PEACE RIVER IN SITU OIL SANDS PROJECT
DIRECTIVE 54 ANNUAL PERFORMANCE PRESENTATION

DECEMBER 5, 2018

PREMIUM VALUE. DEFINED GROWTH. INDEPENDENT.

Outline – Subsurface

Outline – Surface

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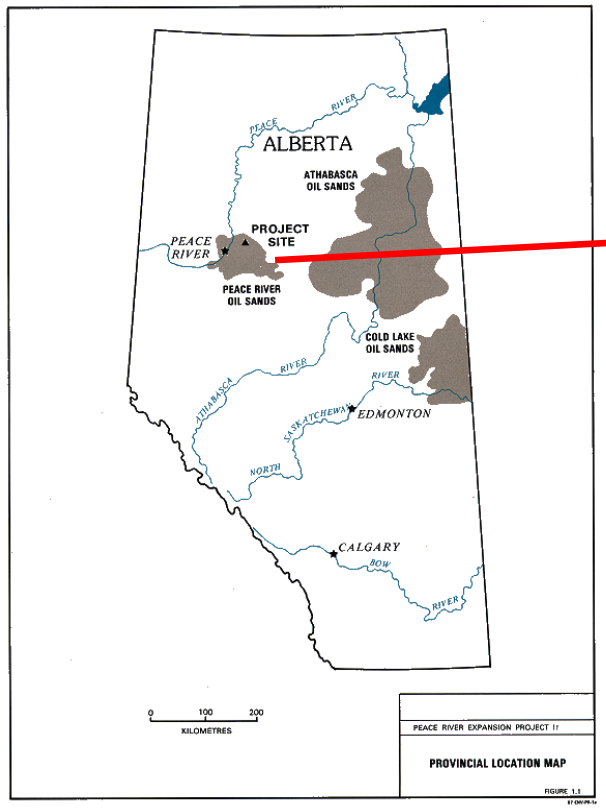
Acronyms

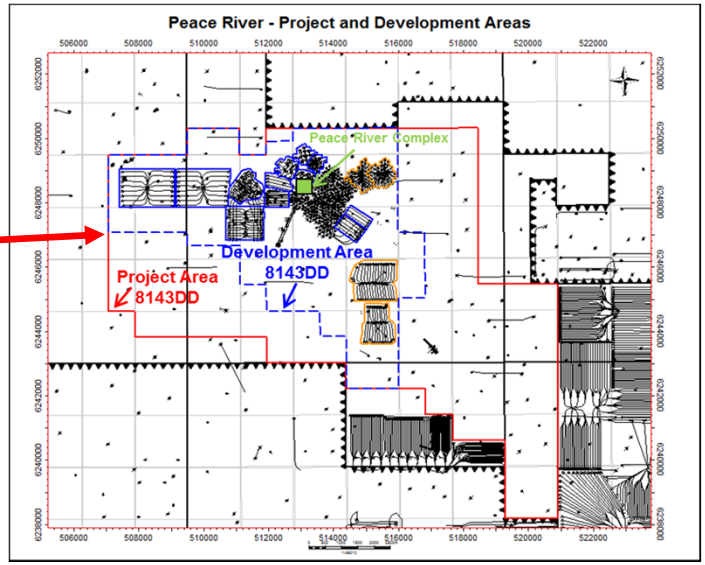
AER	Alberta Energy Regulator
Avg.	average
bbl	barrel, petroleum, (42 U.S. gallons)
BHA	bottom hole assembly
bitwt	bitumen weight
CD	cyclic drive
CDOR	calendar day oil rate
CDSR	calendar day steam rate
cP	centipoise
CSOR	cumulative steam to oil ratio
CSS	cyclic steam simulation
Cumm	cumulative
DFIT	diagnostic fracture injection testing
DI	depletion index
dP	pressure differential
e3m3	thousand cubic metres
ESP	electric submersible pumps
ESRD	Environment and Sustainable Resource Development
FUP	follow up process
HP	horse power
hz	horizontal
ICP	intermediate casing point
IHS	Inclined hetreolithic stratification
InSAR	interferometric synthetic aperture radar
J-Well	horizontal wellbore with toe-up lateral trajectory
KB	Kelly Bushing
kg/m	kilograms per metre
kPA	kiloPascal
kPa/day	kiloPascal per day
LIDAR	laser imaging, detection and ranging
LPCSS	low pressure cyclic steam stimulation
m	metre
m^3	cubic metres
m^3/d	cubic metres per day

Acronyms (...continued)

mD	milli-Darcy
mm	millimetre
MMbbl	million barrels
MPa	megapascal
mTVD	metres true vertical depth
OBIP	original bitumen in place
Obs	observation
ohm·m	ohm·metre
PV	pore volume
PVS, PVStm	pore volume steam
RF	recovery factor
SAGD	steam assisted gravity drainage
SF	steamflood
So	oil saturation
SOR	steam oil ratio
SPM	strokes per minute
SAR	synthetic aperture radar
Tbg.	tubing
TD	total depth
TVD	true vertical depth
VAF	volume over fill-up
WDI	water depletion index
WHT	wellhead temperature
YE	yearly

CNUL Peace River - Location





- Located in Northwestern Alberta
- OBIP 219 Million m³ for the area in Approval 8143DD Development Area

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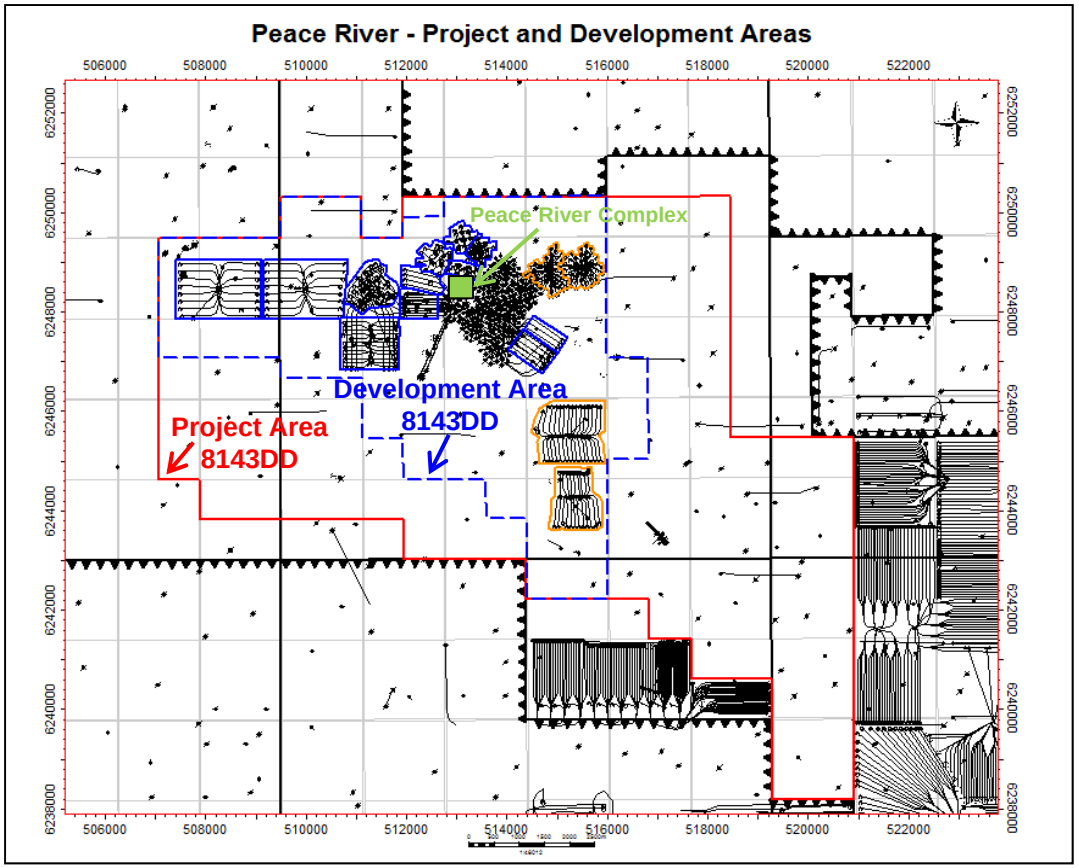
Peace River Approval Areas



Peace River Thermal Area

- Operating Pad
- Suspended Pad
- Lease Boundary
- Approved Project Area
- Approved Development Area

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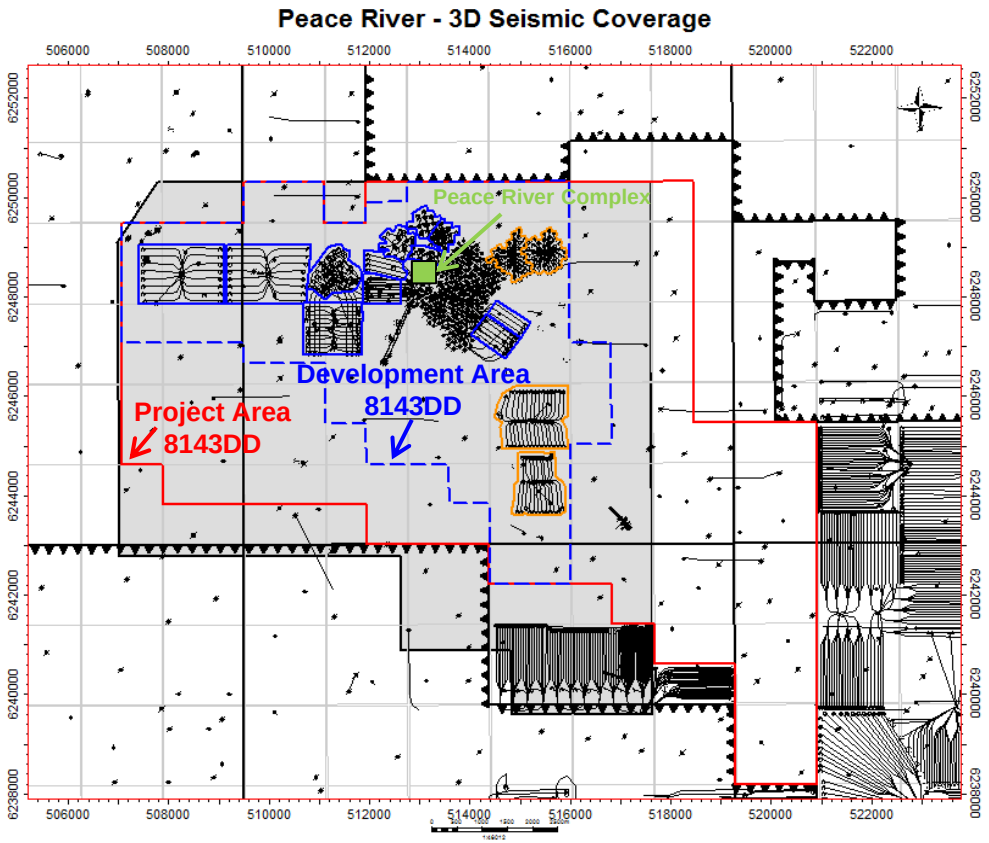
GEOSCIENCE

Peace River - Bluesky Reservoir Properties

General Properties	Approval Area
Target Formation	Bluesky
Pay Thickness	15 – 30m
Depth	550 - 600 m TVD
API Gravity	6-11^0
Porosity	0.25 – 0.30
Viscosity	10,000 – 1,000,000 cP (dead oil)
Initial pressure	3,800 kPa (sub-hydro static)
Initial temperature	18°C
Horizontal permeability	0.1 – 10 D (air)
Kv / Kh	0.3 – 0.9
Oil Saturation	0.70 – 0.85

Peace River Seismic Coverage



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- Approved Development Area
- 3D Seismic Area

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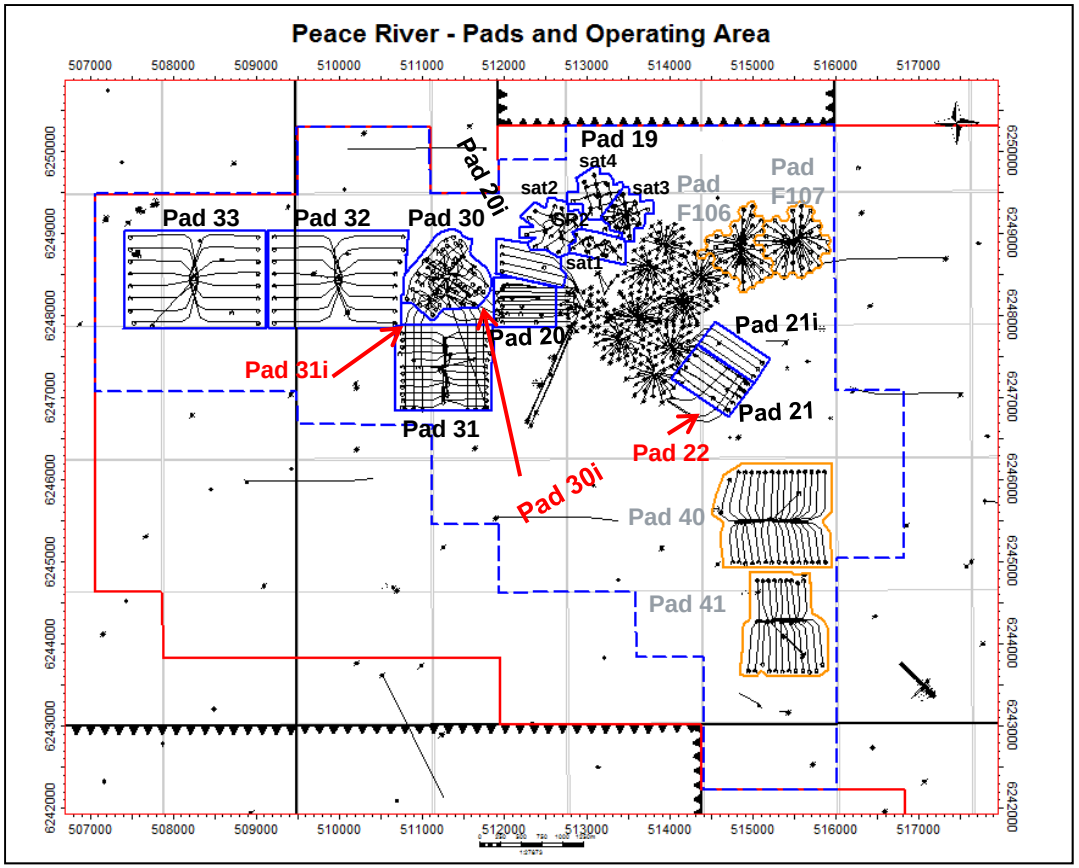
Peace River - Zoom in on Operating Area Pads



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- Suspended Pads:
  - Pads 40 & 41
  - Pads F106 & F107
- Injector Pads:
  - Pads 30i, 31i and 22

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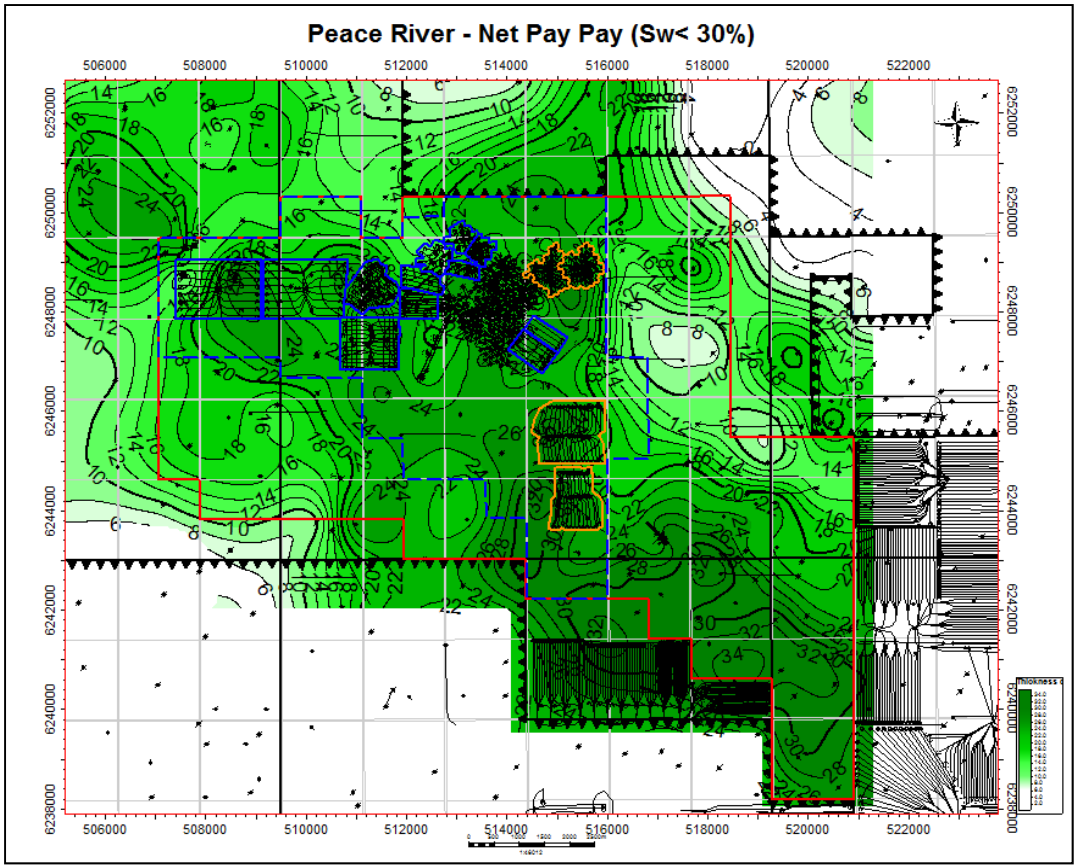
Peace River Project Area - Net Pay Isopach



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Project Area Volumetrics

	Average Pay Thickness (m)	Average Oil Saturation (%)	Average Porosity (%)	OBIP ($E6m^3$)
Project Area	**21.6**	**79.3**	**26.6**	**441**
Development Area	**22.7**	**81.1**	**27**	**220**

- Volumetric calculation:
  - Area × Pay Thickness × Oil Saturation × Porosity

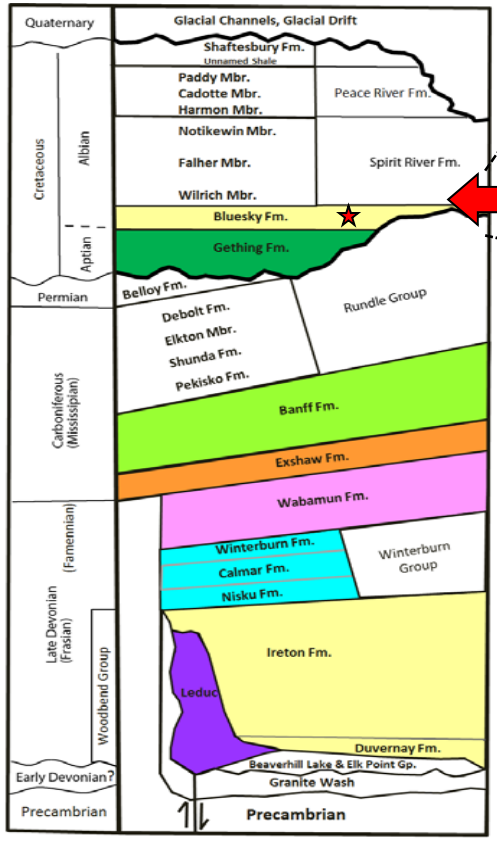
  - **OBIP: Project Area**

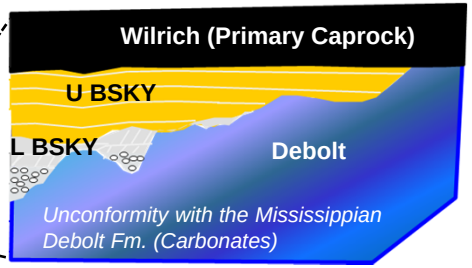
  $96{,}700{,}000\ m^2 \times 21.6\ m \times 0.793 \times 0.266 = 441\ E6m^3$

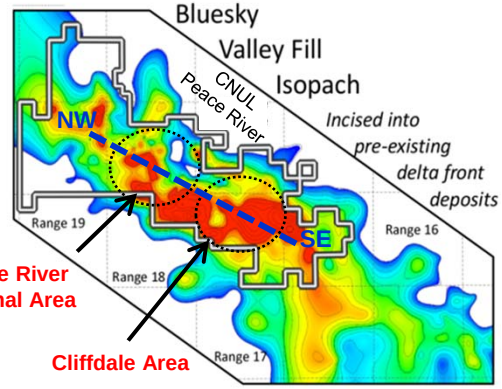
  - **OBIP: Development Area**

  $44{,}000{,}000\ m^2 \times 22.7\ m \times 0.811 \times 0.27 = 220\ E6m^3$

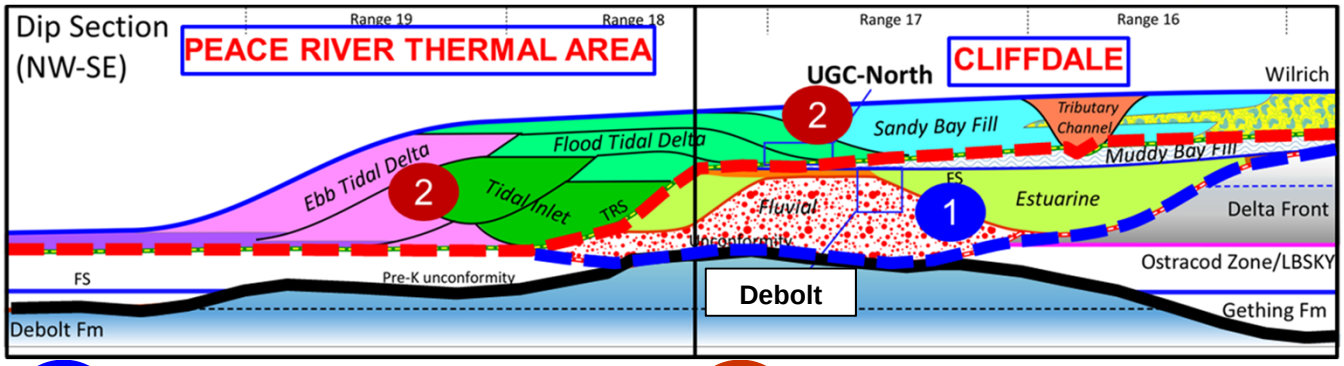
Geology - Stratigraphic Schematic







- The depositional environment of the Upper Bluesky (Sandstone) is a marginal marine estuarine complex.



