

# Waskada Unit No. 2

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## Waterflood Progress Report

**January 1<sup>st</sup> – December 31<sup>st</sup>, 2013**

**PennWest**

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Senior Waterflood Engineer

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## **Introduction:**

The Waskada Unit No.2 pressure maintenance project commenced water injection into the Lower Amaranth designed and in accordance with Manitoba Energy and Mines Approval No. PM 58.

Please refer to Attachment 1 – Area Map.

PRESSURE MAINTENANCE: Governed by Board Order No. PM 58

## **Unit Information**

UNITIZED ZONE: Lower Amaranth

Original Unit, January 1, 1984 Board Order – Voluntary

First Enlargement, September 1, 1985 Board Order - Voluntary

Second Enlargement, October 1, 1986 Board Order - Voluntary

POOL: Waskada Lower Amaranth A (03 29A)

This report documents the performance of the Waskada Unit No.2 pressure maintenance project for the period of January 1 to December 31, 2013. The Unit had 23 active producers and no active injectors at the end of 2013.

Please refer to Attachment 1A – Area Map of New Drills

Unit No. 2 is part of the main Waskada field. The Waskada field is situated on the northeast rim of the Williston Basin in southern Manitoba. It comprises a large portion of Township 1 and 2, Ranges 25 and 26 W1.

## **Geology**

The Waskada Fields produce light density crude (approximately 36° API), predominantly from the Lower Amaranth formation. This is an interlaminated, shallow marine to subtidal succession of sandstones, silstones, and shale progressively onlaps the Mississippian unconformity surface from basin center, up dip to the north and eastern basin limits in Saskatchewan and Manitoba. The fine grained reservoir rock has a complex reservoir characterization with 13 to 16 % porosity and permeability on the order of 0.5 to 15 md. The Lower Amaranth, the oldest Mesozoic unit, is a clastic red bed sequence lying directly on the Paleozoic erosional surface. It consists of a series of dolomitic siltstones and sandstones interbedded with argillaceous siltstones and shales. The section is usually subdivided into a lower sandy unit and an overlying shale unit. The lower sequence is the oil production zone. The bulk of pay is found in the laminated sandstone/siltstone facies.

The Lower Amaranth has been classified into four general lithological types:

1. Interbedded shale/siltstone/sandstone by grain size, color and texture

2. Siltstone – This lithology occurs in distinct intervals up to two or three metres in thickness. It is generally light green in color and dolomitic.
3. Laminated sandstone – This occurs in distinct sandy intervals with a wide range of grain sizes and primary sedimentary structures.
4. Massive sandstone – This lithology occurs in thin intervals and usually associated with the laminated sandstones facies. Beds are usually light grey to reddish grey in color and coarse to medium – grained.

## **Discussion**

### **Production and Injection Performance**

Board Order No. PM 58 provided for pressure maintenance operations in Waskada Unit No.2. From the startup of injection in December 1983, injection rates fluctuated to the same degree in each injector, making it difficult to link any production responses to any injector. The Unit includes 9 injection wells, at the end of 2013 none are currently active, and 22 active producers. Pressure maintenance by water injection ceased in May 2012.

Please refer to Attachment 2 – A Summary of the Unit Well List and History.

Please refer to Attachment 3 – A Production and Injection plot of the Unit.

Please refer to Attachment 4 – A Summary of Unit Annual Volumes and Rates.

Please refer to Attachment 5 – A Cumulative Production and Injection plot of the Unit.

### **Voidage Replacement Ratio Calculation:**

The Cumulative VRR from production start reached a maximum of 1 in 1987 and has declined in the last 2 years to 0.6. The Cumulative VRR from injection start stabilized at approximately 1 dropping in the last 2 years to 0.7. The decline in both Cumulative VRR's in the last 2 years is coincident with reduced Monthly VRR's in 2010, essentially no injection in 2012 and 2013 and the startup of new producers from 2010 to 2012. Currently there are no active injector in this Unit and PennWest has no plans to reactivate at this time any of the old injectors.

Please refer to Attachment 6 – A Unit Voidage Replacement Ratio Plot.

Please refer to Attachment 7 – Individual Injection Well Performance Plots.

### **Pressure Surveys:**

There were no pressure surveys conducted in 2013.

### **Corrosion and Scale Prevention Program:**

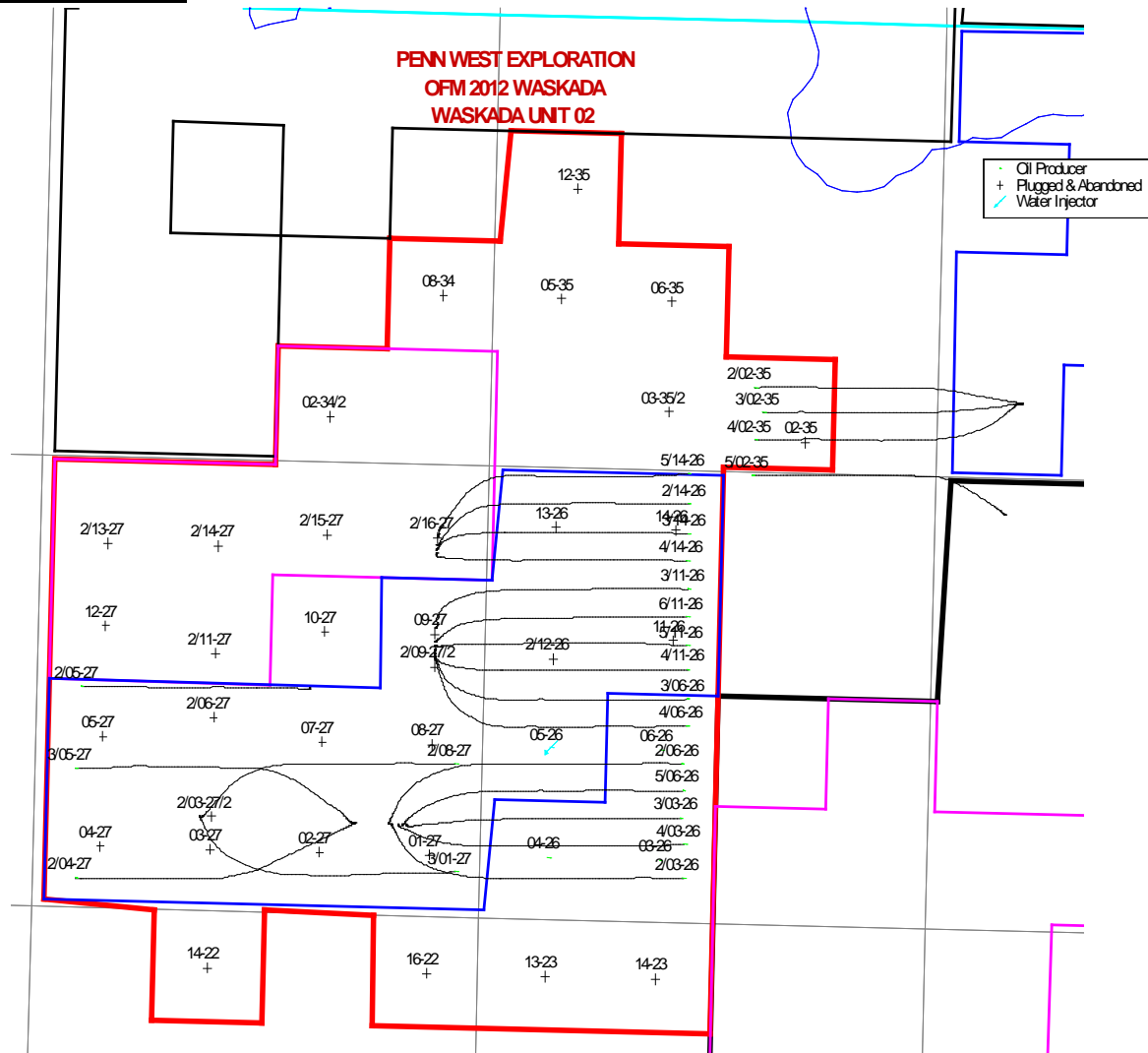
We currently inject ScalCor down all the new horizontal wells. PennWest will be installing cathodic protection on the wells. The new gathering system is Fibreglass and as such is not susceptible to corrosion.

