

**EBOR UNIT NO. 2**  
**WATERFLOOD EOR PROJECT**  
**ANNUAL REPORT FOR 2015**

**March 9, 2016**

**Tundra Oil and Gas Partnership**

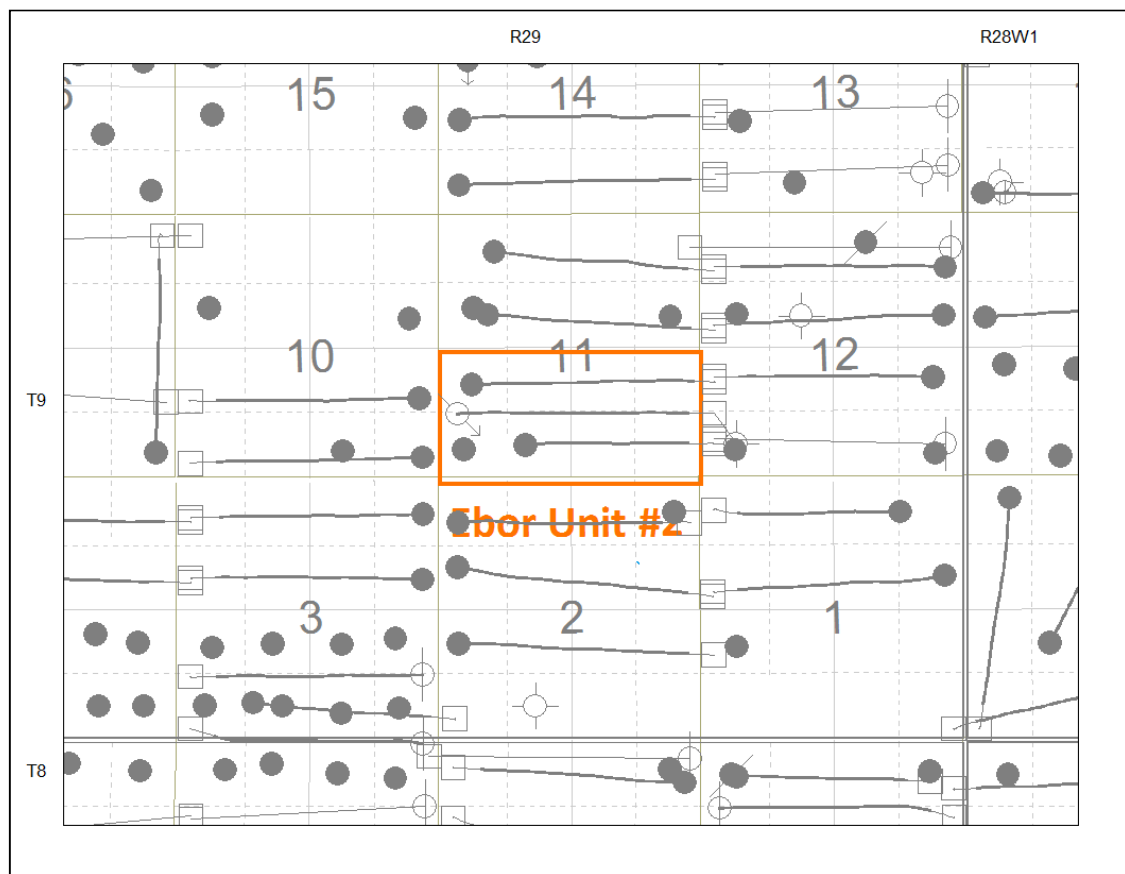
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## **INTRODUCTION**

Ebor Unit No. 2 Enhanced Oil Recovery (EOR) Waterflood Project was approved under Waterflood Order No. 20 effective March 2010 with Tundra Oil and Gas (Tundra) as Operator. The EOR project area, outlined in Orange in Figure 1, contains 4 wells in the South half of Section 11 in Township 9, Range 29 W1. A well list and status is included as Appendix A.

**Figure 1: Ebor Unit No. 2 Area Outline**



In accordance with Section 73 of the Manitoba Drilling and Production Regulation, Tundra submits the following 2015 Annual Progress Report for Ebor Unit No. 2 as required by Waterflood Order No 20.

## **DISCUSSION**

### **Production History**

For the wells included in Ebor Unit No. 2, production started in August 2007 with the 00/04-11-009-29W1/0 well. Oil production peaked at 17.65 m<sup>3</sup>/d in January of 2009,

when the 00/05-11-009-29W1/0 well came on production. In December 2015, the Unit was producing 1.41 m<sup>3</sup>/d of oil and 4.71 m<sup>3</sup>/d of water. The water oil ratio (WOR) averaged 3.33 m<sup>3</sup>/m<sup>3</sup> in 2015. The rates and WOR are presented in Figure 2.