1 **Tidally-influenced estuary with fluvial influx**
- Estuary channels and channel bars
- Fluvial bars

2 **Wave dominated estuary**
- Ebb tidal delta/ flood tidal delta/ Tidal Inlet/ Bay Fill

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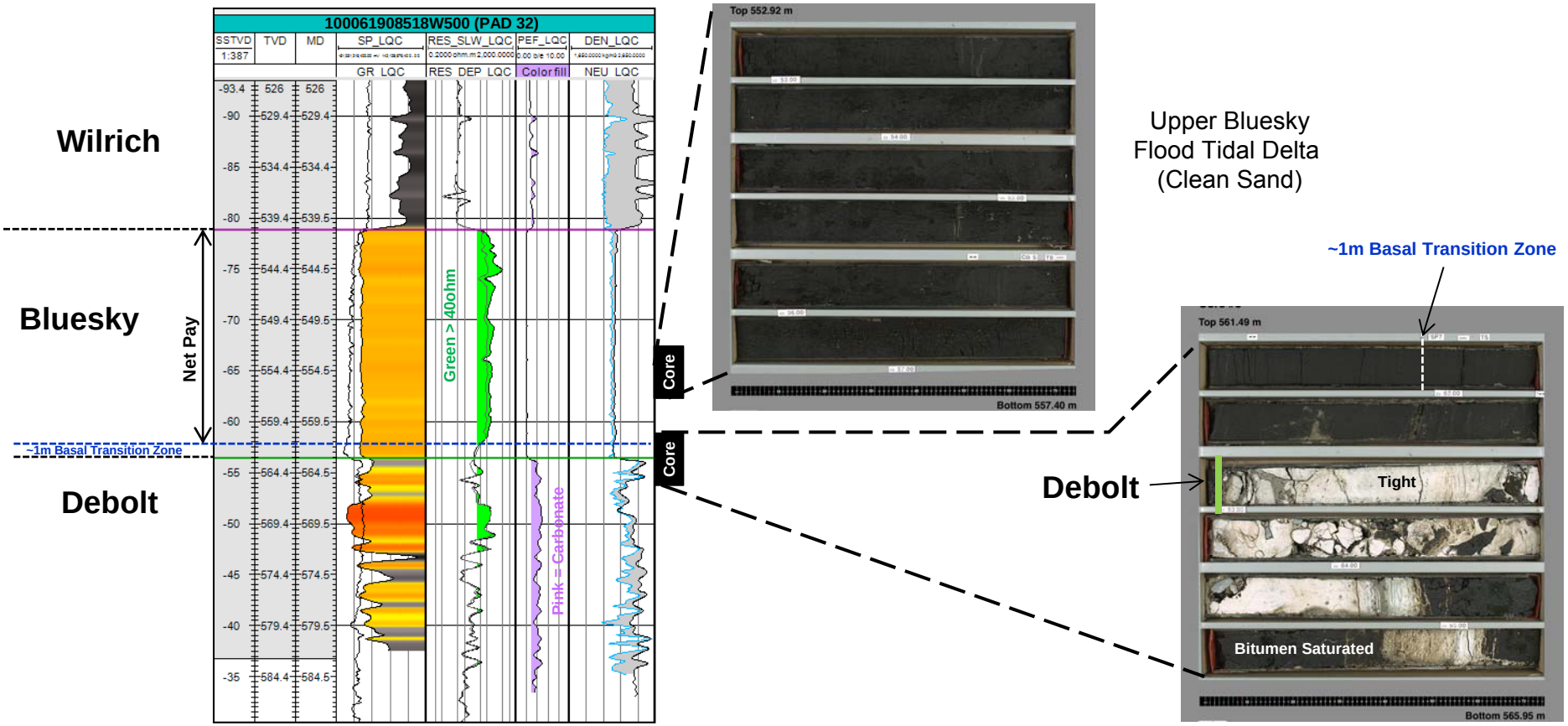
Peace River - Type Log



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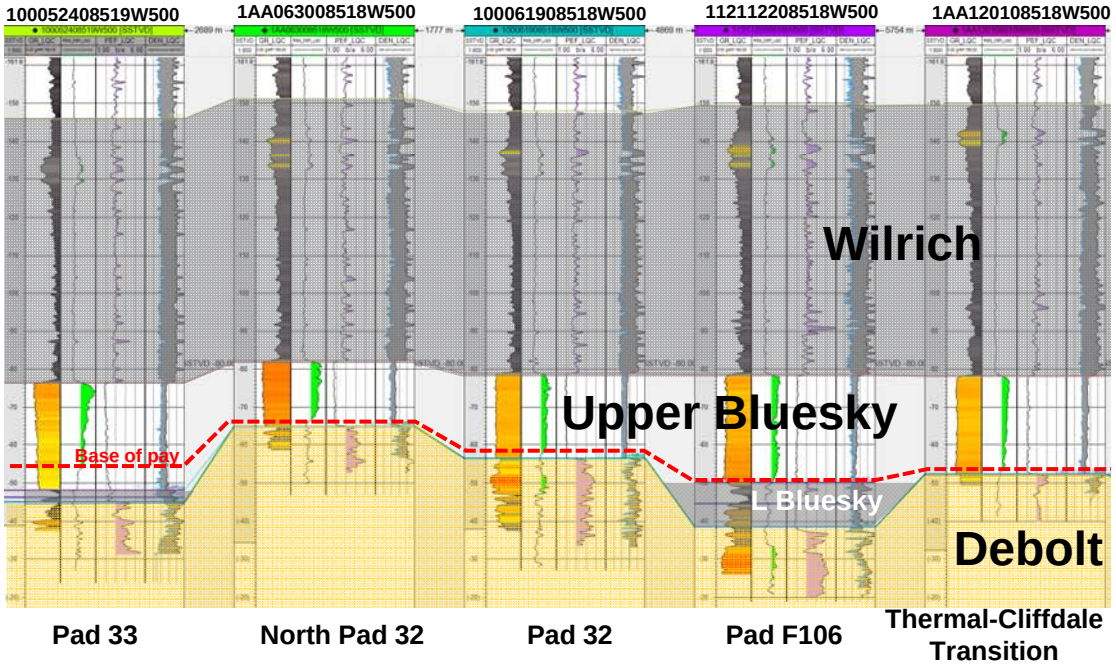
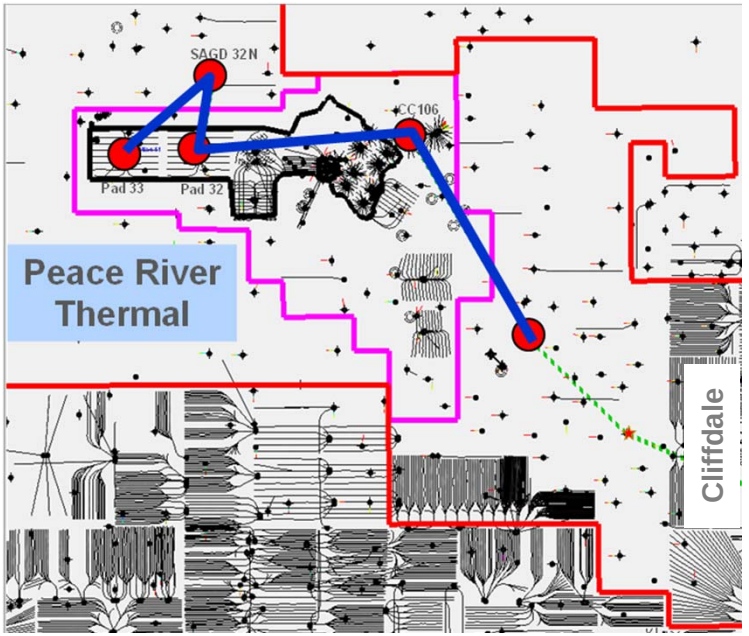
Peace River Structural Cross-Section

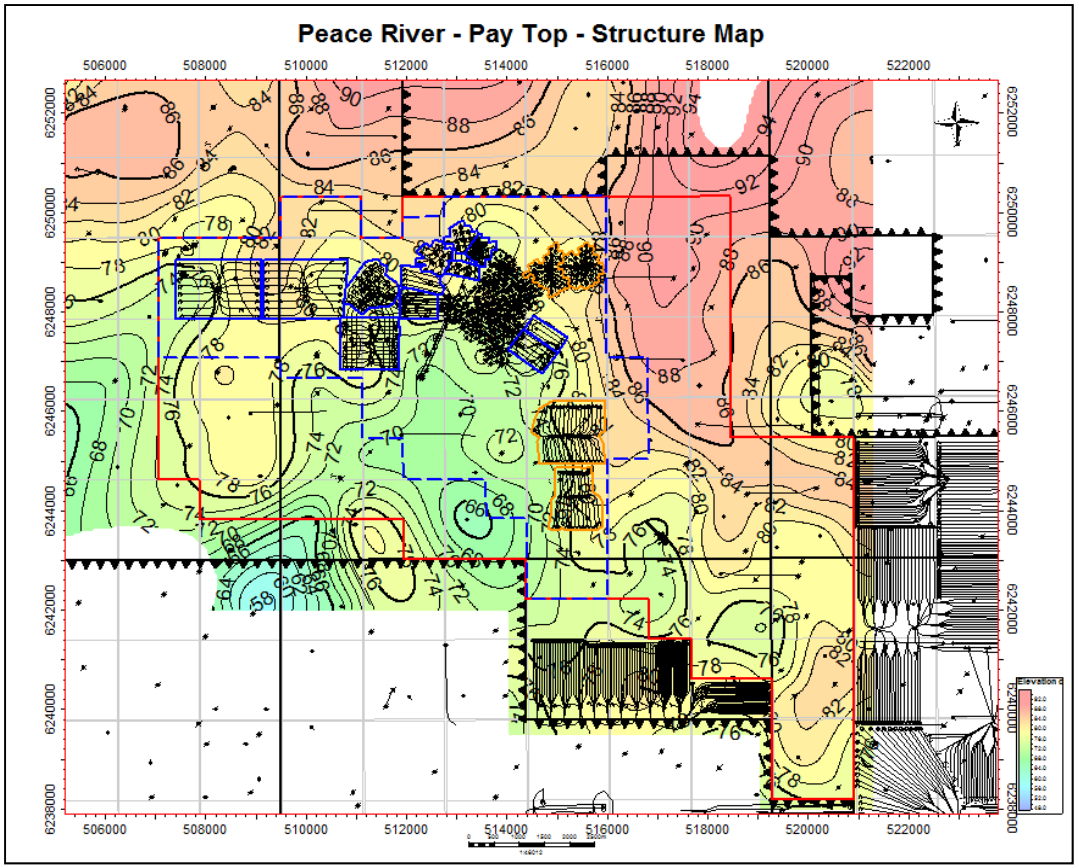
- Wilrich member of Spirit River Fm (Primary Caprock) ~ 80m
- Spirit River Formation minimum continuous Caprock Thickness ~ 240m
- Upper Bluesky Sand sitting on Debolt unconformity or Lower Bluesky filling lows in Debolt
- Reservoir Base Defined Sw = 30% cut-off (equivalent to Resistivity ~40ohms)





Top of Pay = Top of Bluesky (unless gas or lean zone present; not in project area)

Peace River Pay Top Structure



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- This is typically the top of the Bluesky unless gas or lean zone with S_w> 30% exist
- Top Lean zones or gas do not exist within the approved Development Area

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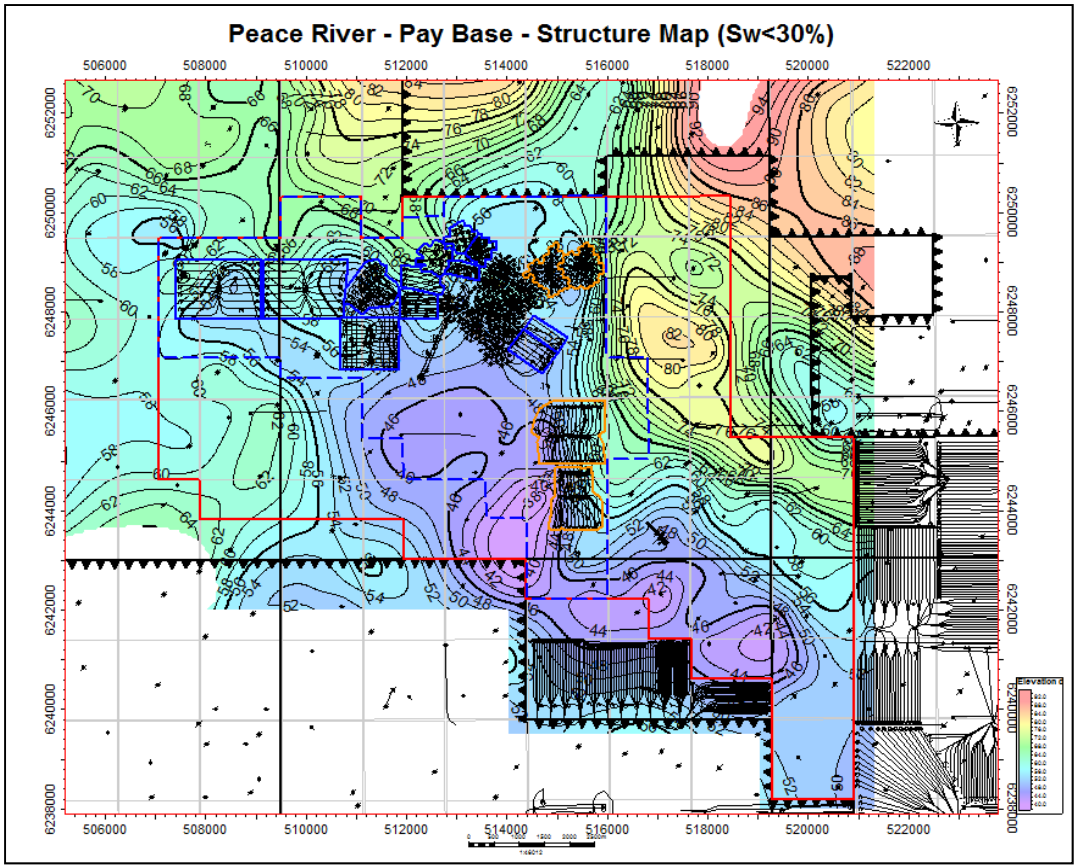
Peace River Pay Base Structure



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- Cut-off for base of pay: Base of continuous sand from Top of pay (normally top of Bluesky) to $S_w \leq 30\%$; equivalent to Res_D ~ 40ohm

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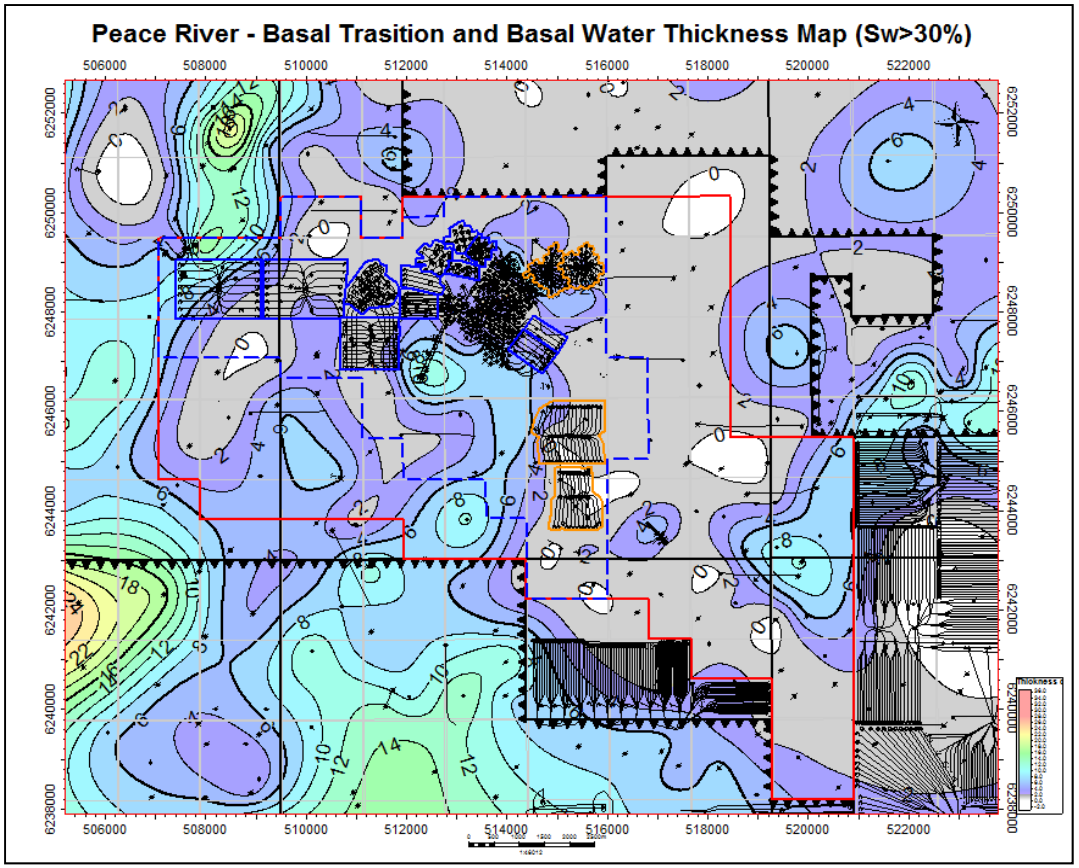
Peace River - Net Water Sand Isopach



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- This thickness map includes a basal transition zone (BTZ) with S_w = 30-50%; and a basal water zone (BWZ) with S_w>50%

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New Logs / Seismic Data Acquisition

- No new wells drilled in 2018
- No new seismic acquired in 2018

Caprock Integrity

- Caprock: consists of the highly continuous Spirit River Formation (Wilrich/Falher/ Notikewin) which has a minimum thickness of 240m over the approval area.