## **Summary and Recommendations**

The behaviour of Waskada Unit 2 producers are indicated by good initial oil productivity, rapidly declining to low rates, with almost no discernible water flood response. It is also believed that fracture stimulation treatments, performed on these wells prior to initiation of water injection, “broke through” into the higher productivity Mississippian and that the majority of injected water to date has entered this zone. This is one of the major explanations for lack of waterflood response to date and the continued decline in oil productivities.

A horizontal producer and conversion of vertical producers to injector well pilot was contemplated for the Lower Amaranth targeting Unit 13 with results scalable to all Lower Amaranth Units. It is currently inactive pending evaluation of alternative schemes.

## ATTACHMENT 1 – Unit Area Map



## ATTACHMENT 2

Unit History: WASKADA UNIT 02

Well	Completion Date	OPERATOR	STATUS	New Drills	Kelly Bushing Elevation m	Total Depth m	First Production Date	Cum Oil Prod Mm3	Cum Water Prod Mm3	Last Production Date	First Injection Date	Cum Water Inj Mm3	Cum Gas Inj MMscm	Last Injection Date
00/14-22-001-26W1/0	10/31/1985	OMEGA_HYDROC	ABD-OIL	<N/A>		464.6	959	11/1/1985	0.36	5.81	4/1/1987	0	0	
00/16-22-001-26W1/0	8/12/1982	OMEGA_HYDROC	ABD	<N/A>		468.8	949		0	0	12/1/1983	61.8	0	2/1/1988
00/13-23-001-26W1/0	6/6/1983	PENN_WEST	ABD-OIL	<N/A>		470.4	948	6/1/1983	1.44	22.33	2/1/1988	16.3	0	3/1/1994
00/14-23-001-26W1/0	8/15/1982	PENN_WEST	ABD-OIL	<N/A>		469.9	952	10/1/1982	10.11	14.24	4/1/1996	0	0	
00/03-26-001-26W1/0	6/22/1982	PENN_WEST	OIL	<N/A>		470.5	941	7/1/1982	12.24	15.79	4/1/2012	0	0	
02/03-26-001-26W1/0	2/1/2011	PENN_WEST	OIL	<N/A>		467.9	1855	8/1/2011	4.59	11.58	1/1/2014	0	0	
03/03-26-001-26W1/0	1/29/2012	PENN_WEST	OIL	<N/A>		467.7	1779	4/1/2012	3.68	7.32	1/1/2014	0	0	
04/03-26-001-26W1/0	2/14/2012	PENN_WEST	OIL	<N/A>		467.3	1803	4/1/2012	2.77	4.56	1/1/2014	0	0	
00/04-26-001-26W1/0	7/20/1982	PENN_WEST	OIL	<N/A>		465.2	947	10/1/1982	22.62	59.34	5/1/2013	0	0	
00/05-26-001-26W1/0	6/17/1982	PENN_WEST	WTR-INJ	<N/A>		469.1	955	7/1/1982	4.45	0.56	1/1/1984	144.21	0	5/1/2012
00/06-26-001-26W1/0	2/27/1982	PENN_WEST	OIL	<N/A>		470	948	6/1/1982	17.22	8.48	5/1/2013	0	0	
02/06-26-001-26W1/0	2/8/2011	PENN_WEST	OIL	<N/A>		466.9	1866	8/1/2011	3.98	9.36	1/1/2014	0	0	
03/06-26-001-26W1/0	12/4/2011	PENN_WEST	OIL	<N/A>		467.7	1760	3/1/2012	2.54	5.86	1/1/2014	0	0	
04/06-26-001-26W1/0	11/25/2011	PENN_WEST	OIL	<N/A>		468.4	1803	3/1/2012	4.01	7.46	1/1/2014	0	0	
05/06-26-001-26W1/0	2/6/2012	PENN_WEST	OIL	<N/A>		467.4	1803	4/1/2012	4.04	6.63	1/1/2014	0	0	
00/11-26-001-26W1/0	6/13/1982	PENN_WEST	ABD-OIL	<N/A>		471	942	7/1/1982	5.29	9.75	6/1/1996	0	0	
03/11-26-001-26W1/0	1/20/2012	PENN_WEST	OIL	<N/A>		467.8	1752	3/1/2012	2.94	7.02	1/1/2014	0	0	
