



PennWest

Seal Main HCSS Pilot
Subsurface Review

- 1. Background**
2. Geology
3. Drilling and Completions
4. Artificial Lift
5. Well Instrumentation
6. 4D Seismic
7. Scheme Performance
8. Future Plans

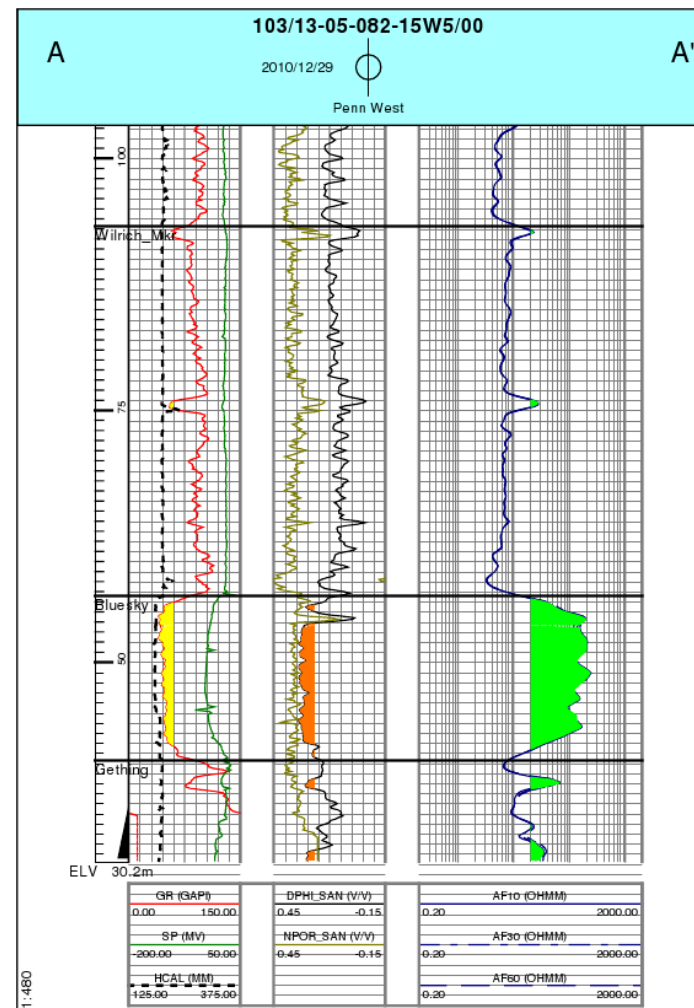
- Approval No. 11377 for a thermal in-situ scheme consisting of a single well HCSS (horizontal cyclic steam stimulation) was received on November 10, 2009
- Approval No. 11377A was received on August 31, 2010 for a revised bottomhole location for the pilot well
- Approval No. 11377B was received on April 20, 2012 to extend the approval expiry to November 30, 2016

- A single HCSS well in the Bluesky Formation to evaluate thermal development in the area
- Inter-well spacing of 75m with respect to the thermal well and the offsetting primary wells, and a well length of 1,200m
- 80% quality steam injected at the heel of the well, not exceeding maximum bottomhole pressure of 10.5MPa

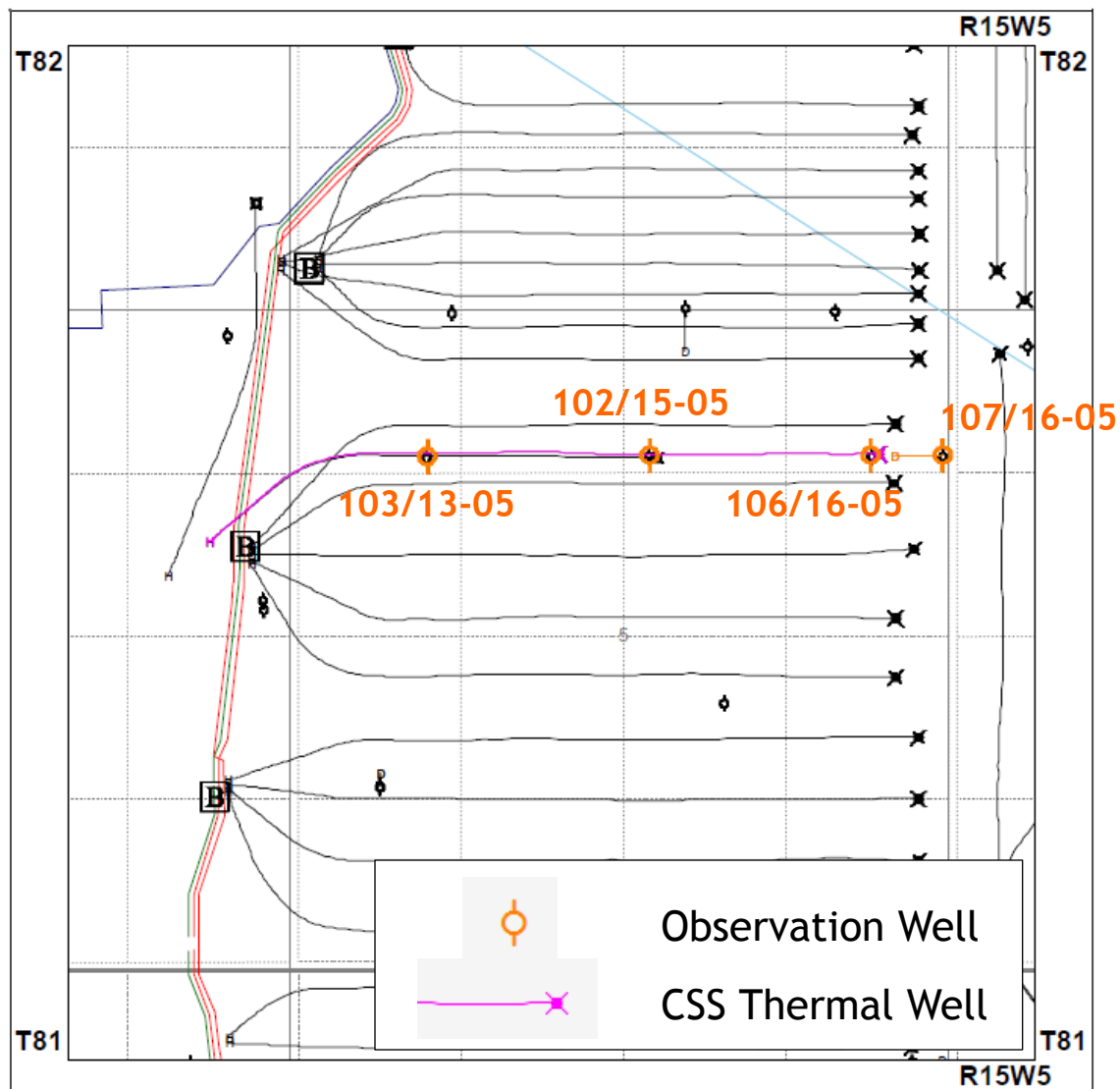
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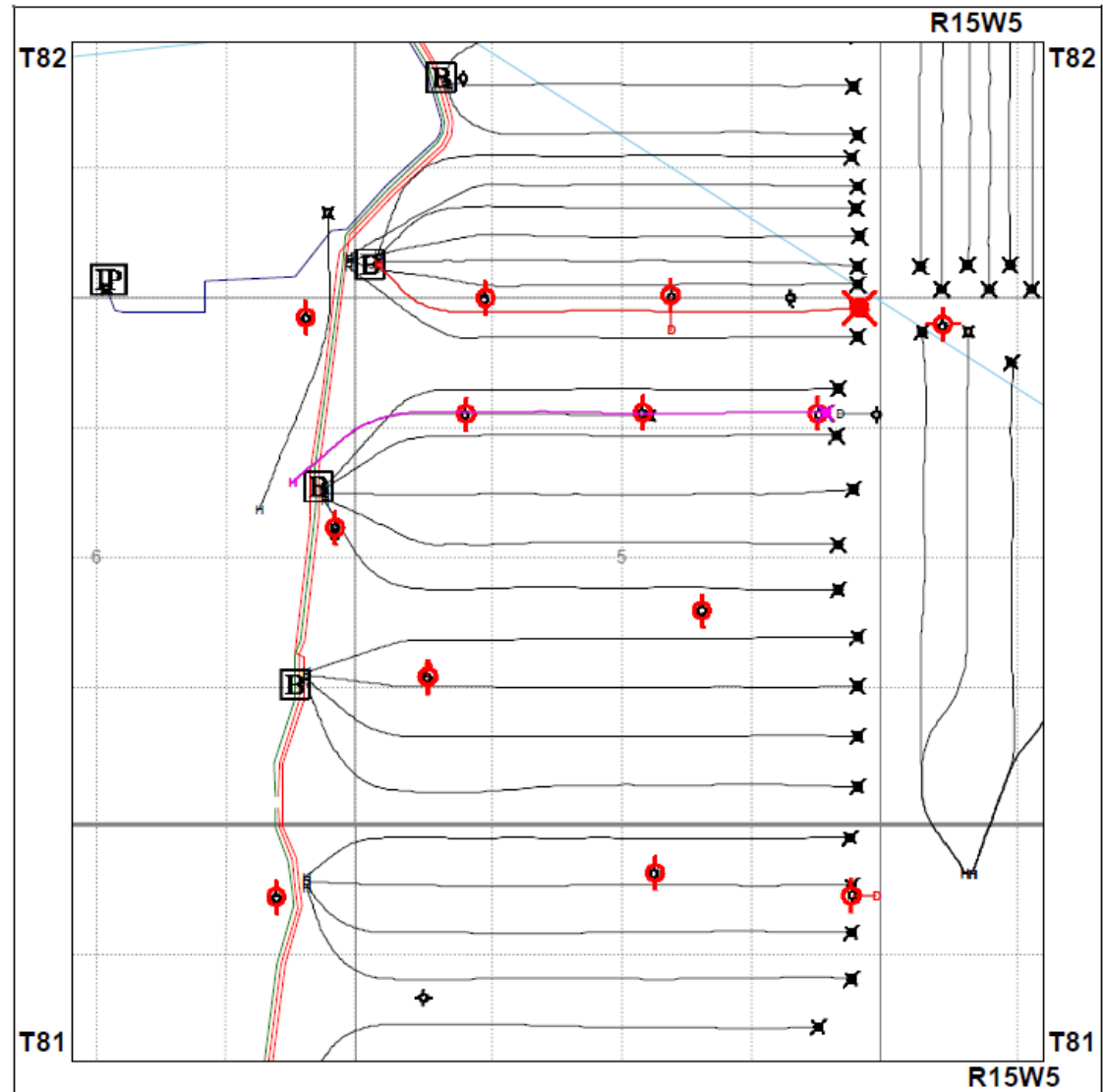
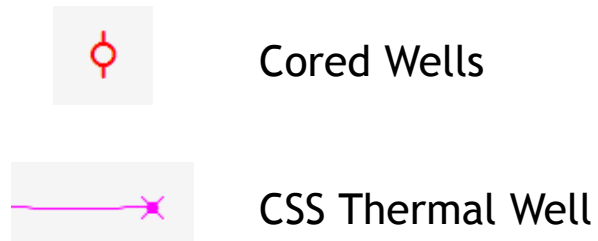
- Series of north/south oriented, stacked distributary channels that have incised into the surrounding sand dominated tidal flat sediments
- Fine to medium grained litharenite
- Average depth is 650m TVD
- Thickness up to 24m
- Porosities from 24% to 33% (Avg 28%)
- Permeability from 50 to 5,500mD
- Oil Saturation from 40% to 85% (Avg 79%)
- API Gravities of 8.7 to 9.8 API at 15.6°C
- Viscosities from 8,300 – 26,000 cSt at 20°C