**Figure 2: Ebor Unit No. 2 Production/Injection Rates and WOR vs Time**

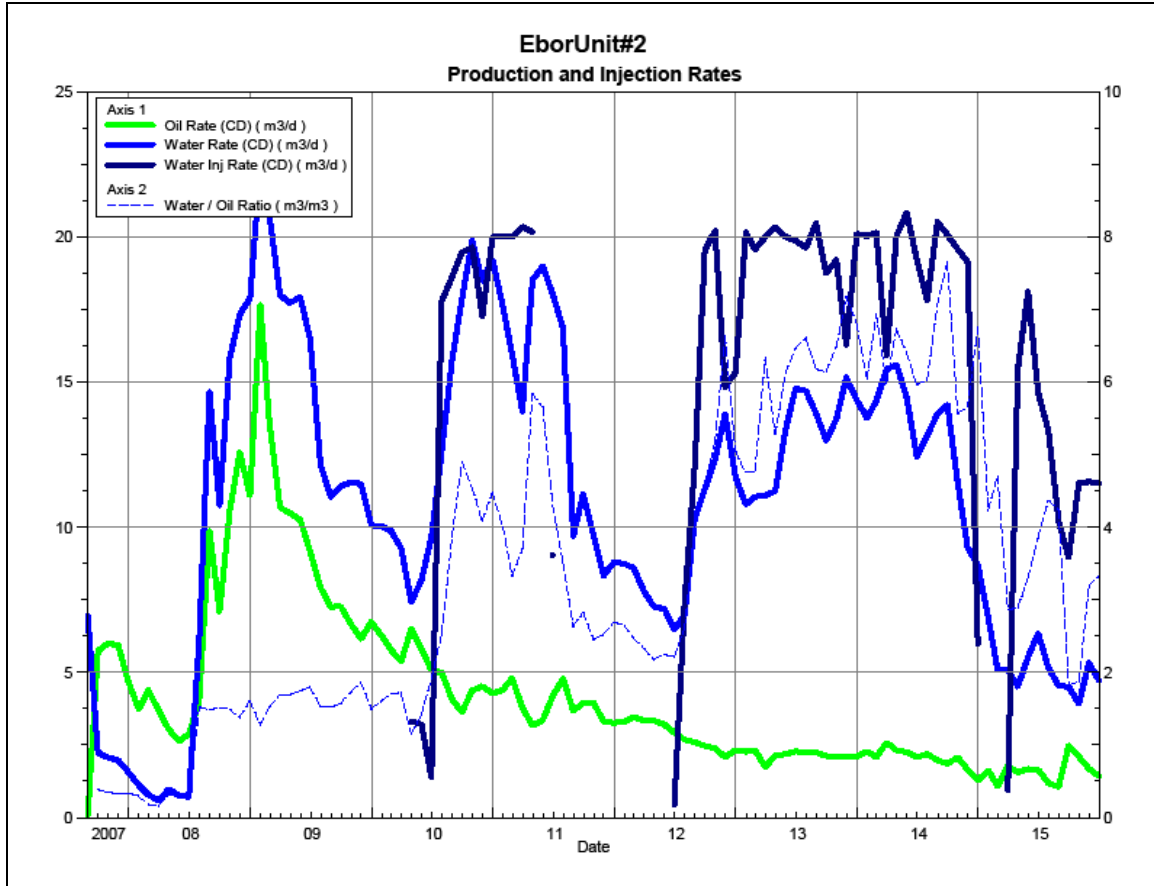
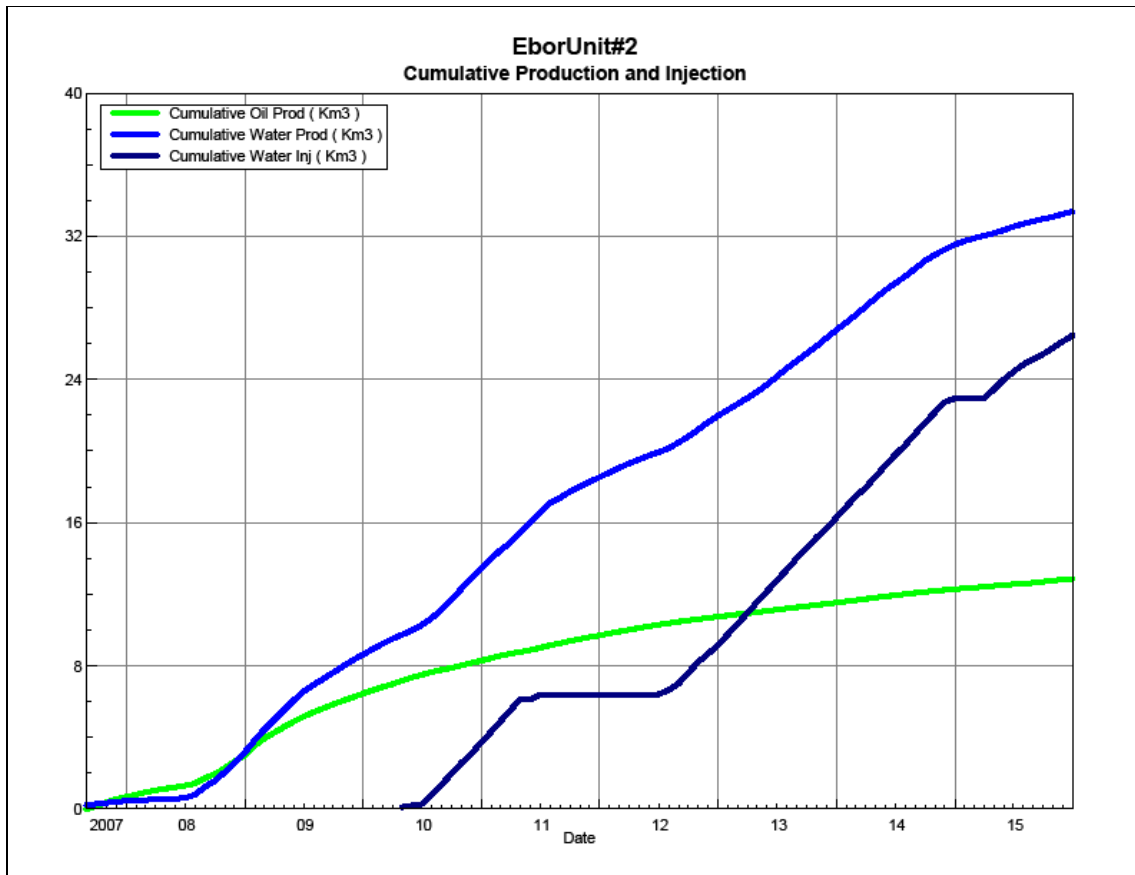