04/11-26-001-26W1/0	12/13/2011	PENN_WEST	OIL	<N/A>		468.4	1734	3/1/2012	2.3	6.93	1/1/2014	0	0	
05/11-26-001-26W1/0	1/6/2012	PENN_WEST	OIL	<N/A>		467.7	1727	3/1/2012	2.26	6.44	1/1/2014	0	0	
06/11-26-001-26W1/0	1/13/2012	PENN_WEST	OIL	<N/A>		467.6	1728	3/1/2012	3.07	9.68	1/1/2014	0	0	
02/12-26-001-26W1/0	6/15/1983	PENN_WEST	ABD-OIL	<N/A>		469.2	951	6/1/1983	10.87	23.41	5/1/1996	0	0	
00/13-26-001-26W1/0	12/17/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		469.1	950.1	3/1/1983	0.46	3.11	1/1/1984	57.7	0	3/1/1987
00/14-26-001-26W1/0	6/29/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		470.4	954	11/1/1982	1.26	17.09	10/1/1989	0	0	
02/14-26-001-26W1/0	12/19/2011	PENN_WEST	OIL	<N/A>		467.9	1752	3/1/2012	1.95	11.1	1/1/2014	0	0	
03/14-26-001-26W1/0	12/11/2011	PENN_WEST	OIL	<N/A>		468.1	1728	3/1/2012	2.55	10.18	1/1/2014	0	0	
04/14-26-001-26W1/0	12/4/2011	PENN_WEST	OIL	<N/A>		468.1	1719	3/1/2012	2.86	7.47	1/1/2014	0	0	
05/14-26-001-26W1/0	1/4/2012	PENN_WEST	OIL	<N/A>		467.9	1768	3/1/2012	1.72	14.19	1/1/2014	0	0	
00/01-27-001-26W1/0	11/19/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		466.5	955	12/1/1982	3.81	22.88	8/1/1988	0	0	
03/01-27-001-26W1/0	7/20/2010	PENN_WEST	OIL	<N/A>		464.7	1751	9/1/2010	5.29	19.84	1/1/2014	0	0	
00/02-27-001-26W1/0	8/22/1982	PENN_WEST	ABD-OIL	<N/A>		466.4	956	11/1/1982	2.72	10.45	12/1/1991	0	0	
00/03-27-001-26W1/0	10/29/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		465.8	950	3/1/1983	1.81	14.4	6/1/1988	0	0	
02/03-27-001-26W1/2	7/5/1983	PENN_WEST	ABD	<N/A>		466.3	950	11/1/1988	0	1.28	2/1/1989	0	0	
00/04-27-001-26W1/0	12/7/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		464.3	954	2/1/1983	3.24	24.52	5/1/1988	0	0	
02/04-27-001-26W1/0	11/18/2010	PENN_WEST	OIL	<N/A>		467	1807	12/1/2010	2.32	37.54	1/1/2014	0	0	
00/05-27-001-26W1/0	9/23/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		466	951.8	12/1/1982	1.92	3.49	1/1/1984	70.88	0	3/1/1987
02/05-27-001-26W1/0	1/7/2010	PENN_WEST	OIL	<N/A>		468.7	1660	3/1/2010	3.3	16.96	1/1/2014	0	0	
03/05-27-001-26W1/0	11/24/2010	PENN_WEST	OIL	<N/A>		467	1773	12/1/2010	2.51	22.08	1/1/2014	0	0	
02/06-27-001-26W1/0	6/21/1983	PENN_WEST	ABD-OIL	<N/A>		468.4	948	7/1/1983	9.37	22.33	3/1/1993	0	0	
00/07-27-001-26W1/0	8/27/1982	PENN_WEST	ABD-WINJ	<N/A>		467.3	955	12/1/1982	2.29	3.67	1/1/1984	102.31	0	3/1/1999
00/08-27-001-26W1/0	6/26/1982	PENN_WEST	ABD-OIL	<N/A>		469.2	955	8/1/1982	9.2	34.45	4/1/1992	0	0	
02/08-27-001-26W1/0	7/15/2010	PENN_WEST	OIL	<N/A>		464.8	1737	9/1/2010	5.59	13.62	1/1/2014	0	0	
00/09-27-001-26W1/0	8/28/1982	OMEGA_HYDROC	ABD-OIL	<N/A>		467.8	951	12/1/1982	1.82	6.78	1/1/1990	0	0	
02/09-27-001-26W1/2	7/8/1983	PENN_WEST	ABD-OIL	<N/A>		466.5	950	3/1/1987	0.53	2.83	4/1/1992	0	0	
00/10-27-001-26W1/0	9/1/1982	PENN_WEST	ABD-OIL	<N/A>		467	951	12/1/1982	4.36	11.77	12/1/1995	0	0	