13-5-82-15W5 Type Log



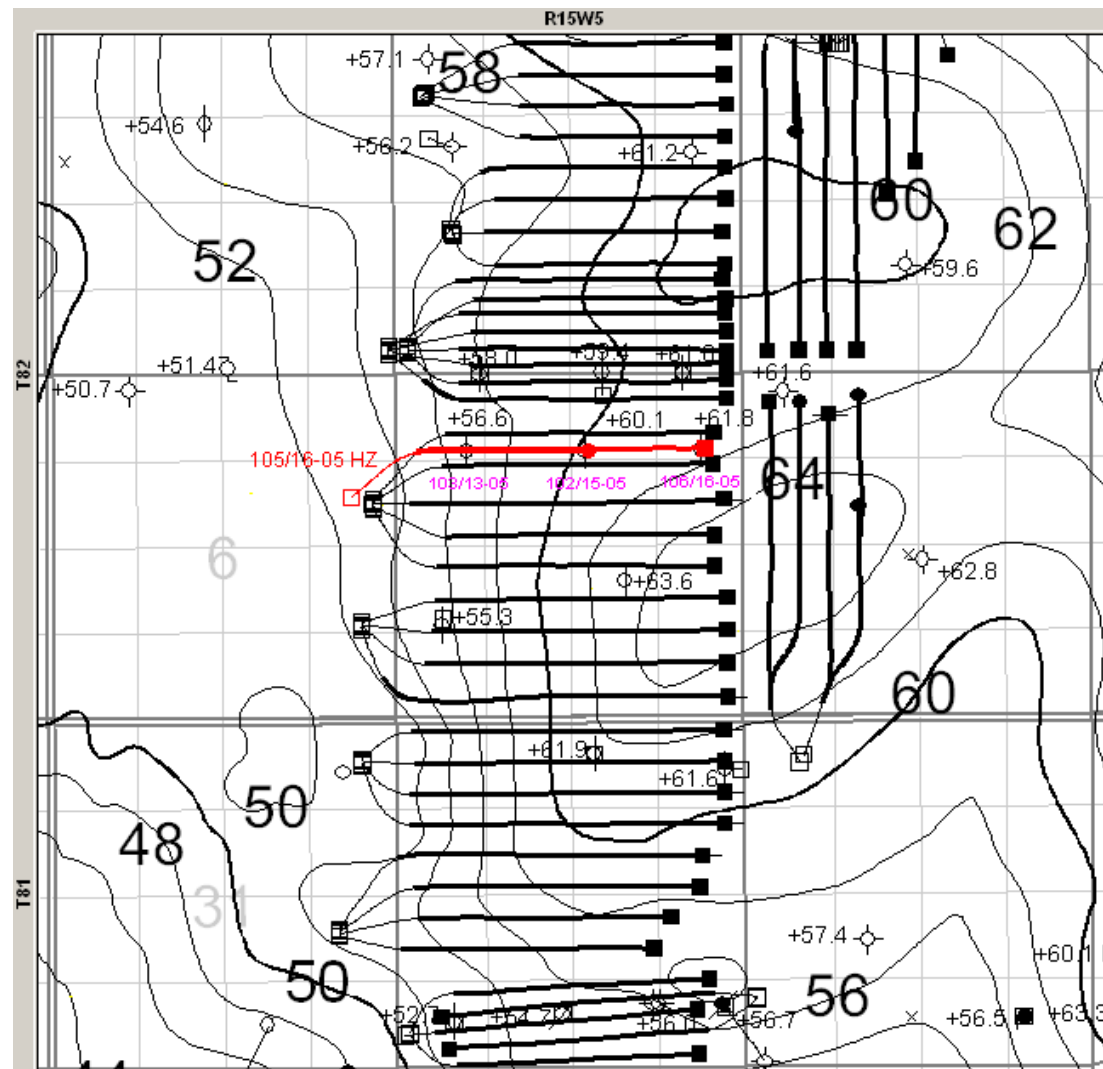
- Pilot HCSS well
 - 105/16-05-082-15W5
- Three vertical observation wells
 - 103/13-05-082-15W5
 - 102/15-05-082-15W5
 - 106/16-05-082-15W5
- One deviated observation well
 - 107/16-05-082-15W5