Figure 3 shows the cumulative production for Ebor Unit No. 2 to the end of December 2015 as 12.87 e<sup>3</sup>m<sup>3</sup> of oil, and 33.40 e<sup>3</sup>m<sup>3</sup> of water, representing a 5.2% recovery factor of the OOIP. Cumulative water injected at the end of 2015 is 26.48 e<sup>3</sup>m<sup>3</sup>.

**Figure 3: Ebor Unit No. 2 Cumulative Oil, Water and Water Injected vs. Time**



### **Waterflood Development Plan**

Ebor Unit No. 2 has one horizontal water injector, 02/04-11-009-29W1/2 (02/04-11), which started injecting in April 2010. Injection for this unit was suspended in June 2011, to try and mitigate the water breakthrough that had occurred at 00/05-11-009-29W1 (00/05-11) in July 2010.

The 02/04-11 injector had a very high reservoir pressure (~6559 kPaa) when it was placed on injection. It is Tundra's belief that placing an injector with such high reservoir pressure leads to premature water breakthrough. The learning's from this Unit has played a major role in Tundra's new protocol of producing the newly drilled injector wells first prior to putting them on injection to clean-up the area near the wellbore and to reduce the pressure surrounding the injection well. This should lead to better waterflood performance and minimize premature breakthroughs.

It is evident in Figure 2, that since shutting in the injection at 02/04-11, the amount of water being produced from this Unit has decreased without substantially sacrificing the

oil production. It is our belief that once the pressure is relieved from this injector, the breakthrough channel that was created between the 02/04-11 and 00/05-11 wells should relax and heal. In July 2012, injection was restarted. Both the 00/03-11-009-29W1/0 (00/03-11) and 00/05-11 horizontal wells and the 00/04-11 vertical well showed waterflood response.

In September 2013, calcium carbonate was used as a bridging agent to repair the direct fracture from the 02/04-11 injector to the 00/05-11 producer. The workover saw an increase in injection pressure. A second workover was done November 2013 which resulted in a reduction in water cut in both the 00/03-11 and 00/05-11 wells.

Any future revisions to the waterflood development or surveillance plan would be based on new production or performance response data, technical studies, or observed reservoir behavior and reserves recovery interpretations.

## **Waterflood EOR Operating Strategy and Performance**

### **Water Source and Quality**

The injection water for Ebor Unit No. 2 is sourced from the 16-32-007-29W1 well (Lodgepole formation). The water is treated at the 03-04-008-29W1 battery where it is filtered to 0.5 microns and has scale inhibitor added. The injection water is then distributed to the injectors through the dedicated infrastructure system.

### **Injection Wellhead Pressures**

The monthly wellhead injection pressures for 02/04-11 are summarized in Appendix C. The injection pressures in April and May 2010 are pre-hydraulic fracture. The injection rates during these months were low and hence the well was fractured after which the injection rates improved but led to water breakthrough at the 00/05-11 well.

### **Reservoir Pressure**

No reservoir pressure measurements were taken at Ebor Unit No. 2 in 2015.

### **Well Servicing**

Table 1 lists the maintenance that was required in Ebor Unit No. 2 in 2015.

