Suncor ESEIEH Phase 2 Small Scale Pilot Project
2015 AER Performance Presentation
Experimental Scheme Approval No. 12074

November 19, 2015
Reporting Period September 1, 2014 – August 31, 2015

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ESEIEH Pilot Project Overview

Effective Solvent Extraction Incorporating Electromagnetic Heating

- "ESEIEH" is an in-situ process using solvent dilution with moderate electromagnetic heating that may:
  - minimize Greenhouse Gas Emissions
  - improve efficiency, eliminating steam and water
  - access more bitumen at shallower depths
  - lower capital intensity and improve economics
  - present a *transformative technology* beyond SAGD
- Partners
  - CCEMC, Suncor, Devon, Nexen, Harris.

ESEIEH Pilot: Objectives

The primary objective of the Pilot Project is to demonstrate the proof of concept field test for the coupled vapour extraction and electromagnetic heating recovery process.

The principal objectives are to:

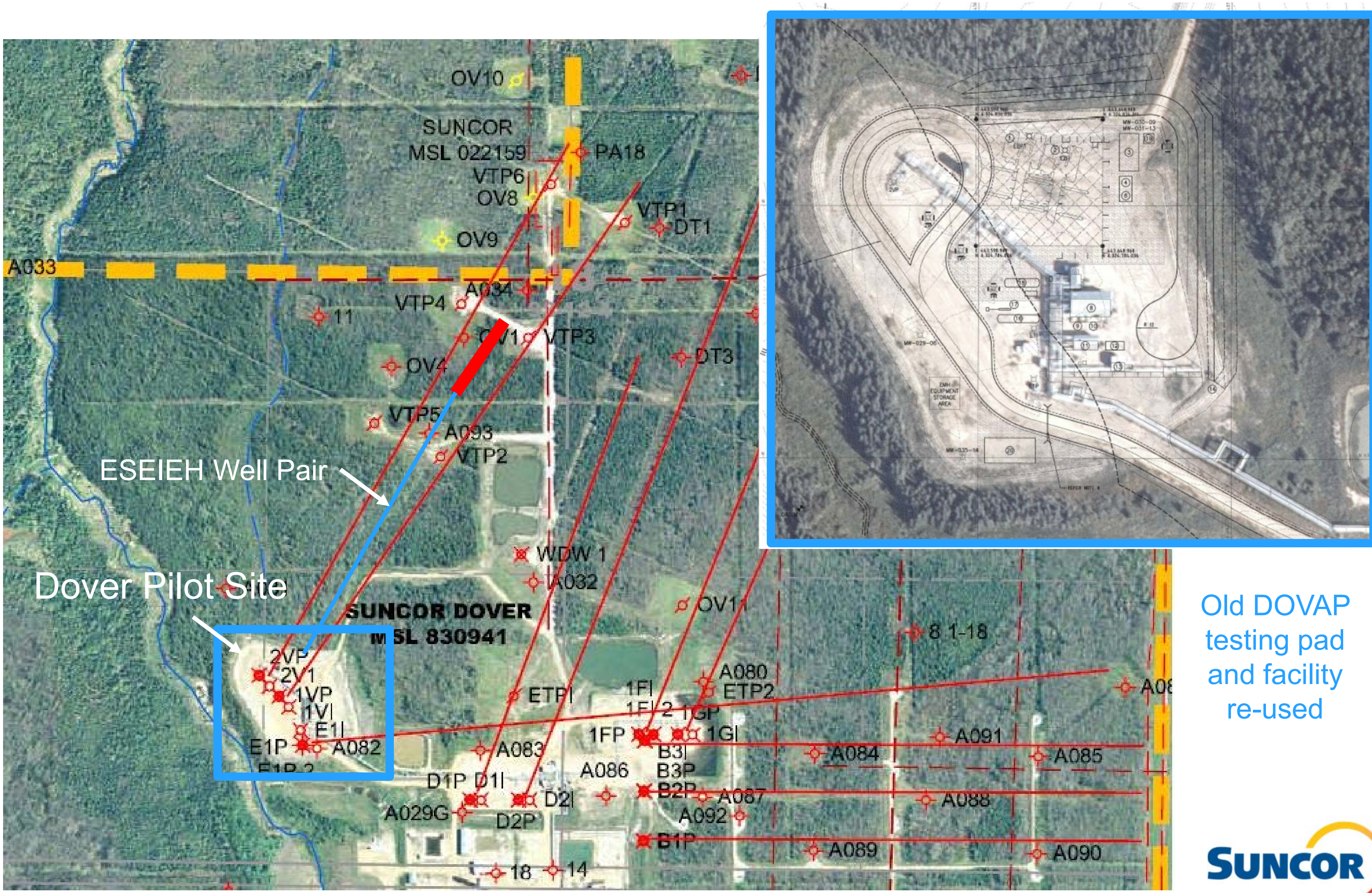
- Quantify bitumen drainage due to RF reservoir heating and propane vapour (the ESEIEH process extraction).
- Test the sensitivity of drainage to operating conditions (power, solvent injection rate or pressure, production rate control, etc.).
- Provide reliable field data to guide predictive numerical modelling and optimization studies.
- Establish key economic indicators including solvent performance, retention, power consumption, and delivery efficiency of RF energy to the reservoir.
- Pioneer the development of ESEIEH RF hardware and well design with respect to installation, functionality, reliability and efficiency.

ESEIEH Pilot: Key Criteria

Key criteria necessary to ensure a successful pilot operation are:

- Obtain sufficiently accurate field data to guide predictive numerical modelling and optimization studies for commercialization.
- Develop a comprehensive understanding of the effect of operating parameters on production controls.
- Determine the impact of factors such as methane accumulation and related controls on bitumen drainage.
- Validate the antenna design capable of delivering sufficient power to the formation to sustain the solvent extraction process (up to 4 kW/m).
- Establish that the well design and RF system can be efficiently and reliably installed and operated.
- Establish measured economic indicators including production rates, solvent retention, power consumption, and delivery efficiency of RF energy to the reservoir.
- Evaluate process economics and determine viability for commercialization.

Project Site



Old DOVAP testing pad and facility re-used

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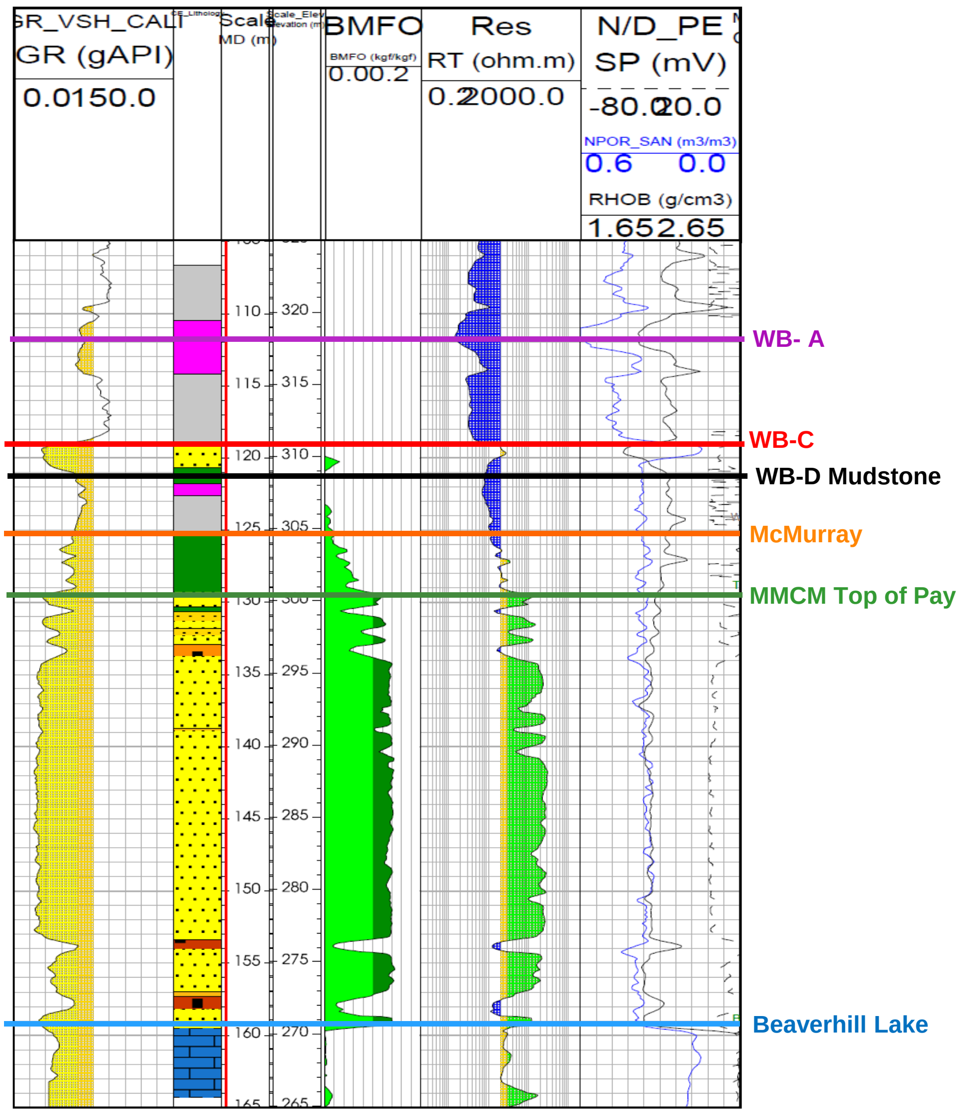
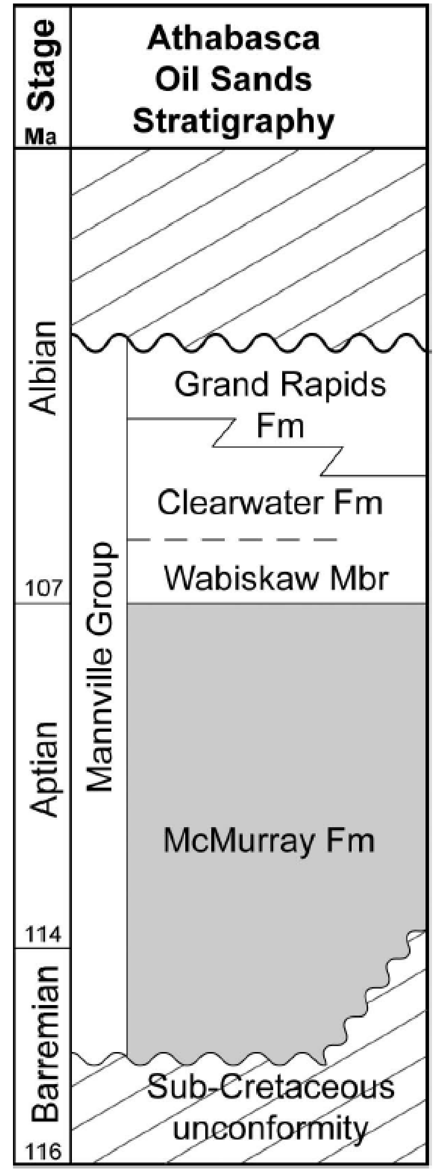
Geoscience