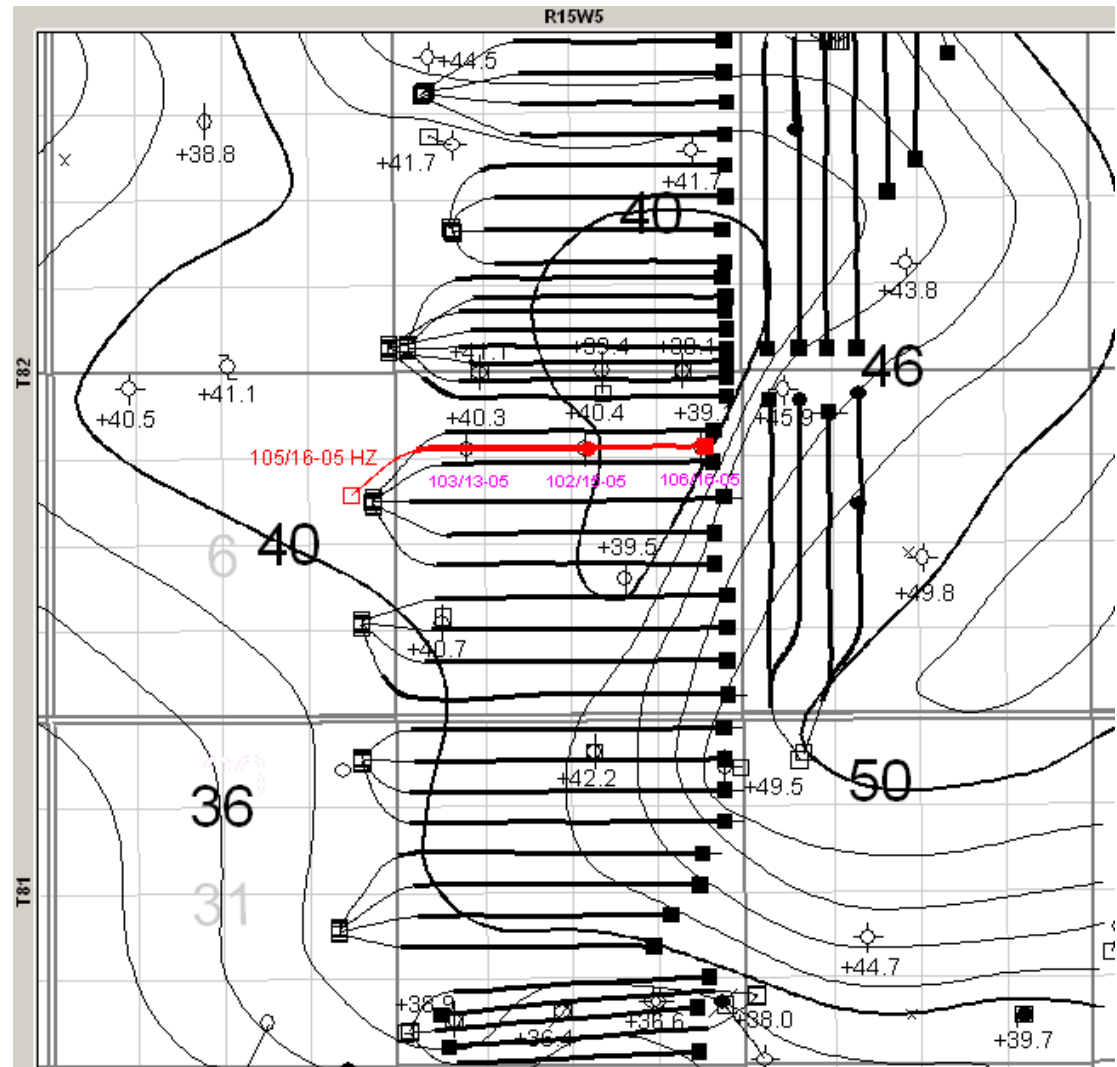


Geology – Top Bluesky Structure Map

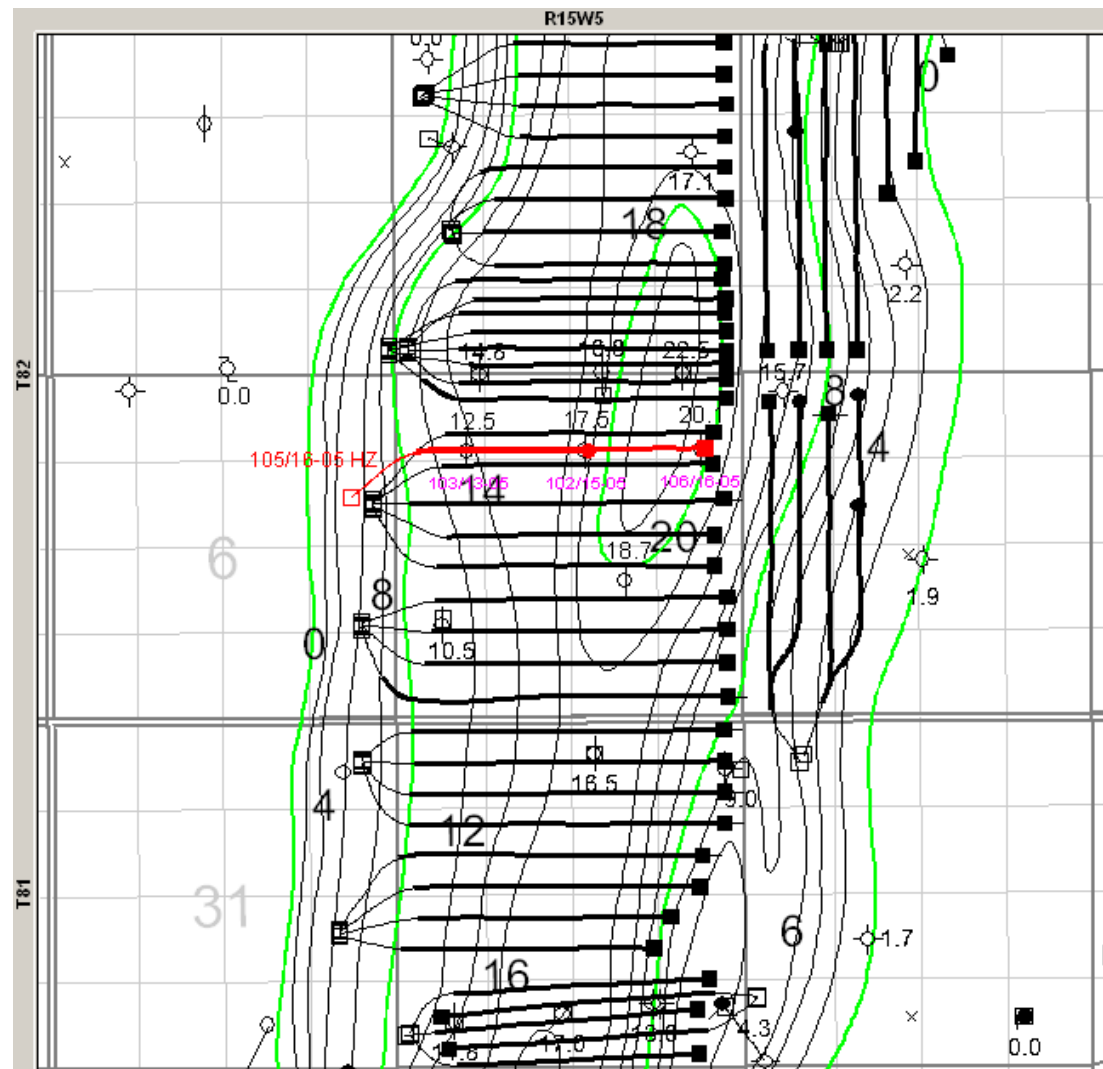
PennWest




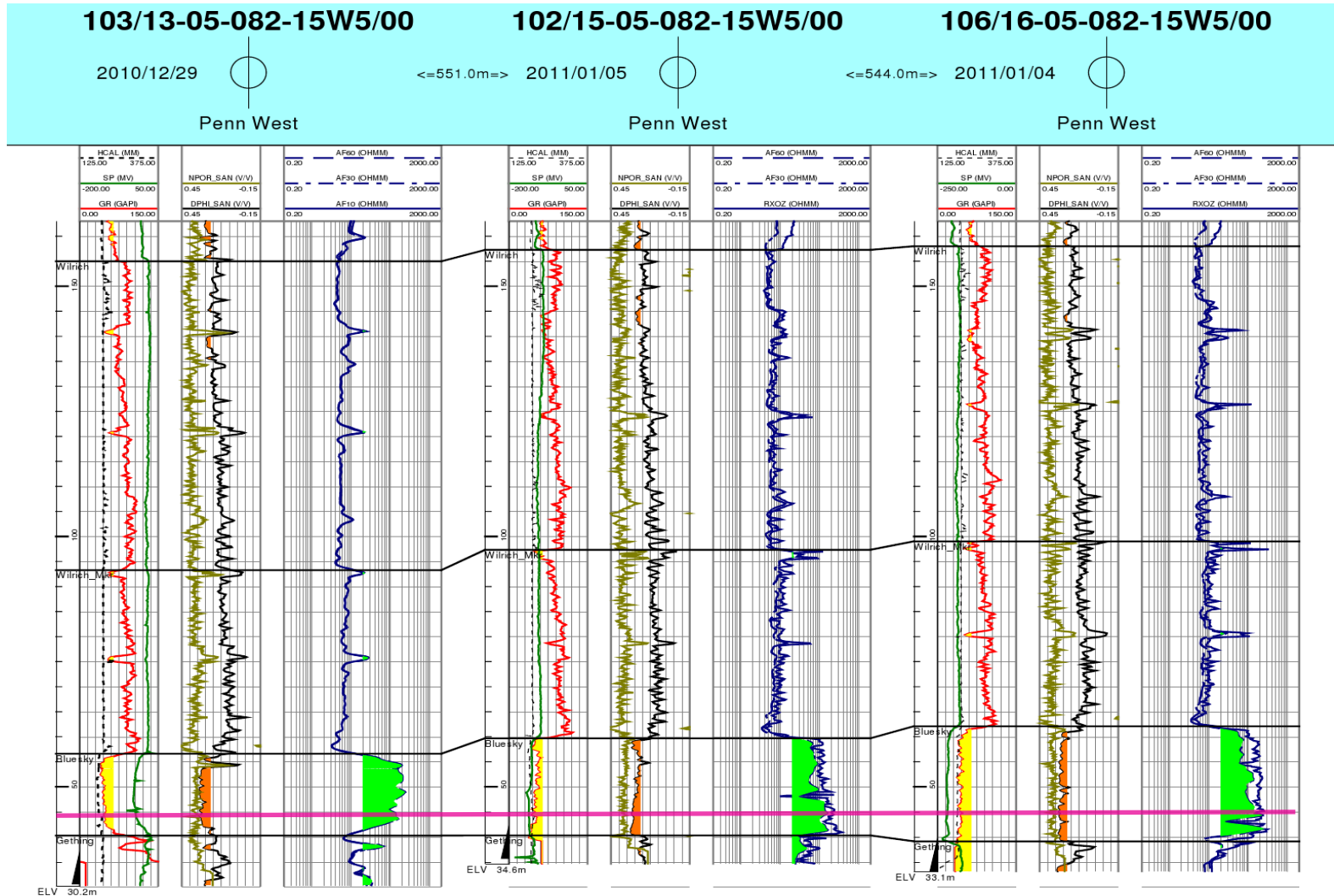
PennWest Exploration		
Bluesky Structure (mss)		
Licensed to : Penn West Petroleum		
	By: JW Scale = 1:20000	Date : 2011/11/02 Project: Seal Regional O

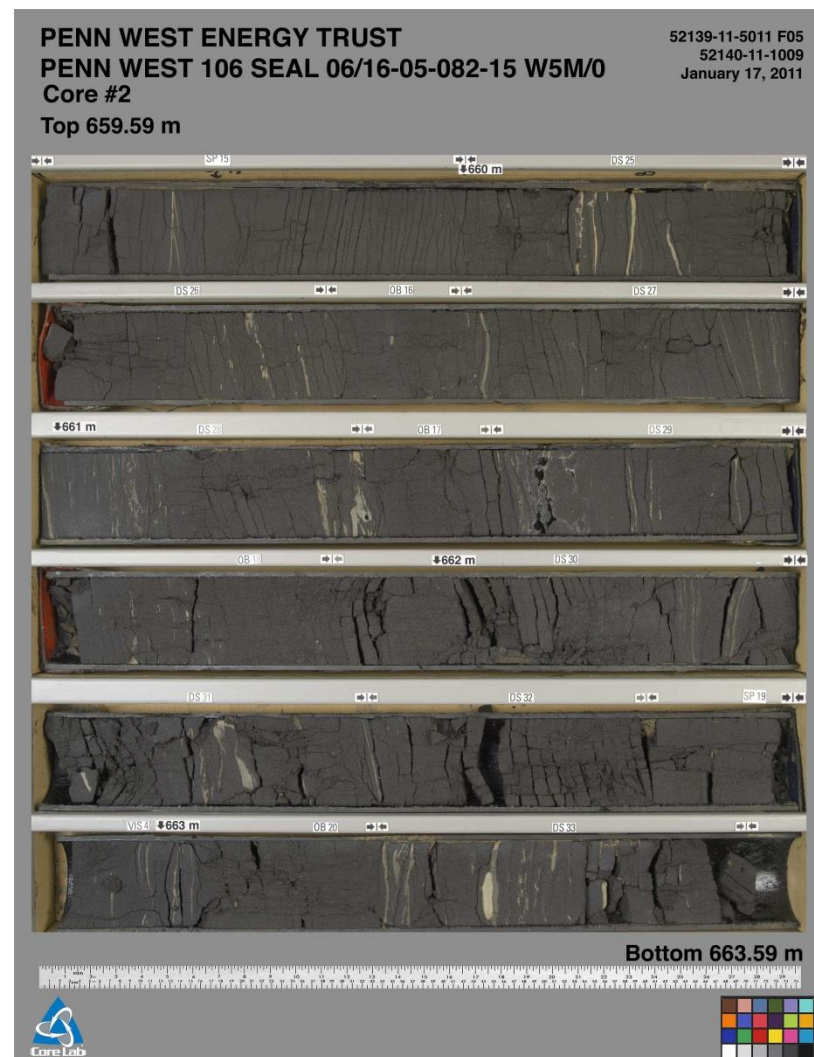
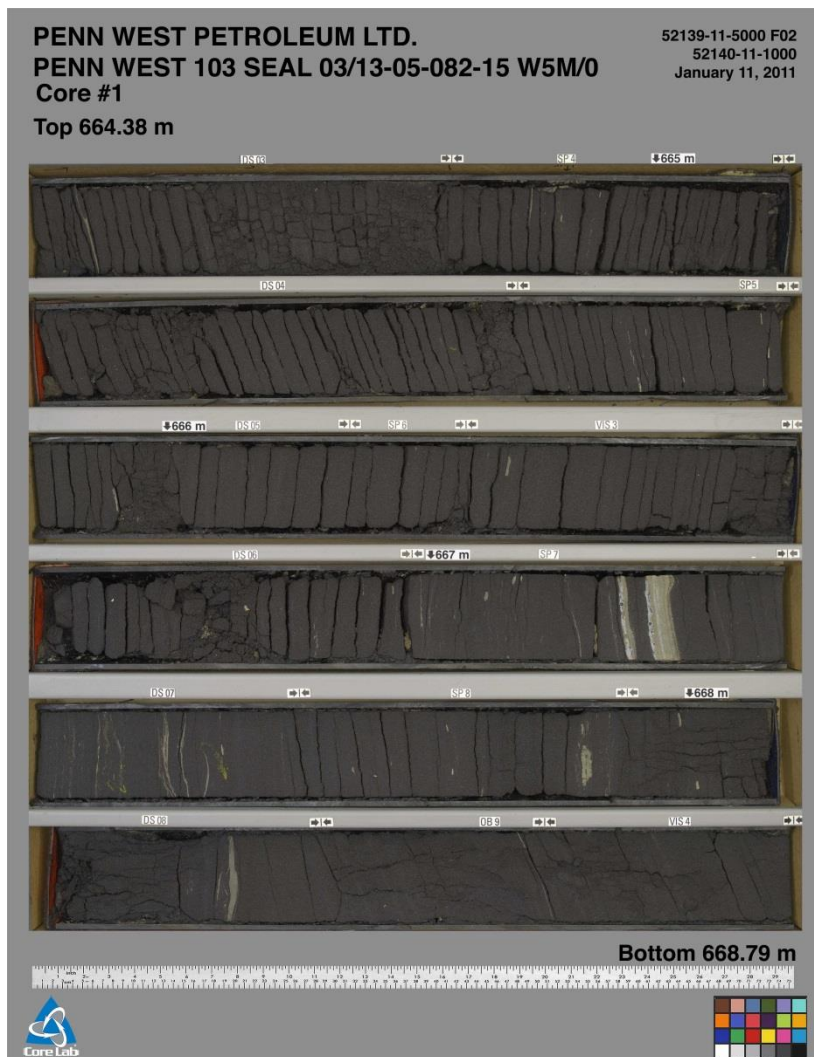


PennWest Exploration		
Base Bluesky Structure (mss)		
<small> Licensed to: Penn West Petroleum By: JW Date: 2012/01/10 Scale: 1:20000 Project: Seal Regions geoSCOUT </small>		



PennWest Exploration		
Bluesky Net Pay (m) (Phi >24%, Res >20ohmm)		
Licensed to : Penn West Petroleum		
	By: JW	Date: 2011/11/02
	Scale = 1:20000	Project: Seal Regional O





- Penn West currently uses petrophysical cutoffs of 24% porosity and 50% water saturation to determine pay within the Bluesky in our thermal project areas at Seal Main and Harmon Valley South. These cutoffs closely conform to the 6 wt% bitumen cutoff that the AER prefers for oil sands projects. Penn West also uses an 8m pay thickness cutoff which we believe to be a generalized economic threshold for our CSS projects (as long as the above stated saturation and porosity cutoffs are met or exceeded).
- Within the estimated drainage area of the pilot well in Seal Main, the entire Bluesky sand section meets or exceeds these three cutoffs, with the exception of the lean zone at the base of the reservoir, which falls below the minimum saturation cutoff of 50%. Average weight% bitumen within the lean zone is approximately 4%. For this reason, the lean zone is not included in our OBIP calculation.
- The Net Pay map above shows that 20.3 ha was used for revised OBIP calculation. The 26.3 ha area shown originally on the average reservoir properties slide was for a longer thermal pilot horizontal well Penn West originally planned. Average reservoir properties slide has been revised to correct for this oversight.