- Reviewing caprock integrity in regards to the following:
  - In-situ stresses
  - Field observations within the caprocks
  - Potential surveillance improvements
  - Injected steam volume above fill-up


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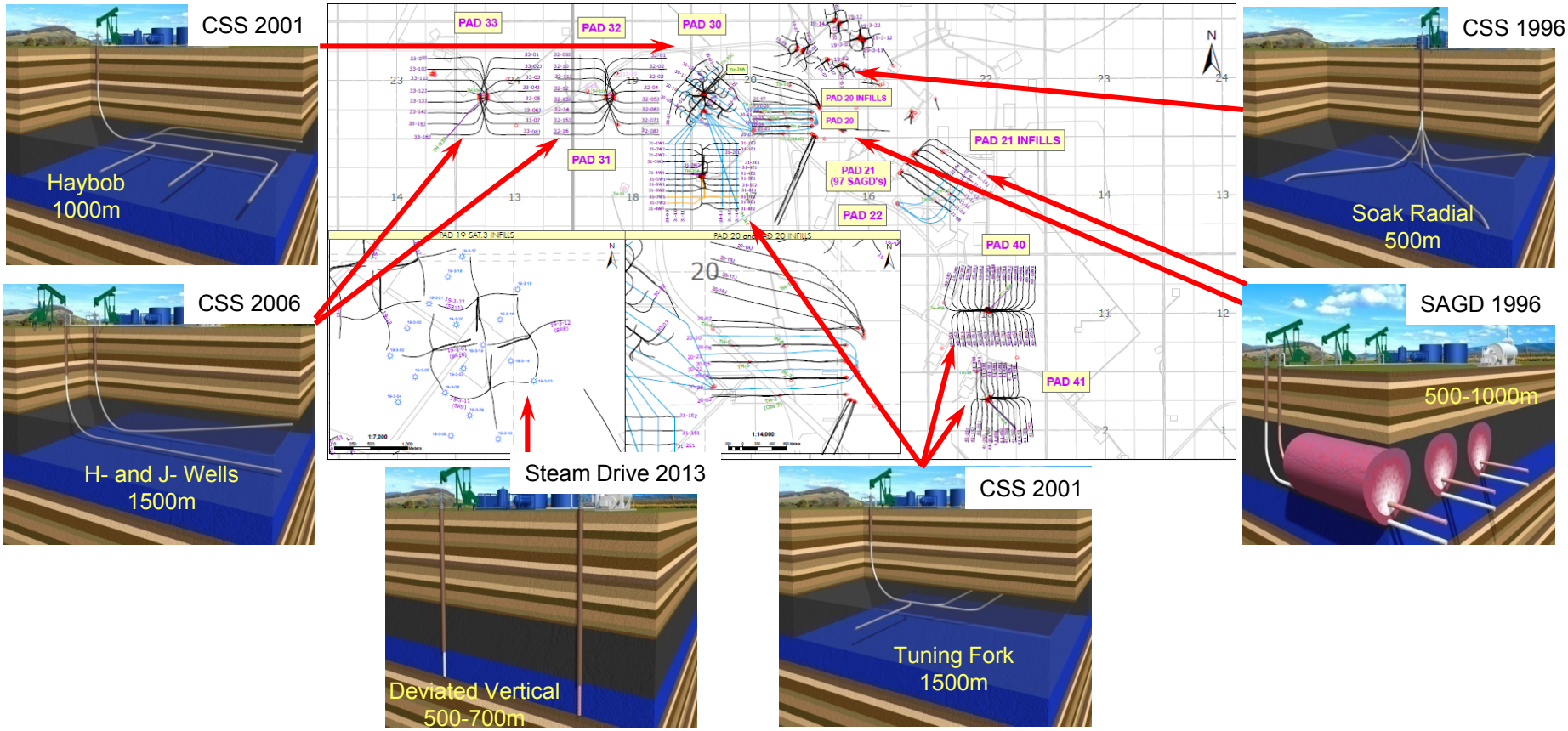
DRILLING & COMPLETIONS

Drilling & 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 (2014/2015)
  - Pad F106
    - 43 wells, 3 surface holes, 1 Observation well
  - Pad F107
    - 46 wells, 1 Observation well
  - 2 Acid gas injection well & 1 monitoring well
  - 2 water back producers
- TH32C Future Observation Well - (2017)

Well Type Overview

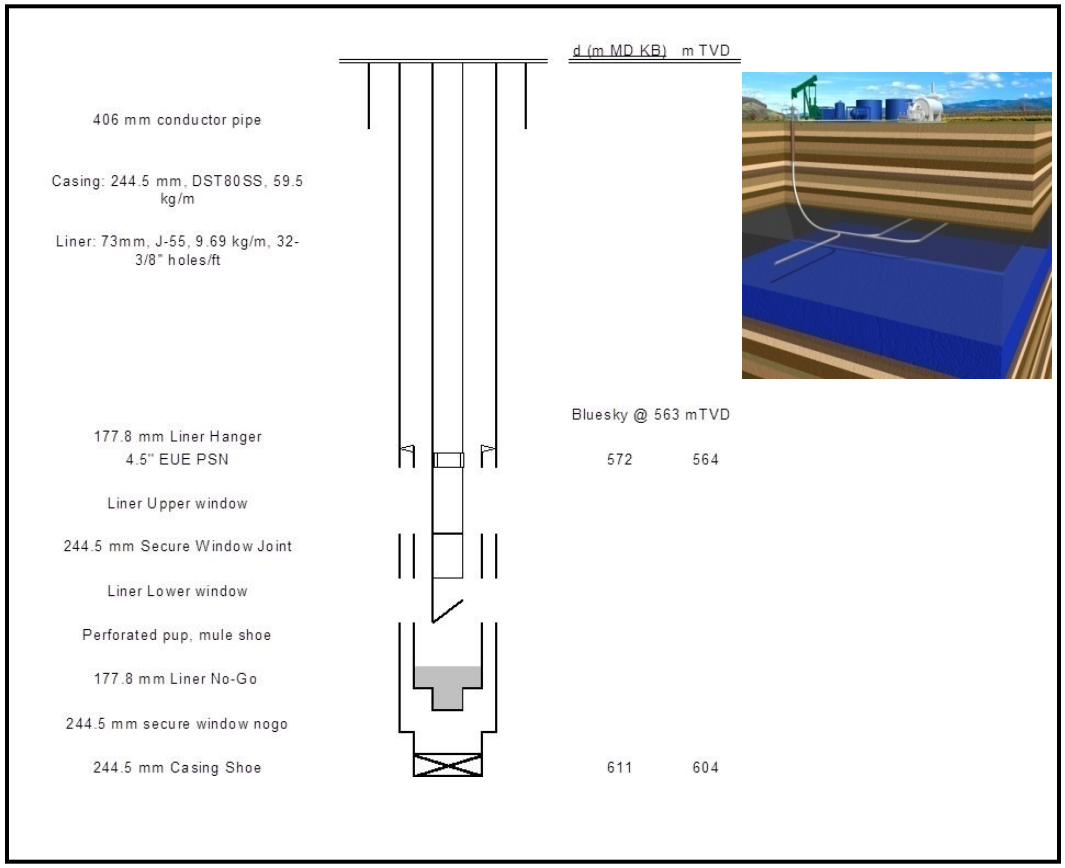


Well Spacing by Pad

- **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**
  - 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

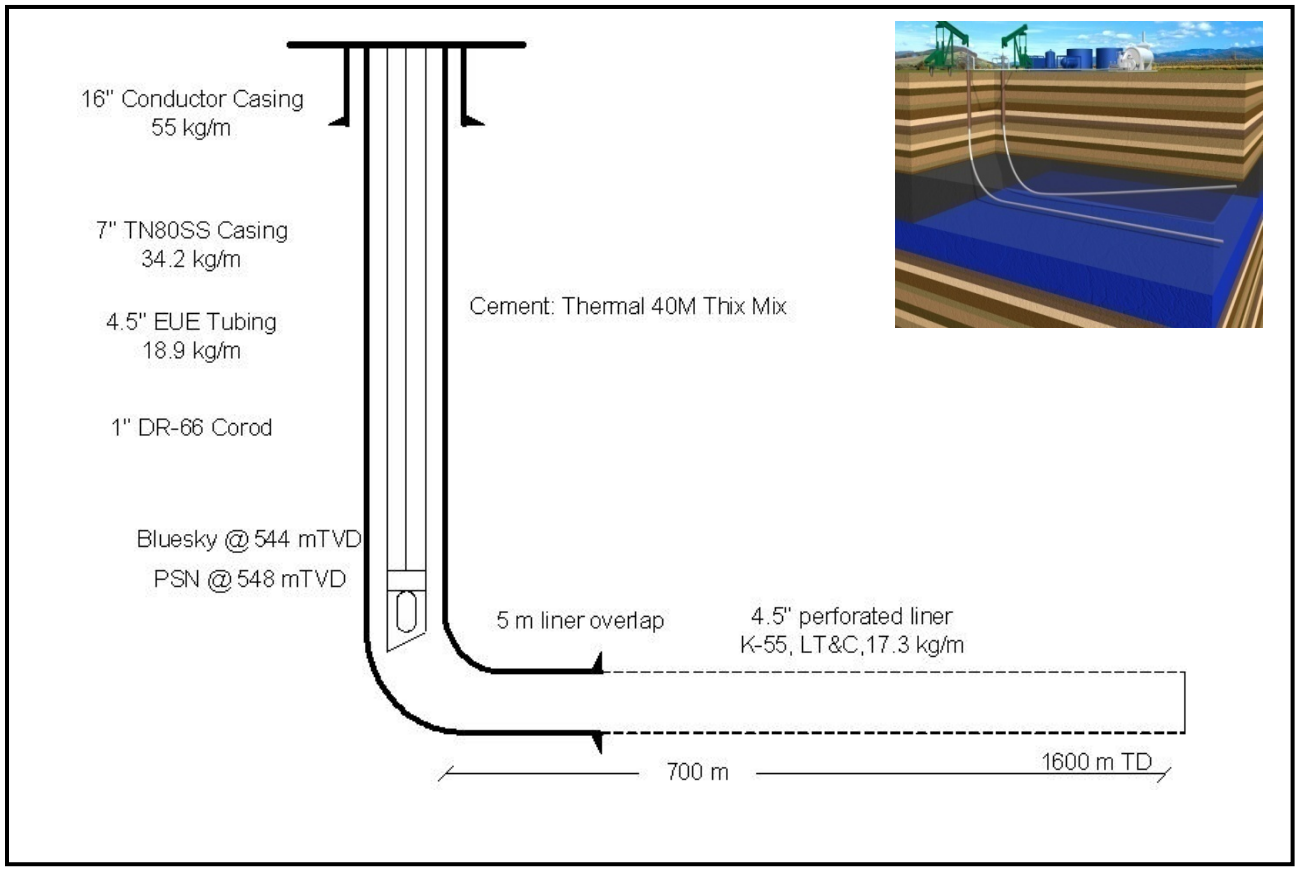
Multi Lateral Completion

- Pads 30, 31, 40, 41
- 244.5 mm L80 Production Casing
- 177.8 mm Window sleeve
- 73 mm Liner
- Thermal cement
- 114.3 mm tubing
- Insert pumps
- 550-700m laterals



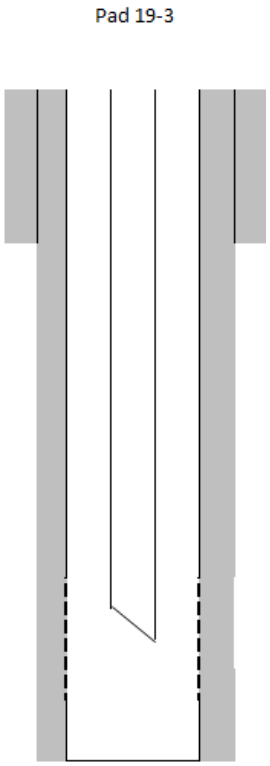
Single Lateral Completion

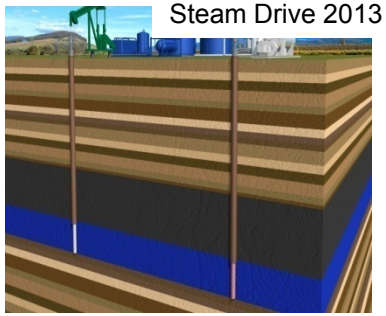
- Pads 32, 33
- 177.8 mm L80 Production Casing
- 114.3 mm Perforated Liner
- 114.3 mm Tubing
- Insert pumps
- Thermal cement
- 500-700 m lateral
- Pump is removed and steam injected down the tubing for high pressure CSS



Vertical Deviated Completion

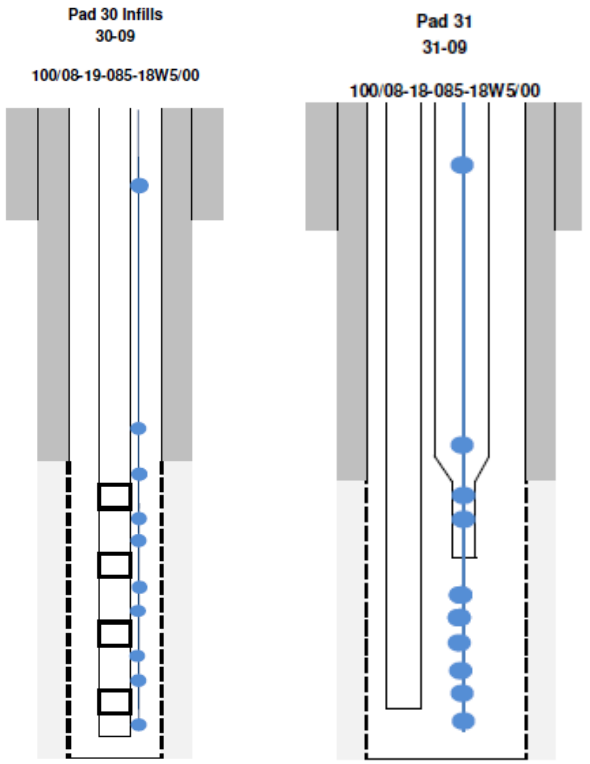
- Pad 19, Satellite 3
- 298 mm Surface Casing
- 219.1 mm L80IRP Production Casing
- 88.9 mm Tubing
- Insert pumps
- Thermal cement
- 19-24 m perforation interval



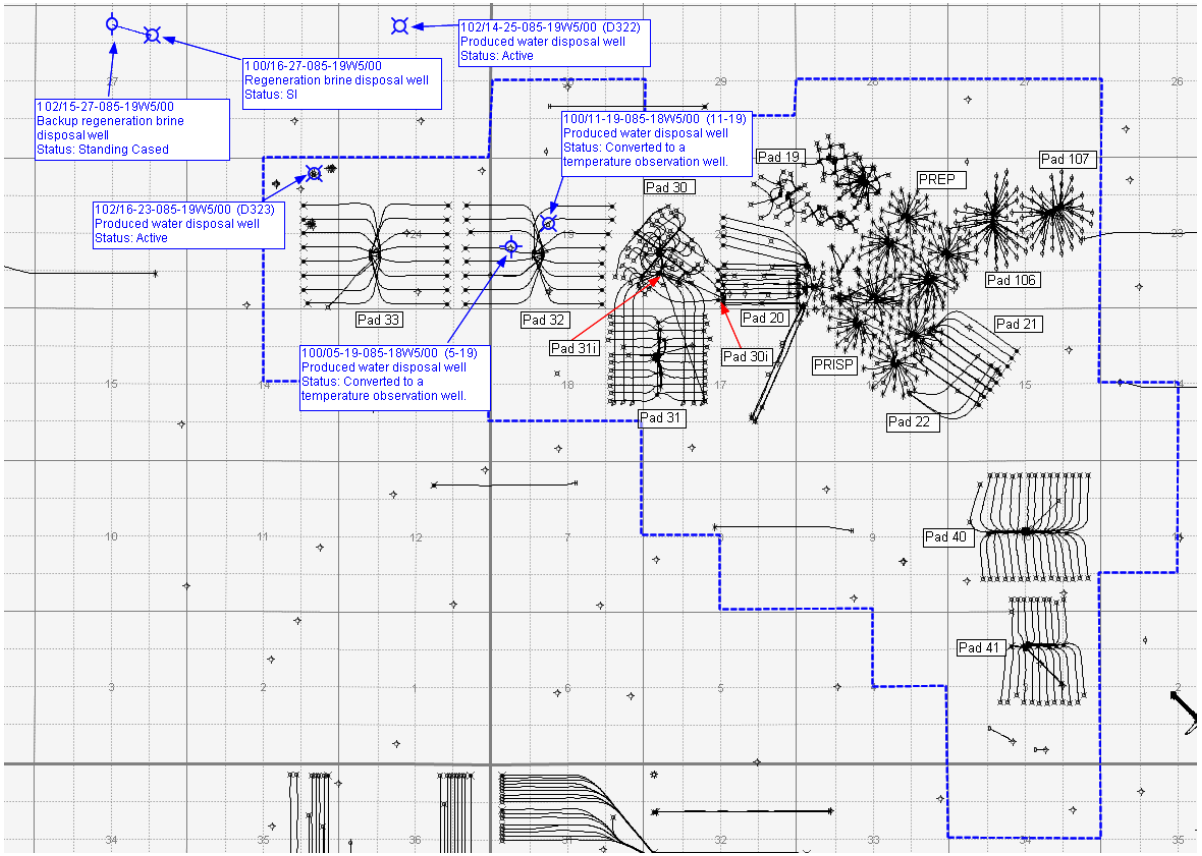

Steam Drive 2013

Horizontal Injector Completion

- Pad 20 Phase 3, Pad 30/31 Infills
- 339 or 298 mm Surface Casing
- 219.1 or 244.9 mm L80IRP Production Casing
- 177.8 or 139 mm wire wrap screen liner
- 88.9 and/or 73 mm Tubing
- Select wells completed with Flow Control Devices
- Thermal cement
- 500-1000 m lateral
- Select wells completed with thermocouples and/or DTS

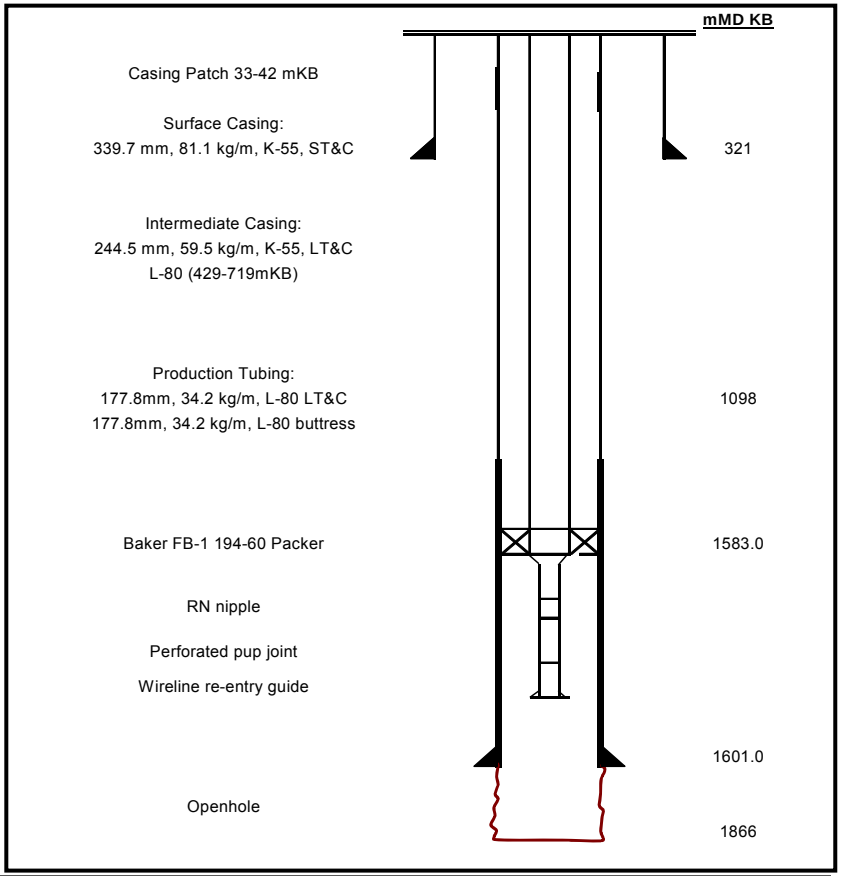


Active and Previous Source & Disposal Wells



Produced & Brine Water Disposal Completion

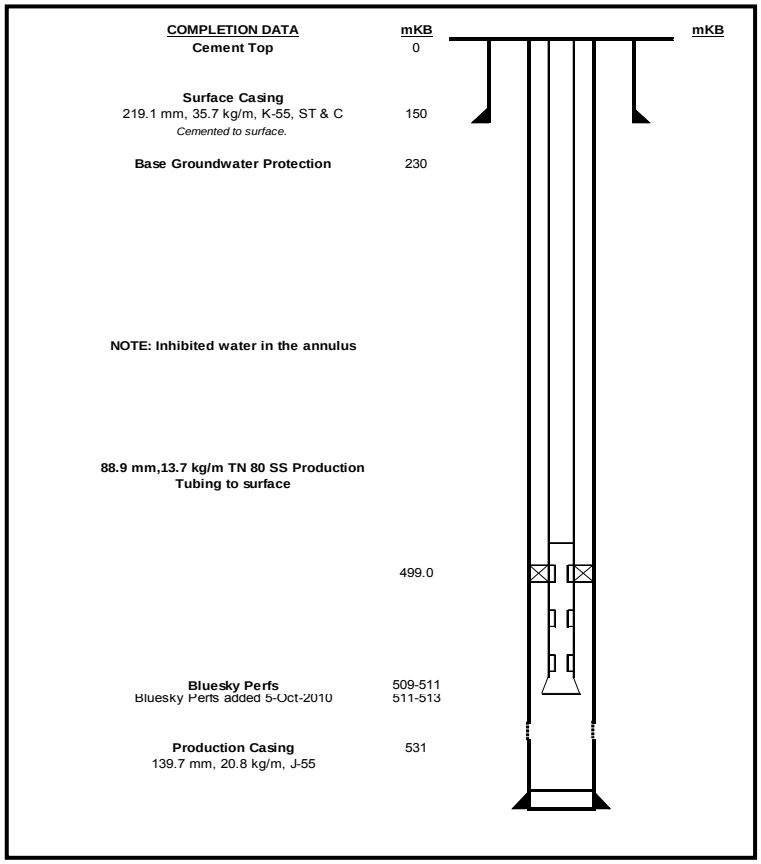
- 02/16-23-085-19W5/00
- 02/14-25-085-19W5/00
- Both dispose of produced water, boiler blowdown and brine into the Leduc formation.



Sour Gas Injector Completion

- The 8-11 sour gas injector was completed Nov 2009 as part of the Three Creeks Sour Gas Storage project.

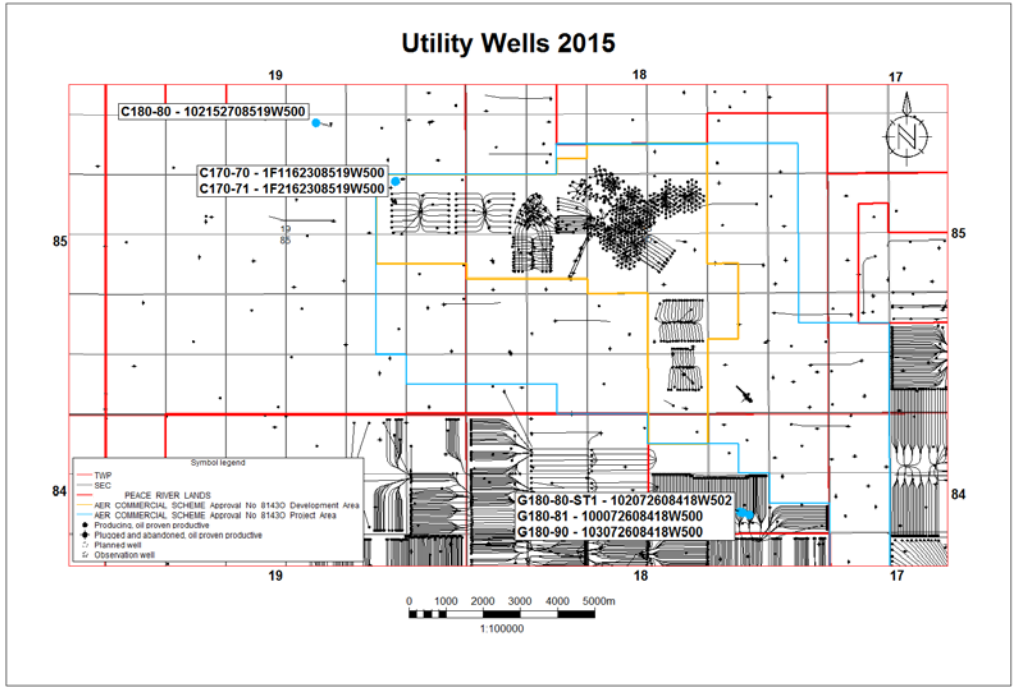
- Injection started Aug 2010.