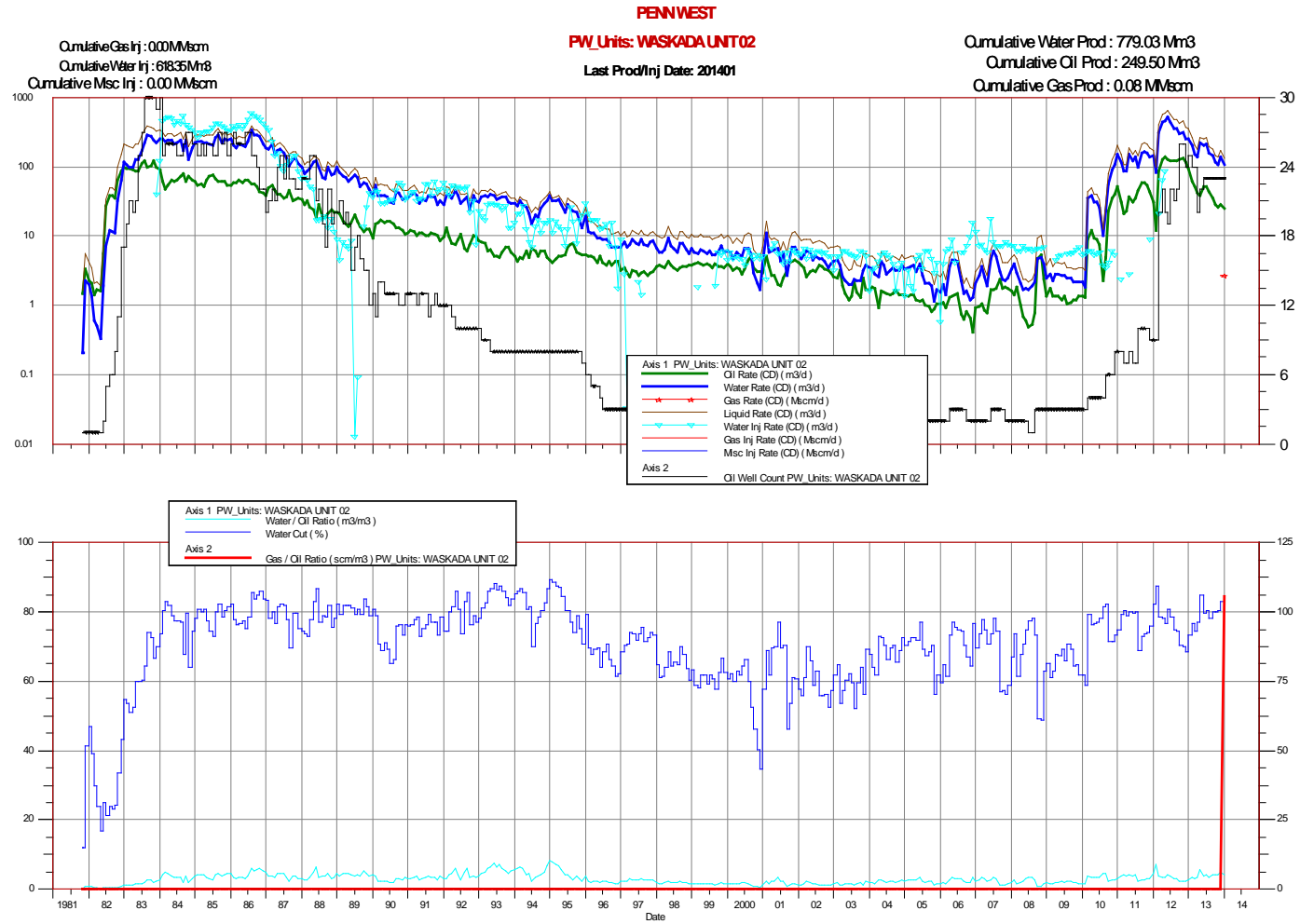
00/10-27-001-26W1/0	9/1/1982 PENN_WEST	ABD-OIL	<N/A>	467	951	12/1/1982	4.36	11.77	12/1/1995		0	0
02/11-27-001-26W1/0	6/30/1983 OMEGA_HYDROC	ABD-OIL	<N/A>	467.9	950	8/1/1983	1.76	28.32	4/1/1989		0	0
00/12-27-001-26W1/0	8/30/1982 PENN_WEST	ABD-OIL	<N/A>	466	948	11/1/1982	8.12	27.66	5/1/1993		0	0
02/13-27-001-26W1/0	6/22/1983 PENN_WEST	ABD-OIL	<N/A>	466.1	957	7/1/1983	1.43	1.35	1/1/1984	2/1/1984	65.79	0 12/1/1986
02/14-27-001-26W1/0	6/27/1983 PENN_WEST	ABD-OIL	<N/A>	468	946	8/1/1983	23.44	50.26	12/1/1995		0	0
02/15-27-001-26W1/0	6/5/1983 OMEGA_HYDROC	ABD-OIL	<N/A>	468.8	952	6/1/1983	1.83	0.38	1/1/1984	1/1/1984	75.78	0 12/1/1987
02/16-27-001-26W1/0	6/9/1983 PENN_WEST	ABD-OIL	<N/A>	468.8	954	6/1/1983	3.33	26.57	5/1/1990		0	0
00/02-34-001-26W1/2	3/16/1983 OMEGA_HYDROC	ABD-OIL	<N/A>	469.5	964	8/1/1983	1.07	7.92	3/1/1990		0	0
00/08-34-001-26W1/0	6/4/1982 OMEGA_HYDROC	ABD-OIL	<N/A>	468.4	951	2/1/1983	1.5	14.81	2/1/1990		0	0
00/02-35-001-26W1/0	9/6/1981 OMEGA_HYDROC	ABD-OIL	<N/A>	467.1	964	11/1/1981	1.24	1.02	2/1/1989		0	0
02/02-35-001-26W1/0	8/13/2012 PENN_WEST	OIL	<N/A>	472.5	1722	10/1/2012	1.45	1.58	9/1/2013		0	0
03/02-35-001-26W1/0	8/2/2012 PENN_WEST	OIL	<N/A>	472.5	1700	10/1/2012	1.57	2.18	1/1/2014		0	0
04/02-35-001-26W1/0	8/7/2012 PENN_WEST	OIL	<N/A>	472.5	1716	10/1/2012	1.49	1.87	1/1/2014		0	0
05/02-35-001-26W1/0	8/17/2012 PENN_WEST	OIL	<N/A>	470.5	1717	10/1/2012	4.34	3.56	1/1/2014		0	0
00/03-35-001-26W1/2	7/25/1983 OMEGA_HYDROC	ABD-OIL	<N/A>	471.5	970	3/1/1984	0.44	9.28	10/1/1989		0	0
00/05-35-001-26W1/0	7/22/1983 PENN_WEST	ABD-OIL	<N/A>	470.2	950	10/1/1983	0.63	6.05	9/1/1985	10/1/1985	23.57	0 10/1/1992
00/06-35-001-26W1/0	11/29/1982 PENN_WEST	ABD-OIL	<N/A>	471.4	948.5	12/1/1982	3.52	13.75	4/1/1991		0	0
00/12-35-001-26W1/0	10/8/1983 PENN_WEST	ABD-OIL	<N/A>	469.9	965	10/1/1983	0.7	7.89	11/1/1989		0	0