Net pay (m)	18.6
Area (ha)	20.3
Porosity (%)	27
Water Saturation (%)	21.6
Viscosity (cSt at 20°C)	16,950
Permeability (mD)	2,615
Formation Temperature (°C)	20
Original Formation Pressure (kPa)	4,670
Formation Volume Factor	1.02
OBIP (e ³ m ³)*	782

*Based on the area immediately around the pilot well bounded by the adjacent primary wells

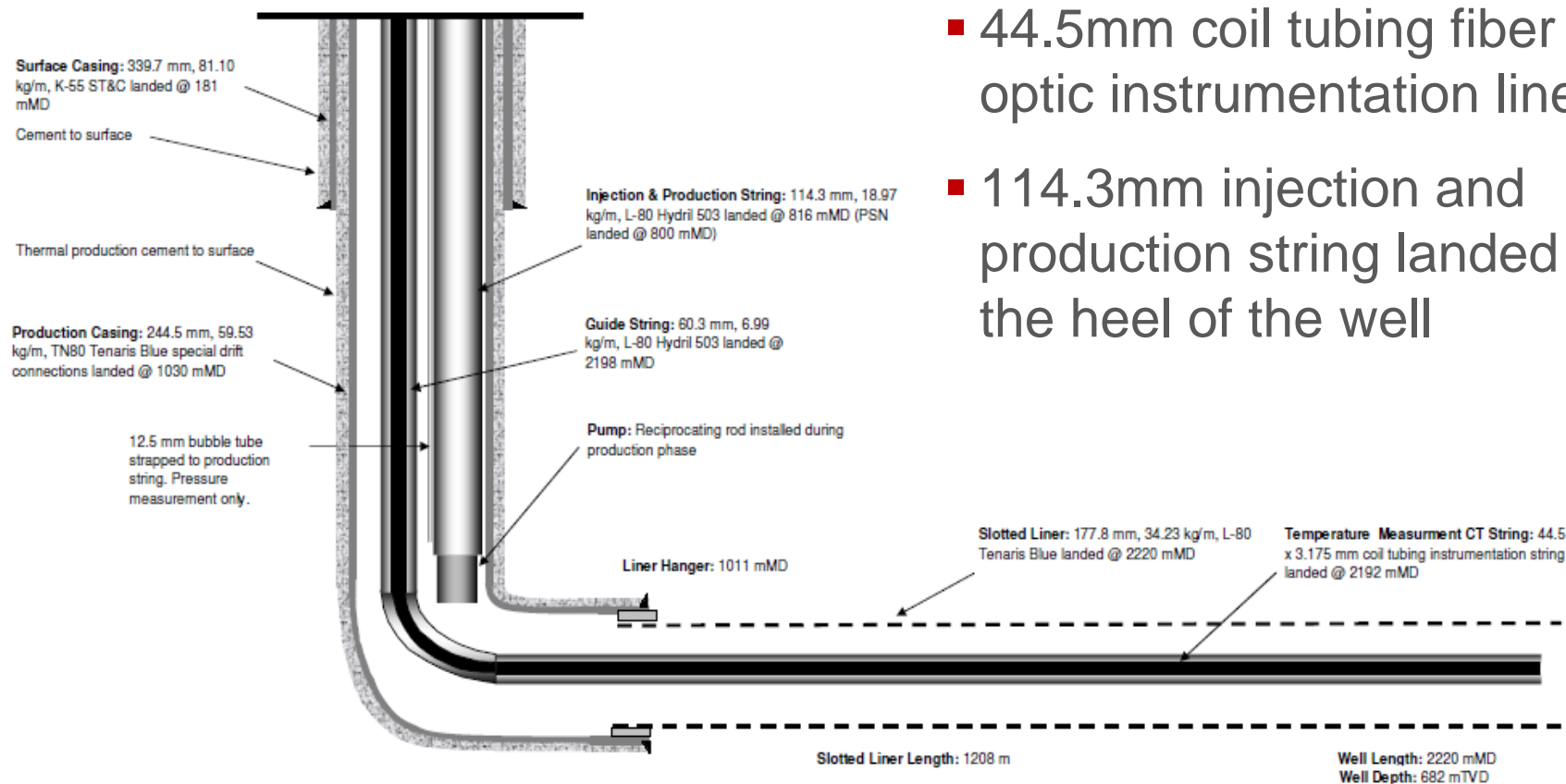
- In 2009, a mini-frac test was conducted in 100/03-32-082-15W5
- When Penn West re-evaluated the data in 2011, it deemed the test data as inconclusive
- Penn West performed two new MDT mini-frac tests to determine the closure stress in the Wilrich and Bluesky Formations:
 - At 05-29-082-15W5 crossing the fault in Section 29
 - At 15-08-082-15W5 away from the fault
- After processing the data, the following gradients are calculated:

Stress Gradient Source	Stress Gradient kPa/m
Overburden stress (from density log)	21.3
Overburden stress (from minifrac) in Wilrich	21.4
Minimum horizontal stress in Wilrich	22.3
Minimum horizontal stress in Bluesky	18.6

- The MOP granted by the AER for the pilot is 10.5MPa (16.5 kPa / m)

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- 60.3mm guide string run to the toe of the well
- 44.5mm coil tubing fiber optic instrumentation line
- 114.3mm injection and production string landed at the heel of the well



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- For the first two production cycles, a 3.25" insert rod pump was installed
 - A VFD was installed to control pump speed and efficiently maximize production rates
 - A 1280-365-240 pumpjack capable of moving 216 m³/d total fluids was installed
- For the third production cycle, a 220 MET 1000 PCP was installed
 - Rated for temperatures to 350°C
 - Good success to date, currently still running same pump in fourth production cycle

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- Fiber optic DTS was installed in the pilot well to monitor temperature from wellhead to the toe of the well at 2,036m MD
- An automated dual bubble tube N₂ system was installed at the heel and toe for accurate pressure data measurement
- The system is designed with the ability to perform a N₂ purge from surface

- Three observation wells were drilled at a lateral distance of 5.3m to 9.9m from the horizontal wellbore, at the heel, midpoint and toe
- Real-time pressure and temperature monitoring accomplished via fiber optics and single point pressure gauges spaced in the reservoir
- Deviated observation well at the toe of the horizontal wellbore equipped with casing conveyed pressure gauges

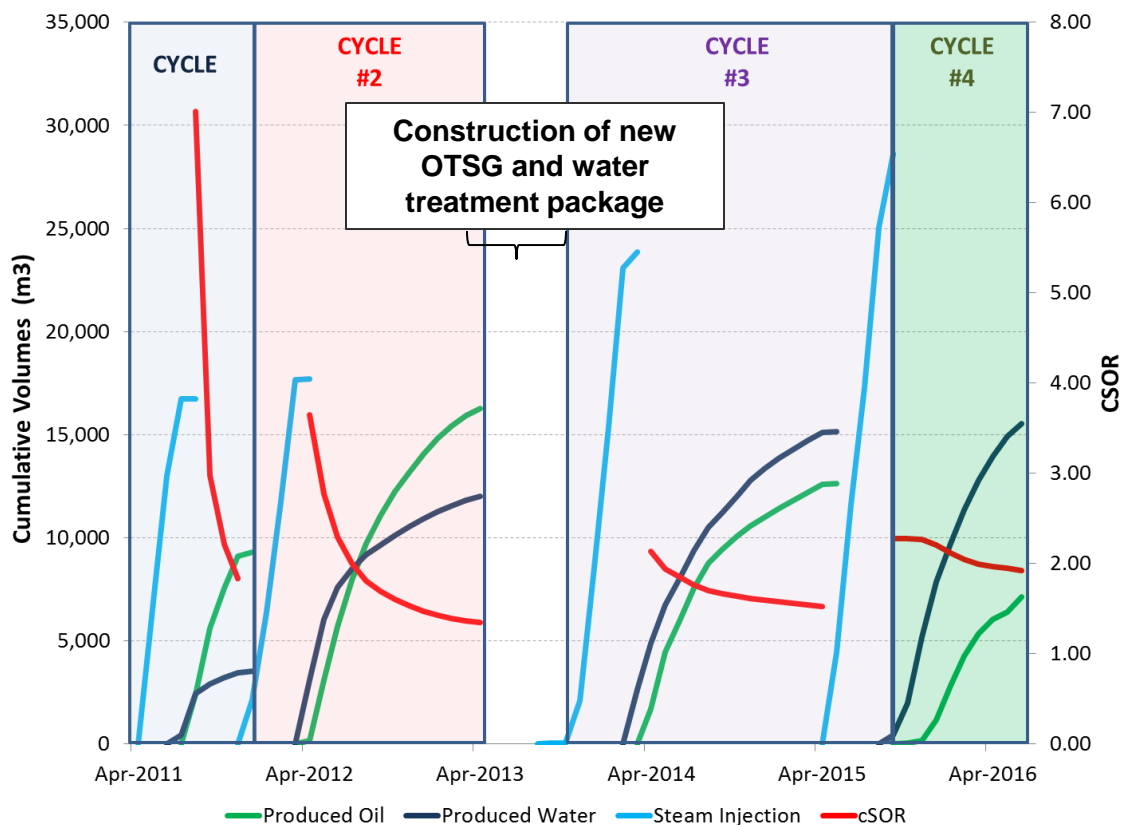
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- No current plans to conduct 4D seismic at Seal Main Pilot Project

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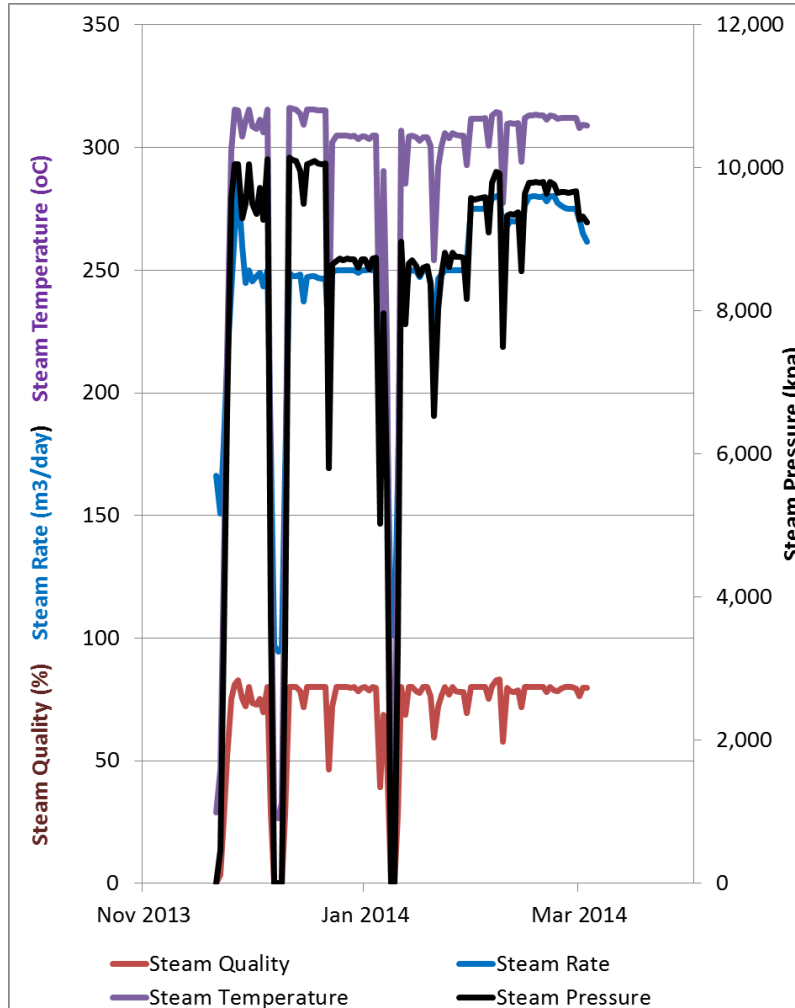
Scheme Performance – Cumulative Volumes PennWest

	Steam	Oil	Water	Gas	CSOR
1 st cycle	16,749 m ³	9,304 m ³	3,531 m ³	58 e ³ m ³	1.8
2 nd cycle	17,699 m ³	16,277 m ³	11,992 m ³	744 e ³ m ³	1.35
3 rd cycle	23,872 m ³	12,615 m ³	15,151 m ³	1,438 m ³	1.53
4 th cycle	28,616 m ³	7,142 m ³ **	15,546 m ³ **	898 m ³ **	1.92 **