Stratigraphy

108-06-18-093-12W4 _EZOB-6

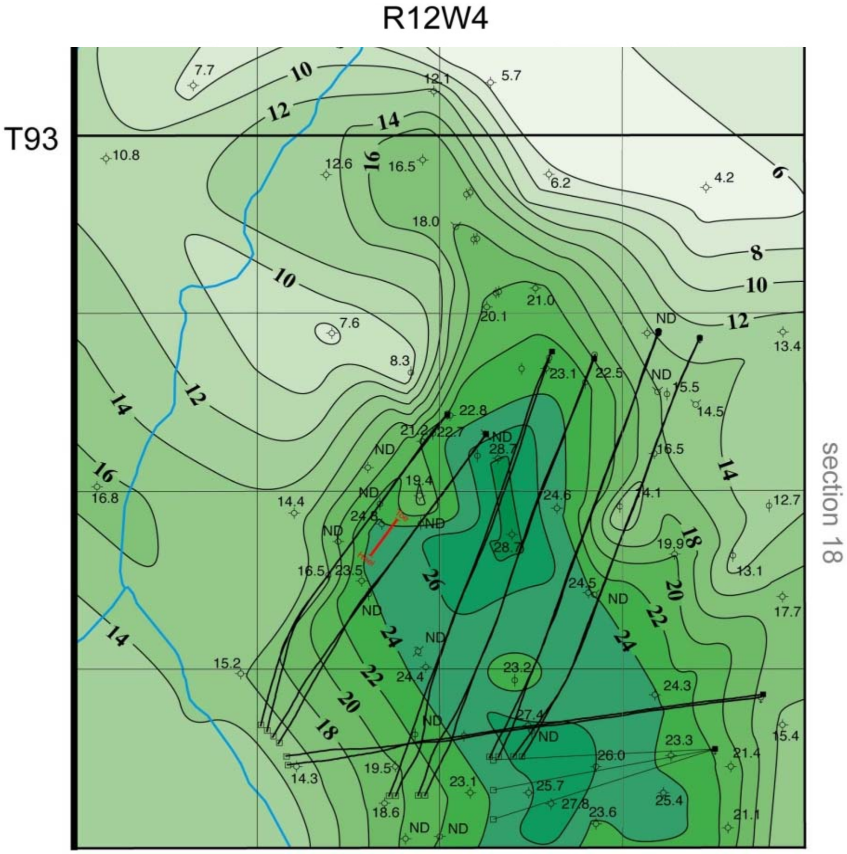




From Crerar and Arnott 2007

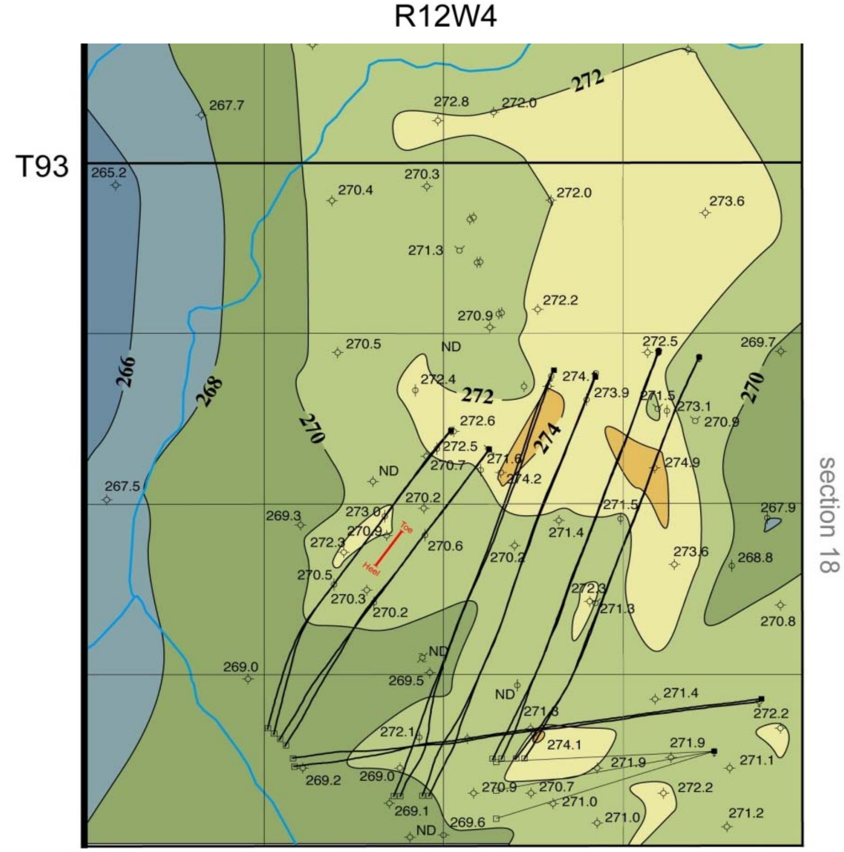
McMurray Pay and Devonian Structure Mapping

MMCM Continuous Bitumen Pay Isopach Thickness (m), CI: 2m



- Up to 31 m thick continuous bitumen pay
- Reservoir:
  - Clean, bitumen saturated sandstone interbedded with breccia.
  - Very little non-reservoir facies expected within pay zone.
  - Characterized by high porosity (> 35%), BMFO (> 0.10) and resistivity (> 30 ohm-m).

Devonian Structure, TVDSS, CI:2m

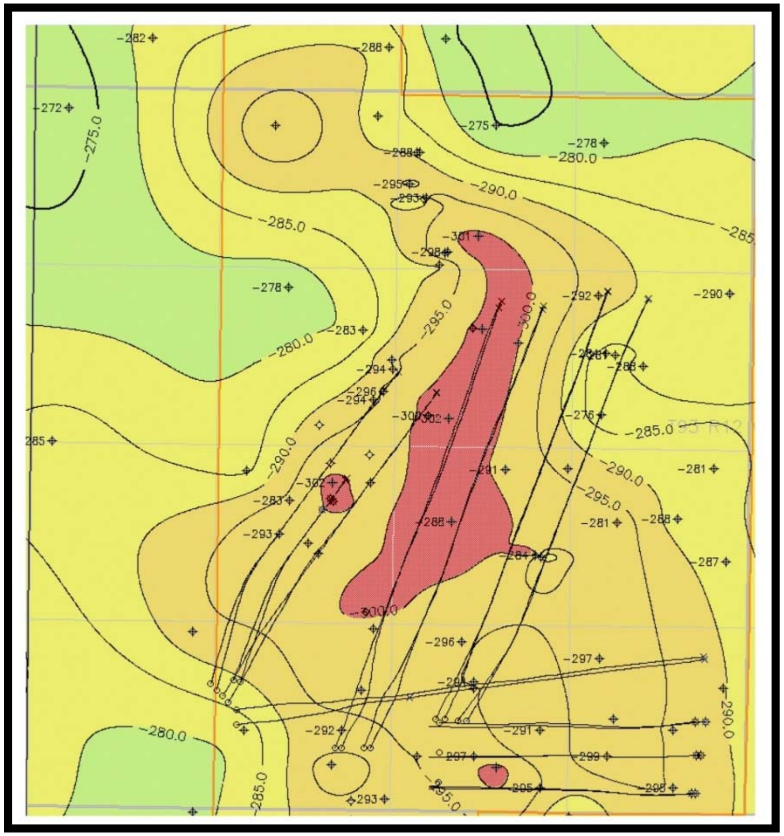


- Pilot site situated atop structurally flat Devonian surface
  - Several offsetting wells with less than 1m structural variation on Devonian surface
- High resolution 2D Seismic (2003) coverage exists in the region and supports structurally flat Devonian surface.

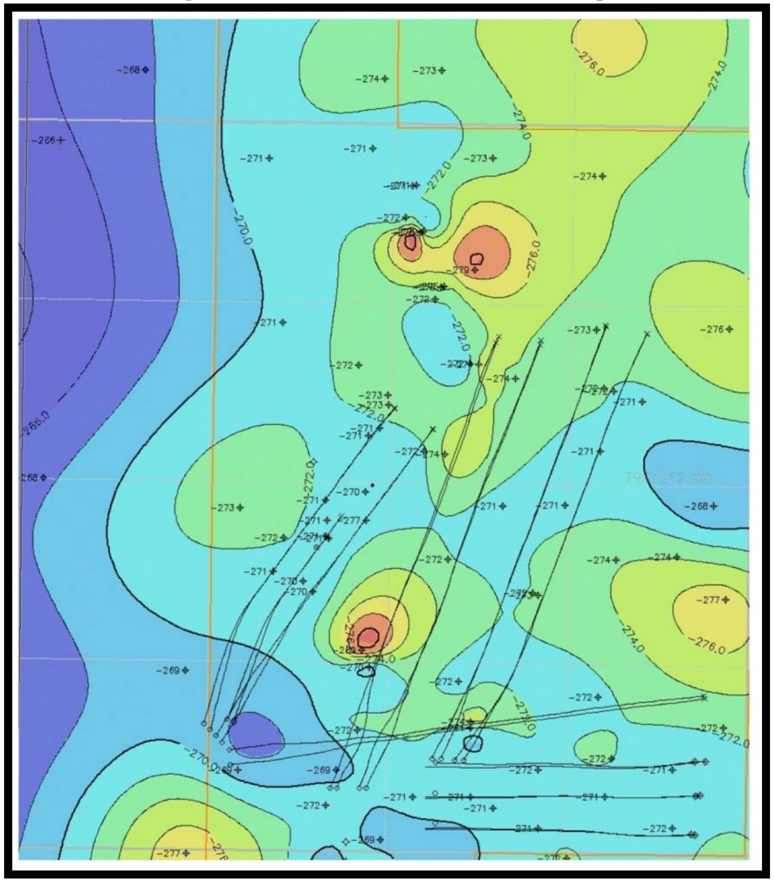
Maps created and prepared by Mike Ranger

Top and Base of Pay Structure Mapping and Average Properties

Pay Top Structure Map



Pay Base Structure Map



Porosity	Water Saturation	Net Sand Ratio	Rock Vol (M3)	OBIP (M3)	OBIP (MM bbls)
31.8%	12.0%	0.884	518,242	128,057	0.81

Maps created and prepared by Faye Warrington

Core Hole Evaluation Program

- Drilled 3 new vertical Observation wells.
- EZOB-2 cored and logged, conventional core analysis was conducted
  - Photography
  - Dean Stark: (avg, BMFO: 0.14 and avg. porosity 37%)
  - PSD
- EZOB-1 & EZOB-6 drilled and logged.
  - Unconventional core analysis conducted on EZOB-6. EZOB-1 was not cored.
  - Dean Stark: (avg, BMFO: 0.13 and avg. porosity 37%)
  - Viscosity
  - Water (Analysis and Salinity)
  - Vertical and Horizontal Permeability
  - XRD/SEM for understanding of clays

Testing Completed (7 samples)

Testing Completed (5 samples)