Utility Well Completion

Drilled 2014/2015 – All wells suspended

- **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**, Observation 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



ARTIFICIAL LIFT

Rod Pumping Specifications

Pumping Units: **Max. Capacity:**

- Pumpjacks:144” – 260” stroke
  - Pump Jacks 280 m3/d
  - Rotoflex: 288’’ stroke 250 m3/d

Automation:

- Pump Off Controllers(POC): load cells, motor sensor, crank sensor, VFD
- XSPOC: Real-time pump cards

Pumps:

- Insert rod pumps, 2.0 – 3.25’’ barrel, 1’’ continuous rod, rod string designs

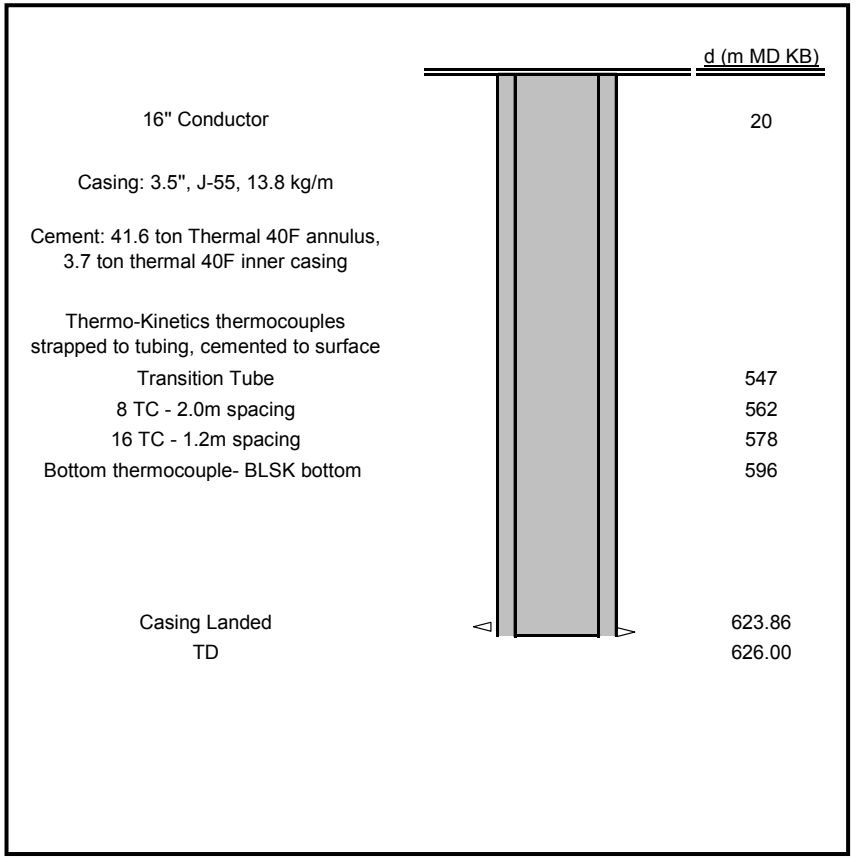
INSTRUMENTATION SUMMARY

Observation Wells

Well Name	Type of observation well	Well Name	Type of observation well
TH6	Temperature	TH32A	Temperature and micro seismic
TH7	Temperature	TH33A	Temperature and micro seismic
TH8	Temperature	TH33B	Temperature
TH2 (Obs 9)	Temperature	TH40A	Disconnected
TH10	Temperature	TH40B	Temperature
TH11	Temperature	TH41A	Disconnected
TH12	Temperature	12-35	Pressure (Three Creeks)
TH14	Temperature	D320 (5-19)	Temperature – DTS
TH30A	Temperature and micro seismic	D321 (11-19)	Temperature – DTS
TH30C	Temperature, pressure and DTS	R3-19	Temperature – DTS
TH31A	Temperature and micro seismic	TH33	Pressure
TH31C	Temperature, pressure and DTS		

Typical Temperature Observation Completion

- Thermocouples situated from the Wilrich to the Debolt formations to monitor steam chamber rise and temperature variations over cycle(s).
- 5 wells with DTS installed (Pads 30, 31 & 32)

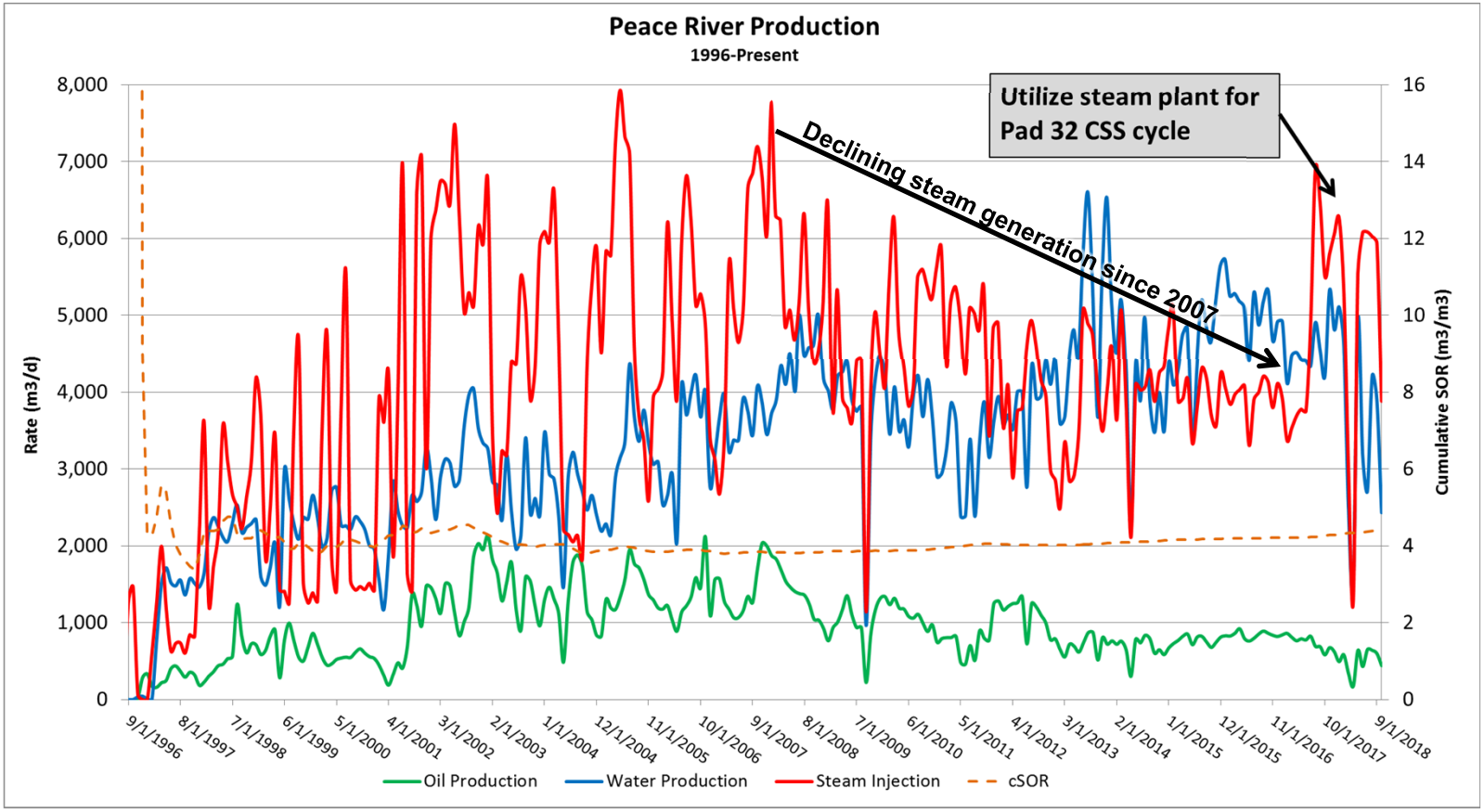


SCHEME PERFORMANCE

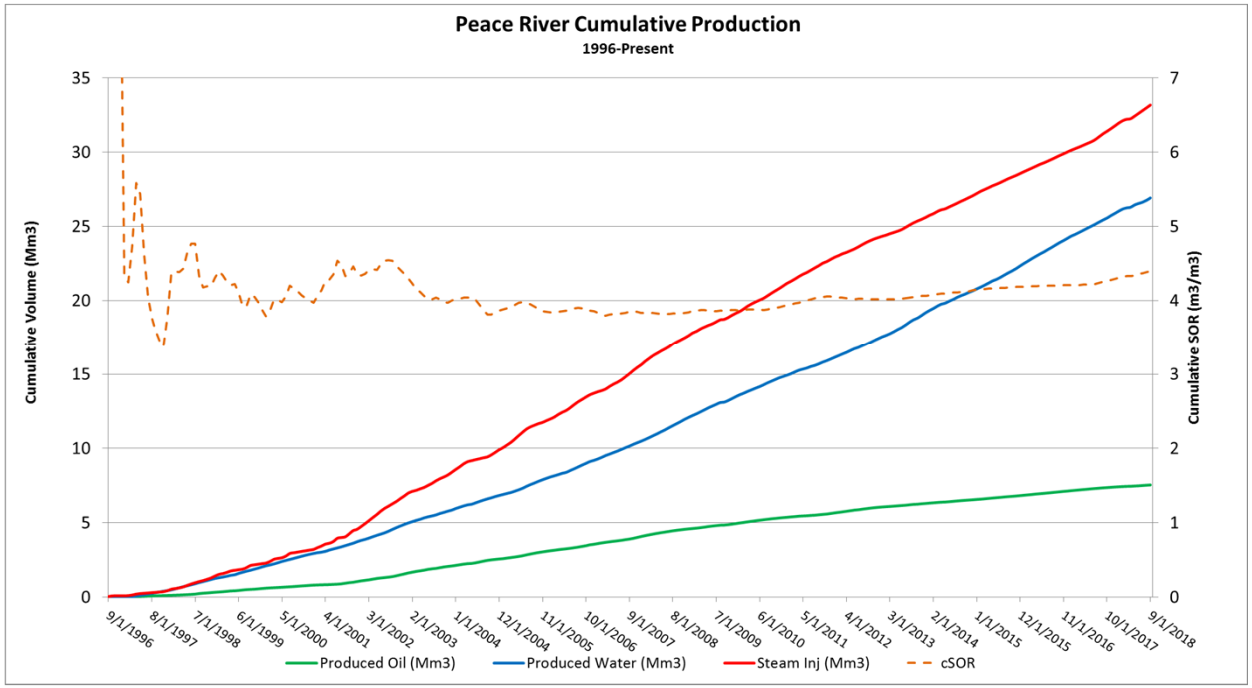
Scheme Recovery Processes

Pad	Recovery Process	Date of Conversion
19 Sat 1 and 2	Steamflood	Oct 2012
19 Infills	Steamflood	July 2013
20 Conv	Steamflood	July 2012
20 Infills	Steamflood	June 2012
21 Conv	Steamflood	Jan 2009
21 Infills	Steamflood	Nov 2011
30	Steamflood	Dec 2014
31	Steamflood	Nov 2014
32/33	32 - Cyclic Steam Stimulation (CSS) 33 - Steamflood	Steamflood Trial began December 2012 Pad 33 – Began conversion to steamflood Aug 2018
40	Suspended	Converted to steamflood June 2012 Blowdown June 2014 Suspended October 2015
41	Suspended	Converted to steamflood June 2012 Blowdown June 2014 Suspended October 2015

Peace River Production



Peace River Production



- All data current as of Oct 2018
  - cOil = 7.5 Mm³
  - cWater = 26.8 Mm³
  - cSteam = 33.0 Mm³
  - Cumulative SOR = 4.4
  - Cumulative WSR = 0.8

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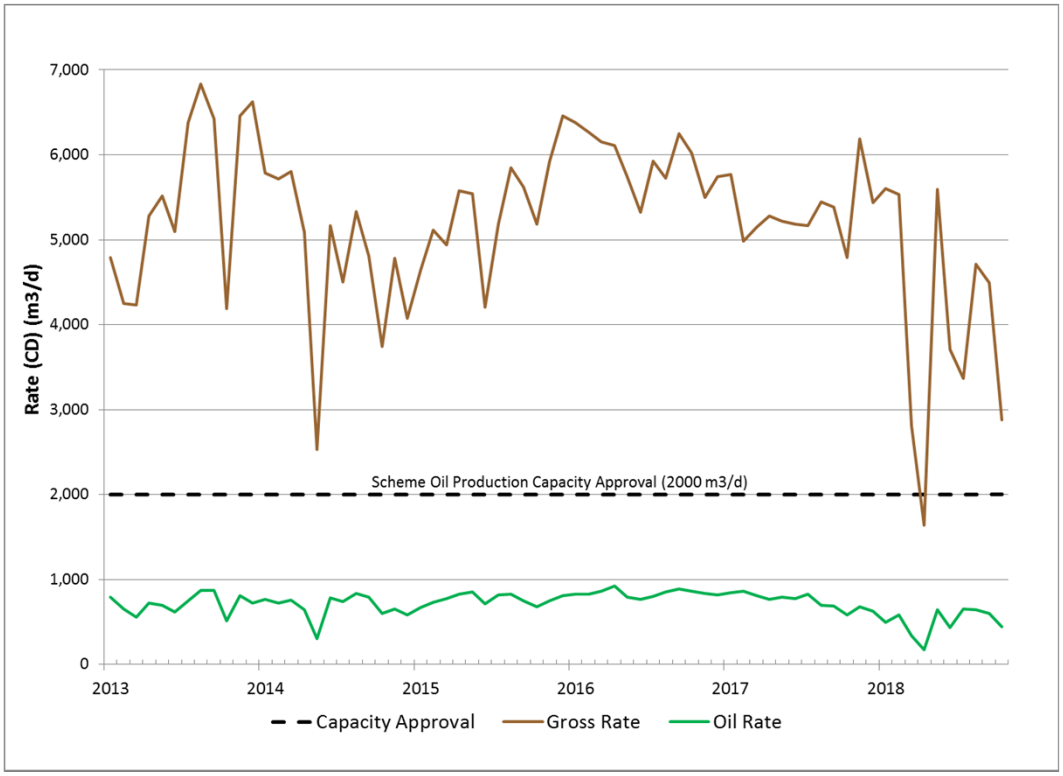
Actual Production vs Approval Capacity

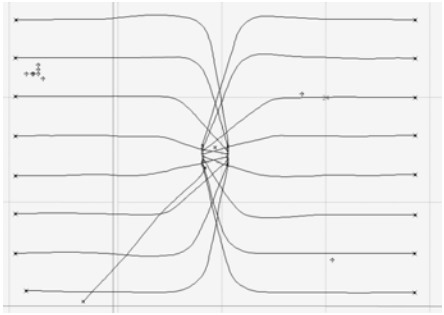


- Bitumen production steady until mid 2017 when Pad 32 was converted for a CSS cycle.

OBIP & Recovery Factors by Pad

Pad	OBIP (e3m3)	Area (m2)	Pay Thickness (m)	Porosity (%)	Cum Oil (e3m3)	Current Recovery	Ultimate Recovery
Pad 19 S1	1,060	199,000	23	28	273	26%	26%
Pad 19 S2	1,370	361,000	16	28.5	243	18%	29%
Pad 19 S3	1,110	238,000	21	28	331	30%	30%
Pad 19 S4	1,200	249,000	20	29	226	19%	29%
Pad 20	2,040	423,000	22	27	664	33%	34%
Pad 20i	1,500	339,000	20	27	216	14%	22%
Pad 21	2,350	431,000	25	27	625	27%	29%
Pad 21i	1,520	287,000	25	26	245	16%	31%
Pad 30	4,250	765,000	24	28	843	20%	34%
Pad 31	6,520	1,232,000	23	28	763	12%	34%
Pad 40	8,790	1,676,000	25	26.5	847	10%	26%
Pad 41	5,990	1,134,000	26	26	483	8%	23%
Pad 32	9,650	1,953,000	22	27.5	890	9%	17%
Pad 33	9,800	2,044,000	22	27.5	905	9%	14%
Total	**57,150**				**7,555**	**18%**	

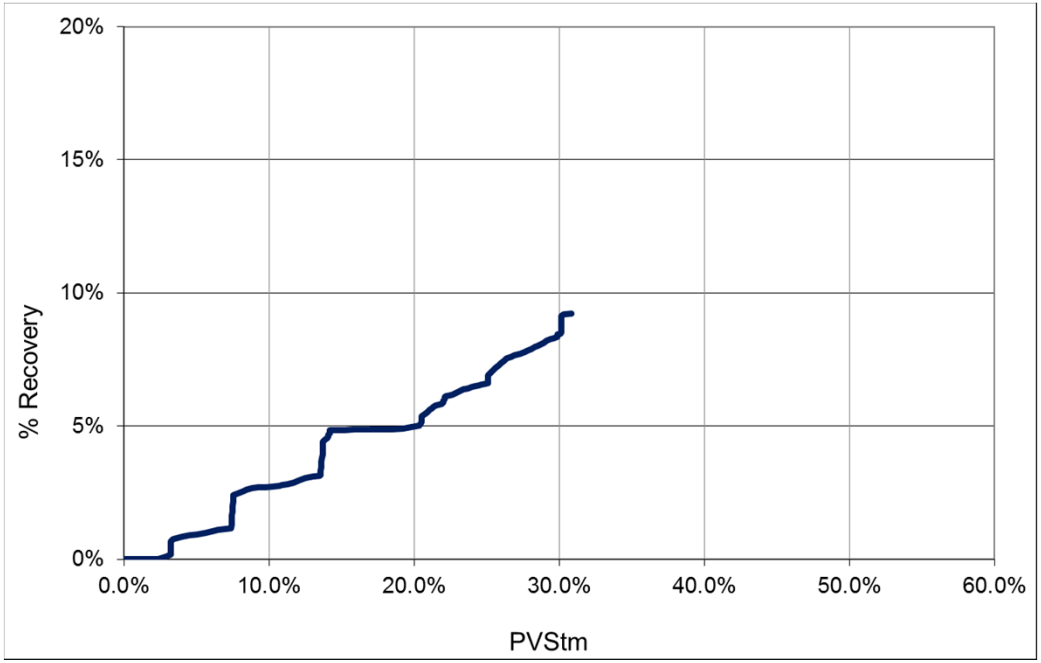
Pad 33 - Low Recovery



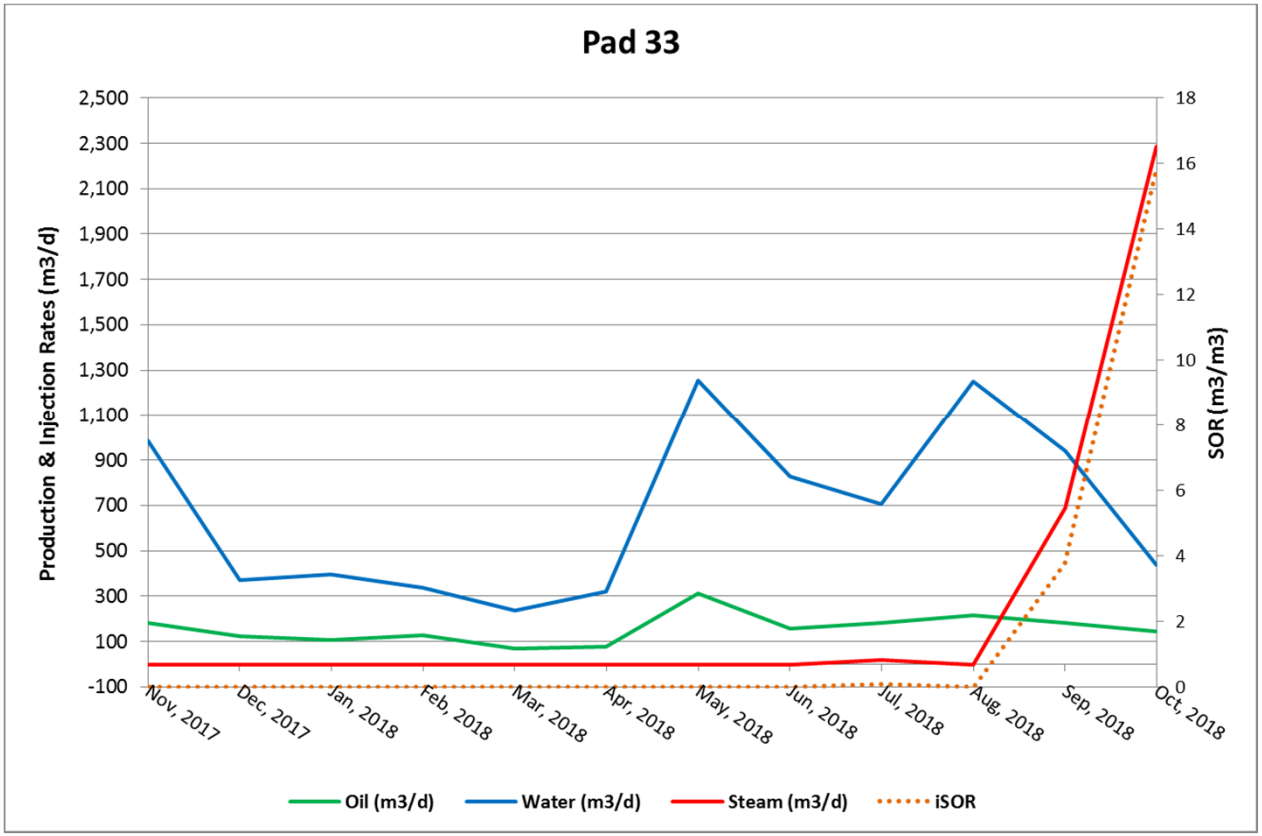
16 Wells – Previously CSS. In the process of converting to steamflood.