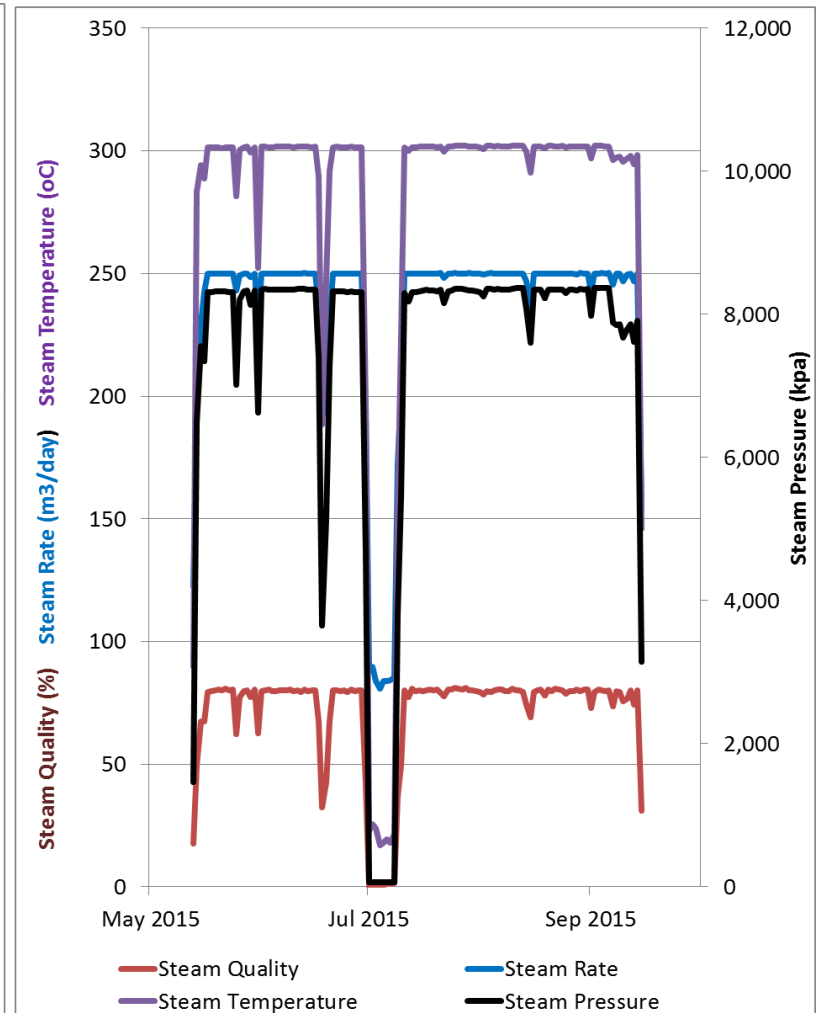


** production as of June 30th

Steam Cycle #3

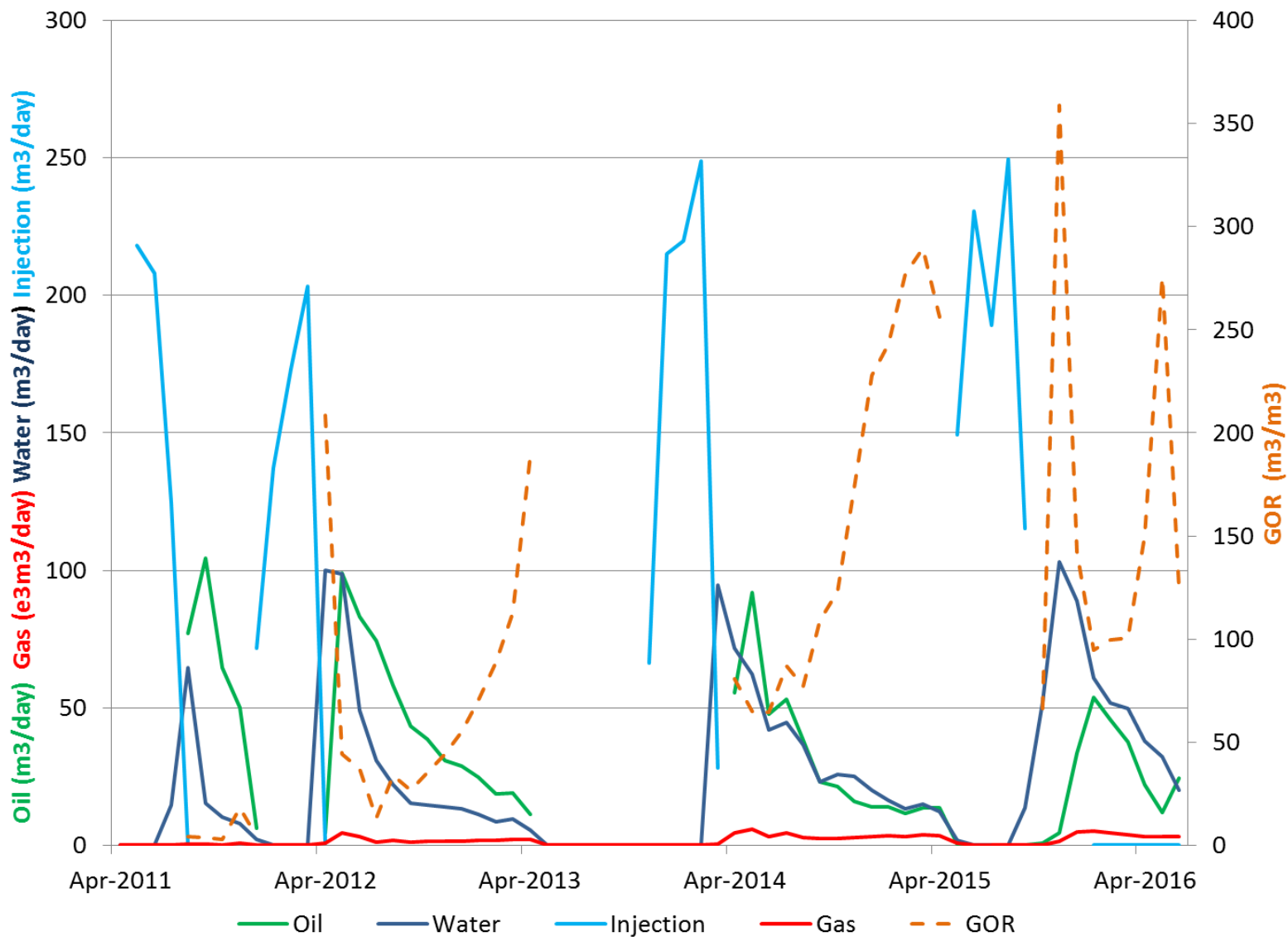


Steam Cycle #4



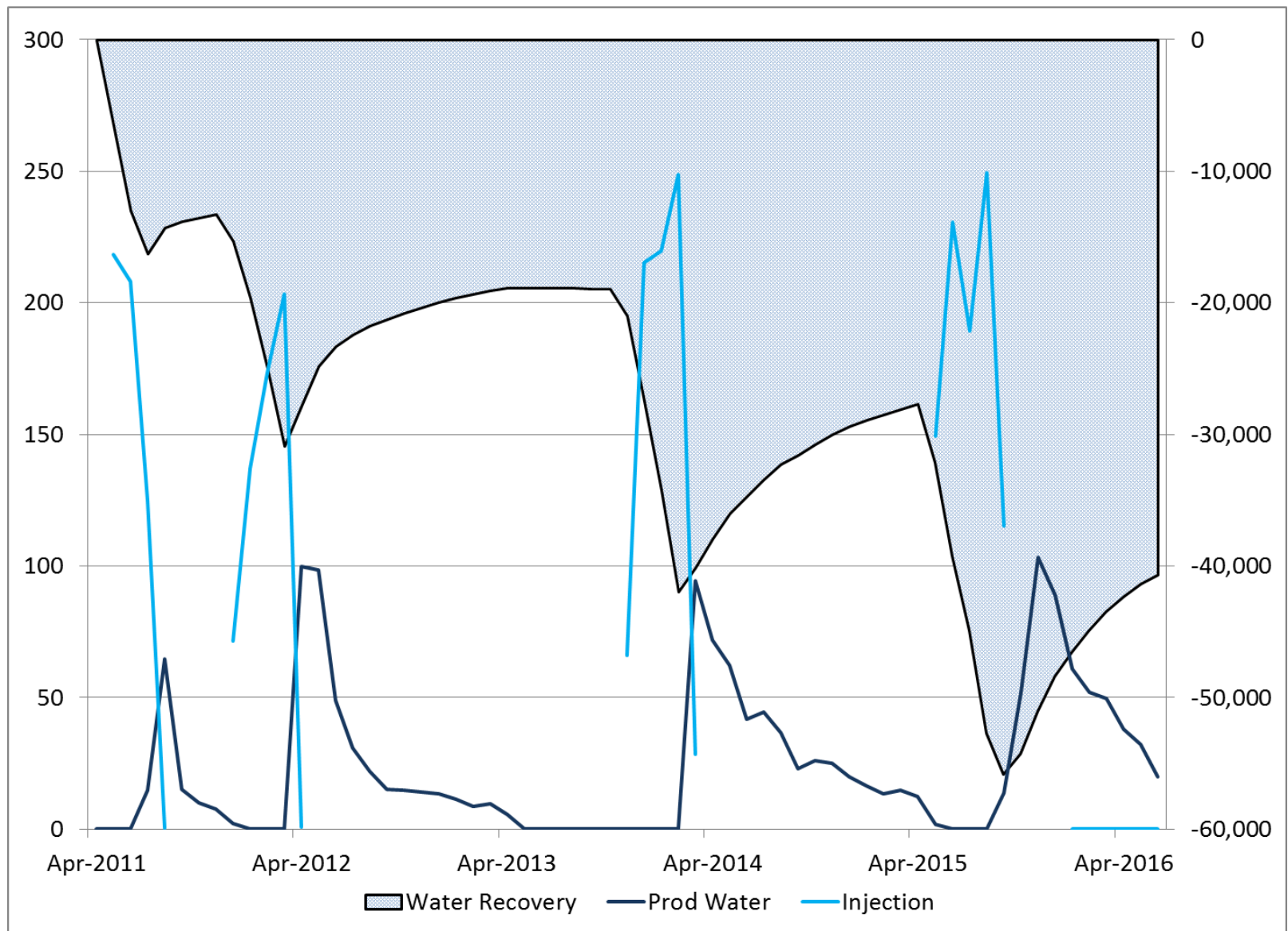
Scheme Performance – Production Rates

PennWest



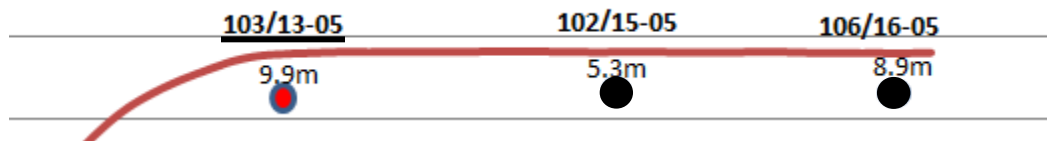