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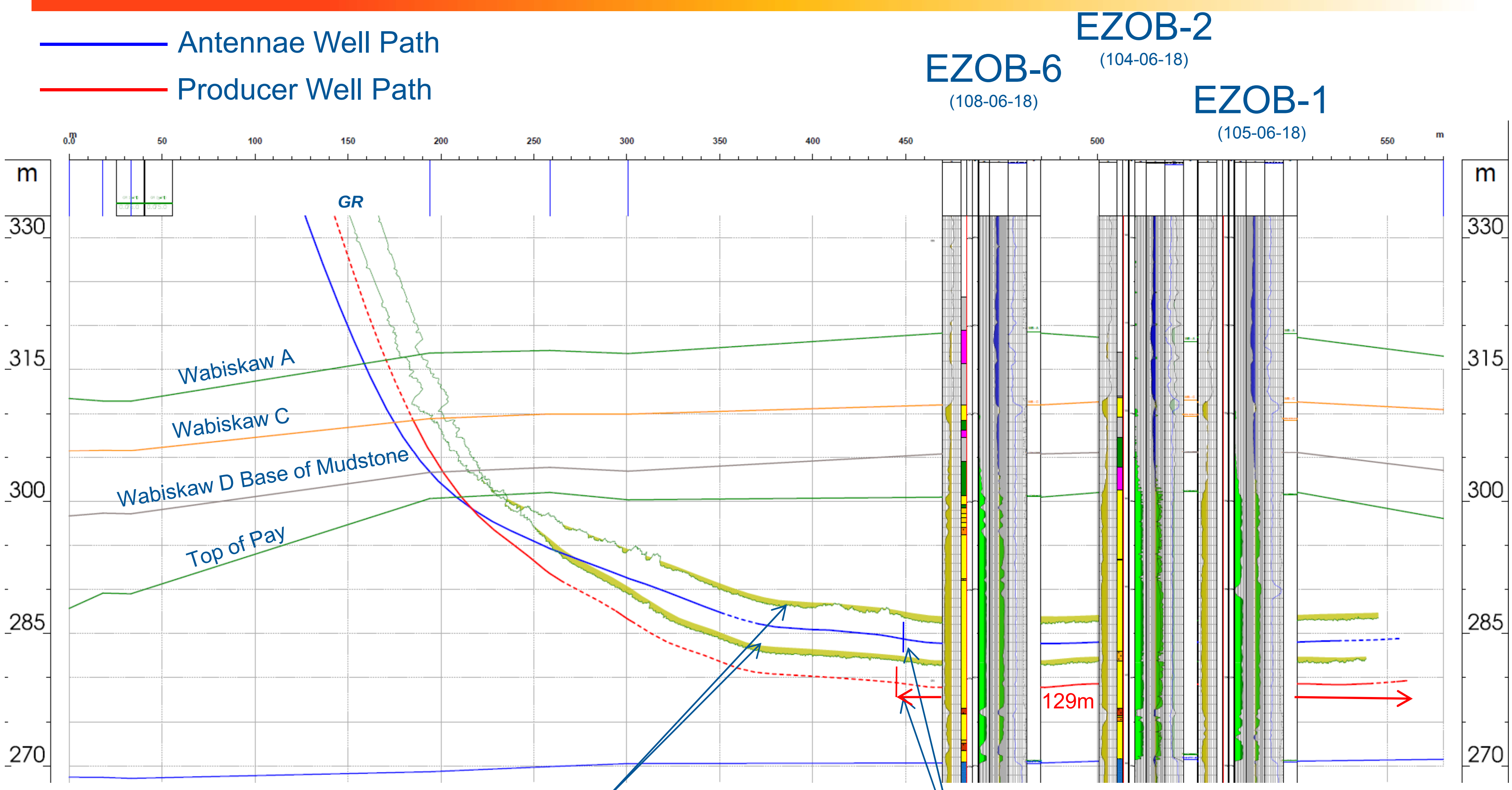
ESEIEH Horizontal Cross Section Results



Color fill on GR is at 35 API cutoff (very clean sand)

Approximate position of ICP
ICP EZI1: 448m
ICP EZP1: 445m

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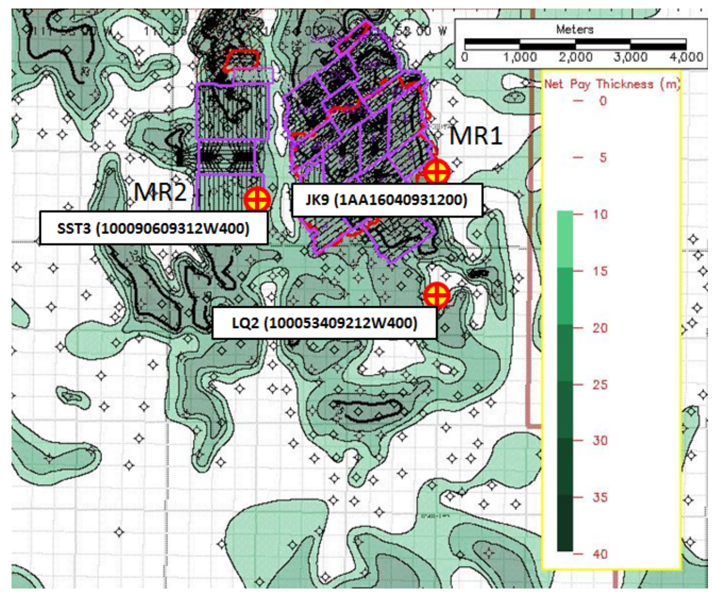
Geo-Mechanics: Mini-frac Test

The following information has been taken from the MacKay River Performance Presentation:

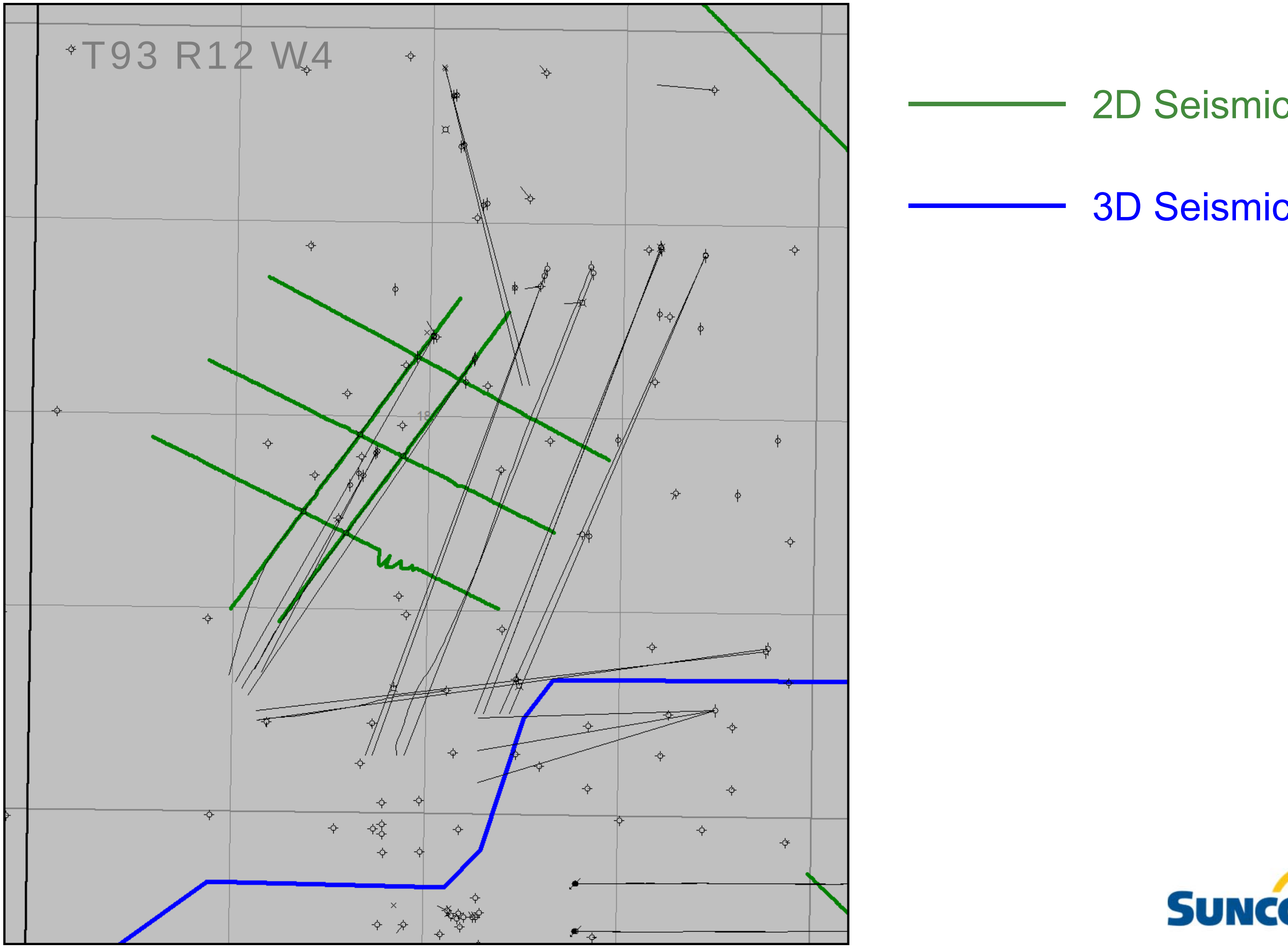
- One (1) mini-frac test was conducted since the last reporting period
  - JK-9 (1AB160409312W400)
  - Fracture gradient for caprock still holds at or above 21 kPag/m

Fracture gradient measured (kPag/m) from mini-frac test

Formation	JK-9 (2014)	SST3 (2008)	LQ2 (2011)
McM		19.9	21.1
WabD	22.1	24.3	22.6
WabA	21.1		21.2
CW	22.3	24.1	21.3



ESEIEH Seismic Database



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Well Drilling and Completion Operations

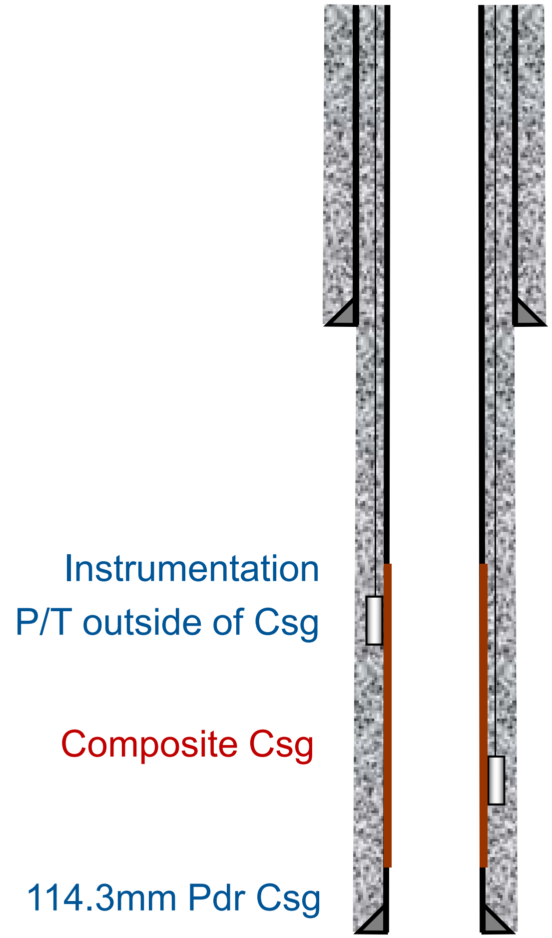
Drilling Operations

- The new well pair (EZ-WP1) was drilled in Feb 2014
  - 5m separation between injector and producer was achieved 100% of the HZ length
  - 8 5/8” production slotted liner with seamed slots 0.014” x 0.020”
  - 10 ¾” injection slotted liner with straight cut slots 0.012”

- 3 new observation wells were drilled within a few meters of the well pair
  - ✓ EZOB-2 is ≈ 5m from EZ-WP1 cored and logged in Sep 2013
  - ✓ EZOB-6 is ≈ 4m from EZ-WP1 cored and logged in Mar 2014
  - ✓ EZOB-1 is ≈ 2m from EZ-WP1 logged only in Mar 2014
  - installed RF transparent composite casing joints and instrumentation in all observation wells (cemented in place)

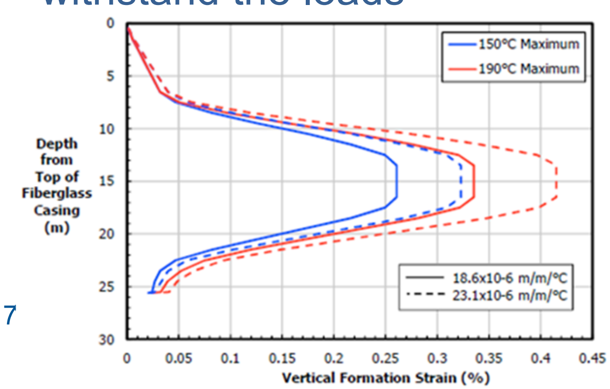
Observation wells Design

- Production casing design with 2 material string in order to guarantee well integrity and hydraulic isolation
  - 114.3mm 17.26 kg/m K55, Hydril 563 Production casing into the McM formation (reservoir), to ensure well integrity across the caprock
  - 114.3mm composite casing (E-Glass/Epoxy material), with K55 metal fittings, Hydril 563
    - 1 Short joint (~6.17m), and 2 long joints (~9.7 m) of composite casing used per OB well
    - E-Glass/Epoxy specially designed by ACPT to withstand thermal loads (external load tests performed)
  - Production casing cementing within McM (reservoir), thus not anchored on Devonian
  - RF instrumentation strapped outside of 4 ½" casing from TD to surface
- With this design fluid containment is similar to a standard Mackay OB well as the design is similar down to the reservoir. The only changes are within the reservoir where the composite casing is used.