**Table 1: Service and Maintenance in Ebor Unit No. 2**

00/04-11-0009-29W1/0	Pump Change	08/28/2015
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### **Voidage Replacement**

As discussed earlier, injection in Ebor Unit No. 2 was suspended in June 2011. The cumulative VRR had been on a decline with final cumulative VRR for Dec 2011 being 0.221. Tundra restarted injection in Ebor Unit No. 2 in July 2012, to understand if the water channels had been healed from relieving the pressure in this Unit. In December 2015, the monthly VRR was 1.851 and the cumulative VRR for Ebor Unit No. 2 was 0.561.

### **Waterflood Performance Discussion**

At the end of 2015, Ebor Unit No. 2 waterflood area had 1 injector pattern in place. Water injection started in April 2010 and was suspended in June 2011 after signs of breakthrough in the horizontal producer at 00/05-11 shortly after injection began. In July 2012, injection was restarted. Plots and tables of the production and injection data along with the VRR information are presented in Appendix D.

## **List of Appendices**

Appendix A: Ebor Unit No. 2 Well List and Status

Appendix B: Ebor Unit No. 2 Injection Pattern Summary

Appendix C: Monthly Injection Wellhead Pressures Table

Appendix D: Production/Injection Rates, Cumulatives and VRRs



## Appendix A

UWI	Surface Location	Well Status
00/03-11-009-29W1/0	04-12-009-29W1	Capable of Oil Production
00/04-11-009-29W1/0		Capable of Oil Production
02/04-11-009-29W1/2	02/04-12-009-29W1	WTR Injection
00/05-11-009-29W1/0	05-12-009-29W1	Capable of Oil Production

## Appendix B

### Ebor Unit No. 2 Pattern Summary as of December 2015

Pattern Name	Injector BH Location (009-29W1)	Injector Surf Location (009-29W1)	Status	Supported Wells (009-29W1)	No. of Supported Wells	Allocation Factor	Pattern Prod Start Month	Inj Start Month	Oil Rate (m³/d)	Water Rate (m³/d)	WOR (m³/m³)	Water Injection (m³/d)	Cum Oil (E³m³)	Cum Water (E³m³)	Cum Inj Water (E³m³)	Monthly VRR	Cum VRR
02/04-11-09-29W1/2 Injector	02/04-11	02/04-12	Water Injection	03-11, 04-11, 05-11	3	1	Aug 2007	Apr 2010	1.41	4.71	3.33	11.5	12.9	33.4	26.5	1.9	0.56