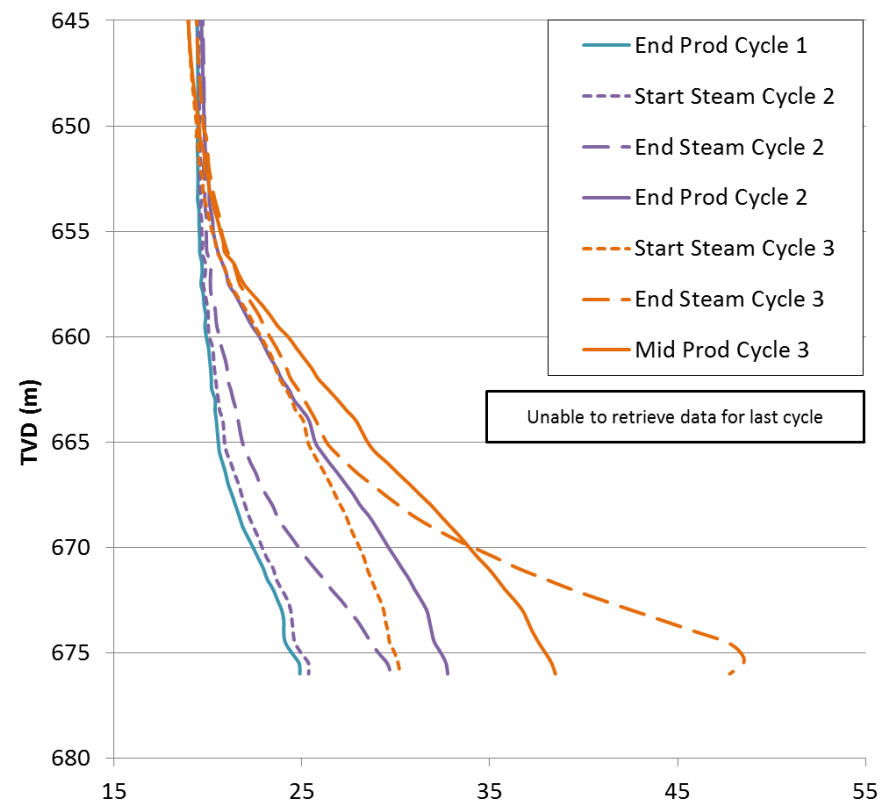
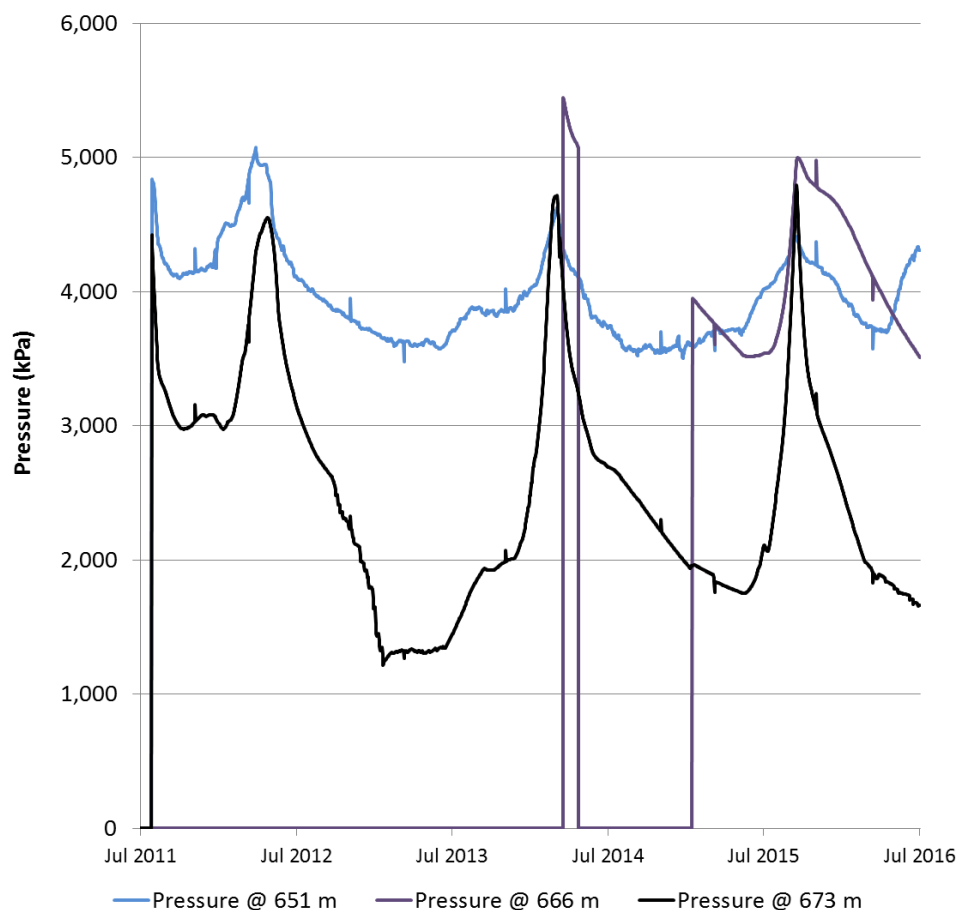
Scheme Performance – Monthly Injection and Water Production

PennWest



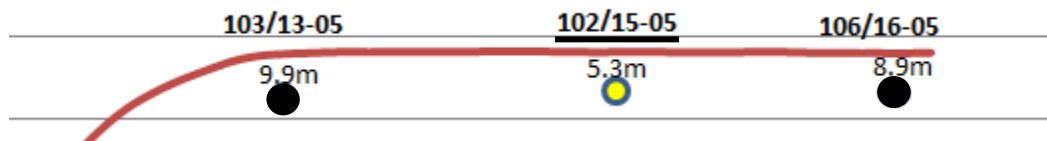
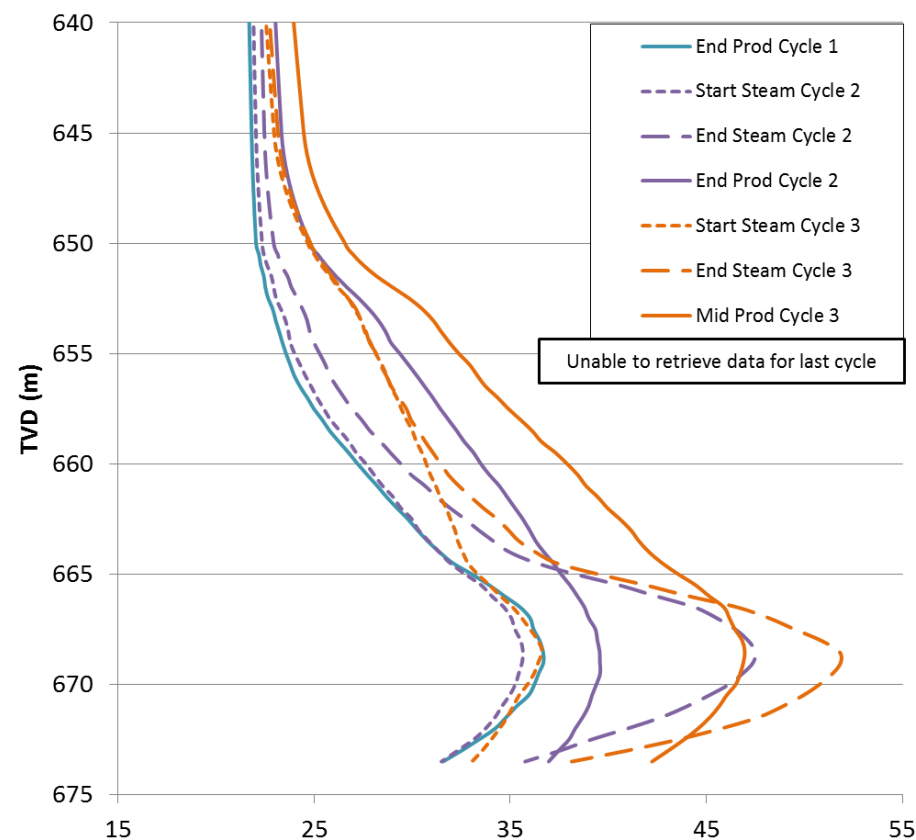
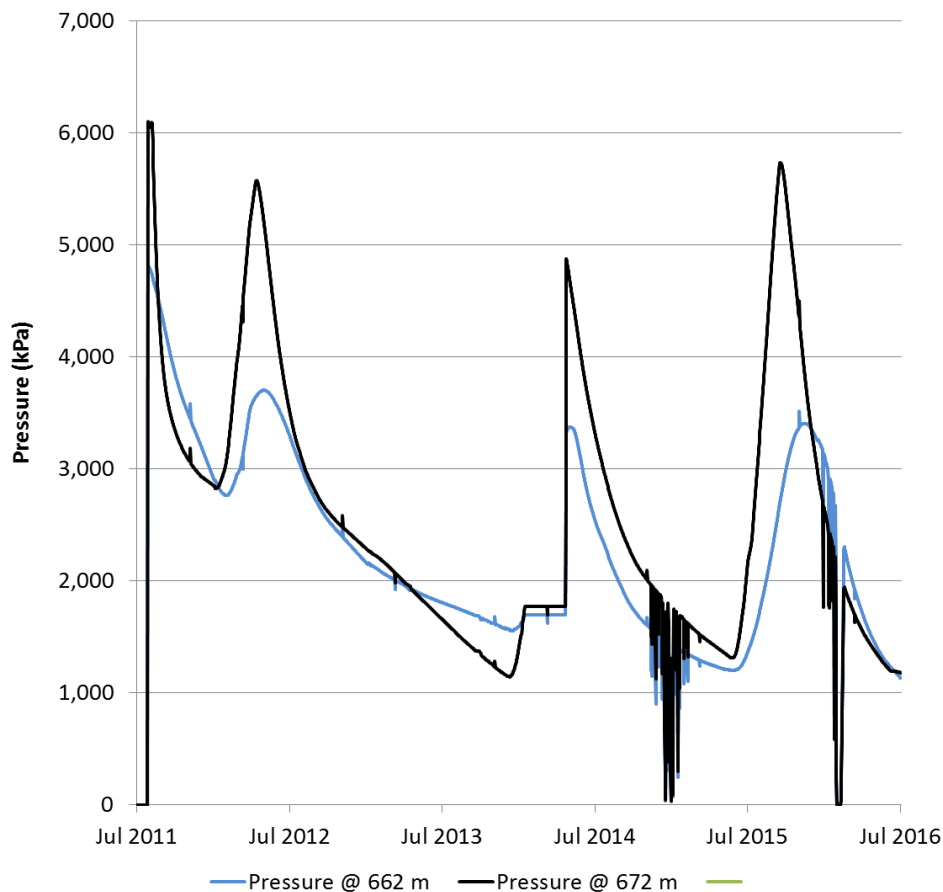
Scheme Performance – Observation Wells