Composite Casing

- Model was originally used to estimate load rates
- Real data lab test was conducted after:
  - Composite casing tests showed reasonable correlation in tension and less accuracy in compression compared to model
  - Compression results do not fully represent tube behavior as boundary conditions of test significantly different from in situ conditions (small block cut from tube was used so there is loss of continuity of fiber winding around a whole cylinder)
- Refined model was done to predict system behavior:
  - Modeled temperature profile
  - Cement CTE obtained from vendor
  - Formation strain both from model and field measured
- 3 different constrain scenarios used and results show that in the worse case scenario composite casing would be able to withstand the loads



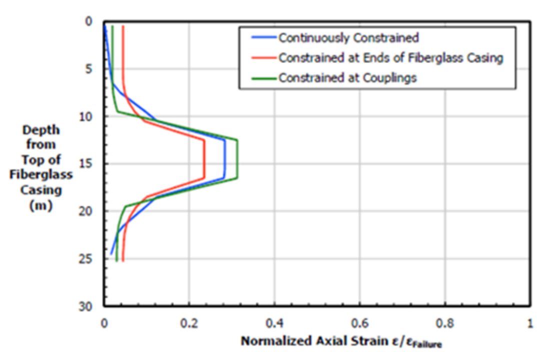
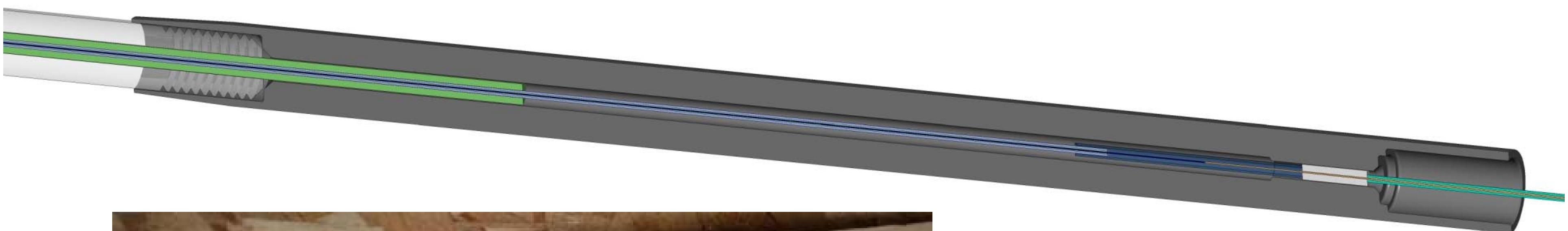
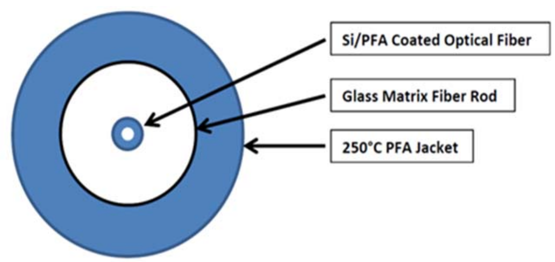


Figure 15. Normalized axial mechanical strains in reservoir heated to 190°C maximum and CTE = 23.1x10^{-6} m/m/°C.

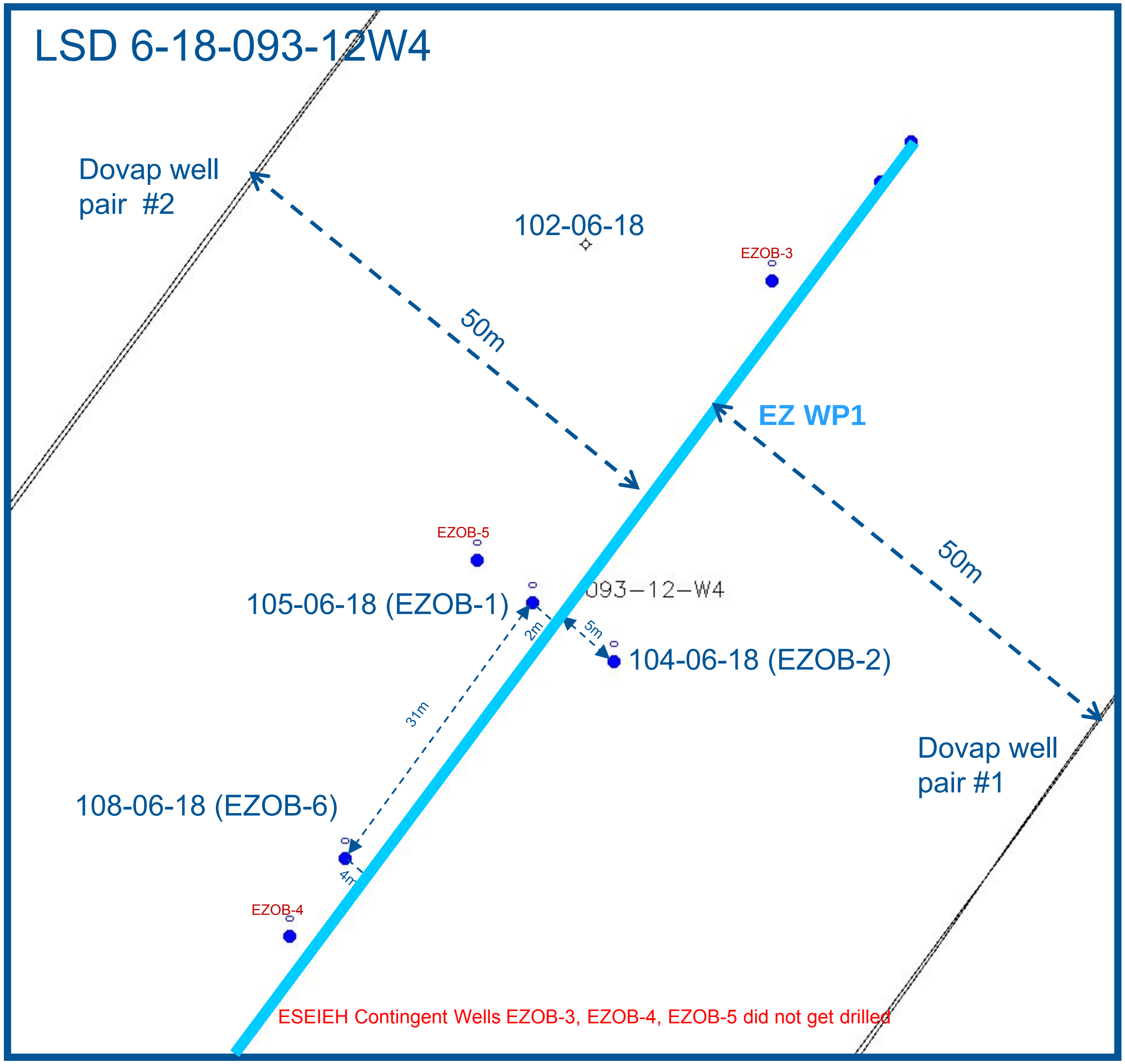
RF Instrumentation Design

- Instrumentation line and attachment to piezometer were specially developed for this project
  - PFA jacket used instead of common stainless steel capillary line
  - Fiber developed by AFL in conjunction with Harris
  - Attachment to piezometer develop by Harris and final assembly develop by Opsens Solutions
- Final assembly successfully passed test in an environment chamber under expected In-Situ pressure and temperature
- Feed through connector on wellhead guarantee isolation of PFA jacket





Wells placement



- ✓ EZOB-2 is ≈ 5m from EZ-WP1
- ✓ EZOB-6 is ≈ 4m from EZ-WP1
- ✓ EZOB-1 is ≈ 2m from EZ-WP1