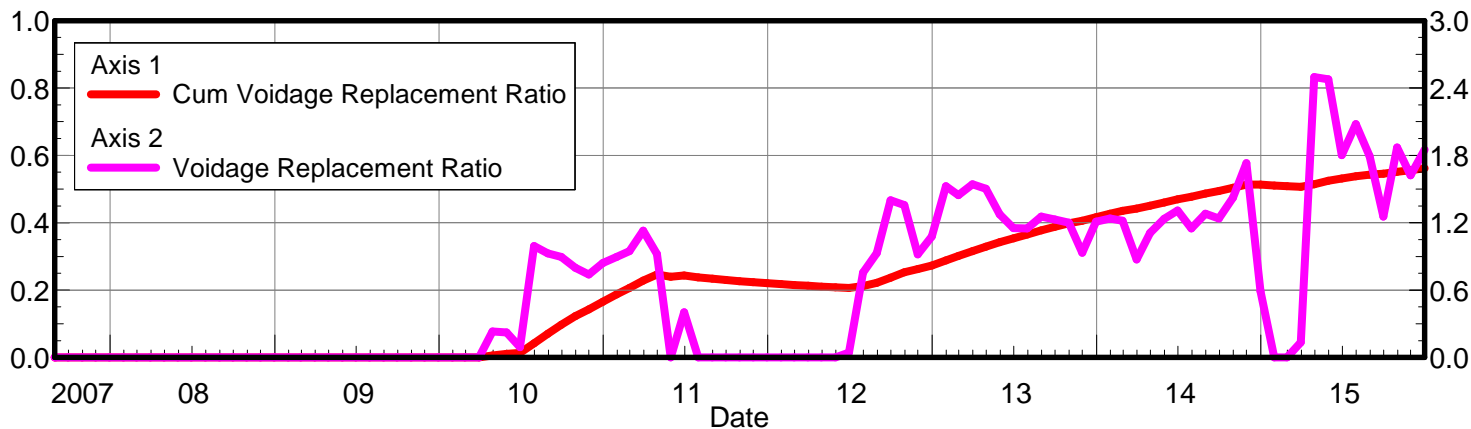
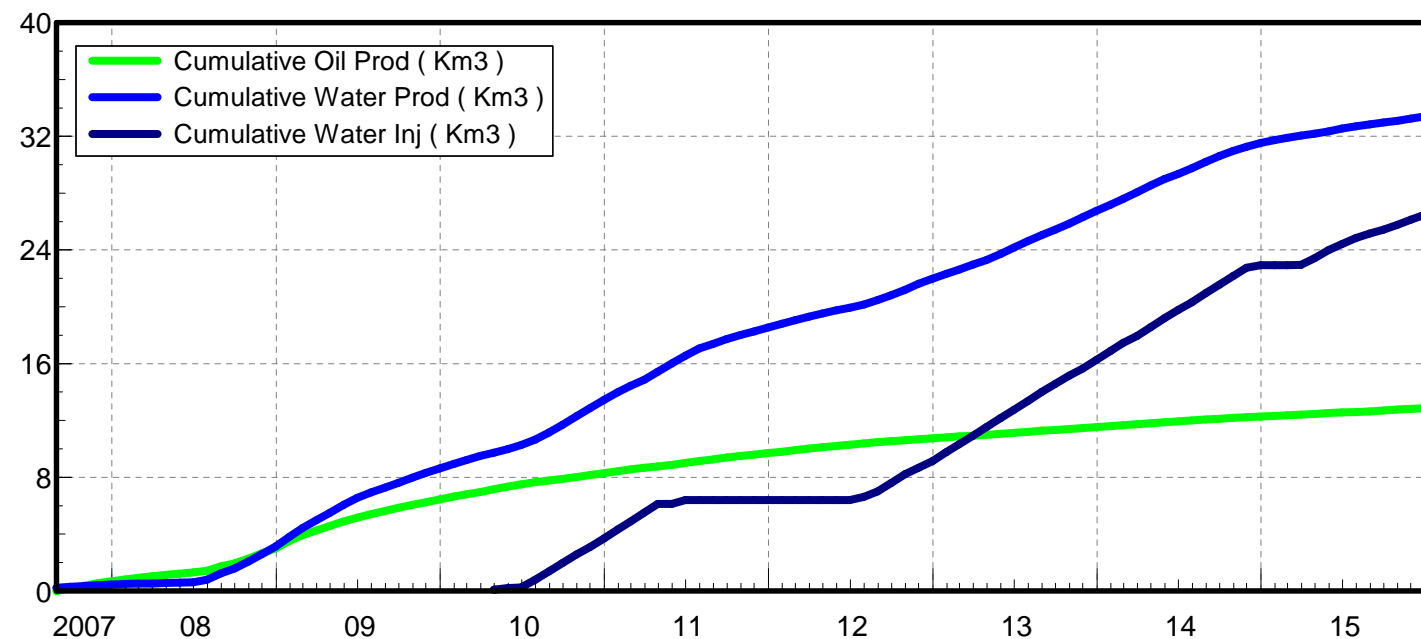
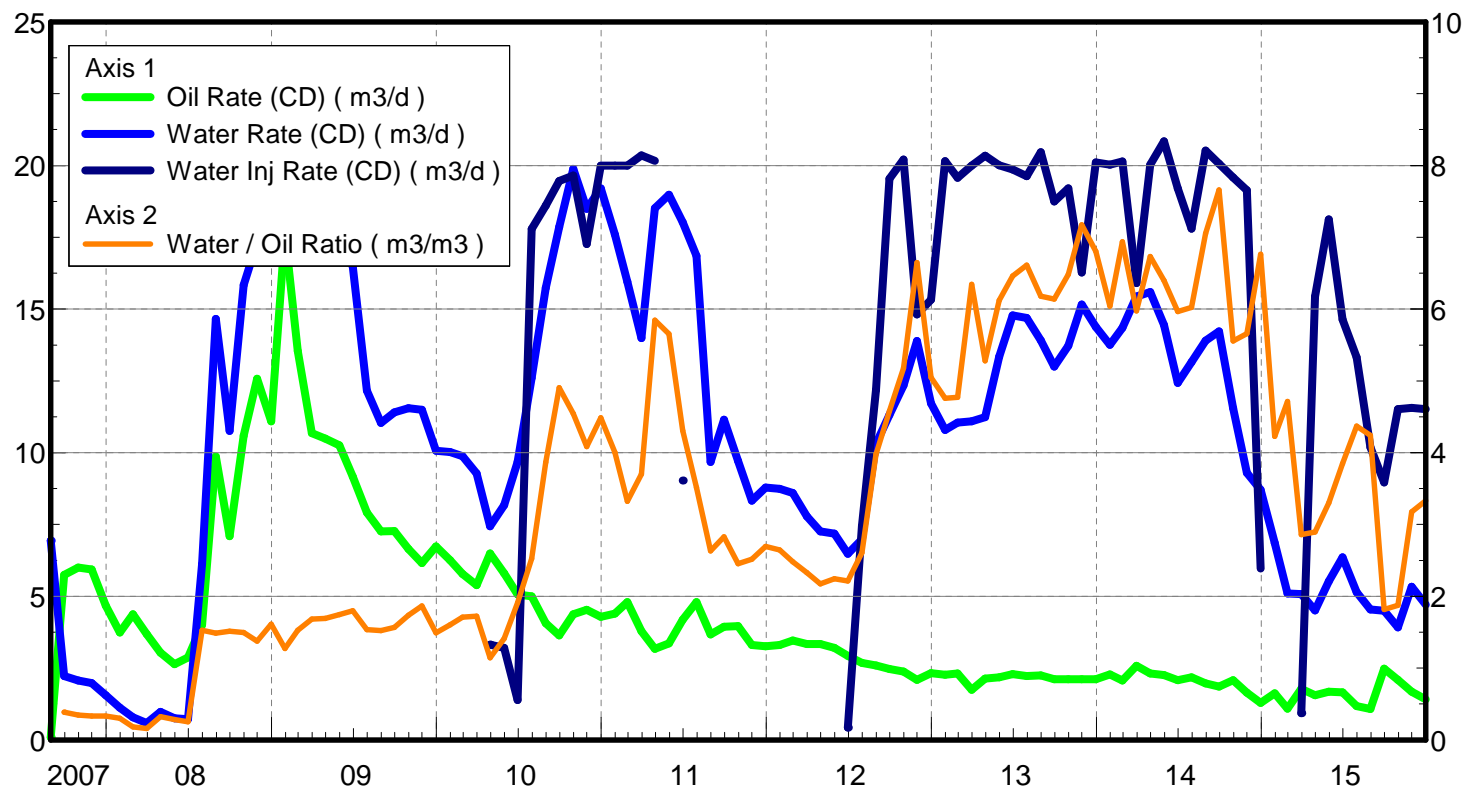
## Appendix C