Current RF: 9%

- Spacing: 150m
- Avg. Net Pay: 22m
- Avg. So: 80%
- Avg. Porosity: 27.5%

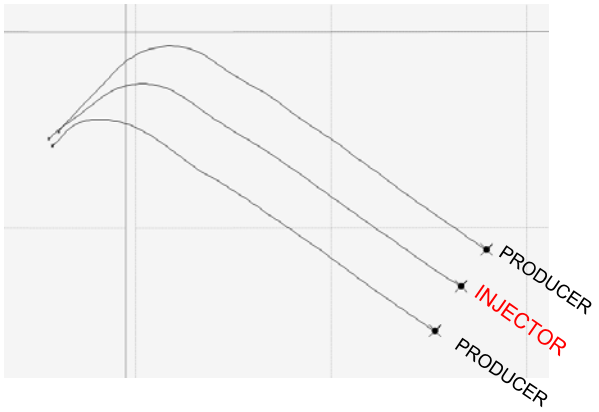


Pad 33 - Low Recovery



- Steaming in previous years has been single well CSS (2016/2017)
- Minimal steam to the Pad in the previous 12 months.
- Low Production from Dec 2017 - April 2018 due to casing repairs.
- Aug 2018 – Began conversion of pad to steamflood.
- 2019 plans:
  - Complete conversion to steamflood. Current injectors and producers at minimum rates.

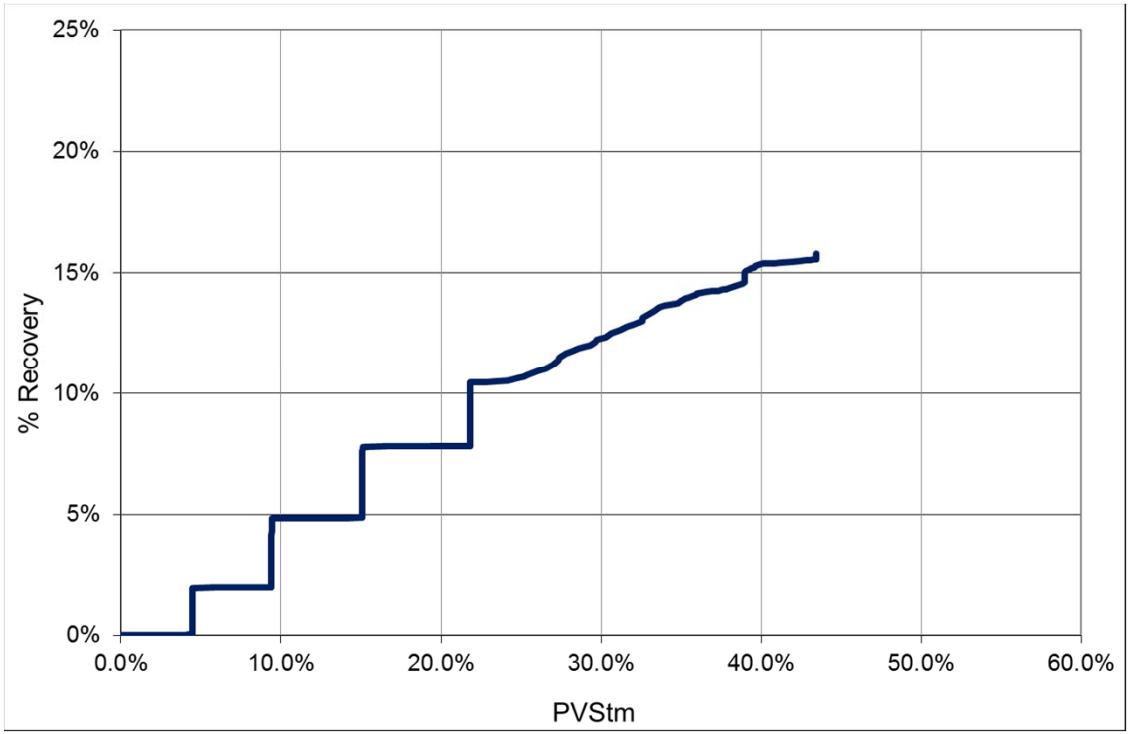
Pad 21 Infills - Medium Recovery



3 well lateral steamflood

Current RF: 16%

- Spacing: 100m
- Avg. Net Pay: 25m
- Avg. So: 83%
- Avg. Porosity: 26%



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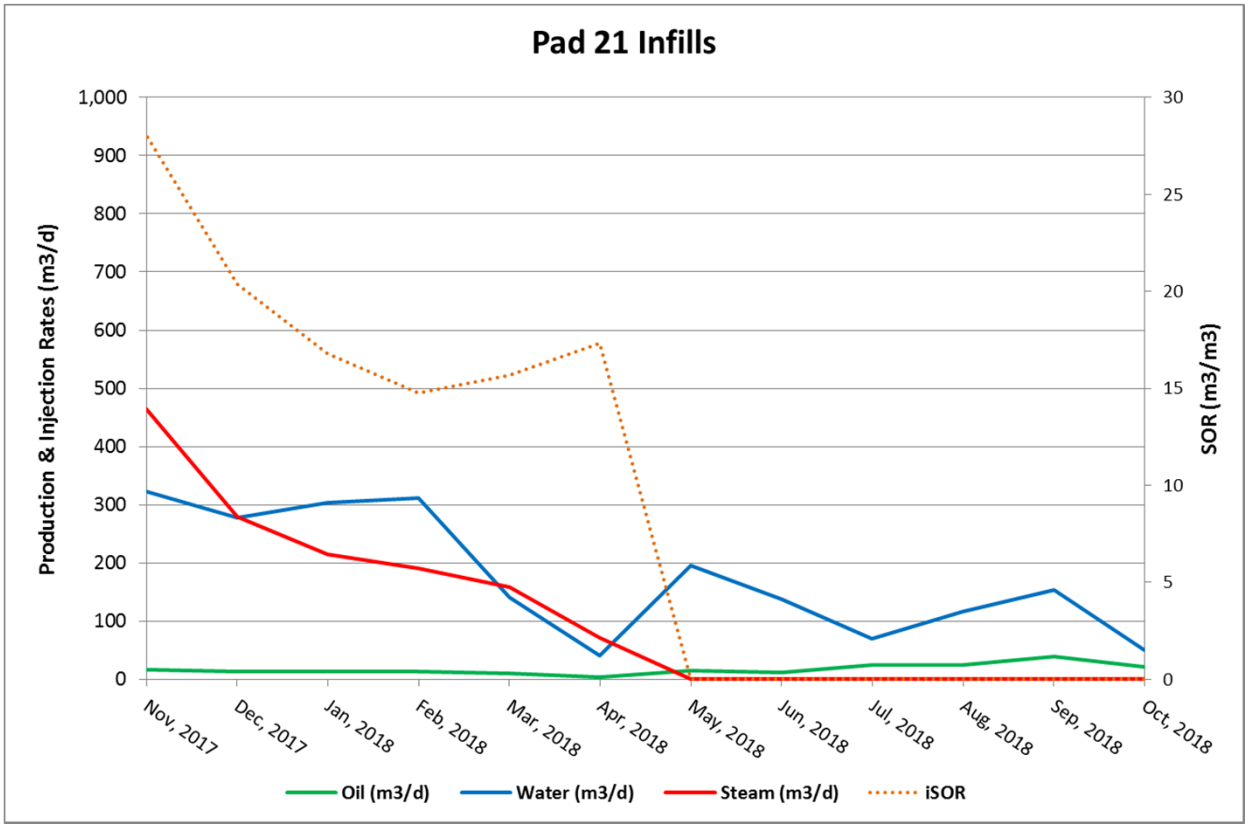
Pad 21 Infills - Medium Recovery



- Tested pad with higher steam rates in late 2017 and then cut steam to 0 for Pad 32 CSS cycle.
- Converted 21-14 injector to producer when steam to pad was off.
- 2019 plans:
  - Pad currently at minimum rates and likely to extend this into Q1 2019.

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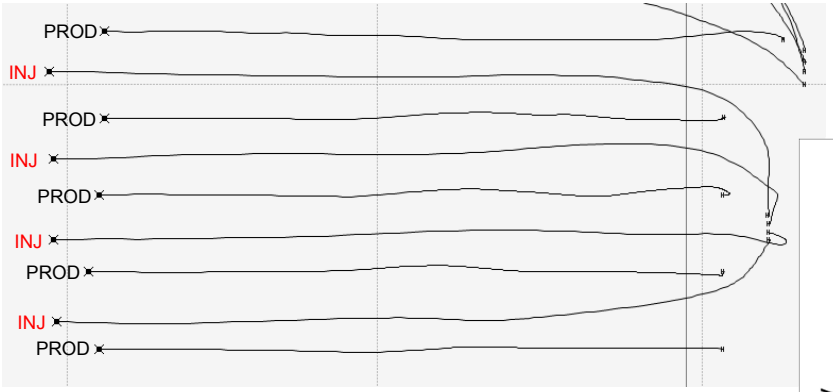
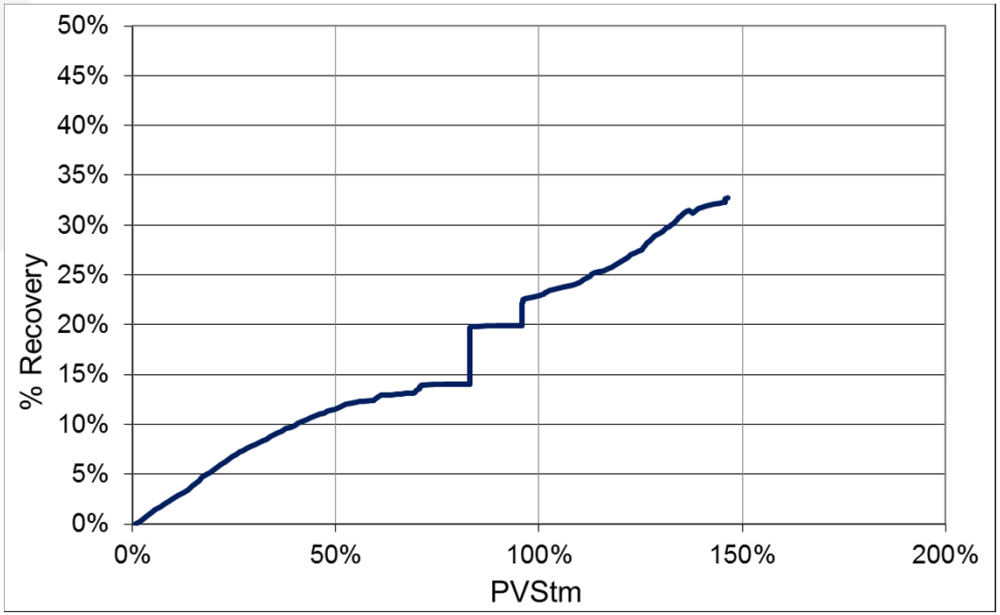
Pad 20 - High Recovery





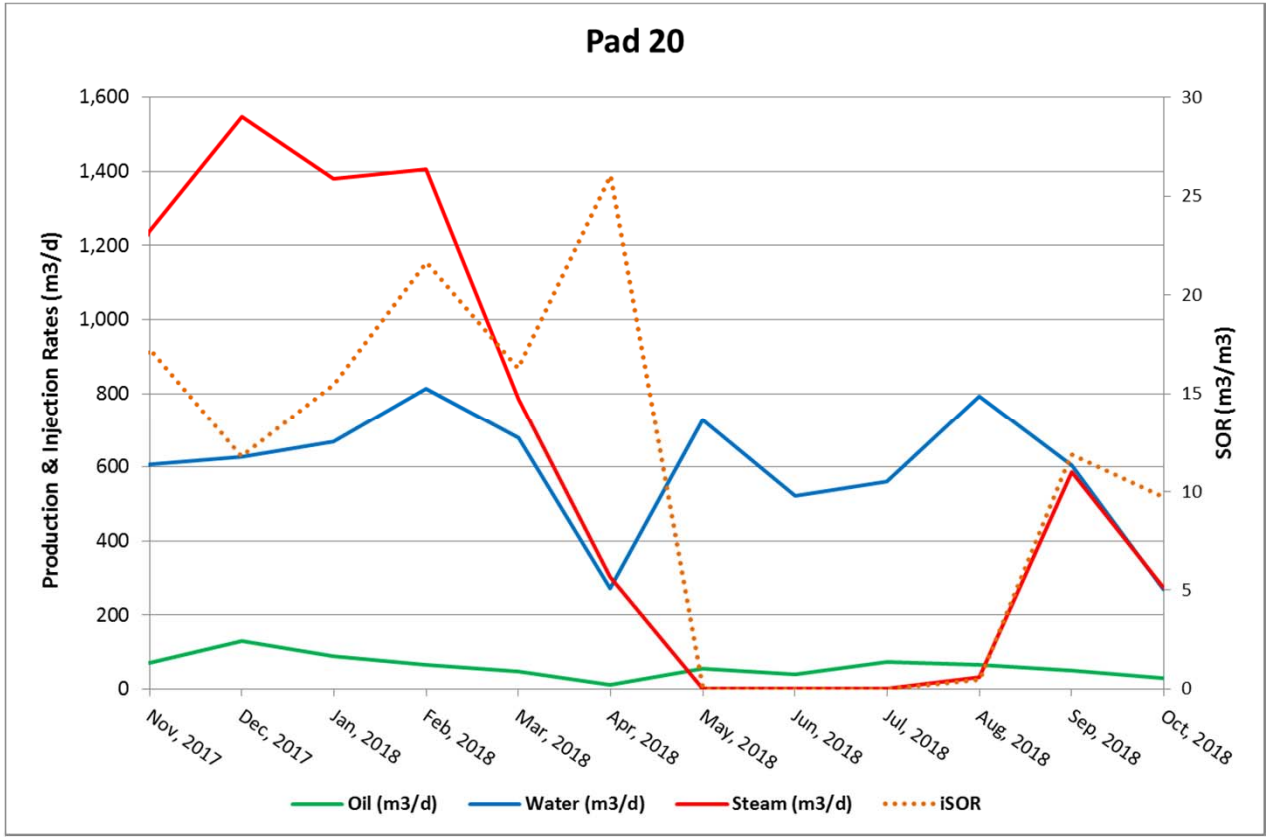
Top Down Steam Drive (prev. SAGD)

4 Injectors, 5 producers

Current RF: 33%

- Spacing: 100m
- Avg. Net Pay: 22m
- Avg. So: 82%
- Avg. Porosity: 27%

Pad 20 - High Recovery



- Tested pad with higher steam rates in late 2017 / early 2018 and then cut steam to 0 for Pad 32 CSS cycle.
- Injectors and producers currently at minimum rates.
- 2019 Plans
  - Potential to cleanout horizontal liners for improved performance.

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Peace River Performance Summary

Pad 32 CSS

- Delay in Pad 32 CSS cycle due to casing failure and casing repairs on Pads 32 and 33.
- Injection completed on Pad 32 and wells on flow back as of mid-Sept 2018.

- Pad 33 is 75% converted over to steamflood.

- All wells currently curtailed to minimum rates due to marketing conditions. Steam generation at minimum rates.

Factors Impacting Recovery

- Well design
  - Multi-well designs have no clear performance advantage
  - Lack of sand control has resulted in significantly plugged portions of liners
  - Unable to re-enter some wells for cleanouts due to complexity of well design and/or small liner diameters
  - No control of steam placement in laterals

- Inter-well and Inter-pad Communication
  - Reduces thermal efficiency by suboptimal placement of injected steam, and/or quenching of heated reservoir with cooler fluids
  - Examples include: Pad 40-41, Pad 32-33, Pad 32 to Pad 30,31
  - Recent block steam cycle on Pad 32 saw less inter-well communication than previous cycles.

Key Learnings

- Oil rates remained fairly steady on steam flood pads when steam was cut completely, although cooling of emulsion led to some treating issues.
  - Steam was cut for ~5 months
  - Pads 19,20,21,30,31

- Issue with external casing corrosion near surface on Pads 32 and 33.
  - Casing was inspected and replaced where necessary.
  - Casing integrity has been proven with a 21 MPa pressure test, rather than a 10 MPa test.
  - Top 1.5m of casing was coated externally on all wells to prevent future corrosion.

2019 Depletion Strategy

- Produce back Pad 32 and monitor performance. Cycle SOR and oil rates will provide direction for future cycles.
- Pad 33 – Complete conversion to steamflood and evaluate performance
- Optimize steamflood areas.

5 Year Outlook of Pad Abandonments

- No pads are scheduled for abandonment from 2019 to 2023

Future Development Plans

- Peace River asset was acquired June 1, 2017.
  - Evaluating future development plans
  - Future development dependent on approval of recently submitted D81 waiver extension application

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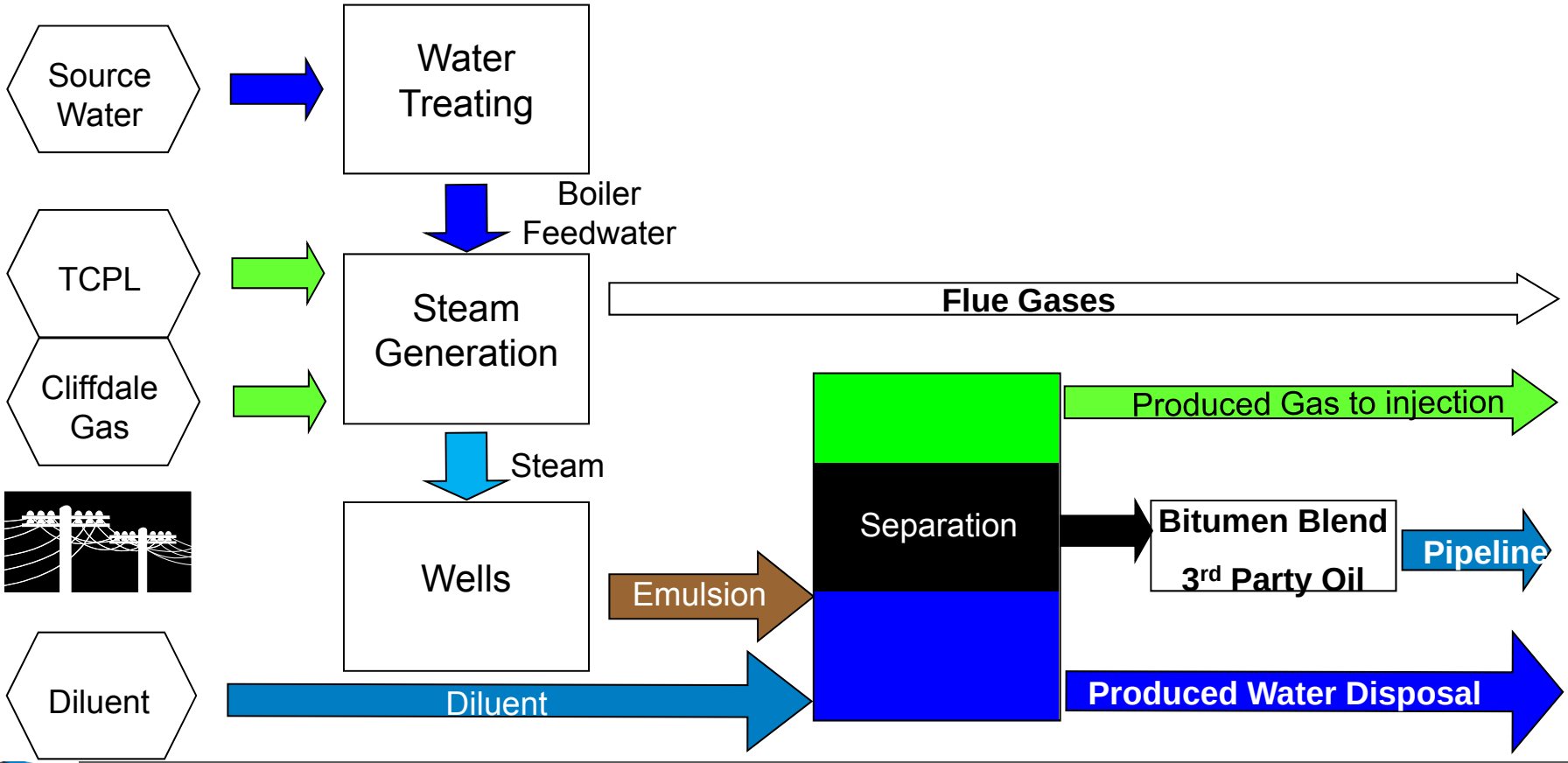
DIRECTIVE 54 SECTION 3.1.2
SURFACE OPERATIONS, COMPLIANCE, AND ISSUES NOT RELATED TO RESOURCE EVALUATION AND RECOVERY