Completion Rig on ESEIEH Injector/Antenna Well

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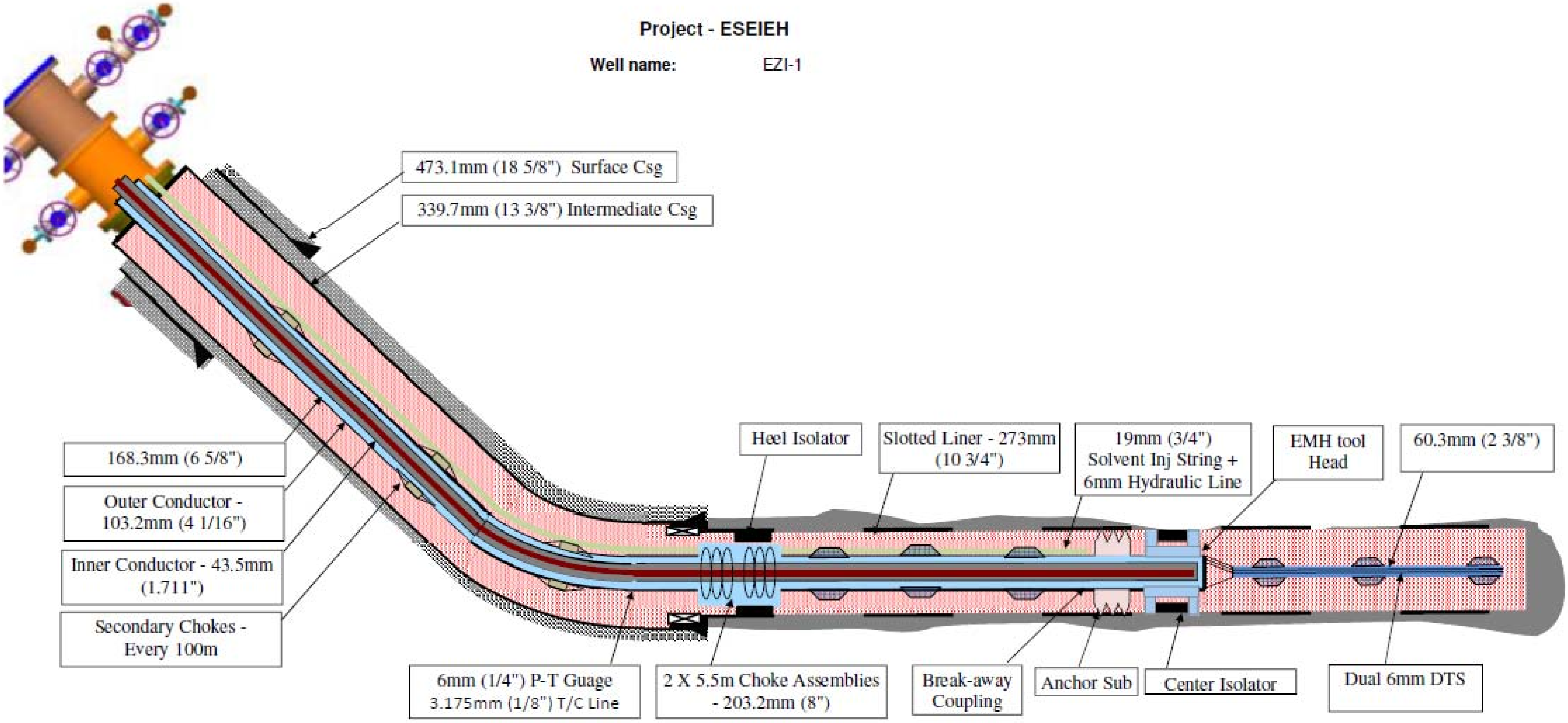
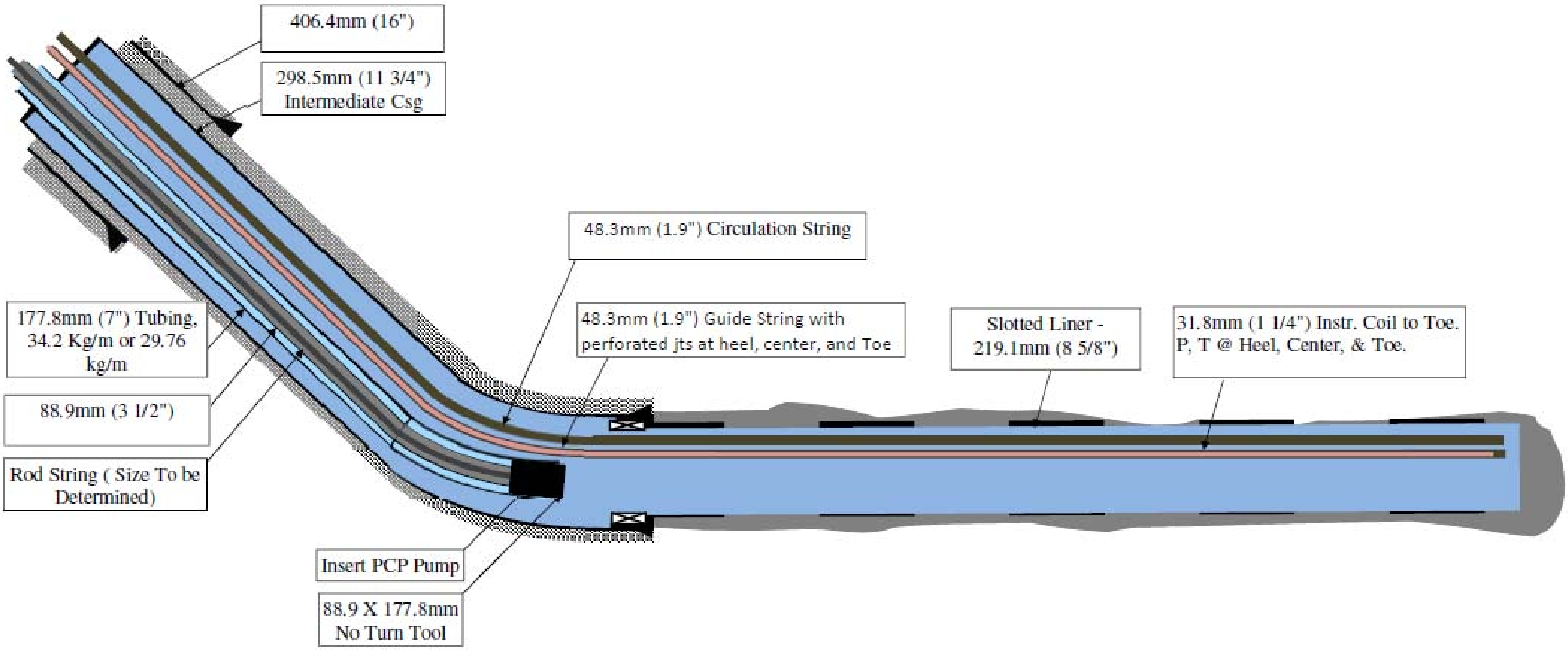
Well Completion – ESEIEH Injector/Antenna Well



Well Completion – ESEIEH Production Well



Completion Operations

- First attempt to run completion from mid-June to mid-August 2014
  - Complex completion design with multiple lines run simultaneously and coaxial transmission line run inside jointed tubing
  - Slow going at the beginning, but pace improved and running became relatively efficient.
  - Lines were pressure tested with Nitrogen every joint at 350 kPa (50 psi)
  - Completion was successfully landed on July 25, 2014
  - Final nitrogen pressure tests of the transmission line at higher pressure 550 kPa (80 psi) failed
  - Completion was pulled out and a few leaks were identified
  - Decision was made to suspend completions operations in order to fix issues with joints

Completion Operations

- Second completions attempt - October 2014
  - Failure analysis was undertaken to determine the leak location. Every joint of transmission line was bench tested and bubble tested in the field. The bubble test revealed a leak in joint number 10 of TX line, and another in the EMH tool head
  - The inner copper conductors of the TX line were repaired on location and composite part of the EMH tool head was replaced with a better material manufactured in US
  - Execution for the second attempt started October 23, 2014.
  - Each additional joint was pressure tested to 1400 Kpa (200 Psi) for 12 hrs, which was a challenging and time consuming endeavor. As the TX line got longer in length, stabilizing the pressure became difficult due to the volume of N2 required and varying ambient temperature during the test.
  - The TX line was landed successfully on November 11, 2014. Pressure and electrical tests passed, and the wellhead was installed
  - The IOB which is a special part of the wellhead that facilitates the injection of dielectric oil and N2 through wellhead was installed successfully in March 2015 after one failed attempt in January because of a failed leak down test.
  - Installation was a difficult due to the weight and angle of the IOB, and care had to be taken to ensure that all the electric contacts and seals remained intact
  - The well was successfully turned over to operations with the acceptable pressure and electrical tests results.

Artificial Lift

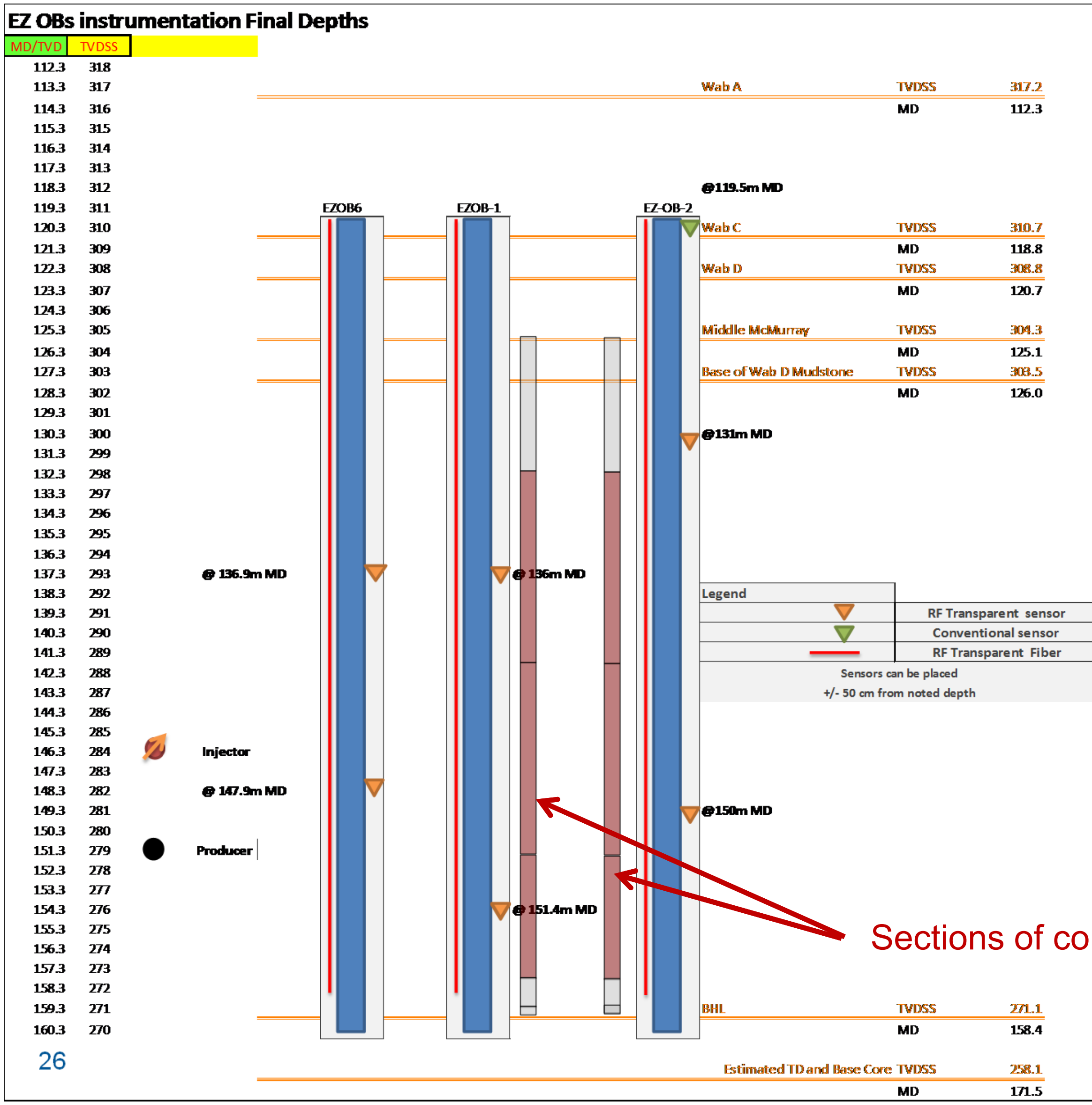
- EZ Producer was completed at the end of November 2014 with PCP, landed at 85° inclination in a 3°/30m slant section, 2m TVD above liner depth.

- 2 x pumps available with theoretical volumetric capacity of $4m^3/d$ or $8m^3/d$ at 100 rpm.
  - Larger capacity 7-750 pump currently installed.

- Artificial lift was run only for a short period of time in July
  - Initially run as part of commissioning and start up activities and to generate a pump performance curve.
  - The downhole pump was shut down to facilitate injector testing, and will remain off until bitumen mobility is suspected.

- A specialized tool was installed on the producer to allow operations to pull the rotor out of the stator without needing a service rig on site. This was added so that in the event of an unplanned shutdown, the pump wouldn't become plugged and inoperable due to cold bitumen inside.

Observation Wells



Sections of composite casing in production casing

- Each well equipped with a RF transparent Temperature Optic Fiber from surface to TD.
- Each well equipped with 2 RF transparent optic Fiber Pressure & Temperature Sensors, located in the McMurray.
- EZ-OB2 equipped with a standard Pressure & Temperature Sensor in the WAB C.

