDS) is 9000 g/m³
  - Approval up to 4500 kPag wellhead injection pressure (as per approval no. 9953A)
WATER DISPOSAL

- **Produced Water Disposal Well 322 (102/14-25-85-19W5)**
  - Disposing into the Leduc formation
  - Used as produced water disposal well
  - Average Disposal Volume/Day = 2,841 m³/d
  - Average Pressure = 5,928 kPa
  - Max Pressure = 9,984 kPa (Approved pressure = 18,000 kPa)
  - Average Temperature = 66 °C
  - Typical Total Dissolved Solids (TDS) is 5300 g/m³
  - Approval up to 18,000 kPag (as per approval no. 6308)

- **Produced Water Disposal Well 323 (102/16-23-85-19W5)**
  - Disposing into the Leduc formation
  - Used as produced water disposal well
  - Average Disposal Volume/Day = 2,326 m³/d
  - Average Pressure = 6,019 kPa
  - Max Pressure = 10,000 kPa (Approved pressure = 18,000 kPa)
  - Average Temperature = 67 °C
  - Typical Total Dissolved Solids (TDS) is 5300 g/m³
  - Approval up to 18,000 kPag (as per approval no. 6308)
• Brine Disposal Well 16-27 had no injection in August due to a pipeline leak.
Brine Disposal well 16-27 was shut-in August due to a pipeline leak.
WASTE DISPOSAL

- Newalta-Red Earth (12-13-87-9W5)
  - Treatment, Recovery & Disposal (TRD) Facility
  - 131.0 m³ to October 2016
  - SLGHYD

- Newalta Seal Lake (11-07-82-15W5)
  - Treatment, Recovery & Disposal (TRD) Facility
  - SLGHYD
  - 176.6 m³ to October 2016

- RBW Waste Management
  - To Edmonton Facility for disposal 3907-69 Ave.
  - 0 m³ of waste solids (SOILCO) to October 2016
WASTE DISPOSAL

- **Tervita Corporation– Peace River (12-24-85-19-W5)**
  - Treatment, Recovery & Disposal (TRD) Facility
  - Primarily hydrocarbon sludge (NON-DOW, CAUS, COEMUL, SLGHYD, SOILCO, SOILEM, WSHWTR)
  - 12,687.02 m³ to October 2016

- **Tervita (Hazco) Environmental (1/4-03-25-22W4)**
  - Tervita Waste Management (TWM)
  - SOILRO, EMTCON and FILOTH
  - 42.75 tonnes to October 2016

- **Tervita Corporation– Spirit River (12-31-77-5W6)**
  - Tervita Waste Management (TWM)
  - Activated Carbon ACTCRB
  - 0 m³ to October 2016
WASTE DISPOSAL

- Tervita Corporation – Valleyview (04-21-069-22W5)
  - Tervita Waste Management (TWM)
  - SLGHYD and LUBOIL
  - 42 m³ to October 2016

- Tervita Corporation – High Prairie (01-14-073-17W5)
  - Tervita Waste Management (TWM)
  - SLGHYD
  - 40 m³ to October 2016
New AER Operating License has 0.99 T/Day continuous SO2
Sulphur emissions have reduced since 2010 due to PRC produced gas injection into Three Creeks.
GREEN HOUSE GAS EMISSIONS

CO2e

The high flare volume in October was a result of a power outage. June’s higher flare volume was due to turn around activities.
Static/Passive Air Monitoring
- Twelve passive stations
- Gathers data on sulphur dioxide and hydrogen sulphide
- 2016 monitoring and reporting satisfactory

Continuous Ambient Monitoring data
- Continuous Monitoring - Monitored parameters: sulphur dioxide, hydrogen sulphide, methane, non-methane hydrocarbons, total hydrocarbons, total reduced sulphur, ambient temperature, wind speed and direction.
There were no Ambient Air Exceedances at the PRC Environmental Trailer (EPEA Approval 1642-02-08) from October 2015-October 2016. The air trailer maintained over 90% uptime each month as per license requirements.

Government (AER and/or AESRD) reportable spills and releases at PRC

- 1 government reportable spills from October 2015 to end of September 2016.
- July 15, 2016 we had a brine disposal pipeline failure. 32 m³ of brine was released and all contained to the Peace River Complex site.
  - Approximately 10 m³ runoff water flowed off lease.
- 2 releases to atmosphere from tanks (venting) from October and December 2015.
  - Total volume vented for this period was 0.0078 e³m³.
- 2 releases to atmosphere from tanks (venting) from January to end of September 2016.
  - Total volume vented for this period was 0.0054 e³m³.
On February 2016, during a DOI audit with AER, we were informed that we are out of compliance with berms around existing well pads at Peace River.