Peace River Plant

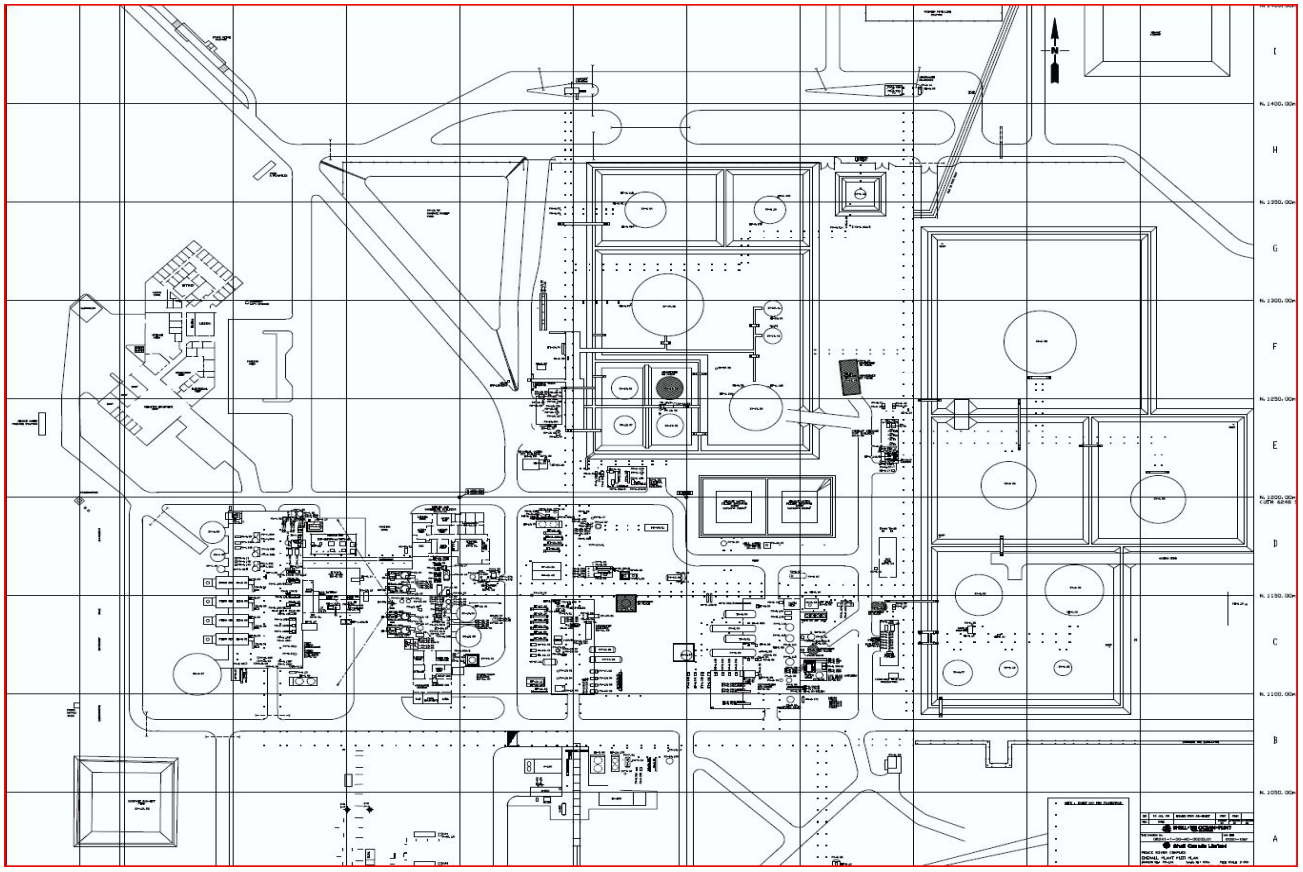
Thermal Production Treating: Process Flow Diagram



2018 Facility Modifications

- Commissioned one of the original PRISP boilers to provide utility steam demands
- Implemented vent VRU and fuel gas connections for improved trucking operations
- Added safe sampling stations for six pads (Pads 19, 20, 30, 31, 32 and 33)

Peace River Complex Plot Plan



Facility Performance: Production & Oil Treating

- Production averaged between 10-40% of 2,000 m^3/day licensed capacity in 2018
- One week outage in June due to false alarm on the produced water pipeline
- Adjusted Treater operation to improve dryness
- Oil treatment has largely not been an issue due to low oil volumes
- Degasser pressures fluctuate significantly due to slugging in emulsion lines

Facility Performance: Source Water

- PRC pulls water from the Peace River on a continuous basis. Source water treatment facility located on the east bank of the Peace River
- PRC is licensed to withdraw 4.3 e^6m^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 (Jan 1 to Sep 30) is 1.5 e^6m^3 or an average of 5,582 m^3/day
  - Before being sent to the main complex, source water is treated to:
    - less than 5 ntu, and less than 0 ppm oxygen
- A small volume of water is also withdrawn from the PRC intake and pumped to New Water Limited for use as potable water for public consumption
  - Northern Sunrise County has it's own withdrawal license and reporting requirements
- Waste brine previously disposed down disposal well (16-27) in the Leduc Formation but now co-mingled with produced water before disposal down wells at 14-25 and 16-23

Facility Performance: Produced Water

- Typical produced water quality:
  - Produced water TSS 30 mg/L, Oil and Grease 75 ppm, Total Hardness 375 mg/L, Chlorides 3,200 mg/L
- Solids are periodically disposed of through approved waste stream treating companies
- Design produced water handling and injection capacity is 7,977 m^3/day
  - Disposal pump capacity currently limited to 7,400 m3/d as a result of VFD being undersized
- In June 2018, signature alarm detected on the produced water pipeline
  - Leak testing performed and confirmed to be a false alarm as a result of operating at the low end of the leak detection system's capabilities

Produced Water Treatment & D81 Compliance

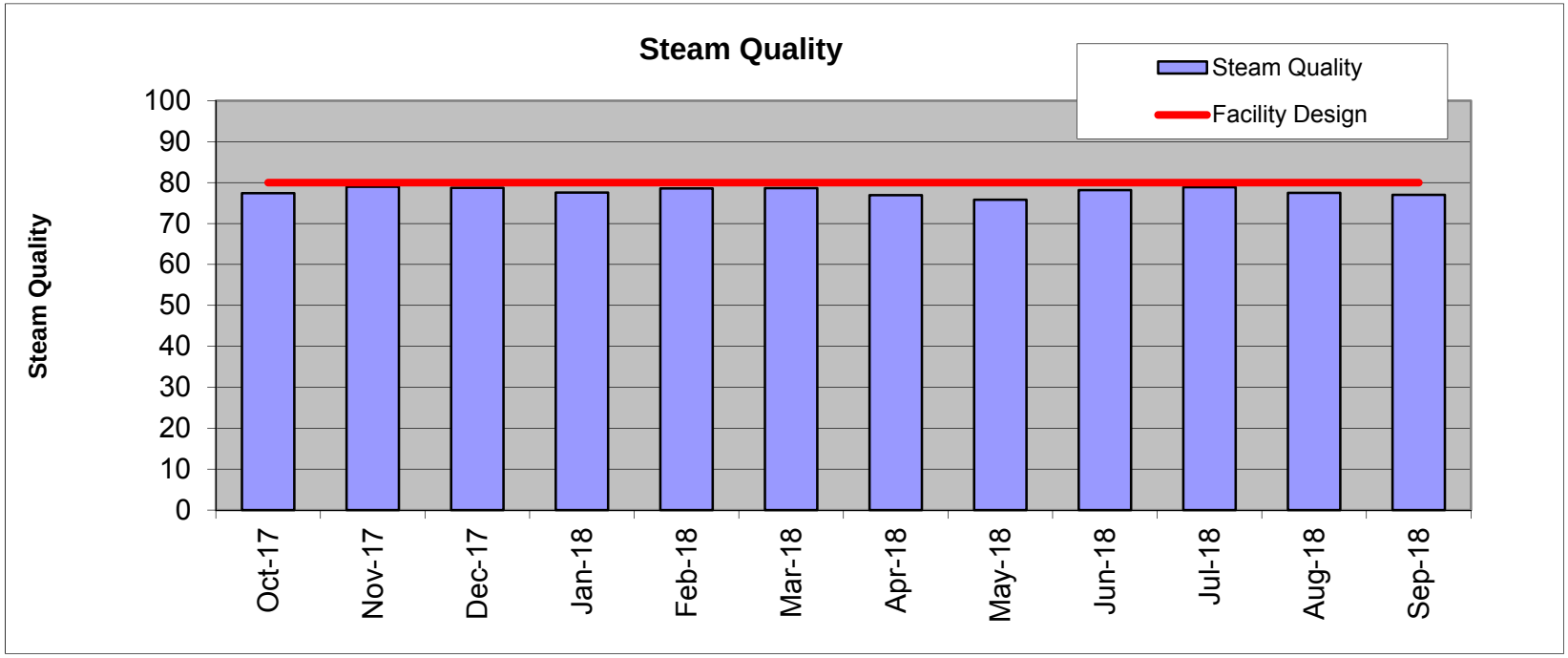
- Current Directive 081 waiver to the end of 2020
  - Application for extension to existing Directive 081 waiver submitted October 2018

- Water Treatment Plans
  - Seeking to match the produced water treatment solution to the reservoir strategy and corresponding steam water specification
  - Conventional water treatment technologies such as evaporation and warm lime softening continue to be investigated but are very costly

Facility Performance: Steam Generation

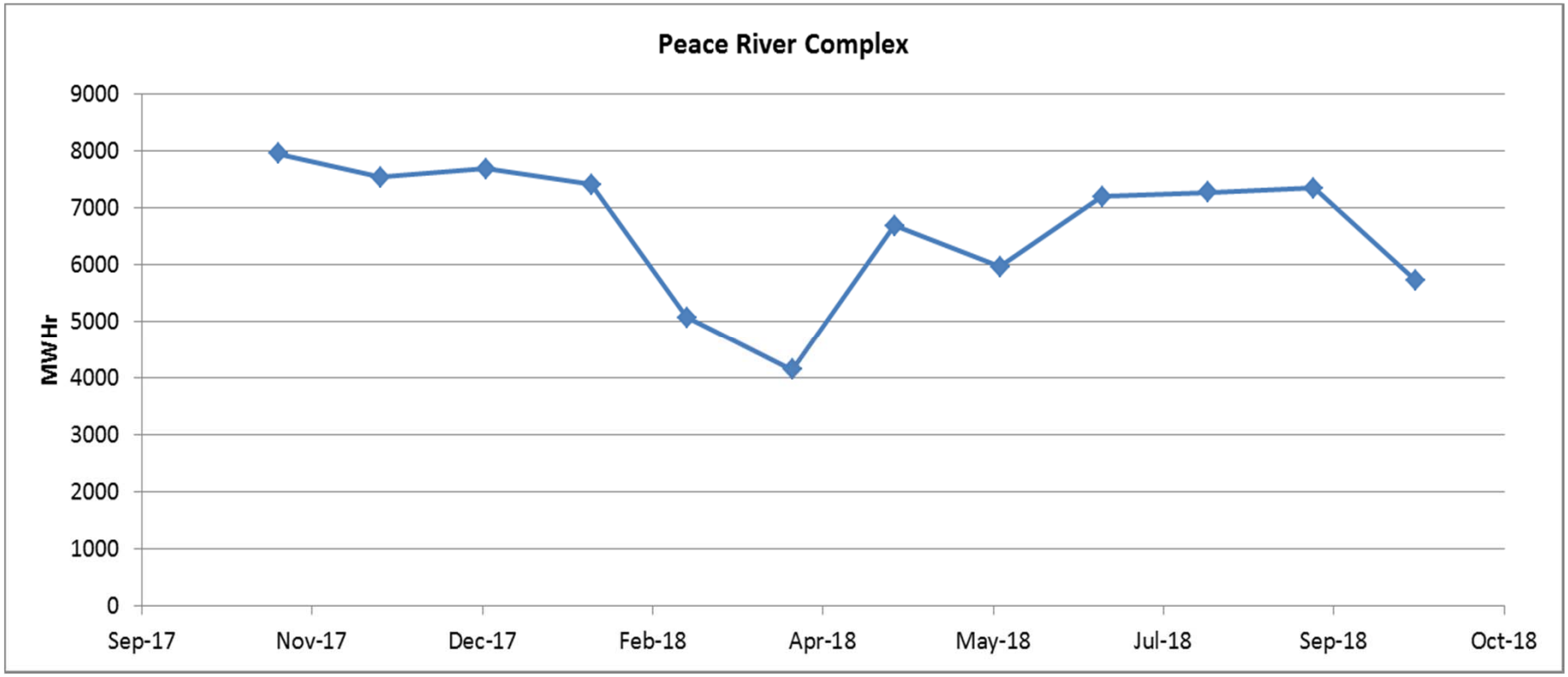
- PRC generates 80% steam quality from four once through steam generators.
- The four steam generators have a total capacity of approximately 8,000 t/d.
- Steam pressures of 14 MPa and 335^{o}C.
- Facility modified to use a dedicated PRISP boiler to provide 350-400 t/d of utility steam.
- PRC has a100% utility steam system blowdown recycle back in to the plant steam condensate recovery system.
- All Steam Generators use a mixture of up to 75% Cliffdale and 25% Natural Gas by volume as their fuel source.

Facility Performance: Steam Generated



- Four PREP boilers at 2,000 t/d capacity each

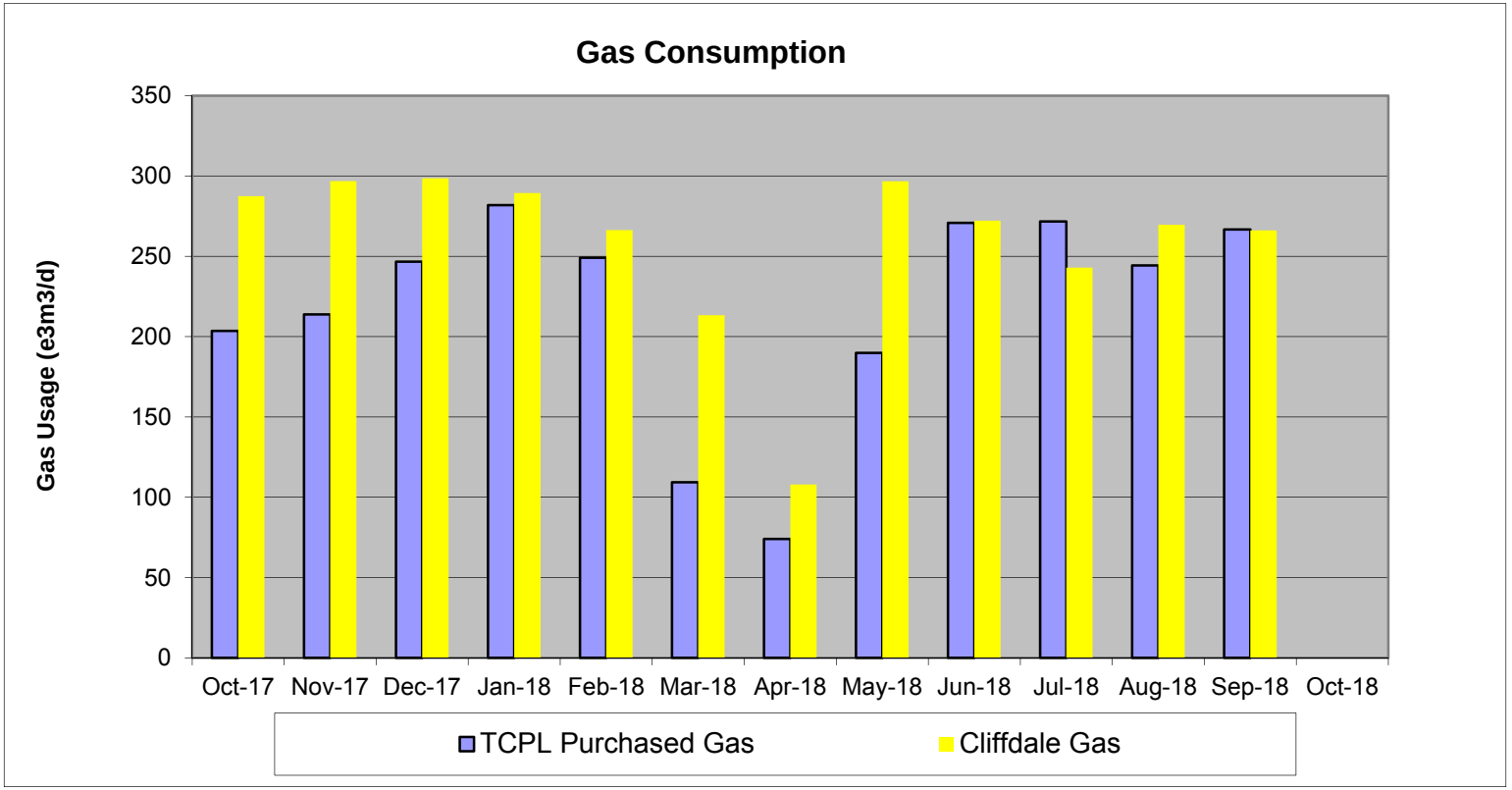
Facility Performance: Power Usage



Facility Performance: Gas Usage

- 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 Approval previously restricted using sour fuel in the boilers to events less than 72 hours in duration.
  - Application submitted and subsequently approved in 2018 to modify the EPEA Approval to allow up to 2 t/d of SO_2 emissions from boilers 1 through 4 and 5 for future flexibility
  - Facility not burning sour gas since 2010 due to reliability concerns and modifications would be required to burn sour gas reliably and make use of recent 2t/d EPEA Approval

Facility Performance: Gas Usage



Facility Performance: Three Creeks Compressor

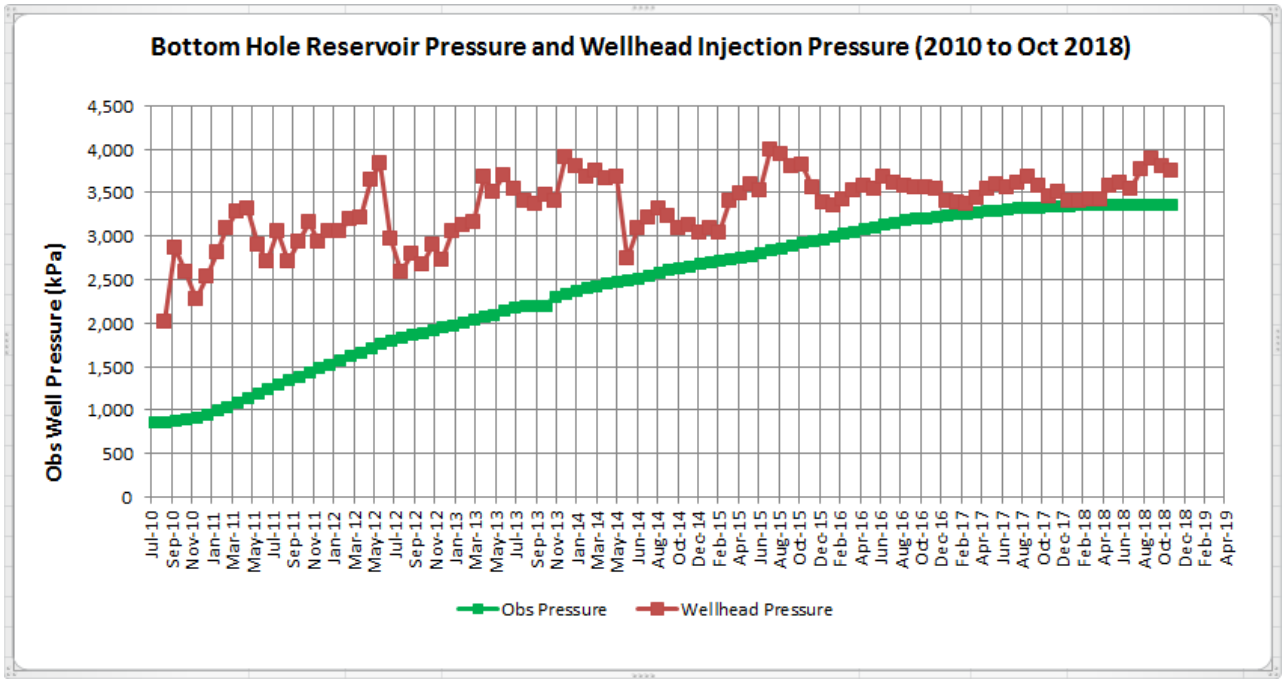
- Three Creeks Gas injection facility has been operational for six years.
  - Sour produced gas from PRC currently going to Three Creeks storage well

- Gas is currently analyzed once per month at the Three Creeks dehydration outlet to the Three Creeks gas injection pipeline. Analysis done by third party.