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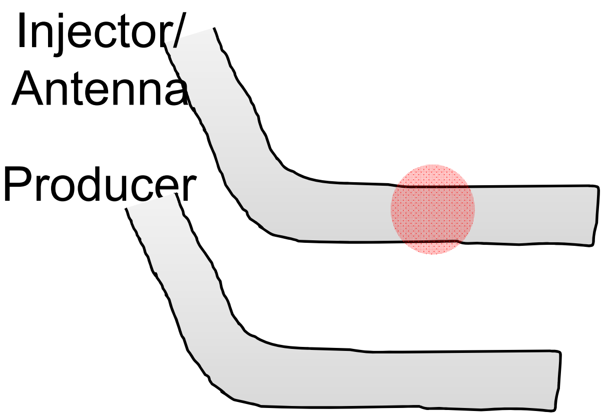
Operating Plan

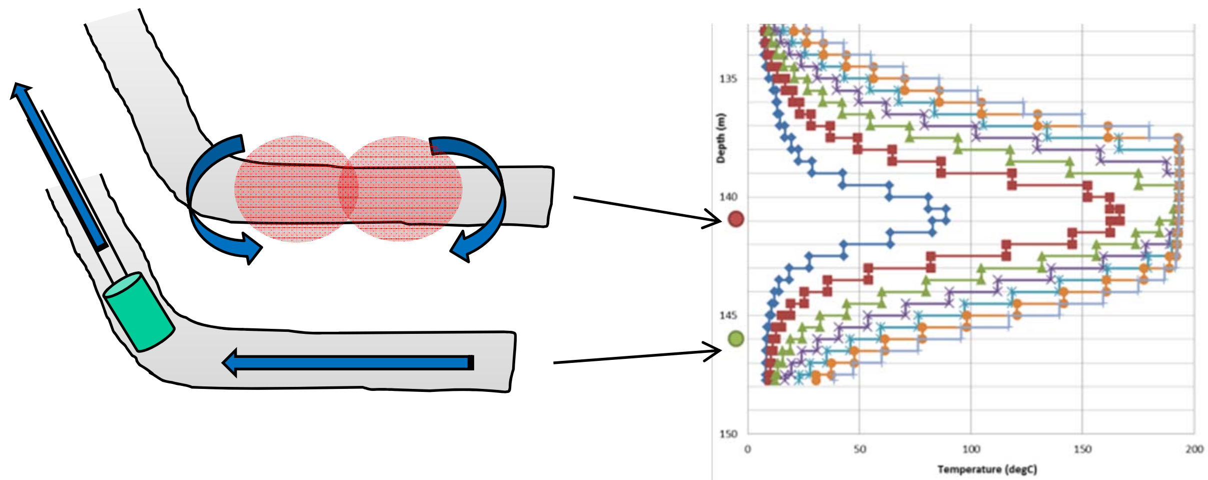
Summary of Operating Plan

1 Initialization / Antenna Ramp-up

2 Initial Flow Establishment

3 Initial Inter-wellbore Bitumen Mobility





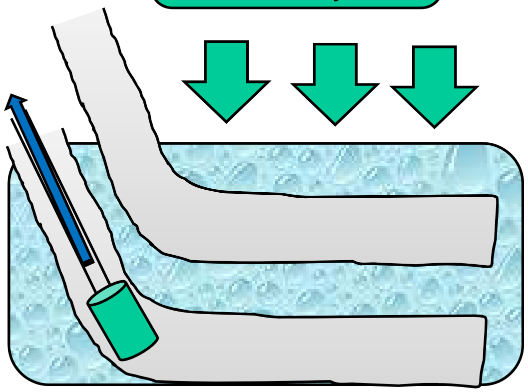
- Review all instrumentation outputs
- Begin ramp-up of antenna power levels
- Heat is initially localized to center of antenna

- As heated fluids expand they are produced to control reservoir pressure
- Pump operation is initiated with diesel circulation

- Look for indications of initial mobile bitumen
- Manage pressure differential between wells to prevent “pushing” reservoir fluids

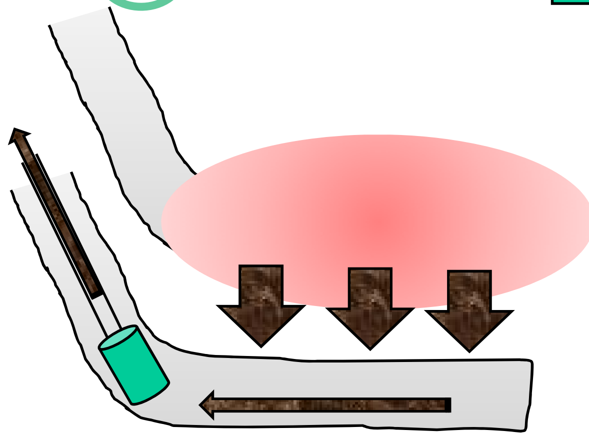
Summary of Operating Plan

4 Draw-down / Reservoir Deliverability Test



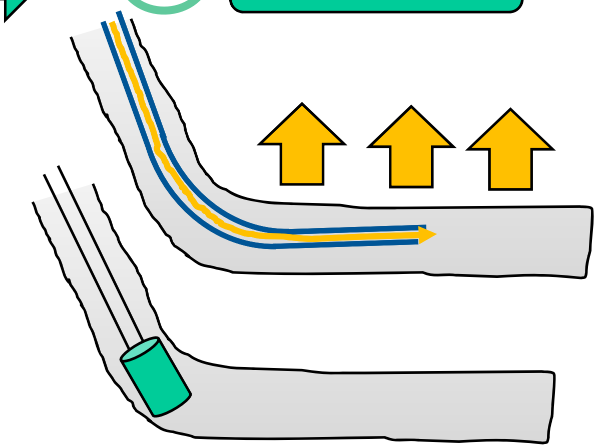
- Confirm reservoir deliverability can sustain pump operation w/o diesel circulation

5



- Produce hot reservoir fluids to create void space for propane

6 Propane Injection



- Draw down liquid level below injector elevation
- Initiate propane injection at high antenna power

7 Power Optimization

- Once producer conformance is achieved, reduce power to long term optimum level

8 Process Testing

- Once ESEIEH base objectives have been met, test variants of process variables, such as power and pressure

Summary of Operating Plan

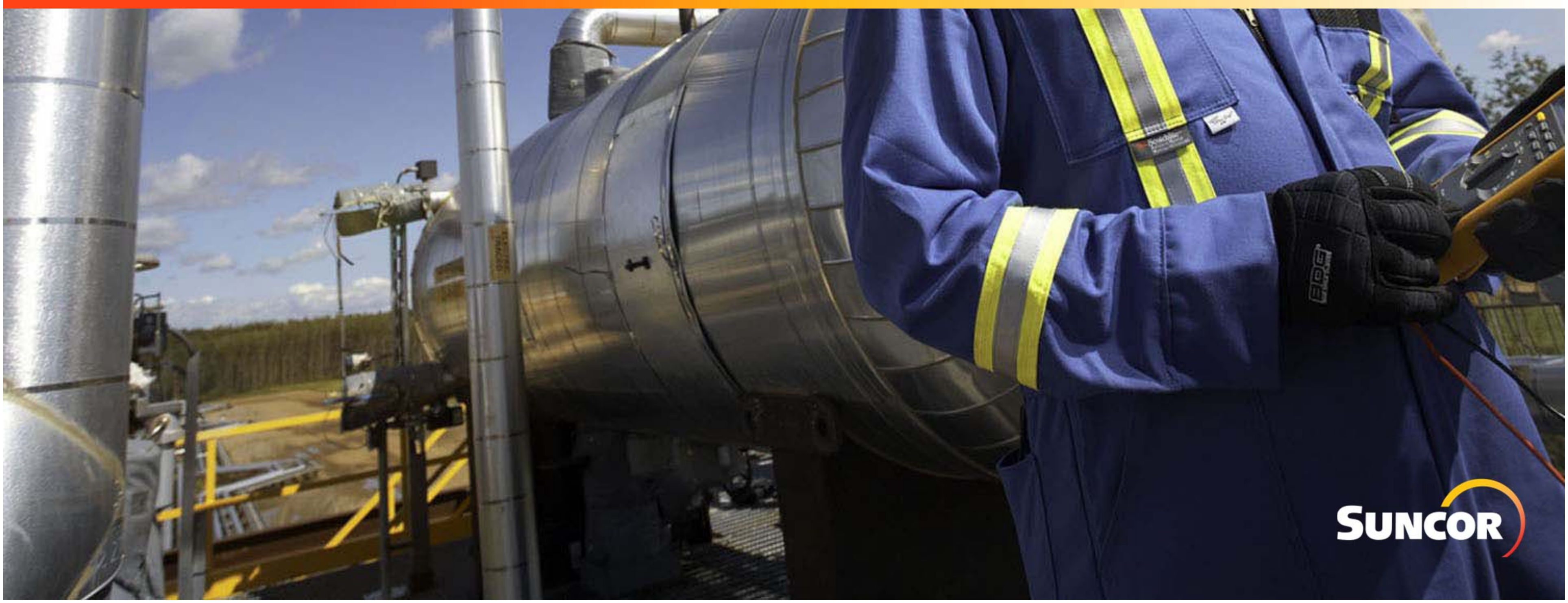
- Steward to reservoir pressure of 1750 kPag (MOP of 2230 kPag)
- Steady heating and passive displacement of inter-wellbore region
- Prevent solvent coning through pump, antenna, and injection operation
- Build a healthy solvent chamber
- Find optimum power levels and solvent injection rates
- Once ESEIEH successfully demonstrated - test boundaries of process (low power, etc.)

Summary of Operations To Date

- First RF energy was delivered to the reservoir on May 31, 2015
  - Part of commissioning activities
  - Power run for short durations (~15 minutes) at 10-15 kW
- Pilot officially started on July 10, 2015 and power began ramping up
  - Reached 60kW before a high VSWR (measure of reflected power) and transmitter trip led to shutting down the antenna to troubleshoot
- Since the initial transmitter trip, efforts have been made to try and condition the antenna tool head area to improve the ability to deliver power
  - Nitrogen applied to injector casing July 23-25, 2015 to try and flush fluid in the tool head
  - 17m^3 of diesel was injected into the casing on August 11, 2015
  - An additional 10m^3 of diesel was injected on August 27, 2015 - 2m^3 in the solvent line and 8m^3 down the casing
- Downhole pump was run briefly, but decision was made to shut it down on July 18, 2015 and leave it off to maintain reservoir integrity until fluid mobility could be established.