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## ATTACHMENT 3 – Unit Production and Injection Plot



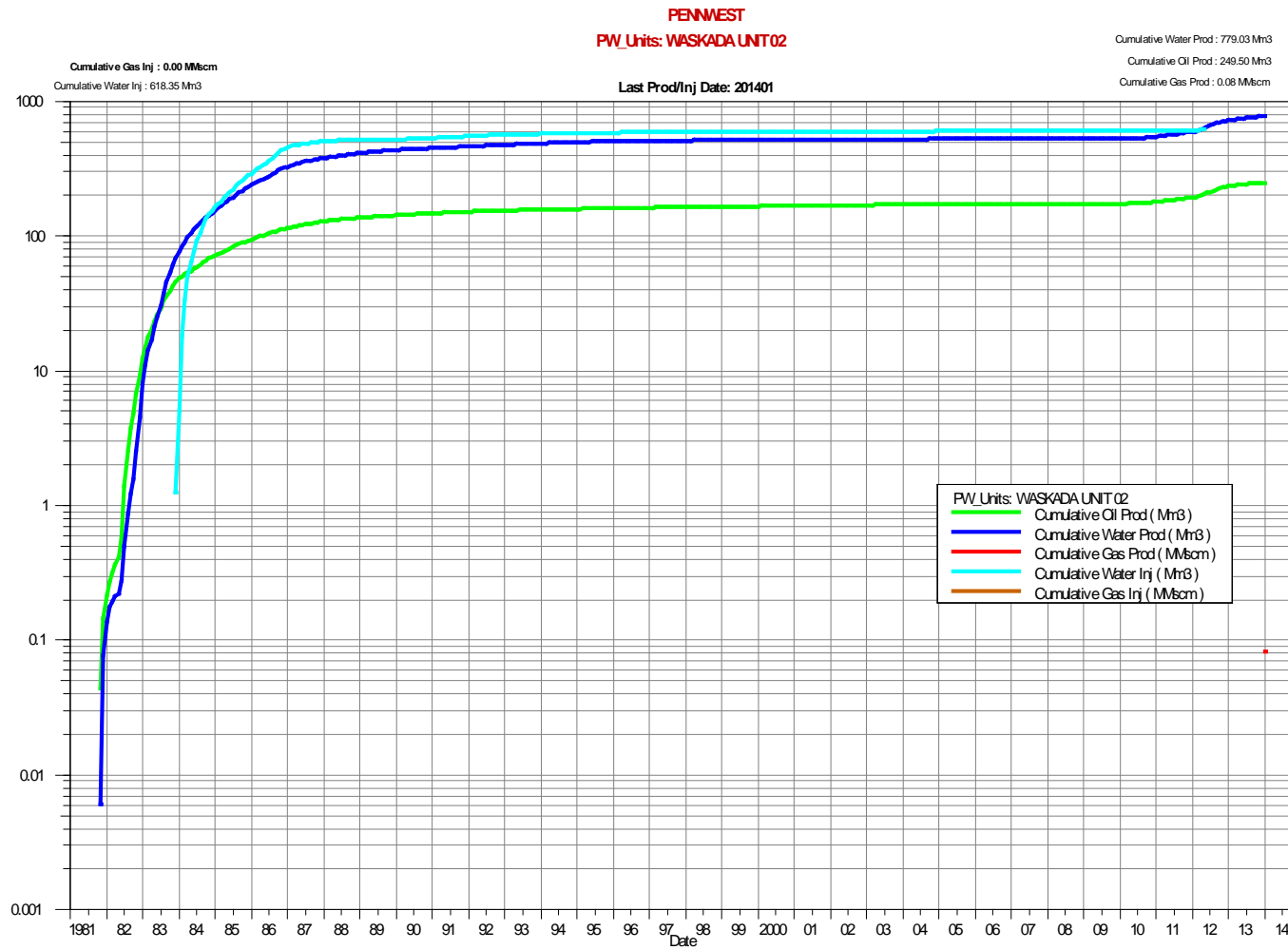
## ATTACHMENT 4

PW\_Units: WASKADA UNIT 02

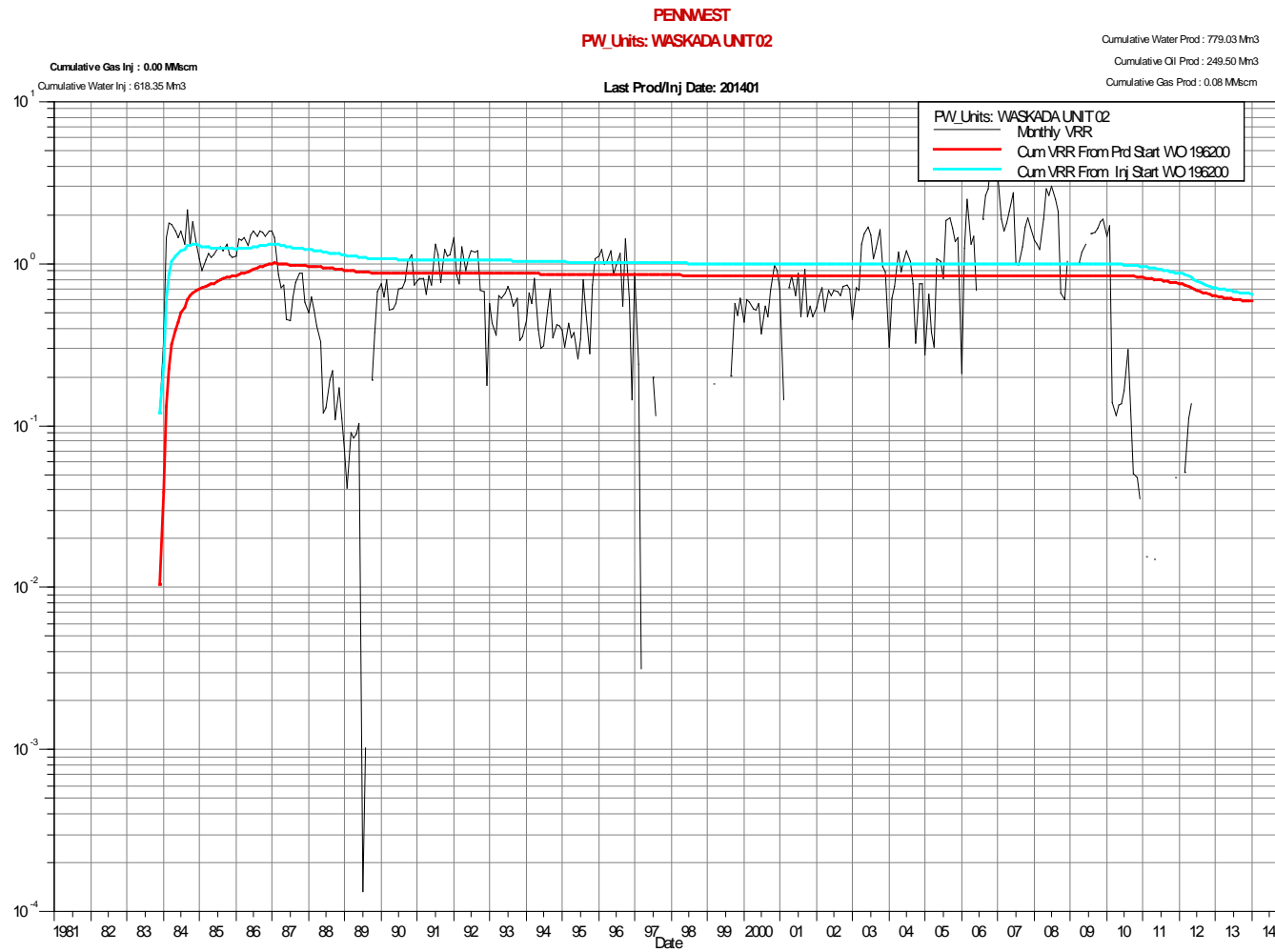
## Rates and Volume History

Date	Annual Oil Prod m3	Annual Oil Rate m3/d	Annual Water Prod m3	Annual Water Rate m3/d	Annual Water Inj m3	Annual Water Inj Rate m3/d	Annual Gas Inj Mscm	Annual Gas Inj Rate Mscm/d
1/1/1981	145.8	0.4	77.6	0.21				
1/1/1982	9220	25.26	4445	12.18				
1/1/1983	36384.1	99.68	63552.2	174.12	1239	3.39	0	0
1/1/1984	24119.9	65.9	79843.2	218.15	153606	419.69	0	0
1/1/1985	22558.8	61.8	85327.7	233.77	126181	345.7	0	0
1/1/1986	20364	55.79	87504	239.74	160776	440.48	0	0
1/1/1987	14682.3	40.23	56167.8	153.88	61485	168.45	0	0
1/1/1988	9025.3	24.66	32920.7	89.95	12461	34.05	0	0
1/1/1989	5778.2	15.83	24659.2	67.56	3834	10.51	0	0
1/1/1990	5145.3	14.1	13878.1	38.02	14370	39.37	0	0
1/1/1991	3887.2	10.65	12753.7	34.94	15978	43.78	0	0
1/1/1992	3269.7	8.93	12726.5	34.77	15440	42.19	0	0
1/1/1993	2364.9	6.48	12922.2	35.4	8431	23.1	0	0