On November 10, 2016, Shell received approval from the AER to continue with a risk based approach to bring well pads at PRC into compliance with Conditions 4 and 5 of Schedule V, of Approval 1615-02-03.

<table>
<thead>
<tr>
<th>Berm Completion Date</th>
<th>Pad Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 31, 2017</td>
<td>Pad 20, Pad 32, Pad 19-D [(SR-8-11)SAT3]</td>
</tr>
<tr>
<td>December 31, 2018</td>
<td>Pad 33, Pad D323, Pad 21</td>
</tr>
<tr>
<td>December 31, 2019</td>
<td>Three Creeks Gas Injection Pad, Pad 30, Pad 31</td>
</tr>
</tbody>
</table>

This schedule addresses the higher risk pads first before the expiry of our existing EPEA Approval (August 31, 2020).
To the best of Shell’s knowledge, operations at Peace River are consistent with all conditions of our Peace River Thermal Scheme No. 8143.

<table>
<thead>
<tr>
<th>Amendment</th>
<th>Approval Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>October 2, 2012</td>
<td>Carmon Creek Phase 1 and 2 Project.</td>
</tr>
<tr>
<td>P</td>
<td>Oct 4, 2013</td>
<td>Carmon Creek changes to CPF designs and adding a third separator to all well pads.</td>
</tr>
<tr>
<td>R</td>
<td>Dec 12, 2013</td>
<td>Carmon Creek conversion of well pads from injectors to CSS producers.</td>
</tr>
<tr>
<td>S</td>
<td>March 6, 2014</td>
<td>Carmon Creek updates to the CPF</td>
</tr>
<tr>
<td>T</td>
<td>April 15, 2014</td>
<td>Directive 81 variance application for Peace River Complex</td>
</tr>
<tr>
<td>U</td>
<td>Oct 10, 2014</td>
<td>Peace River Pad 20 AGAR meter installation</td>
</tr>
<tr>
<td>V</td>
<td>Nov 7, 2014</td>
<td>Peace River Pad 22 addition of 2 infill wells</td>
</tr>
<tr>
<td>W</td>
<td>May 4, 2015</td>
<td>Carmon Creek – removing conditions to re-abandon, re-enter two wells in our original approval condition.</td>
</tr>
<tr>
<td>X</td>
<td>April 6, 2015</td>
<td>Carmon Creek- pressure monitoring wells-variance approval to not drill these wells.</td>
</tr>
<tr>
<td>Y</td>
<td>April 14, 2015</td>
<td>Peace River Pad 19-Sat 3- 6 additional well license approvals</td>
</tr>
<tr>
<td>Z</td>
<td>May 21, 2015</td>
<td>Carmon Creek development area expansion and additional 13 well pads approval.</td>
</tr>
<tr>
<td>AA</td>
<td>Jan 4, 2016</td>
<td>Steam Foam Proof on Concept (PoC) injection trial up to two wells within the existing Pad 19 Satellite 3 and the temporary surface facilities required to operate the PoC trial.</td>
</tr>
</tbody>
</table>
EPEA Operating Approval 1642-02-03 had 1 amendment during 2016.

- 1642-02-08 amendment incorporated two 1.25MW generator sets at Peace River Complex for generation up to 2.5MW of electricity for the plant.
- Shell also obtained written authorization from the AER to reduce the stack height of the two generator sets on October 3, 2016.

Shell’s Surface Lands department deals with many amendments to leases as a part of day to day business.
Groundwater Program

- Per EPEA 1642-02-08, PRC has requirements for both groundwater and deep well water testing. Testing and reporting are both required on an annual basis.
- Testing was completed in October 2016.
- Results will be reported in the 2016 annual report.

Soil Monitoring Program

- Results to be reported in annual report.
Shallow groundwater monitoring program:
Groundwater testing occurred in November 2015 on plant piezometers. Results of the GWMP were summarized in the 2015 Groundwater Monitoring Program Peace River Complex Project Report (Matrix, 2016) and submitted to AER in March 2016. Continued groundwater monitoring per EPEA approval.