ESEIEH Pilot Performance Presentation

Surface facilities



Surface Facilities – 3D Model

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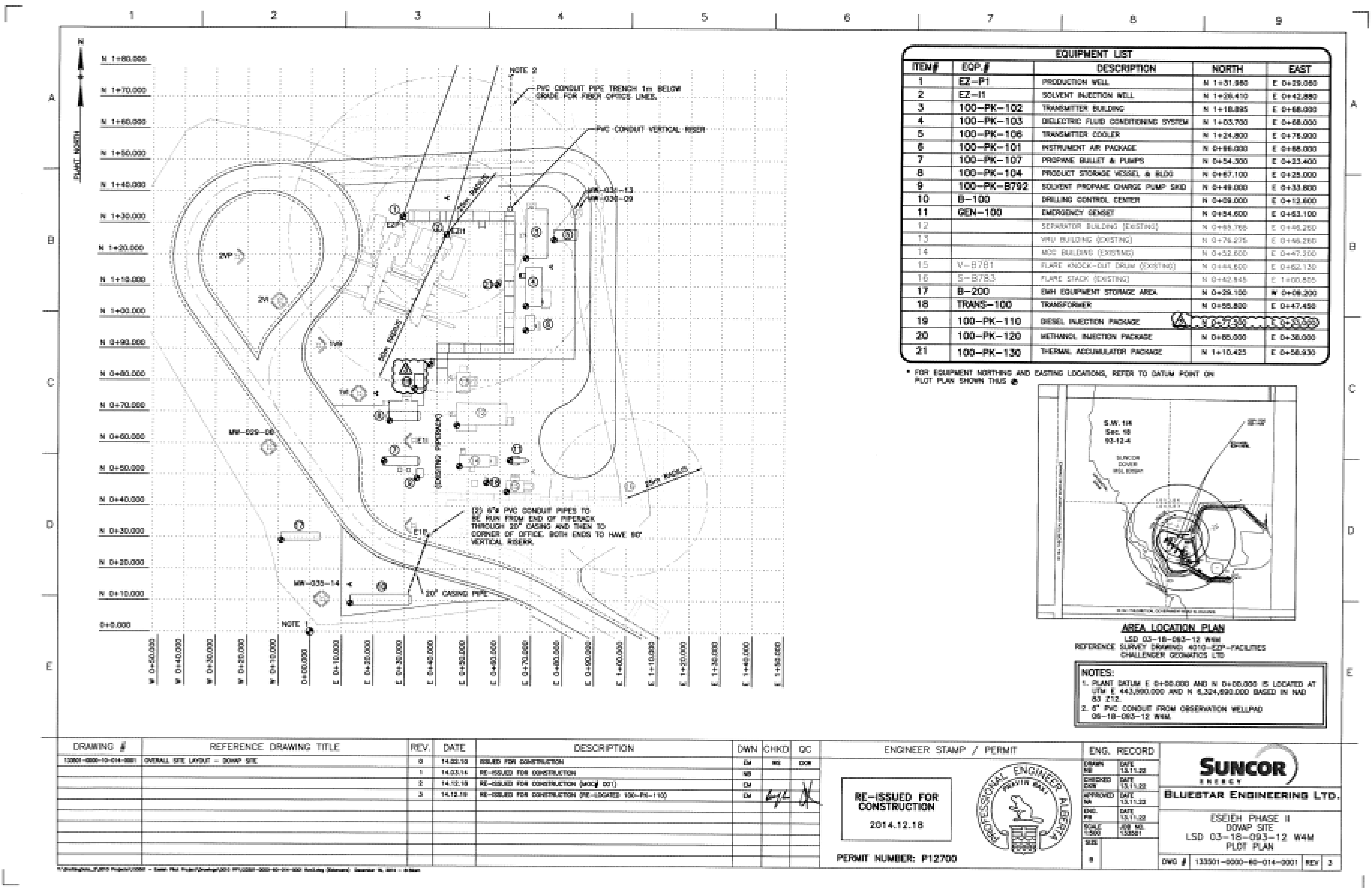
Surface Facilities – Plot Plan

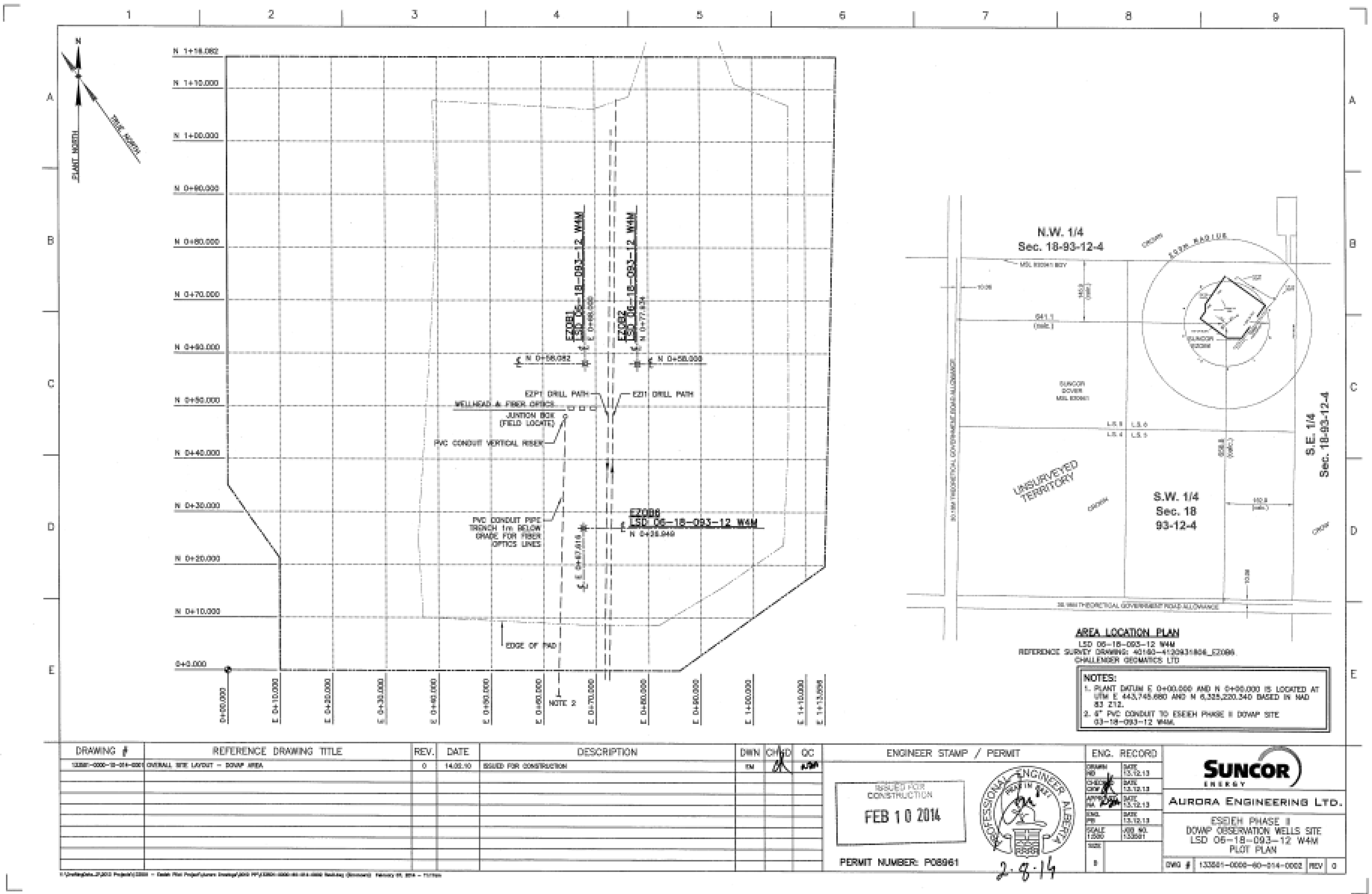


EQUIPMENT LIST

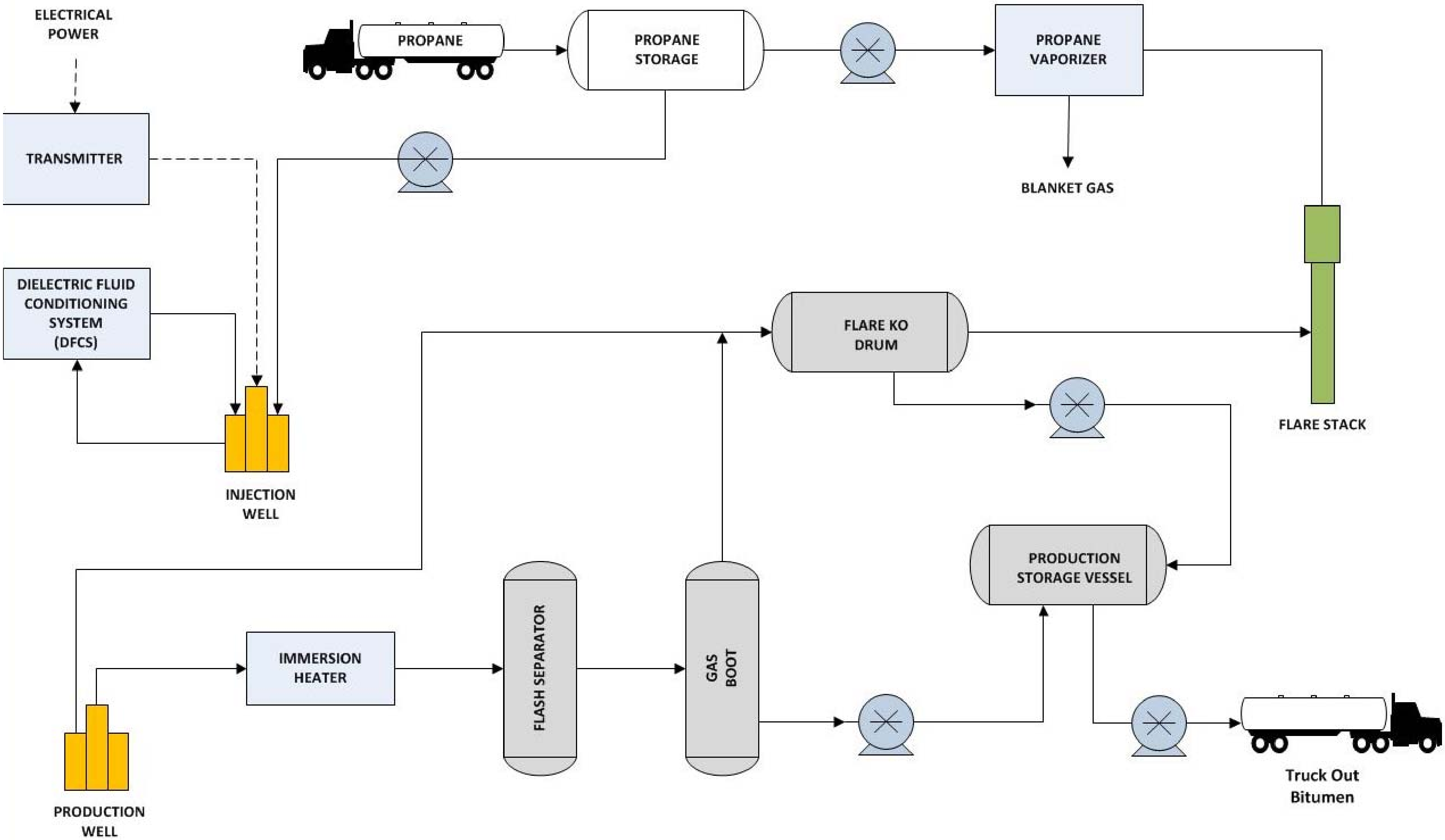
ITEM#	EQP.#	DESCRIPTION	NORTH	EAST
1	EZ-P1	PRODUCTION WELL	N 1+31.980	E 0+29.080
2	EZ-I1	SOLVENT INJECTION WELL	N 1+28.410	E 0+42.880
3	100-PK-102	TRANSMITTER BUILDING	N 1+18.895	E 0+68.000
4	100-PK-103	DIELECTRIC FLUID CONDITIONING SYSTEM	N 1+03.700	E 0+68.000
5	100-PK-106	TRANSMITTER COOLER	N 1+24.800	E 0+76.900
6	100-PK-101	INSTRUMENT AIR PACKAGE	N 0+86.000	E 0+68.000
7	100-PK-107	PROPANE BULLET & PUMPS	N 0+54.300	E 0+23.400
8	100-PK-104	PRODUCT STORAGE VESSEL & BLDG	N 0+67.100	E 0+25.000
9	100-PK-B792	SOLVENT PROPANE CHARGE PUMP SKID	N 0+49.000	E 0+33.800
10	B-100	DRILLING CONTROL CENTER	N 0+09.000	E 0+12.600
11	GEN-100	EMERGENCY GENSET	N 0+54.600	E 0+63.100
12		SEPARATOR BUILDING (EXISTING)	N 0+85.766	E 0+46.260
13		VRU BUILDING (EXISTING)	N 0+76.275	E 0+46.260
14		MCC BUILDING (EXISTING)	N 0+52.600	E 0+47.200
15	V-B781	FLARE KNOCK-OUT DRUM (EXISTING)	N 0+44.600	E 0+62.130
16	S-B783	FLARE STACK (EXISTING)	N 0+42.945	E 1+00.805
17	B-200	EMH EQUIPMENT STORAGE AREA	N 0+29.100	W 0+06.200
18	TRANS-100	TRANSFORMER	N 0+55.800	E 0+47.450
19	100-PK-110	DIESEL INJECTION PACKAGE	[illegible]	[illegible]
20	100-PK-120	METHANOL INJECTION PACKAGE	N 0+85.000	E 0+38.000
21	100-PK-130	THERMAL ACCUMULATOR PACKAGE	N 1+10.425	E 0+58.930