1/1/1994	1970.1	5.4	9266.6	25.39	5612	15.38	0	0
1/1/1995	2063.8	5.65	9529.6	26.11	5405	14.81	0	0
1/1/1996	1646.9	4.5	3642.4	9.95	5289	14.45	0	0
1/1/1997	1084.4	2.97	2866.5	7.85	469	1.28	0	0
1/1/1998	1326.5	3.63	2462.8	6.75				
1/1/1999	1378.5	3.78	2186.9	5.99	639	1.75	0	0
1/1/2000	1300.4	3.55	1779.2	4.86	1818	4.97	0	0
1/1/2001	1198.3	3.28	2168.2	5.94	1816	4.97	0	0
1/1/2002	1213.1	3.32	1780.9	4.88	2044	5.6	0	0
1/1/2003	711.2	1.95	1068	2.93	1921	5.26	0	0
1/1/2004	554	1.51	1214.4	3.32	1437	3.92	0	0
1/1/2005	421.4	1.15	998.7	2.74	1383	3.79	0	0
1/1/2006	359.5	0.98	905.9	2.48	2275	6.23	0	0
1/1/2007	526.9	1.44	1189.6	3.26	3093	8.47	0	0
1/1/2008	648	1.77	1062.2	2.9	2396	6.55	0	0
1/1/2009	472.5	1.29	912.3	2.5	1378	3.77	0	0
1/1/2010	4704.1	12.89	13795.9	37.8	1905	5.22	0	0
1/1/2011	14902.6	40.83	47773.9	130.89	432	1.18	0	0
1/1/2012	38528.6	105.27	122350.8	334.29	5240	14.32	0	0
1/1/2013	16760.5	45.92	62053.3	170.01				
	----- 248716.8		----- 775786		----- 618353			Sum

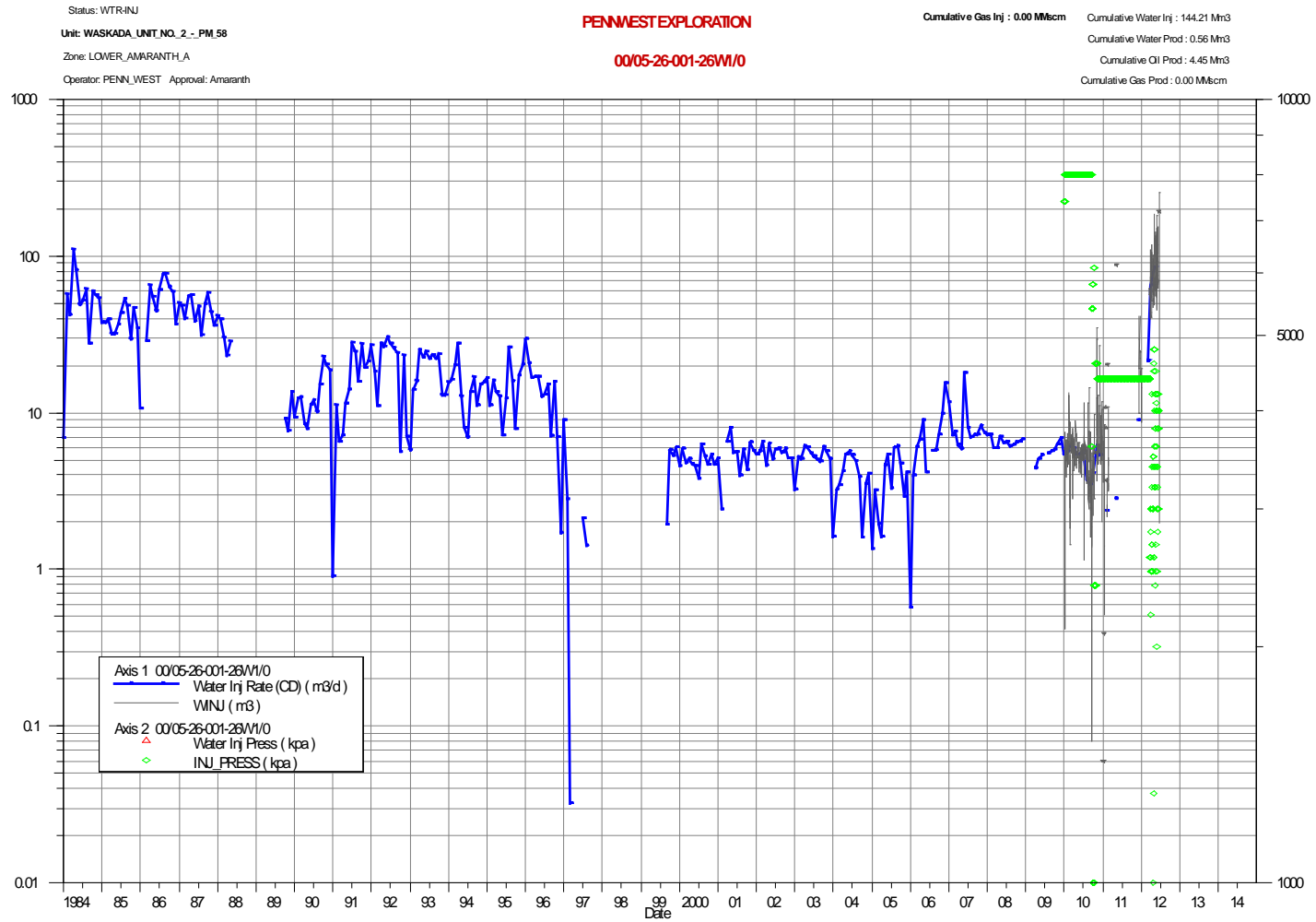
## ATTACHMENT 5 – Unit Cumulative Production and Injection Plot