### Average Monthly Injection Pressure (kPag)

Month	102/04-11	Month	102/04-11
Mar-10	0	Jan-14	4160
Apr-10	4663	Feb-14	4359
May-10	5158	Mar-14	3644
Jun-10	0	Apr-14	4307
Jul-10	0	May-14	4448
Aug-10	0	Jun-14	4588
Sep-10	0	Jul-14	4265
Oct-10	0	Aug-14	4716
Nov-10	0	Sep-14	4767
Dec-10	0	Oct-14	4955
Jan-11	0	Nov-14	5182
Feb-11	0	Dec-14	5342
Mar-11	94	Jan-15	5350
Apr-11	481	Feb-15	5350
May-11	540	Mar-15	4656
Jun-11	703	Apr-15	3260
Jul-11	750	May-15	4899
Aug-11	750	Jun-15	4965
Sep-11	750	Jul-15	4969
Oct-11	750	Aug-15	4868
Nov-11	750	Sep-15	4509
Dec-11	750	Oct-15	4486
Jan-12	750	Nov-15	4785
Feb-12	750	Dec-15	4963
Mar-12	750		
Apr-12	750		
May-12	750		
Jun-12	750		
Jul-12	73		
Aug-12	0		
Sep-12	140		
Oct-12	975		
Nov-12	881		
Dec-12	693		
Jan-13	1451		
Feb-13	1564		
Mar-13	1904		
Apr-13	1961		
May-13	2103		
Jun-13	2147		
Jul-13	2315		
Aug-13	2621		
Sep-13	3055		
Oct-13	3460		
Nov-13	3720		
Dec-13	4090		

**Appendix D**  
**Rates and VRR**  
**Plots and Tables**

Oil Formation Vol Factor : 1.00150 m<sup>3</sup>/m<sup>3</sup>      Pattern: 02/04-11-009-29Inj Set: EborUnit#2      Oil Rate (CD) : 1.41 m<sup>3</sup>/d  
 Water Formation Vol Factor : 1.00150 m<sup>3</sup>/m<sup>3</sup>      March 07, 2016      Water Rate (CD) : 4.71 m<sup>3</sup>/d  
 Water / Oil Ratio : 3.33 m<sup>3</sup>/m<sup>3</sup>      Operator: Tundra\_O&G\_Prtshp      Water Inj Rate (CD) : 11.52 m<sup>3</sup>/d