DRAWING #	REFERENCE DRAWING TITLE	REV.	DATE	DESCRIPTION	DWN	CHKD	QC
133501-0000-10-014-0001	OVERALL SITE LAYOUT - DOVAP SITE	0	14.03.10	ISSUED FOR CONSTRUCTION	EM	RG	DOR
		1	14.03.14	RE-ISSUED FOR CONSTRUCTION	NB		
		2	14.12.18	RE-ISSUED FOR CONSTRUCTION (MOC# 001)	EM		
		3	14.12.19	RE-ISSUED FOR CONSTRUCTION (RE-LOCATED 100-PK-110)	EM		

Surface Facilities – Plot Plan



Surface Facilities – Simplified Schematic



Summary of Facility Modifications

1. Diesel injection system
   - In order to execute diesel injection it is further recommended that a small volume (4-4.9m3) storage tank, with redundant pumping capability of 2.3m3/hr (volume required to purge pump discharge tubing is 2.3m3), with design pressure of 3600kPag at pump discharge, be added to the facility (with associated piping etc.) in order to conduct continuous diesel injection in production mode, and provide on-demand diesel immediately upstream of PSHH1000, in order to provide operational flexibility for the system.

2. HX-101 Instrumentation
   - Relocate TIT-1003 to the top of 100-HX-101 with high temperature shutdown and install a pressure gauge.
   - Rev.1 add PSV as requirement by ABSA inspector

3. PK-103 DFCS Isolation Valves
   - Add isolation valves on dielectic fluid supply and return lines

4. PK-103 DFCS Design Review
   - IFC HazOp partially completed on May 14, 2014 identified design gaps and inconsistent operations documentation. Harris supplied vendor package will need to be operated and maintained to Suncor standards. Package is connected to Suncor well and therefore multi discipline review is required.

5. PK-103 DFCS PSV & PT
   - Add block flow PSV's on di-electric oil supply and return lines with relief setpoints below level that would cause damage to downhole toolhead.
   - Add pressure transmitters on di-electric supply and return lines to alarm and then shutdown in the event of high pressures caused by blocked flow or thermal expansion. Setpoints need to include safety margins to ensure no damage to downhole toolhead.

Summary of Facility Modifications

6. EZ-I1 Bubble Tube on Propane Inj.
   - Add tubing connection between nitrogen purge line and propane supply as shown on dwg# 133501-0000-05-031-0002 Rev.1

7. Mitigate JT across PV 1004
   - Implement a pressure reduction design change to ensure minimal impacts from hydrate formation as a result of JT effect across PV 1004. Produced casing gas pressure is controlled by PV 1004 as shown on dwg# 133501-0000-05-031-0001 Rev.2.

8. Thermal Accumulator Change
   - Added a Thermal Accumulator package which will act as a Pulsation dampener for the DFCS skid.

9. Propane Pump Skid Re-design
   - Replace isolation valve downstream of P-B792A/B with a block and bleed valve.

10. Programming Automatic Operation of FKOD Pumps P-B782A/B
   - Change of programming from manual to automatic operation of FKOD Pumps P-B782A/B

Summary of Facility Performance

- To date the ESEIEH facility has been fully commissioned, but since starting has not been fully utilized as we have not been regularly producing fluids to surface.
- Generally speaking the facility performance has met expectations and the aforementioned modifications were made to improve performance issues.

ESEIEH Pilot Performance Presentation

Regulatory and Environment

Regulatory Summary

- Regulatory Approvals and Licenses
  - AER Experimental Scheme Approval No. 12074 issued May 1, 2013
  - EPEA Amending Approval No. 705-02-02 issued July 19, 2013
  - Measurement, Accounting and Reporting Plan (MARP) approved February 19, 2014
  - Facility License F-47236 issued March 24, 2014
  - Well License 0462395 (EZP1) issued December 13, 2013
  - Well License 0462501 (EZI1) issued December 16, 2013
  - RMWB Development Permit 2013-DP-01311 issued November 27, 2013
  - MARP was updated on February 27, 2015
  - AER Experimental Scheme Amendment No. 12074A issued July 27, 2015
    - Scheme approval extension granted until November 30, 2018

Regulatory Compliance

- AER Non-Compliance:
  - Voluntary self-disclosure of propane release on August 27, 2015 submitted to AER Fort McMurray Field Office on September 2, 2015
  - Operations shut-in propane to production storage tank and the vessel was completely isolated
  - Recommendations from the investigation will be used to develop plan to prevent similar releases in the future

- Suncor Energy Inc. is in compliance with all regulatory approvals, decisions, regulations and conditions not otherwise identified in this presentation or otherwise disclosed.

Environmental Summary

- Environmental
  - Disturbance: no new disturbance associated with the pilot facilities and horizontal well pair. These are within existing Dover well pad. Observation well pad required clearing and construction.
  - Storm water: surface run-off will be contained on the site through the use of existing berms. Water will be collected, sampled and released if it meets EPEA requirements.
  - Domestic wastewater: will be contained and trucked to an approved treatment facility.
  - Spill containment: will consist of storage and secondary containment that complies with Directive 055 requirements. Other measures will include: collection of surface run-off; spill prevention and loss control systems ; groundwater monitoring ; proper maintenance, operating procedures and inspections ; spill contingency and response plans.
  - Air emissions: monitoring and sampling as per the EPEA approval requirements
  - Groundwater: monitoring and sampling as per the EPEA approval requirements

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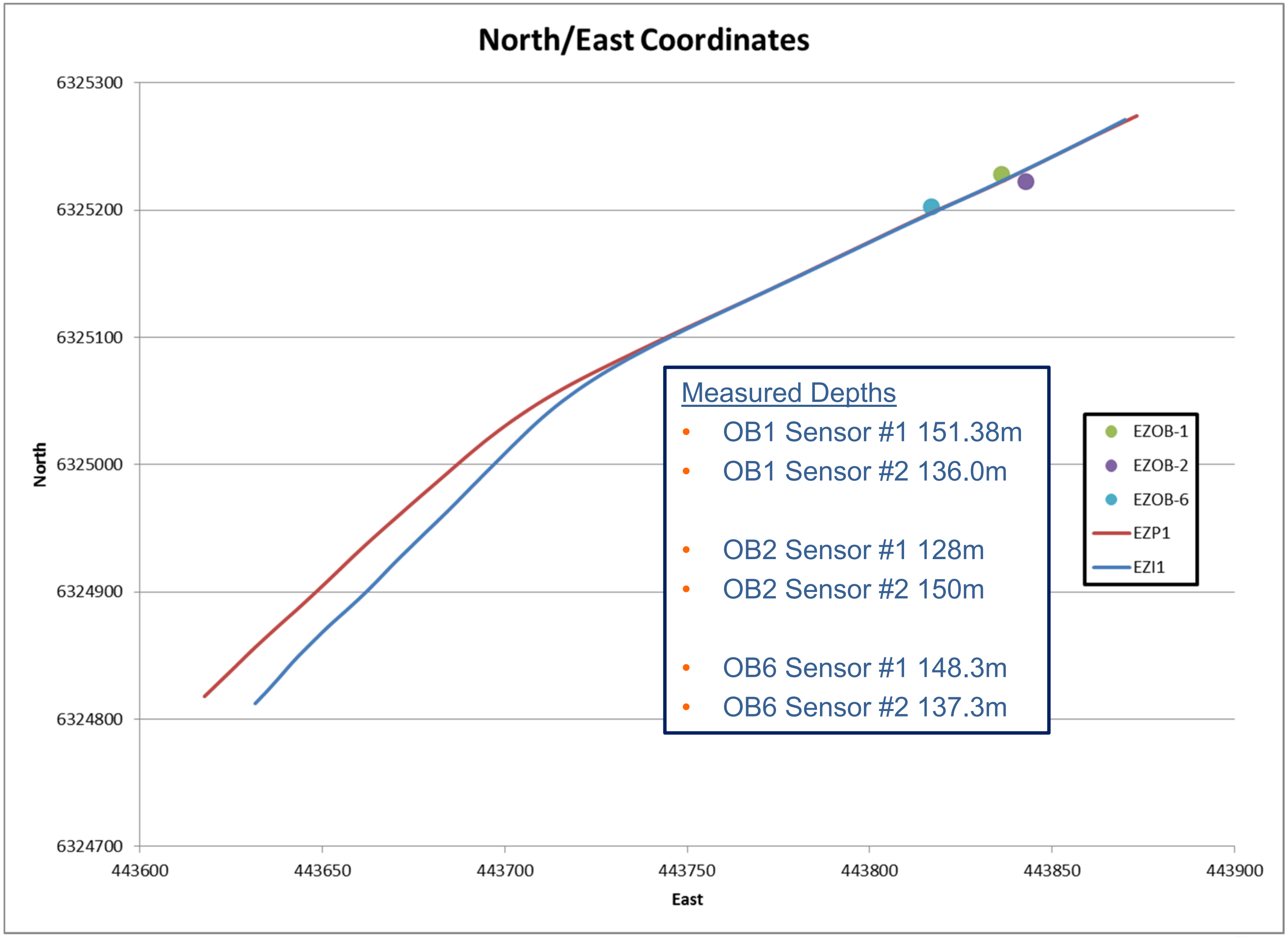
Future Plans

Future Plans

- It is suspected that high conductivity fluid around toolhead/wellbore are hindering our ability to deliver energy, so near term plans are to try and condition wellbore by displacing fluids around the tool head with another fluid
  - Dilbit was selected to condition the well as it has favorable RF properties that should help displace conductive fluid around the toolhead
    - Low conductivity
    - Density closer to water than diesel making it less likely to float on top of the water
    - Higher viscosity allowing for a plug flow displacement
  - If well conditioning proves to be unsuccessful then removal of transmission line/toolhead and modification to enable delivery of dielectric fluid to centre of well may be required.
- Once RF heating process has been established, return to the original operating plan
- End of first 7 months of operations - February 2016
- End of 2 years of operation - mid 2017
- Plant decommissioning and well abandonment - late 2017

SUNCOR ENERGY

Appendix – Observation Well Instrumentation Location



Measured Depths

- OB1 Sensor #1 151.38m
- OB1 Sensor #2 136.0m

- OB2 Sensor #1 128m
- OB2 Sensor #2 150m

- OB6 Sensor #1 148.3m
- OB6 Sensor #2 137.3m