## ATTACHMENT 6 – Unit Voidage Replacement Ratio Plot



## ATTACHMENT 7 – Individual Injection Well Performance Plots (9 Wells)



Status: ABD-OIL

Unit: WASKADA\_UNIT\_NO. 2 - PM\_58

Zone: LOWER\_AMARANTH\_A

Operator: OMEGA\_HYDROC Approval: Amaranth

PENNAEST EXPLORATION

00/05-27-001-26W1/O

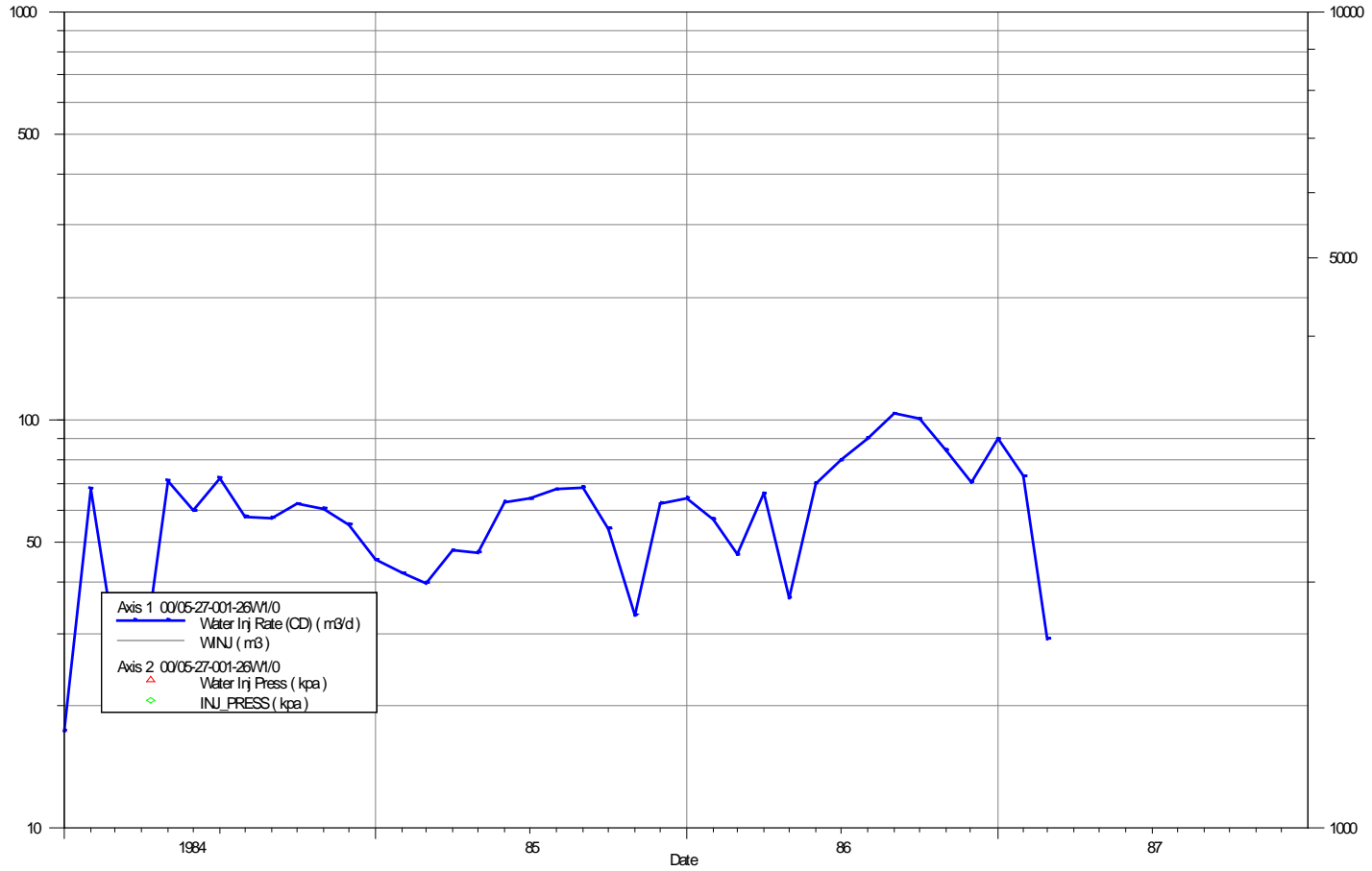
Cumulative Gas Inj : 0.00 MMscm

Cumulative Water Inj : 70.88 Mm3

Cumulative Water Prod : 3.49 Mm3

Cumulative Oil Prod : 1.92 Mm3

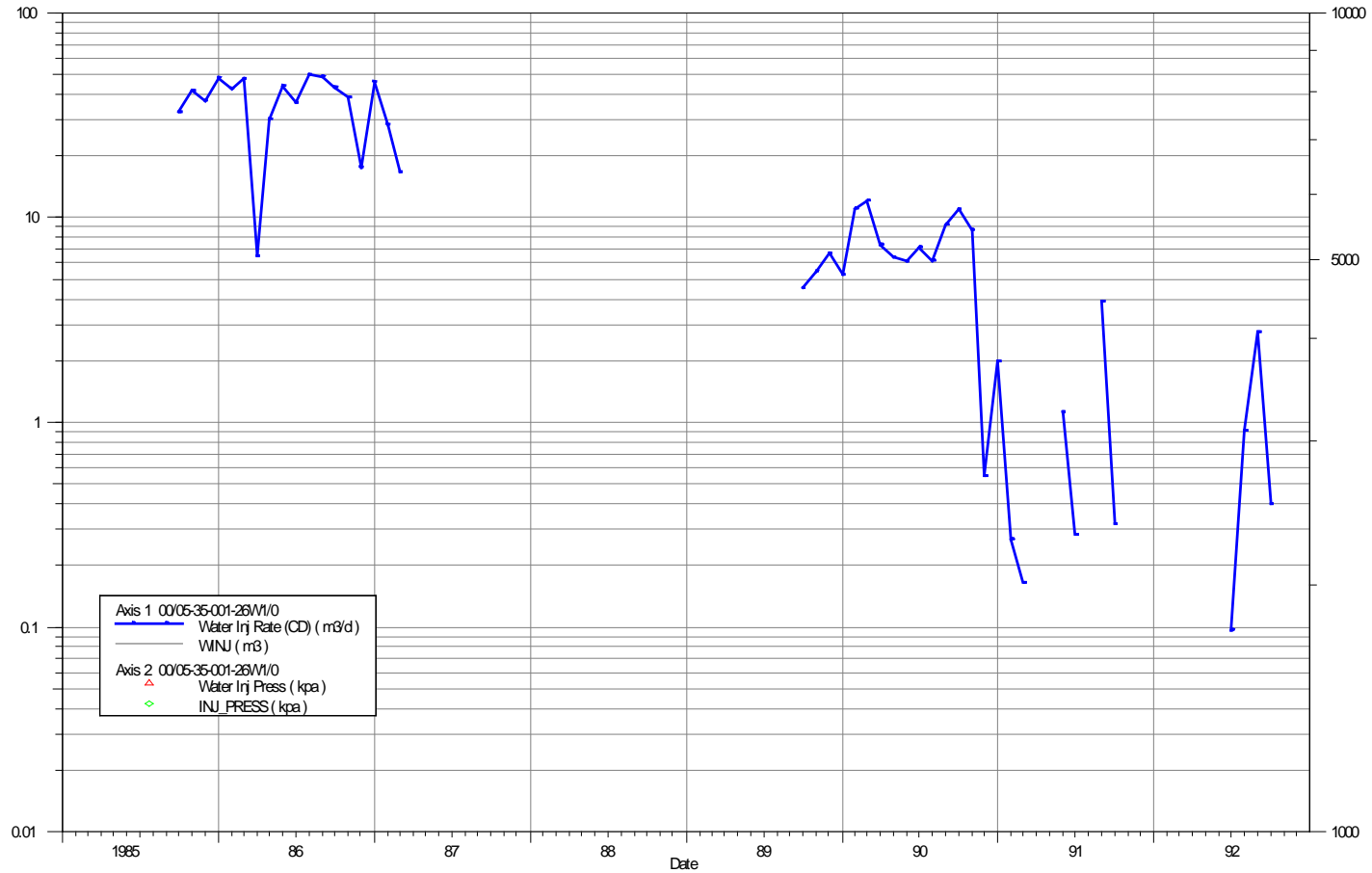
Cumulative Gas Prod : 0.00 MMscm



Operator: PENN\_WEST Approval: Amaranth