103/13-05-082-15W5



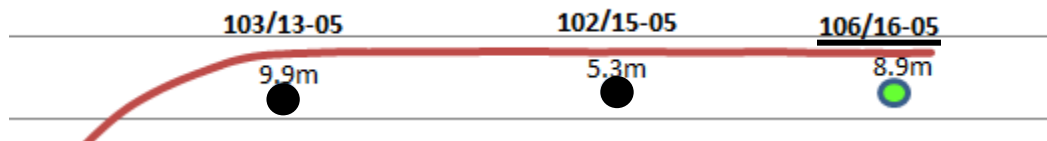
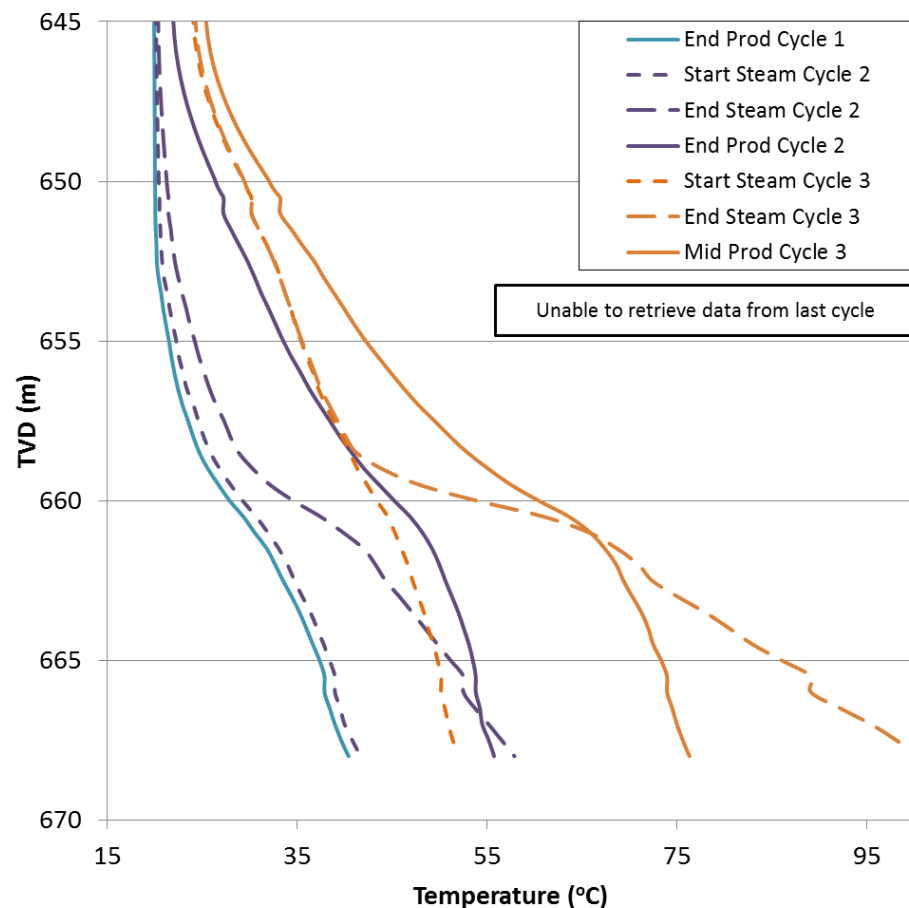
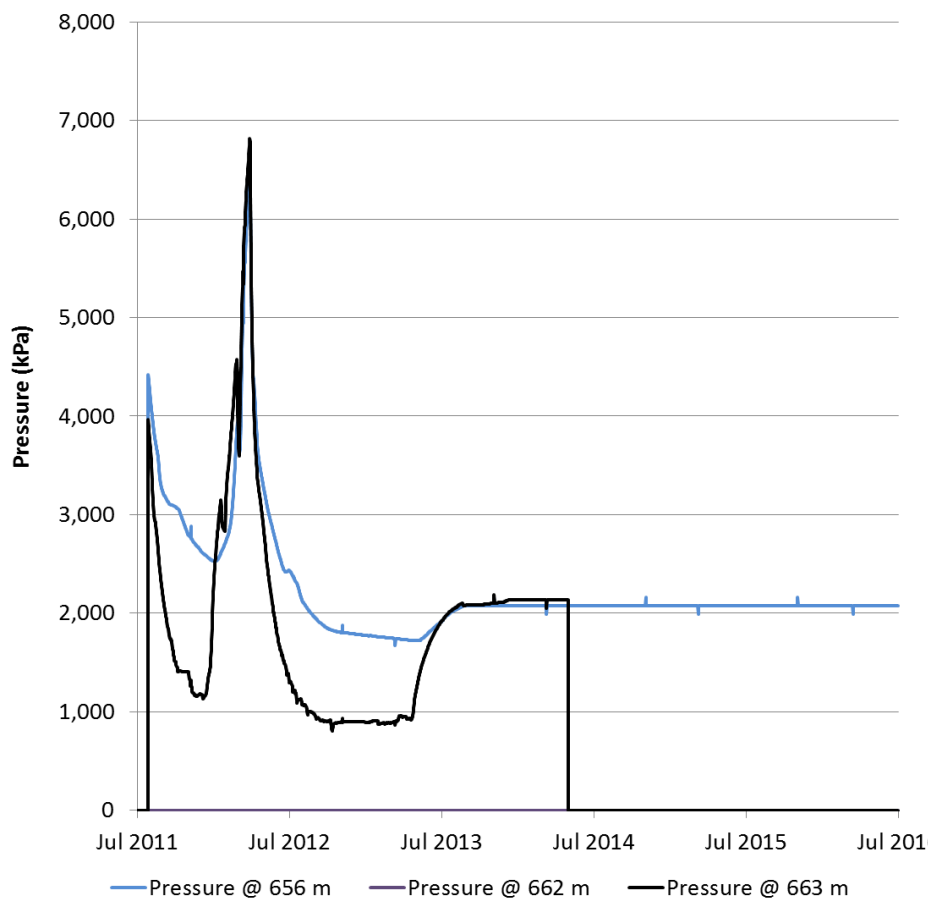
Scheme Performance – Observation Wells

102/15-05-082-15W5



Scheme Performance – Observation Wells

106/16-05-082-15W5



Cycle 1 Production (m ³)	9,304
Cycle 2 Production (m ³)	16,277
Cycle 3 Production to Date (m ³)	12,615
Cycle 3 Production to Date (m ³)	4,232
Total Production to Date (m³)	46,220 *
OBIP (m ³)	782,000
Current Recovery (%)	5.9%
Estimated Ultimate Recovery (%)	12%

* Only Thermal production included – as of June 30th, 2016

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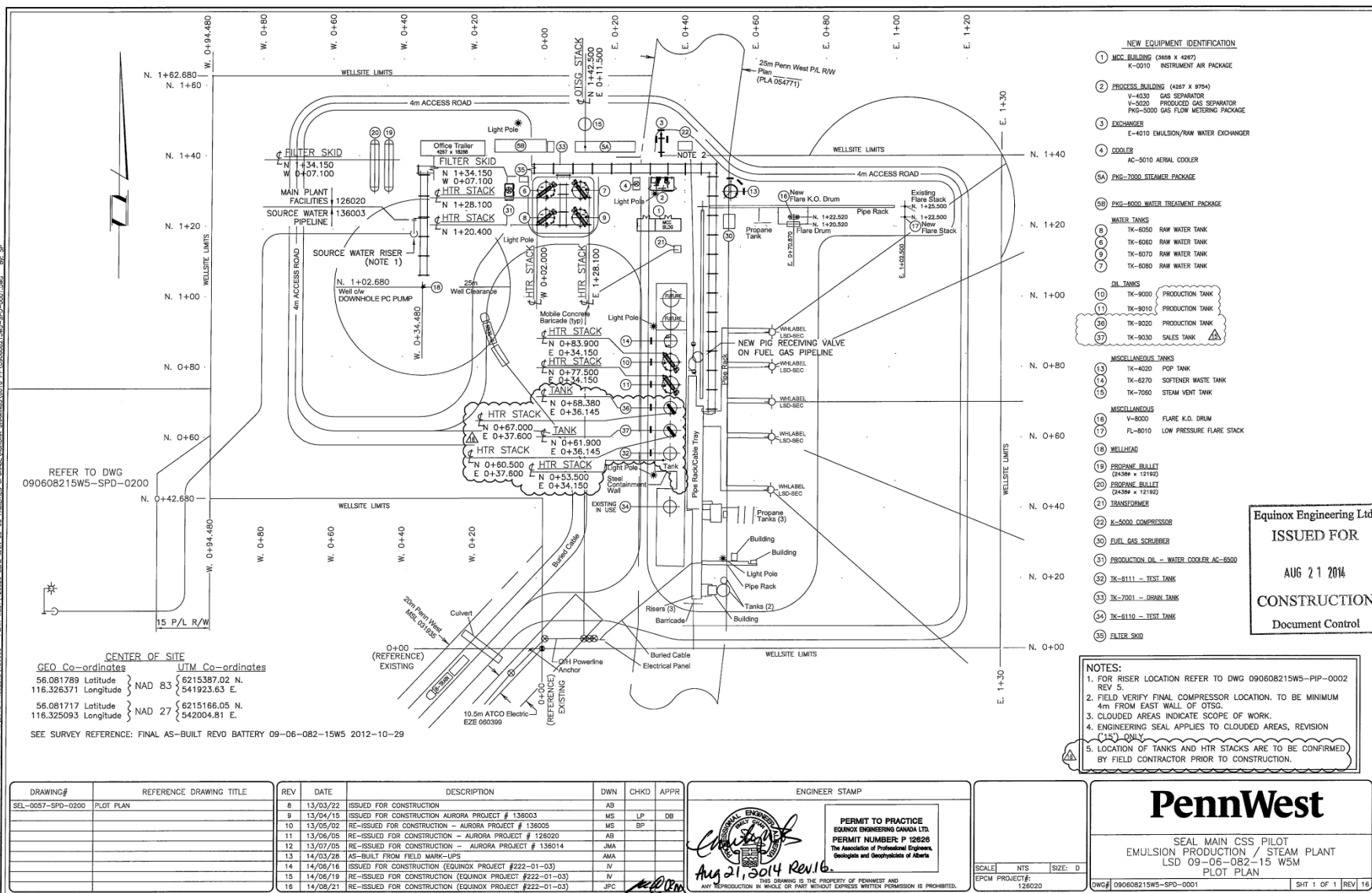
- Currently progressing Seal Main Commercial Application
- Evaluated pilot project response and economics in light of current market conditions and decision made to discontinue the pilot program – suspension underway.



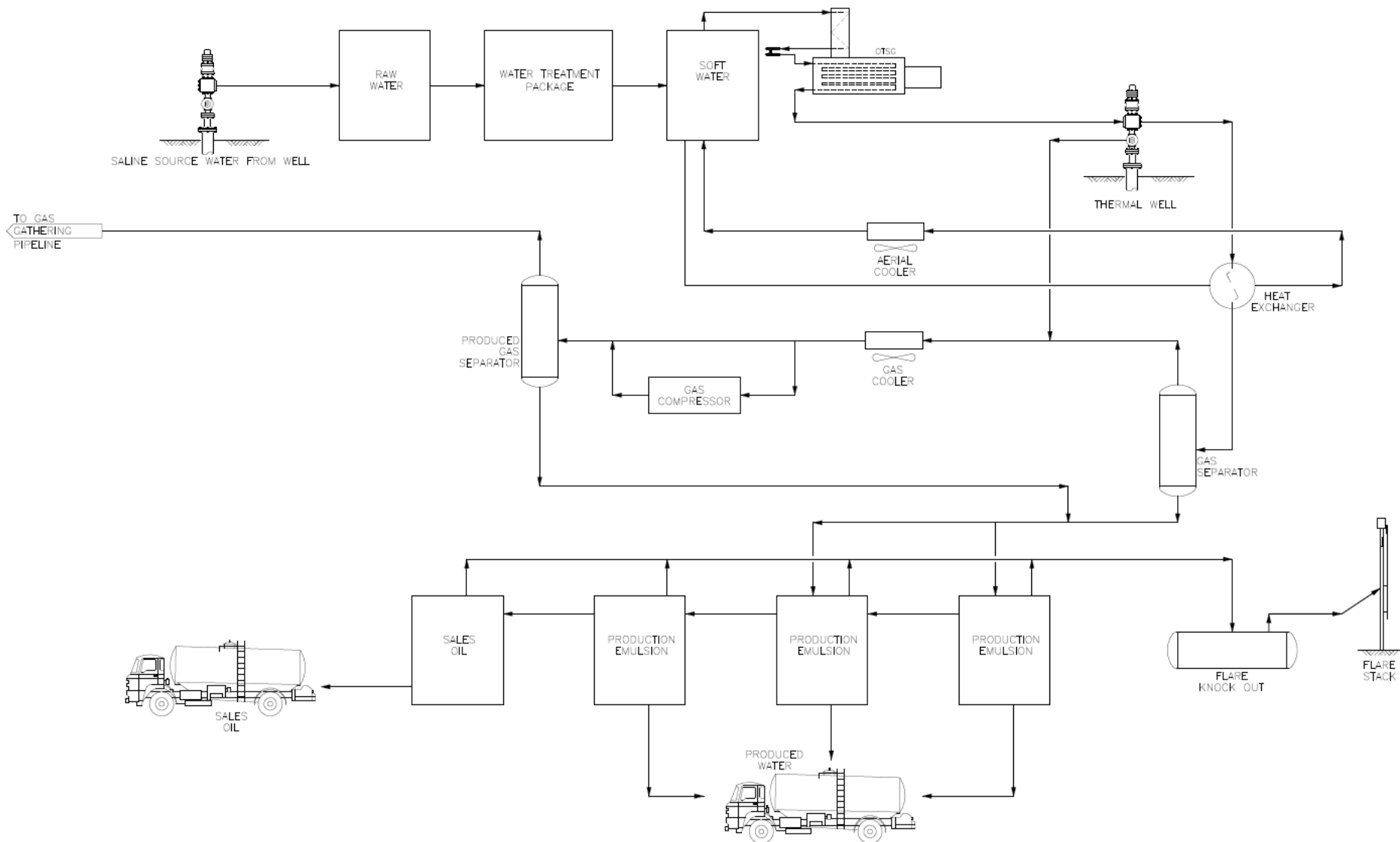
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Seal Main HCSS Pilot
Surface Review

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Facilities – Process Flow Diagram





- No modifications made over last year

■ Bitumen Treatment:

- Off-spec oil trucked to Tervita oil cleaning facility
- Facility can produce sales spec oil

■ Steam Generation:

- OTSG capacity 7.33 MW and 80% steam quality
- OTSG blower was oversized as the unit was built for operation in a warmer climate, Air-Fuel ratio adjusted accordingly
- OTSG installed outside and exposure to low temperatures created a variety of operational issues. Currently steam in summer months to eliminate these operational issues.