**Pattern: 02/04-11-009-29 Inj Set: Ebor Unit No. 2**

Date	Oil Rate (CD) m3/d	Water Rate (CD) m3/d	Water Oil Ratio m3/m3	Water Inj Rate (CD) m3/d	Cum Oil Prod Km3	Cum Water Prod Km3	Cum Water Inj Km3	VRR	Cum VRR
8/31/2007	0.08	6.94	86.04		0.00	0.22	0.00	0.000	0.000
9/30/2007	5.74	2.22	0.39		0.17	0.28	0.00	0.000	0.000
10/31/2007	6.01	2.07	0.34		0.36	0.35	0.00	0.000	0.000
11/30/2007	5.93	1.98	0.33		0.54	0.41	0.00	0.000	0.000
12/31/2007	4.67	1.56	0.33		0.68	0.45	0.00	0.000	0.000
1/31/2008	3.74	1.12	0.30		0.80	0.49	0.00	0.000	0.000
2/29/2008	4.38	0.79	0.18		0.93	0.51	0.00	0.000	0.000
3/31/2008	3.68	0.58	0.16		1.04	0.53	0.00	0.000	0.000
4/30/2008	3.04	0.98	0.32		1.13	0.56	0.00	0.000	0.000
5/31/2008	2.63	0.75	0.29		1.21	0.58	0.00	0.000	0.000
6/30/2008	2.87	0.72	0.25		1.30	0.60	0.00	0.000	0.000
7/31/2008	4.01	6.12	1.53		1.42	0.79	0.00	0.000	0.000
8/31/2008	9.87	14.66	1.48		1.73	1.25	0.00	0.000	0.000
9/30/2008	7.10	10.76	1.52		1.94	1.57	0.00	0.000	0.000
10/31/2008	10.59	15.84	1.50		2.27	2.06	0.00	0.000	0.000
11/30/2008	12.58	17.32	1.38		2.65	2.58	0.00	0.000	0.000
12/31/2008	11.09	17.89	1.61		2.99	3.14	0.00	0.000	0.000
1/31/2009	17.65	22.49	1.27		3.54	3.83	0.00	0.000	0.000
2/28/2009	13.55	20.71	1.53		3.92	4.41	0.00	0.000	0.000
3/31/2009	10.68	17.99	1.68		4.25	4.97	0.00	0.000	0.000
4/30/2009	10.49	17.73	1.69		4.56	5.50	0.00	0.000	0.000
5/31/2009	10.26	17.92	1.75		4.88	6.06	0.00	0.000	0.000
6/30/2009	9.16	16.48	1.80		5.16	6.55	0.00	0.000	0.000
7/31/2009	7.92	12.16	1.54		5.40	6.93	0.00	0.000	0.000
8/31/2009	7.26	11.04	1.52		5.63	7.27	0.00	0.000	0.000
9/30/2009	7.27	11.41	1.57		5.85	7.61	0.00	0.000	0.000
10/31/2009	6.65	11.55	1.74		6.05	7.97	0.00	0.000	0.000
11/30/2009	6.16	11.49	1.87		6.24	8.32	0.00	0.000	0.000
12/31/2009	6.74	10.06	1.49		6.45	8.63	0.00	0.000	0.000
1/31/2010	6.26	10.03	1.60		6.64	8.94	0.00	0.000	0.000
2/28/2010	5.78	9.88	1.71		6.80	9.22	0.00	0.000	0.000
3/31/2010	5.38	9.28	1.72		6.97	9.50	0.00	0.000	0.000
4/30/2010	6.49	7.43	1.15	3.32	7.16	9.73	0.10	0.231	0.006
5/31/2010	5.80	8.18	1.41	3.21	7.34	9.98	0.20	0.223	0.011
6/30/2010	5.06	9.67	1.91	1.39	7.50	10.27	0.24	0.092	0.013
7/31/2010	4.99	12.60	2.52	17.79	7.65	10.66	0.79	0.992	0.042
8/31/2010	4.07	15.74	3.87	18.61	7.78	11.15	1.37	0.926	0.070
9/30/2010	3.64	17.86	4.91	19.47	7.89	11.68	1.95	0.895	0.097
10/31/2010	4.37	19.88	4.54	19.65	8.02	12.30	2.56	0.800	0.123
11/30/2010	4.53	18.49	4.08	17.27	8.16	12.86	3.08	0.740	0.143