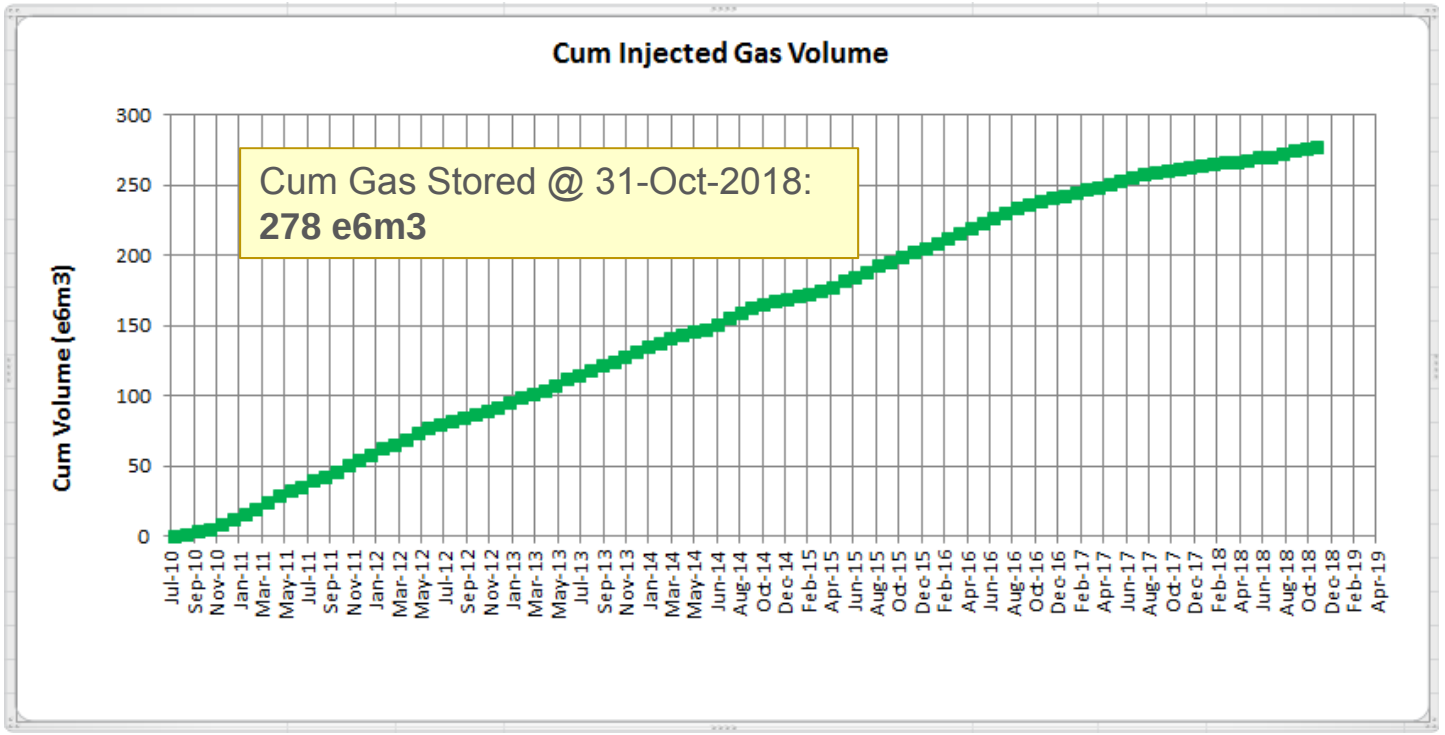
- 2018 Injection facility reliability is currently 99%. This includes planned maintenance shutdowns.

Three Creeks Subsurface Information

- Data as per Three Creeks annual progress report submitted October 31, 2018
  - Approved pressure is 5,000 kPa(a) static reservoir pressure

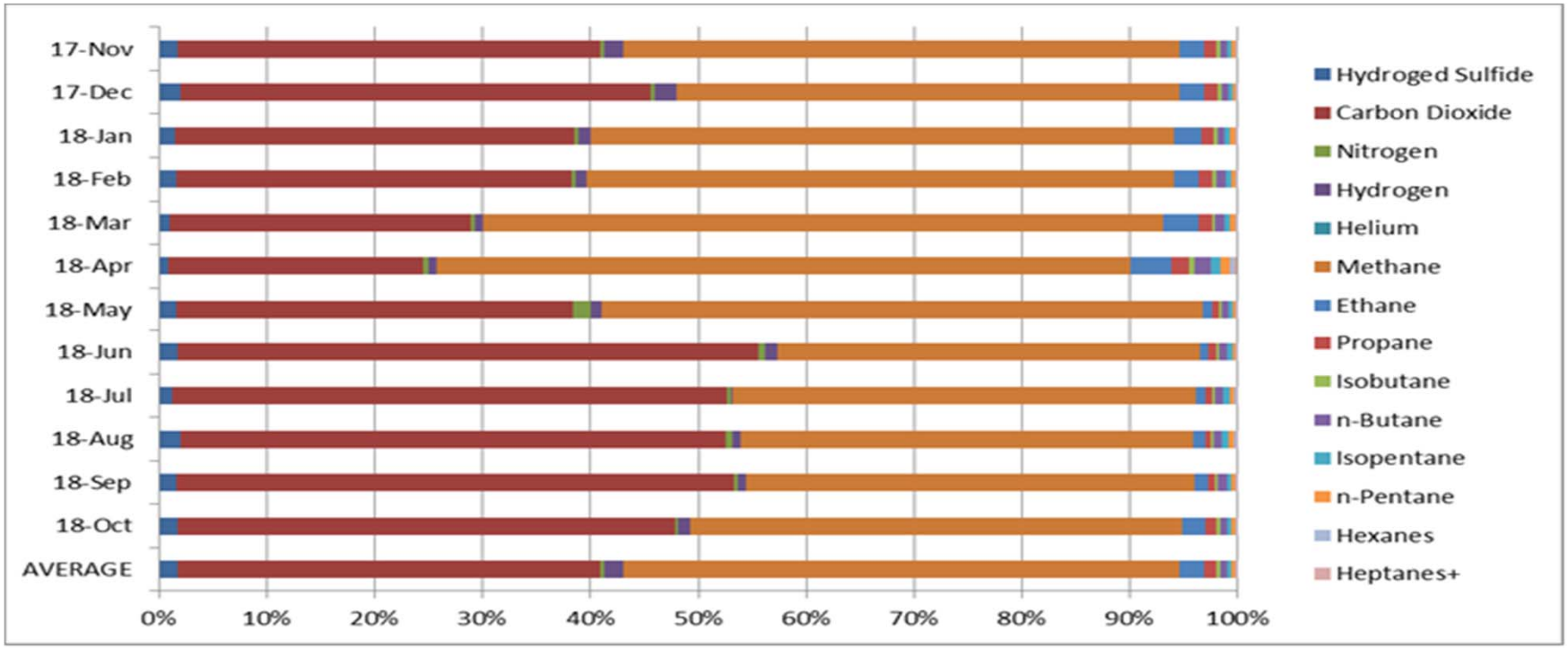


Three Creeks Subsurface Information



Three Creeks Subsurface Information

- Injected gas stream is analyzed once each month. The graph below presents the gas analysis from Nov 2017 to Oct 2018.



Measurement, Accounting & Reporting Plan (MARP)

- The following changes to the Measurement, Accounting and Reporting Plan were included in the last submission:
  - Removed Pad 41 wells (suspended)
  - Added the disposition of gas used as fuel at the Power Generation

Production Well Testing

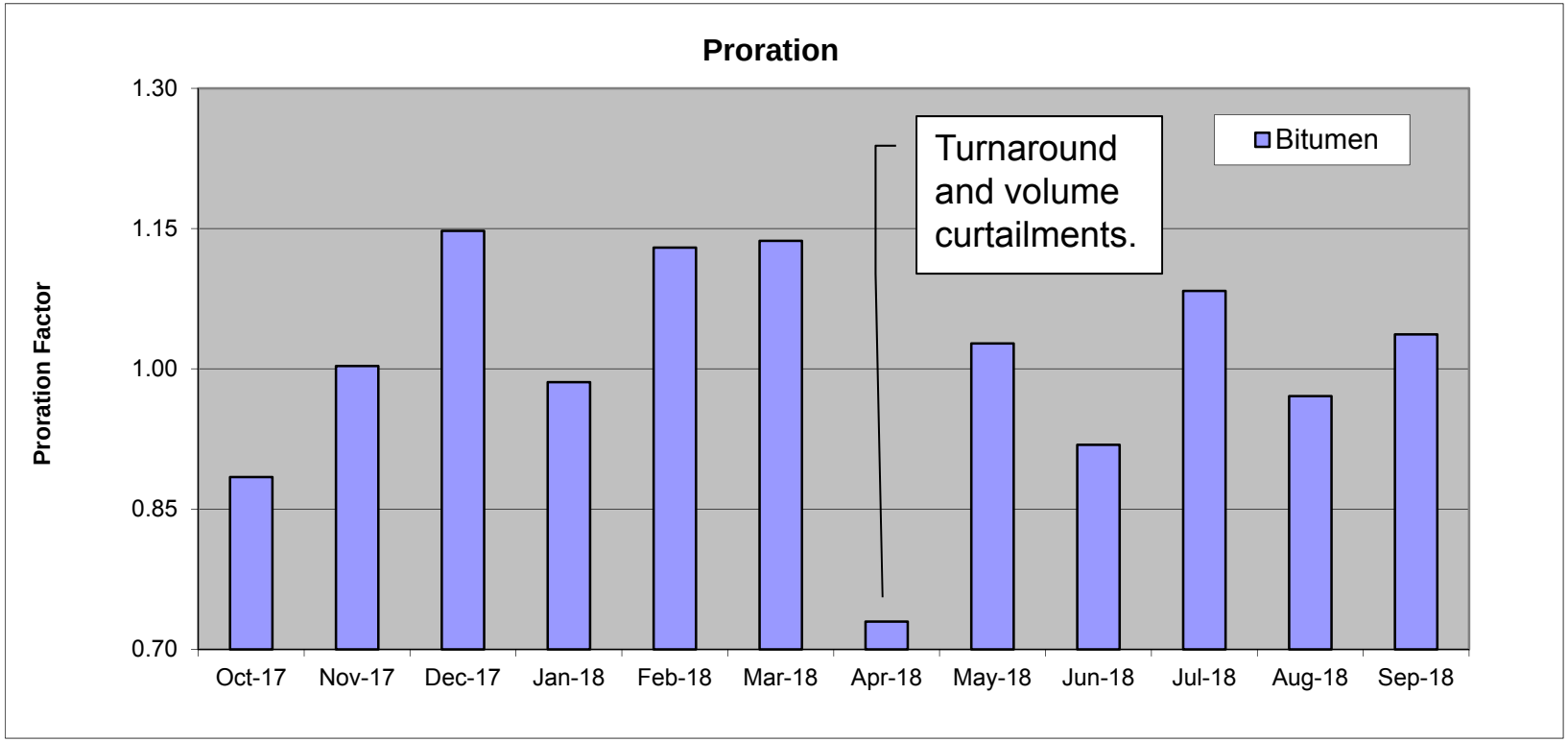
- Wells are directed to a test vessel to separate liquids and gas.
- Liquid flow rates are measured by a Coriolis meter
- Watercuts are determined by inline BS&W analyser (except for 19 sat 1-2-4 & Pad 20, which use a 3 phase separator)
- Reported volumes are prorated based on measured total volumes at the plant

Pad	Separator	Purge time*	Duration	Frequency
21	2 phase	~3-8 hrs	12 hours	2x/week
19 sat 1-2-4 & 20	3 phase	~ 1 to 8 hrs	12 hours	1-2x/week
19 sat 3	2 phase	~0.5 hrs	6 hours	3x/week
30, 31	2 phase	~ 0.5 hrs	3 hours	7x/week
32, 33	2 phase	~ 0.5 hr	3 hours	3x/week

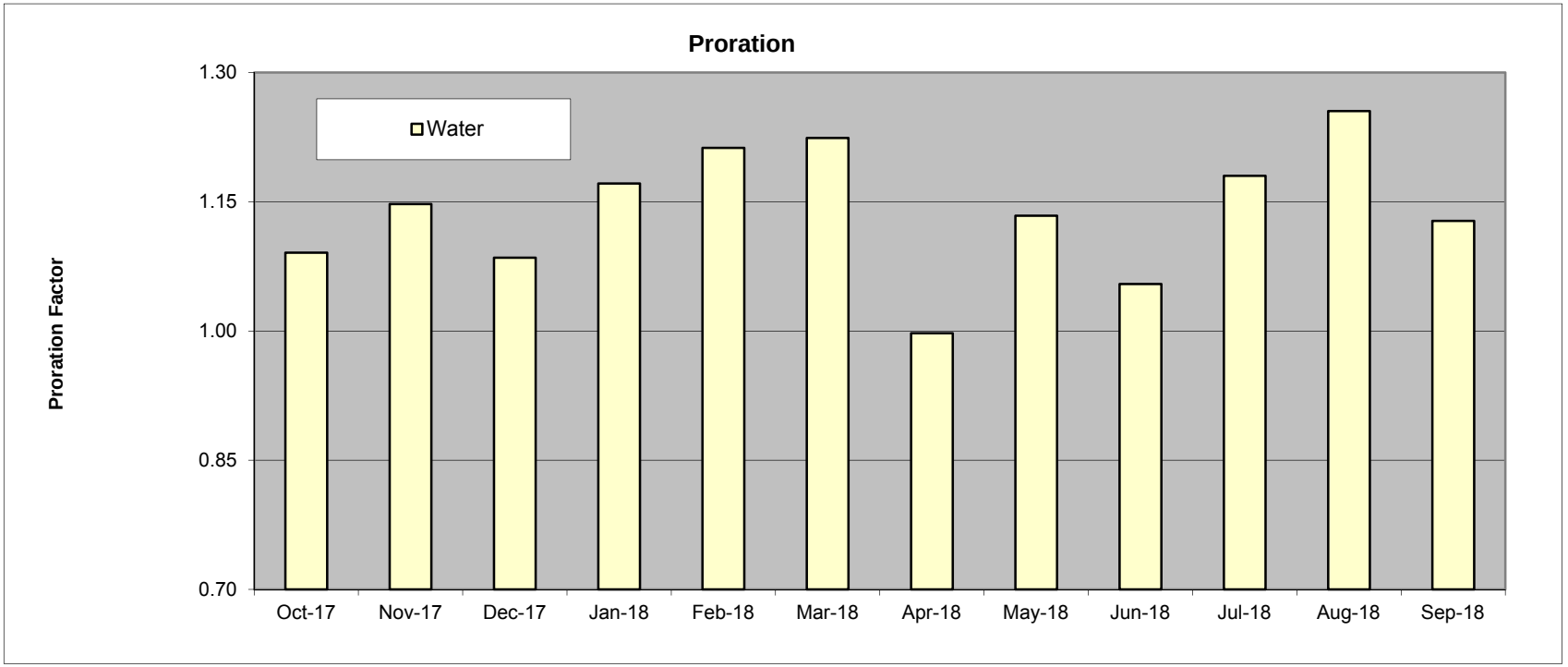
- Well test duration/frequency largely dependent on purge time & number of wells tied into each test separator:

* 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

Bitumen Proration

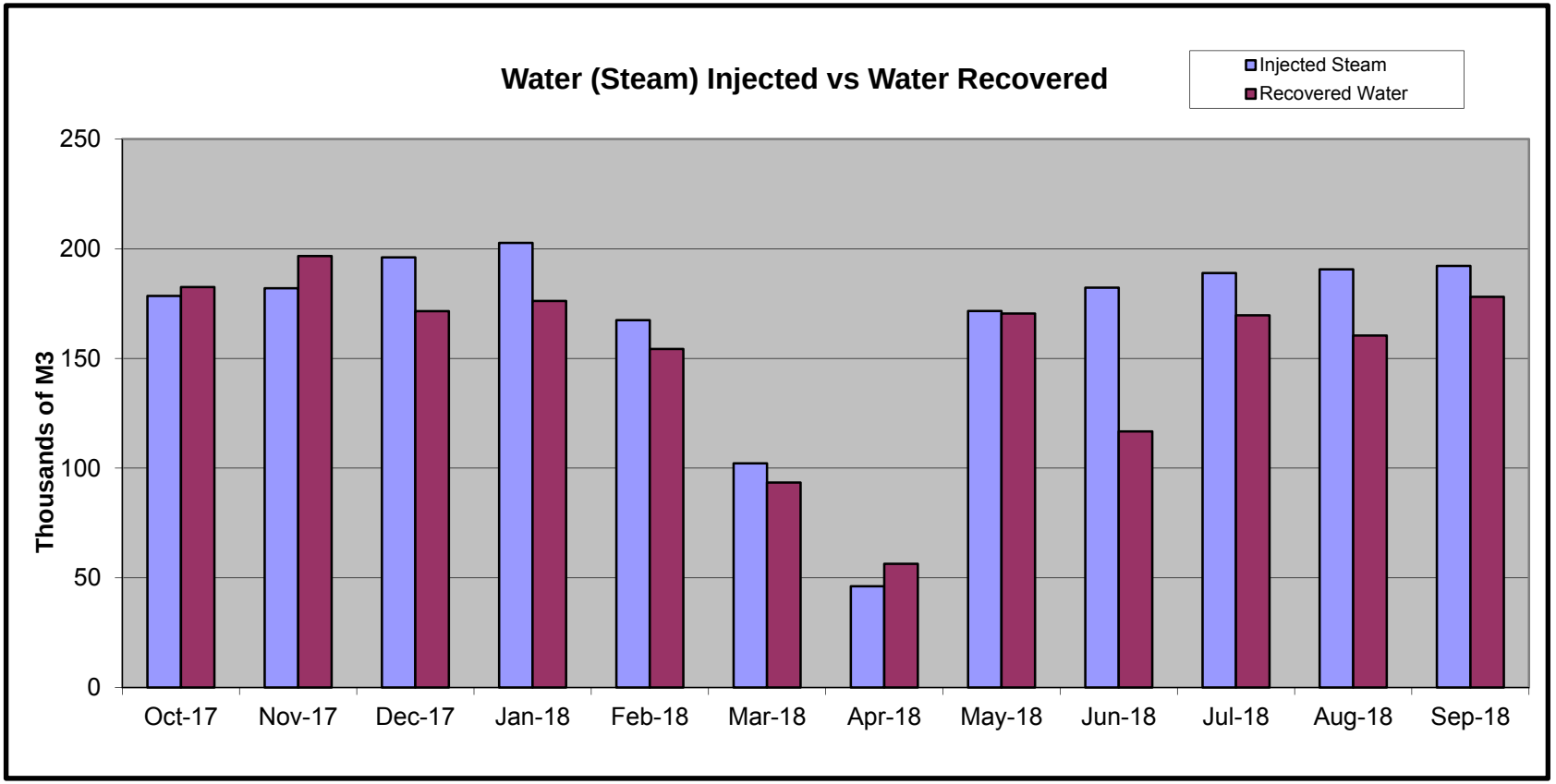


Water Proration



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



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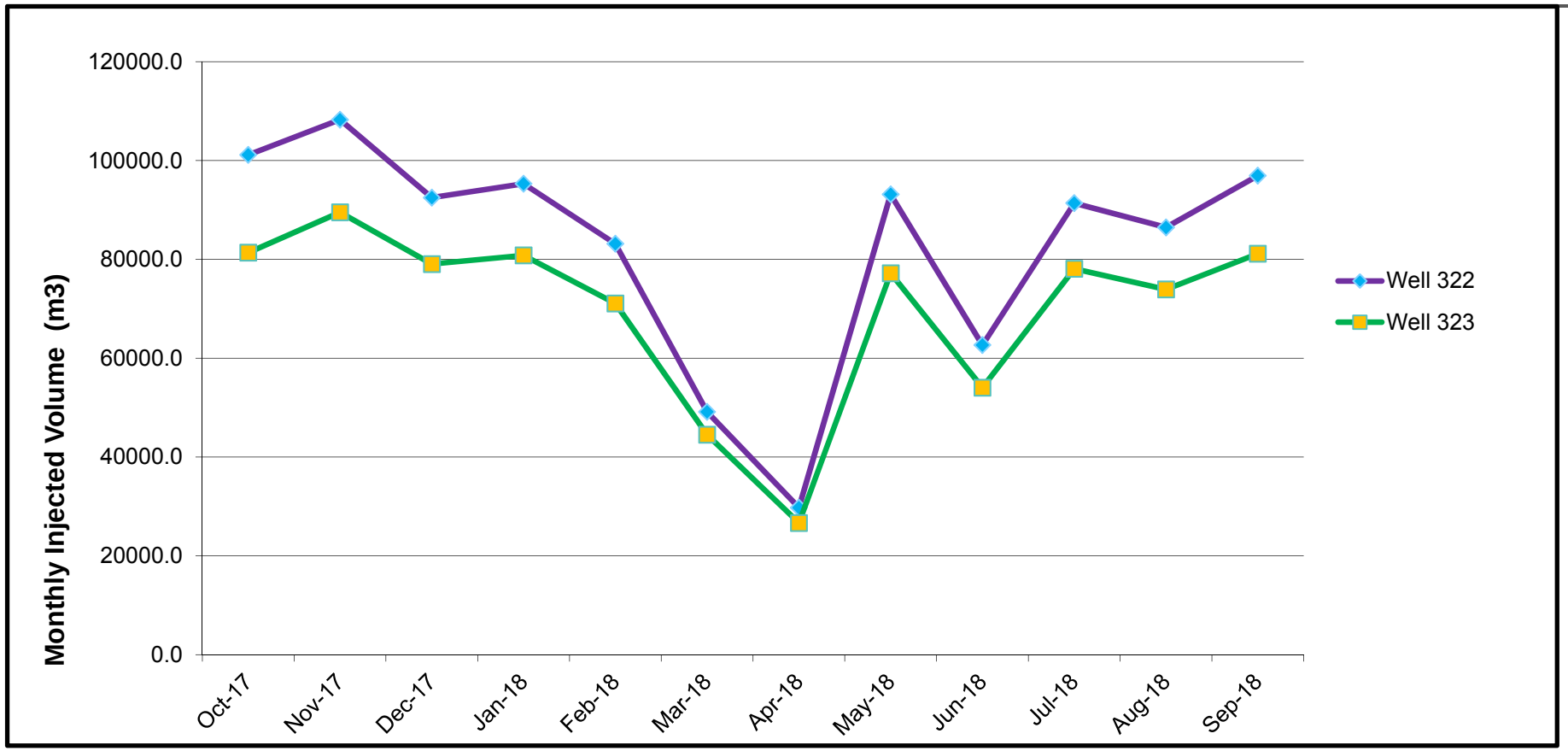
Brine Water Disposal

- Brine Water Disposal Well (100/16-27-85-19W5)
  - Disposed into the Leduc Formation until July 2017
    - Well currently suspended
- Ion Exchange Brine Disposal
  - Brine pipeline shut down due to integrity concerns Q2 2017
  - Brine from Ion Exchange regens now being co-disposed with produced water

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 = 2712.1 m^3/d
  - Average Pressure = 5644 kPa
  - Max Pressure = 9988 kPa
  - Average Temperature = 61 ^oC
  - 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 = 2294.6 m^3/d
  - Average Pressure = 5706 kPa
  - Max Pressure = 7674 kPa
  - Average Temperature = 62 ^oC
  - Typical Total Dissolved Solids (TDS) is 5300 g/m3
  - Approval up to 18,000 kPag (as per approval no. 6308)