Shallow groundwater wells around reclaimed PSDS (Produced Solids Disposal Site):
PSDS has been reclaimed and well Pad 32 was built on the location. Piezometers remain around perimeter of well pad. No impacts observed in these wells with little variation at a majority of the monitoring locations. Results of the GWMP were summarized in the 2015 Groundwater Monitoring Program Peace River Complex Project Report (Matrix, 2016) and submitted to AER in March 2016. Recommendations were made by Matrix in the 2016 EPEA GWMP report to discontinue the PSDS monitoring program in 2016. AER was notified of the change.
Deep Regional Wells

2004 drilling program (50 and 105 meter depth)

2005 drilling program (70 meter depth)

2009 drilling program (3 wells (each approximately 60, 120 and 270 meters deep)

Results of the deep regional well GWMP were summarized in the 2015 Groundwater Monitoring Program Peace River Complex Project Report (Matrix, 2016) and submitted to AER in March 2016.

Continued groundwater monitoring per EPEA approval.
Shell continues to monitor the aboveground wildlife crossing structures on above ground pipelines. This data will continue to be assessed and incorporated into the Comprehensive Wildlife Report. The next report is due in 2018.

Multiple wildlife studies including bird surveys, winter mammal tracking, owl surveys, bat surveys, and amphibian surveys completed in 2015-2016.

- All wildlife data for these surveys is uploaded into the Fish & Wildlife Management Information System (FWMIS) and incorporated into the Comprehensive Wildlife Reports

Partnered with the Miistakis Institute in their Wildwatch Program. Training on the program is being implemented for key site personnel prior to being rolled out across the wider asset area.

Wetland Monitoring Program implementation has begun in Q3 2016.

eDNA partnered with the Alberta Conservation Association (ACA) on a 3-year amphibian study beginning in 2014 and concluding in 2016.

Ongoing peatland reclamation research with NAIT Boreal Research Institute.
## ENVIRONMENTAL STUDIES PROGRAM

<table>
<thead>
<tr>
<th>EPEA Requirement</th>
<th>Report Name</th>
<th>Due Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCP - Schedule VI (1)</td>
<td>Groundwater Monitoring Program (GWMP)</td>
<td>March 31, 2014</td>
<td>Submitted to Alberta Energy regulator (AER) on March 31, 2014; received written authorization from the Director on March 5, 2015.</td>
</tr>
<tr>
<td>CCP - Schedule VIII (4) &amp; (9)</td>
<td>Wildlife Monitoring and Mitigation Program (WMMP) Proposal</td>
<td>March 31, 2014</td>
<td>Submitted to ESRD on March 19, 2014 and resubmitted to AER on May 26, 2015. SIRs received from AER in May 2015. Shell is working on addressing the SIRs for re-submission to the AER by December 31, 2016.</td>
</tr>
<tr>
<td>CCP - Schedule IX (39)</td>
<td>Wetland Reclamation Trial Program Proposal</td>
<td>December 31, 2016</td>
<td>In preparation</td>
</tr>
<tr>
<td>CCP - Schedule IX (44)</td>
<td>Reclamation Monitoring Program (RMP) Proposal</td>
<td>December 31, 2016</td>
<td>In preparation</td>
</tr>
<tr>
<td>CCP - Schedule XI (26)</td>
<td>Project-Level, Conservation, Reclamation and Closure Plan (PLCRCP)</td>
<td>October 31, 2017</td>
<td>In February 2016, the AER has issued new guidelines to the preparation of the PLCRCP. The due date for this document has now been set by the AER to October 31, 2017 [E-File No. 4101-00001642-07].</td>
</tr>
</tbody>
</table>
Environmental research lead by NAIT

- **Peatland Restoration**
  - Funding from Shell is supporting peatland research around the Shell Peace River area (IPAD, pad removal and restoration study, wetland reclamation project at Airstrip and a third project in around the Carmon Creek area that is looking at impacts of linear disturbances on wetland function (carbon, plants etc.)

- **Forest Reclamation**
  - Shell Airstrip Research: field deployment and monitoring of mixed species container stock (hitchhiker planting), utilization of organic amendments on reclaimed sites, riparian area species selection and timing of plant deployment and integrated approaches (site preparation and native cover crops) to manage undesirable plants on reclaimed sites.
RECLAMATION PROGRAMS - DAR

- Completed (12) subsurface abandonment and finished (10) cut and cap work in Peace River and Cliffdale area.
- 14-36-084-17 W5M – Completed fixing the chip road and the reclamation work on the lease.
- Completed weed control and tree planting in various sites particular on 08-22-085-18 W5M and 13-29-084-17 W5M where we completed the pad removal in 2015. Completed tree fill planting the Peace River Air Strip due to dry season last year.
- Completed Phase II drilling at several remote sump sites: 9-23-085-19 W5M, 04-02-085-17 W5M, 08-23-084-17 W5M, 23/24-85-19 W5M.
- Completed Environmental Liability Assessments for both Peace River Complex and Cliffdale Battery.