Date	Oil Rate (CD) m3/d	Water Rate (CD) m3/d	Water Oil Ratio m3/m3	Water Inj Rate (CD) m3/d	Cum Oil Prod Km3	Cum Water Prod Km3	Cum Water Inj Km3	VRR	Cum VRR
12/31/2010	4.28	19.20	4.49	20.00	8.29	13.45	3.70	0.841	0.166
1/31/2011	4.39	17.60	4.01	20.00	8.43	14.00	4.32	0.897	0.188
2/28/2011	4.80	15.95	3.32	20.00	8.56	14.44	4.88	0.948	0.207
3/31/2011	3.78	13.99	3.70	20.35	8.68	14.88	5.51	1.129	0.228
4/30/2011	3.17	18.51	5.85	20.17	8.77	15.43	6.12	0.921	0.246
5/31/2011	3.36	18.98	5.65		8.88	16.02	6.12	0.000	0.240
6/30/2011	4.18	18.02	4.31	9.03	9.00	16.56	6.39	0.402	0.244
7/31/2011	4.79	16.86	3.52		9.15	17.08	6.39	0.000	0.238
8/31/2011	3.68	9.68	2.63		9.26	17.38	6.39	0.000	0.234
9/30/2011	3.94	11.15	2.83		9.38	17.72	6.39	0.000	0.230
10/31/2011	3.96	9.72	2.45		9.51	18.02	6.39	0.000	0.227
11/30/2011	3.31	8.33	2.52		9.60	18.27	6.39	0.000	0.224
12/31/2011	3.26	8.79	2.69		9.71	18.54	6.39	0.000	0.221
1/31/2012	3.30	8.75	2.65		9.81	18.81	6.39	0.000	0.218
2/29/2012	3.47	8.59	2.48		9.91	19.06	6.39	0.000	0.215
3/31/2012	3.34	7.78	2.33		10.01	19.30	6.39	0.000	0.213
4/30/2012	3.34	7.26	2.17		10.11	19.52	6.39	0.000	0.211
5/31/2012	3.20	7.19	2.25		10.21	19.74	6.39	0.000	0.208
6/30/2012	2.93	6.48	2.21	0.43	10.30	19.94	6.40	0.044	0.207
7/31/2012	2.68	6.98	2.61	7.44	10.38	20.15	6.63	0.755	0.212
8/31/2012	2.59	10.31	3.98	12.18	10.46	20.47	7.01	0.931	0.221
9/30/2012	2.47	11.31	4.58	19.54	10.54	20.81	7.59	1.400	0.237
10/31/2012	2.38	12.34	5.18	20.21	10.61	21.20	8.22	1.357	0.253
11/30/2012	2.09	13.89	6.65	14.82	10.67	21.61	8.66	0.919	0.262
12/31/2012	2.32	11.72	5.05	15.33	10.75	21.98	9.14	1.079	0.273
1/31/2013	2.27	10.79	4.76	20.15	10.82	22.31	9.77	1.525	0.288
2/28/2013	2.31	11.05	4.77	19.57	10.88	22.62	10.31	1.447	0.301
3/31/2013	1.75	11.09	6.34	20.00	10.93	22.96	10.93	1.543	0.315
4/30/2013	2.13	11.24	5.28	20.34	11.00	23.30	11.54	1.504	0.329
5/31/2013	2.18	13.35	6.12	20.00	11.07	23.71	12.16	1.276	0.342
6/30/2013	2.29	14.78	6.46	19.86	11.13	24.16	12.76	1.153	0.354
7/31/2013	2.22	14.70	6.61	19.63	11.20	24.61	13.37	1.149	0.365
8/31/2013	2.25	13.91	6.18	20.46	11.27	25.05	14.00	1.254	0.377
9/30/2013	2.12	13.00	6.14	18.75	11.34	25.43	14.56	1.228	0.388
10/31/2013	2.12	13.72	6.48	19.20	11.40	25.86	15.16	1.202	0.398
11/30/2013	2.11	15.16	7.17	16.27	11.47	26.31	15.65	0.934	0.406
12/31/2013	2.11	14.38	6.81	20.10	11.53	26.76	16.27	1.208	0.416
1/31/2014	2.28	13.76	6.04	20.03	11.60	27.19	16.89	1.236	0.427
2/28/2014	2.07	14.35	6.94	20.15	11.66	27.59	17.46	1.216	0.436
3/31/2014	2.58	15.44	5.98	15.91	11.74	28.07	17.95	0.874	0.442
4/30/2014	2.32	15.59	6.73	20.03	11.81	28.54	18.55	1.109	0.451
5/31/2014	2.26	14.45	6.40	20.84	11.88	28.98	19.20	1.236	0.460
6/30/2014	2.08	12.43	5.97	19.20	11.94	29.36	19.77	1.310	0.469

Date	Oil Rate (CD) m3/d	Water Rate (CD) m3/d	Water Oil Ratio m3/m3	Water Inj Rate (CD) m3/d	Cum Oil Prod Km3	Cum Water Prod Km3	Cum Water Inj Km3	VRR	Cum VRR
7/31/2014	2.18	13.15	6.02	17.81	12.01	29.76	20.32	1.150	0.477
8/31/2014	1.97	13.90	7.05	20.52	12.07	30.20	20.96	1.282	0.486
9/30/2014	1.86	14.22	7.66	20.07	12.13	30.62	21.56	1.238	0.495
10/31/2014	2.08	11.55	5.56	19.58	12.19	30.98	22.17	1.422	0.504
11/30/2014	1.64	9.30	5.66	19.13	12.24	31.26	22.74	1.731	0.513
12/31/2014	1.29	8.71	6.76	5.97	12.28	31.53	22.93	0.592	0.513
1/31/2015	1.62	6.86	4.23		12.33	31.74	22.93	0.000	0.510
2/28/2015	1.08	5.10	4.71		12.36	31.88	22.93	0.000	0.508
3/31/2015	1.77	5.07	2.86	0.94	12.42	32.04	22.96	0.134	0.507
4/30/2015	1.56	4.51	2.89	15.43	12.46	32.18	23.42	2.497	0.515
5/31/2015	1.67	5.53	3.30	18.13	12.51	32.35	23.98	2.478	0.524
6/30/2015	1.65	6.35	3.85	14.63	12.56	32.54	24.42	1.803	0.531
7/31/2015	1.18	5.15	4.37	13.32	12.60	32.70	24.83	2.079	0.538
8/31/2015	1.07	4.54	4.24	10.19	12.63	32.84	25.15	1.792	0.543
9/30/2015	2.48	4.50	1.81	8.97	12.71	32.97	25.42	1.254	0.546
10/31/2015	2.09	3.92	1.87	11.52	12.77	33.10	25.78	1.869	0.551
11/30/2015	1.68	5.34	3.18	11.57	12.82	33.26	26.12	1.622	0.556
12/31/2015	1.41	4.71	3.33	11.52	12.87	33.40	26.48	1.851	0.561