Water Disposal Monthly Volumes



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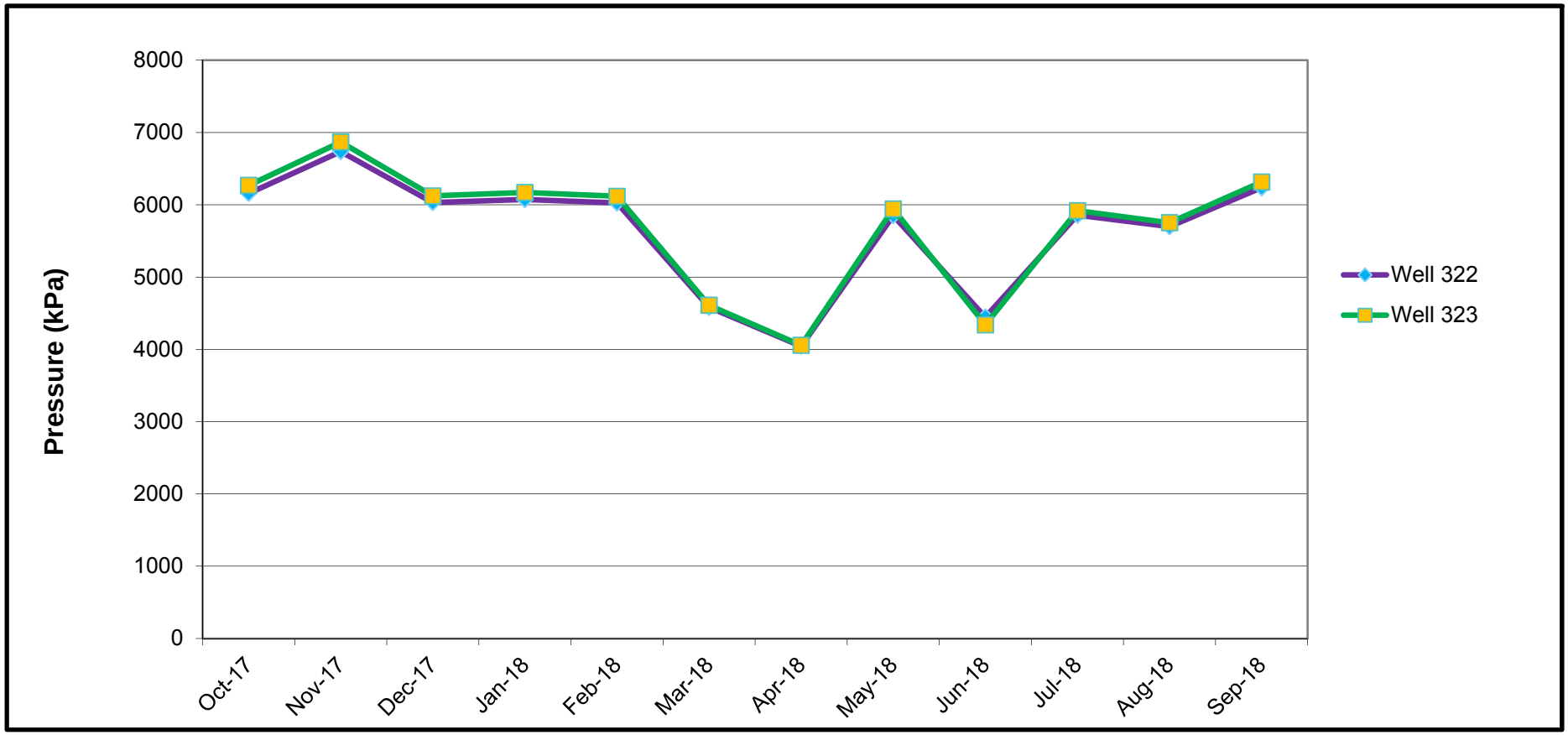
Water Disposal Max Monthly Injection Pressures



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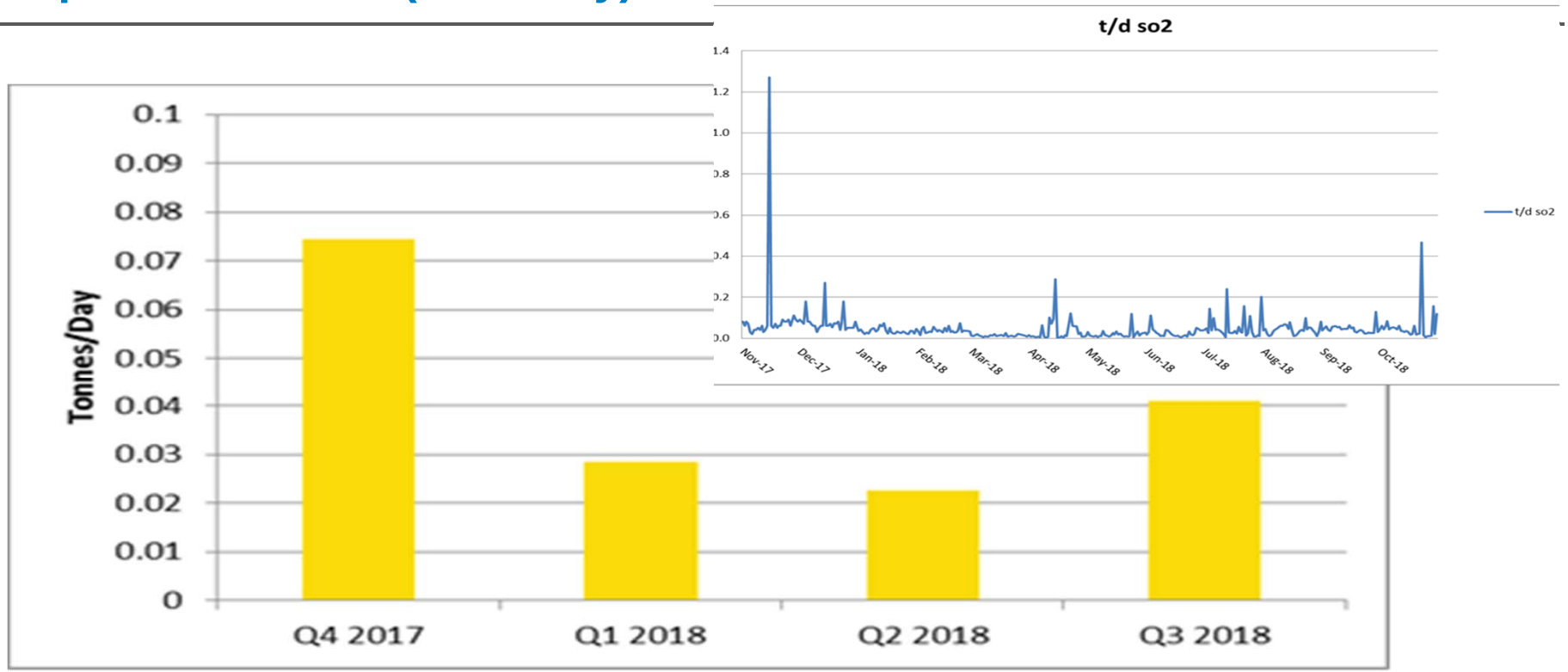
Waste Disposal

- Tervita Corporation– Peace River (12-24-85-19-W5)
  - –Treatment, Recovery & Disposal (TRD) Facility
  - –Total tank bottom, hydrocarbon sludge, and bitumen waste = 1,326 m^3 to October 2018
  - –Total contaminated waster, spill material, pad solids etc. = 1,061 m^3 to October 2018
  - –Grand total = 2,387 m^3 to October 2018

Sulphur Emissions(< 1T/Day)



- SO_2 Emission Sources include:
  - Three Creeks Flare and PRC Flare
  - PRC Steam Generators (as approved September 21, 2018)

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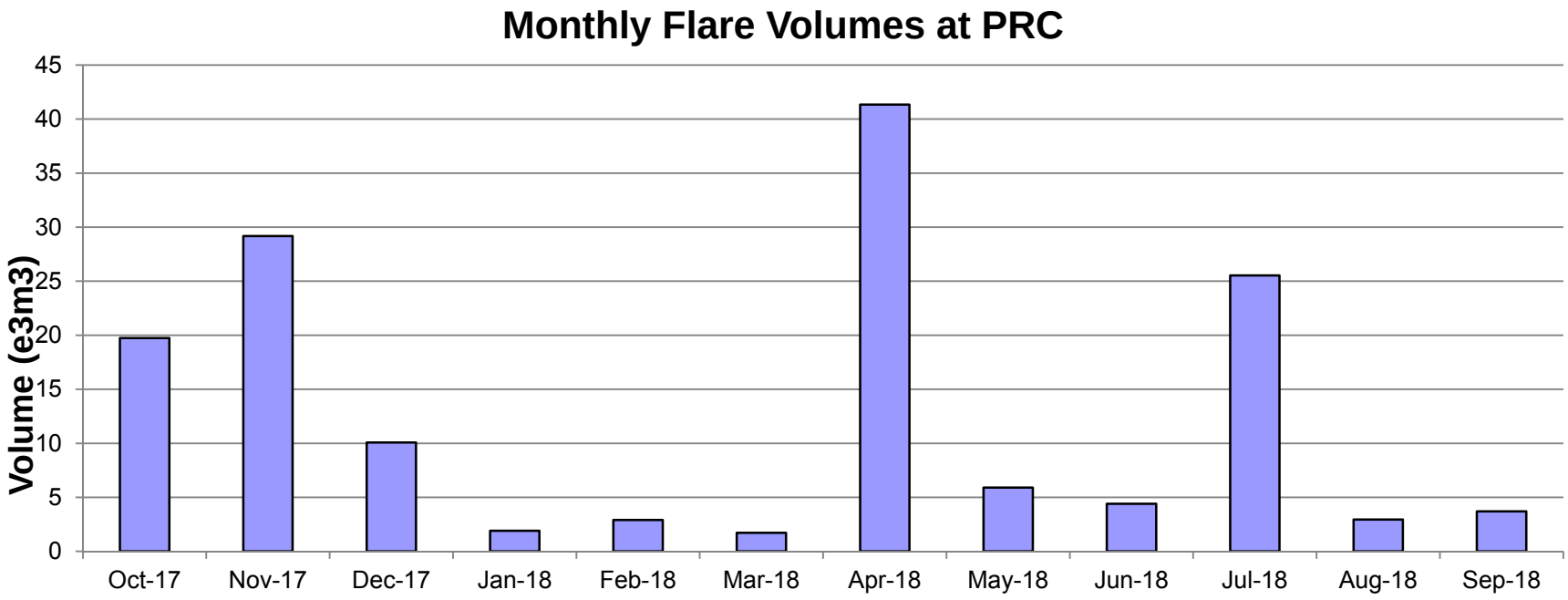
Greenhouse Gas Emissions

- Peace River Complex Greenhouse Gas Emissions
  - October and November 2018 data is estimated
  - Power Generation totals from onsite generators

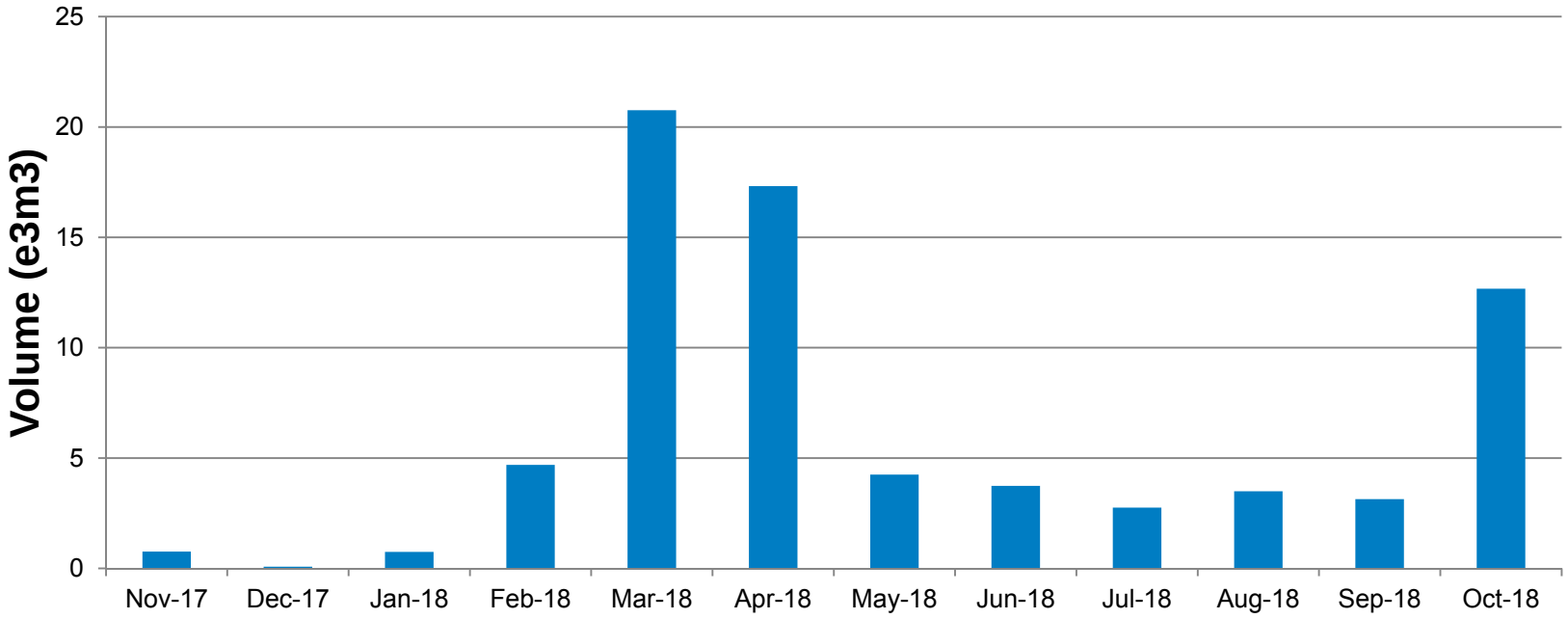
Month	Total (tCO2e)	PRC Plant (tCO2e)	Electricity (tCO2e)
Nov 17	30,700	29,800	900
Dec 17	34,200	33,000	1,200
Jan 18	35,760	34,640	1,120
Feb 18	29,220	28,570	650
Mar 18	20,370	19,300	1,070
Apr 18	10,150	9,540	610
May 18	30,240	29,360	880
Jun 18	31,550	30,420	1,130
Jul 18	31,480	30,680	800
Aug 18	31,470	30,870	590
Sep 18	31,780	31,020	760
Oct 18*	24,240	23,390	850
Nov 18*	21,640	20,790	850

Flare Volumes



The high flare volume in April was a result of a planned plant shutdown for Maintenance

Vented Volumes



The high venting volumes in March, April and October were the result of significant level fluctuations in SV-4.05 (gas blanketed water tank) due to low productions volumes in those months.

Ambient Air Monitoring

- Static/Passive Air Monitoring
  - Twelve passive stations
  - Gathers data on sulphur dioxide and hydrogen sulphide
  - 2018 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.

Environmental Compliance

- There were multiple H_2S Ambient Air Exceedances at the PRC Ambient Air Monitoring Trailer from June-August 2018.
  - Determined that the exceedances were not caused by the facility, but were the result of naturally occurring sulphur reducing bacteria (SRB) in surrounding standing water.
  - The air trailer maintained over 90% uptime each month as per license requirements.
- Reportable spills and releases
  - June 2018: well head steam release on pad 32-06
    - Brine was used to stop the release. No cleanup required.
  - 32-01 steam an kill fluid release.
    - Gravel/soil, stained cladding replaced, etc. All cleanup activities completed Oct 30, 2018.
  - Pad 19 packing failure February 2018: oil released to ground
    - All cleanup activities completed Sept 13, 2018.

EPEA Approval 1642-02-00 Amendments

- EPEA Operating Approval Amendments between October 2017-October 2018:
  - 1642-02-11 Approved September 21, 2018
    - Approval for 2.0 t/d SO_2 limit for Peace River Complex

EPEA Approval 1642-02-03
Monitoring Program Summary

- Groundwater Program
  - As outlined in EPEA Approval 1642-02-03, PRC has requirements for both groundwater and deep well water testing. Testing and reporting are both required on an annual basis.
    - Testing was completed at the end of September/October 2018.
    - Results will be reported in the 2018 annual report.

- Soil Monitoring Program
  - Testing was completed in November 2018.
    - Results to be reported in 2018 annual report.

- Wetland Monitoring Program
  - Testing was completed in August 2018
    - Results will be reported in 2021 comprehensive report.

EPEA Approval 1642-02-03
Monitoring Program Summary

- Shallow groundwater monitoring program:
  - Groundwater testing occurred September/October 2018 on plant piezometers.
  - Results of the GWMP will be summarized in the 2018 Groundwater Monitoring Program Peace River Complex Project Report - to be submitted March 2019.

- 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 will be summarized in the 2018 Groundwater Monitoring Program Peace River Complex Project Report - to be submitted March 2019.

EPEA Approval 1642-02-03
Monitoring Program Summary

- Deep groundwater monitoring program at regional wells:
  - 2004 drilling program (50 and 105 meter depth)
  - 2005 drilling program (70 meter depth) – frozen and could not be sampled
  - 2009 drilling program (3 wells (each approximately 60, 110 and 280 meters deep)
  - Groundwater sampling program at the regional wells occurred from October 2 to 5, 2018.
  - Results of the deep regional well GWMP will be summarized in the 2018 Groundwater Monitoring Program Peace River Complex Project Report – to be submitted March 2019.
  - Assessment of Thermally-Mobilized Constituents in Groundwater for Thermal In Situ Operations (Directive affective June 2018).
    - A Project Assessment will be conducted and a groundwater monitoring report will be submitted prior to March 31, 2020

EPEA Approval 1642-02-03
Monitoring Program Summary

- Wildlife crossing structures monitored on aboveground pipelines:
  - Authorization was received from the AER on March 29, 2018 to remove the wildlife monitoring (remote camera and winter tracking surveys) along aboveground pipelines associated with the PRC.
- Multiple wildlife studies including collection of wildlife identification cards, bird surveys, winter mammal tracking, owl surveys, bat surveys, and amphibian surveys completed in 2015-2018.
- A 3 year comprehensive wildlife monitoring report was submitted to AER August 31, 2018.
- All wildlife data for these surveys is uploaded into the Fish & Wildlife Management Information System (FWMIS) and incorporated into the Comprehensive Wildlife Reports
- Ongoing peatland reclamation research with NAIT Boreal Research Institute.

Environmental Studies Program

EPEA Requirement	Report Name	Submission Date	Status
CCP - Schedule VI (1)	Groundwater Monitoring Program (GWMP)	March 31, 2014	Submitted to Alberta Energy regulator (AER) on March 31, 2014; received written authorization from the Director on March 5, 2015.
CCP - Schedule VIII (4) & (9)	Wildlife Monitoring and Mitigation Program (WMMP)	August 31 ,2018	Submitted to AER August 31, 2018. Next Comprehensive Wildlife Report will be submitted before May 15, 2021.
CCP - Schedule XI (1)	Wetland Monitoring Program (WMP) Proposal	February 28, 2018	Submitted to AER February 28, 2018. Received written authorization from Director on June 12, 2018. The next Comprehensive wetland monitoring report will be submitted March 31, 2021.
CCP - Schedule IX (39)	Wetland Reclamation Trial Program Proposal	December 31, 2016	Submitted to AER on December 21, 2016 - AER written authorization received on January 12, 2016. The wetland reclamation trial is being conducted by NAIT Boreal Research Institute at the Airstrip
CCP - Schedule IX (44)	Reclamation Monitoring Program (RMP) Proposal	December 31, 2016	Submitted to AER on January 26, 2017 - AER written authorization received on February 10, 2017
CCP - Schedule XI (26)	Project-Level, Conservation, Reclamation and Closure Plan (PLCRCP)	October 31, 2018	Submitted October 31, 201

Reclamation Summary

Number of EPEA sites in R&R status in Siteview = 24

- Reclamation activities in 2018:
  - Re-vegetation – fill in planting of birch and willow staking for erosion on 2.65 ha SMC.
  - Vegetation assessment and management completed on 4 sites.
    - ~7.52 hectares – weed control conducted
  - Evaluation of 6 sites, 4 which are still in operation. Two pad sites require phase 2 and full reclamation.
  - Detailed site assessments (DSA) completed on 2 sites, ready for reclamation certificate – 3.18 hectares
- Proposed 2019 Activities:
  - Complete outstanding reclamation certificate applications as per sites evaluated in 2018.
  - Continue weed control.
  - Complete Recon phase for 3 sites.
  - Complete phase 1 reporting in preparation for Phase 2 for 2023.
  - Reclamation certification application submitted for 5 sites – 4.44 hectares

Environmental Research led by NAIT

- Peatland Restoration
  - Funding is supporting peatland research around the 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
  - 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. Ongoing monitoring.
- Technology Transfer and Synthesis
  - As research project ends 2019
    - findings will be summarized into a technology transfer and synthesis document by NAIT.

Future Plans

- D081 waiver extension to 2030 to permit small incremental development opportunities to progress
  - Due to current unfavorable market conditions, the viability of PRC is being evaluated, including the possibility of shutting in the facility
  - Without a D081 waiver extension, the likelihood of PRC being shut-in would increase
- Steam water specification to be developed to coincide with reservoir strategy
- Facility modifications to accomplish revised reservoir and steam water specification strategy (if required)
  - Future water treatment options being considered that will align with both the asset development strategy and steam water specification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