- Other Equipment:
 - Heat exchanger did not perform as designed due to corrosion, downtime required to clean and repair. No concerns since bundle replaced (original issue related to improper suspension of vessel)
- Many systems have no redundancy due to design as pilot facility
- Casing gas compressor in operation

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- Oil production volumes are estimated on lease by tank gauge and measured at the sales point by coriolis meter
- Gas production is measured on lease by orifice meters
- Steam injection volumes are measured by orifice meter
- Water flowing to injection facility from source water well is measured by turbine meter at the wellhead
- Fuel gas supply from 13-08-082-15W5 facility is measured by orifice meter
- As Seal Main is a single well pilot, no proration of injection or production is required
- Reporting as per Directive 017 requirements

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- Continued to use source water from the well: 1F1/01-07-082-15W5
- A total of 29,070 m3 of source water was produced over the past year for one steam cycle.

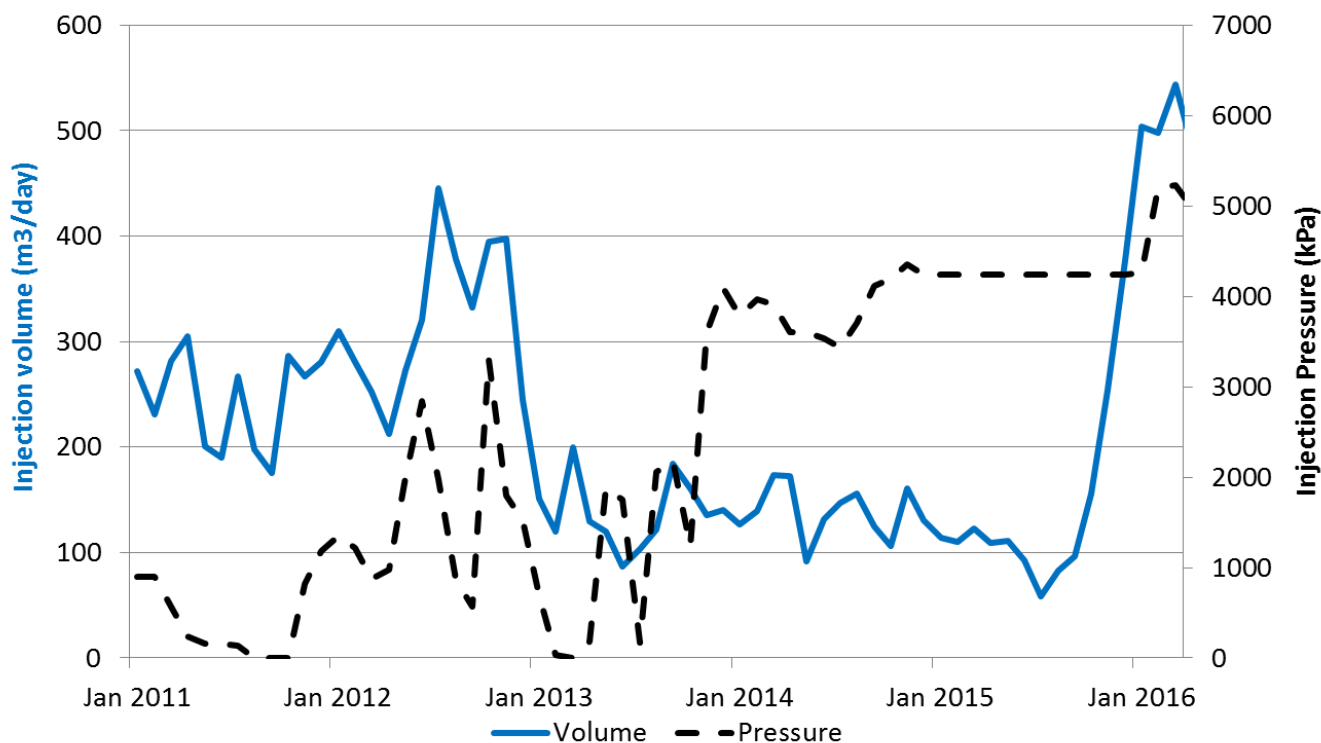
(09-06) 1F1/01-07-082-15W5/0	
Month	Source Water (m3)
Jan 2015	0
Feb 2015	0
Mar 2015	0
Apr 2015	0
May 2015	4988
Jun 2015	7272
Jul 2015	5604
Aug 2015	7725
Sep 2015	3482
Oct 2015	0
Nov 2015	0
Dec 2015	0
Jan 2016	0
Feb 2016	0
Mar 2016	0
Apr 2016	0
May 2016	0
Jun 2016	0

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- Package designed to treat saline water and produce Boiler Feed Water (BFW) quality suitable for a 7.33 MW OTSG
- The system is based on conventional softening technology (Depth Filters, Strong Acid Cation (SAC) & Weak Acid Cation (WAC) Systems) and included dual trains for 100% redundancy

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- Waste water from the pilot and 13-08-082-15W5 primary pad will continue to be injected into a Penn West disposal well located at 02-07-082-15W5 (Class II Disposal Well – Approval No. 10213 B)

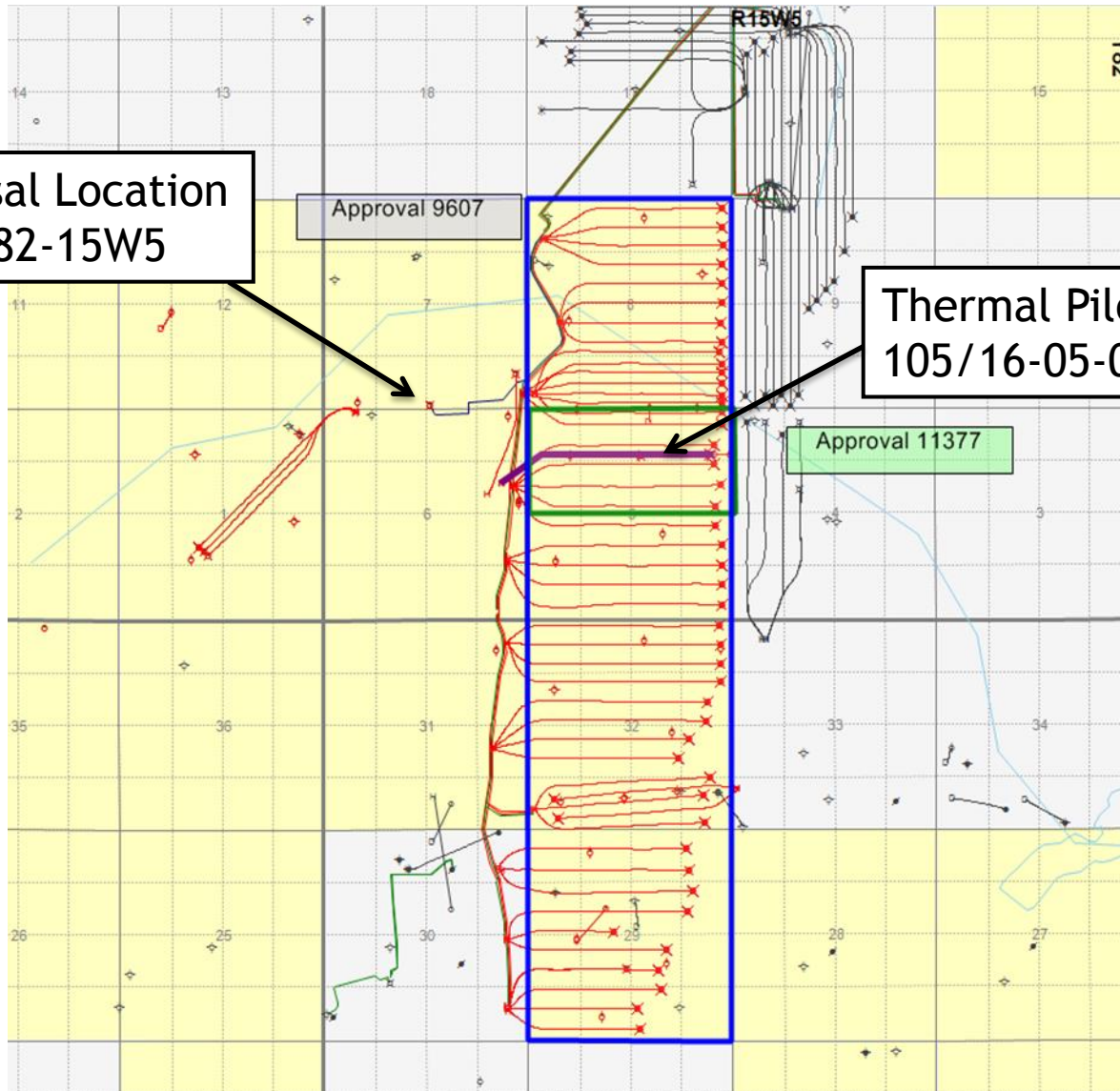


Water Disposal Location
100/02-07-082-15W5

Approval 9607

Thermal Pilot Location
105/16-05-082-15W5

Approval 11377



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- EPEA Approval for Seal Main Pilot facility does not require real-time Sulphur Dioxide (SO₂) emission monitoring
- Site is equipped with passive air monitoring for SO₂, nitrogen dioxide (NO₂) and hydrogen sulphide (H₂S) emissions
- Reports submitted monthly
- No exceedances on passive monitors for 2015.

2015	Average Reading (ppb)	Peak Reading (ppb)
January	0	0
February	0.7	0.9
March	0.4	0.5
April	0.2	0.3
May	0.6	1.1
June	0.4	0.5
July	0.3	0.5
August	0.4	0.4
September	0.6	0.8
October	1.0	1.1
November	1.2	1.5
December	1.4	2.0

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- EPEA Approval No. 308922-00-00 effective May 21, 2013
- Monitoring ongoing as per EPEA Approval conditions:
 - Air Emissions
 - Industrial Wastewater and Industrial Runoff
 - Groundwater
 - Soil Monitoring
- Participation in the Three Creeks Working

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- To the best of our knowledge, Penn West is in compliance with all the requirements and conditions of Commercial Scheme Approval No. 11377B and all other approvals related to the Seal Main HCSS Pilot.

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- No disclosures for 2015

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- No specific surface related plans
- Currently progressing Seal Main Commercial Application
- Evaluated pilot project response and economics in light of current market conditions and decision made to discontinue the pilot program – suspension underway.



Stock Exchange

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New York: PWE

Legal Counsel

Burnet, Duckworth & Palmer LLP

Independent Reserves Evaluator

Sproule Associates Limited

Transfer Agent

Canadian Stock Transfer Company
Toll Free: 1-800-387-0825
Email: inquiries@canstockta.com
Website: www.canstockta.com

Investor Relations

Clayton Paradis Manager, Investor Relations
Telephone: (403) 539-6343
Email: clayton.paradis@pennwest.com

Toll Free: 1-888-770-2633
Email: investor_relations@pennwest.com
Website: www.pennwest.com

Penn West

Suite 200, Penn West Plaza
207 – 9th Avenue SW
Calgary, Alberta, Canada T2P 1K3
Telephone: (403) 777-2707
Toll Free: 1-866-693-2707
Facsimile: (403) 777-2699
Website: www.pennwest.com