00/05-35-001-26WI/0

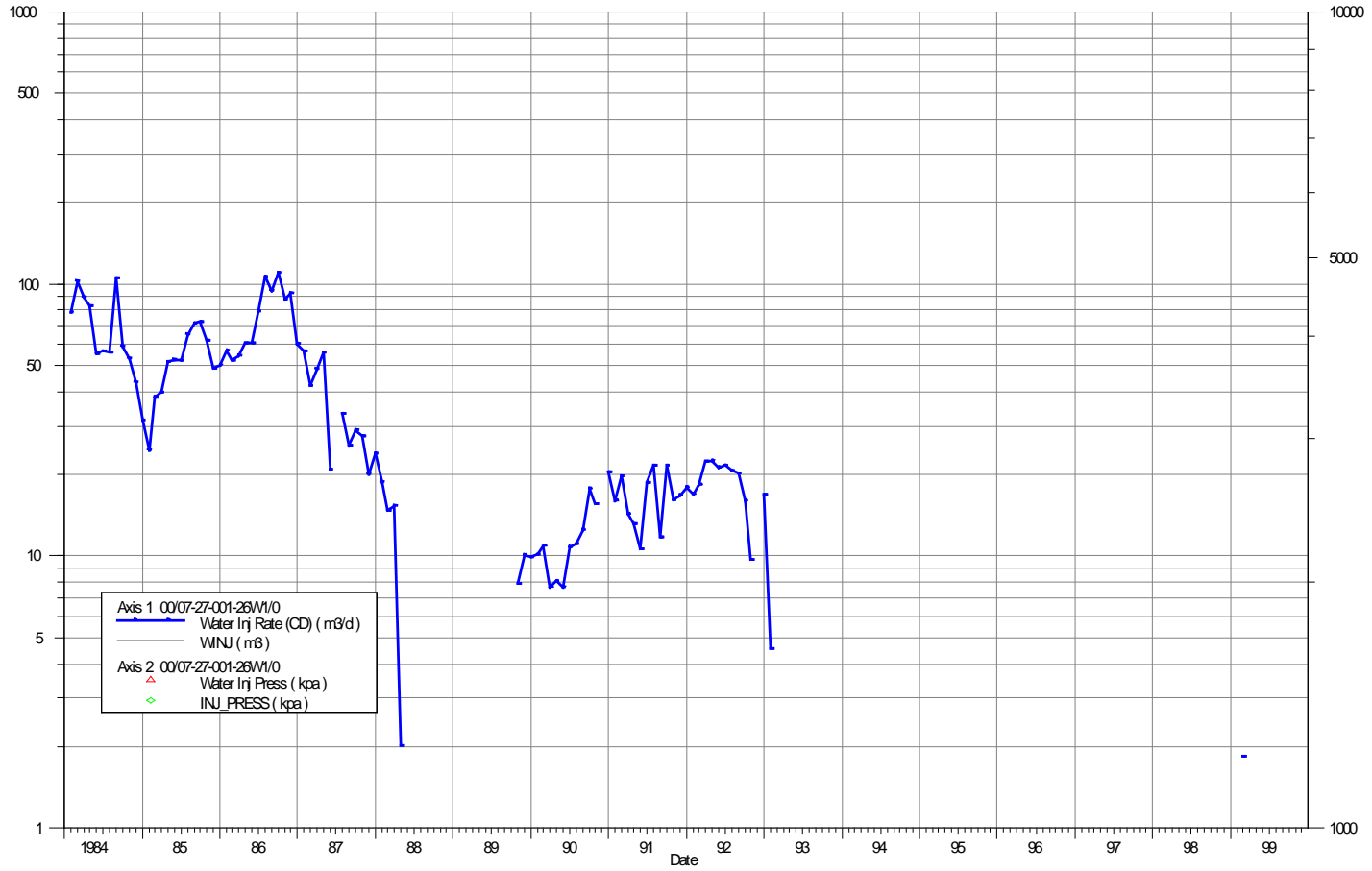
Cumulative Gas Prod : 0.00 MMscm



Status: ABD-WINJ  
Unit: WASKADA\_UNIT\_NO.2 - PM\_58  
Zone: LOWER\_AMARANTH\_A  
Operator: PENN\_WEST Approval: Amaranth

PENNWEST EXPLORATION  
00/07-27-001-26W1/O

Cumulative Gas Inj : 0.00 MMscm  
Cumulative Water Inj : 102.31 Mn3  
Cumulative Water Prod : 3.67 Mn3  
Cumulative Oil Prod : 2.29 Mn3  
Cumulative Gas Prod : 0.00 MMscm





Status: ABD-OIL

Unit: WASKADA\_UNIT\_NO\_2\_-\_PM\_58

Zone: LOWER\_AMARANTH\_A

Operator: PENN\_WEST Approval: Amaranth

PENNVEST EXPLORATION

00/13-23-001-26W1/O

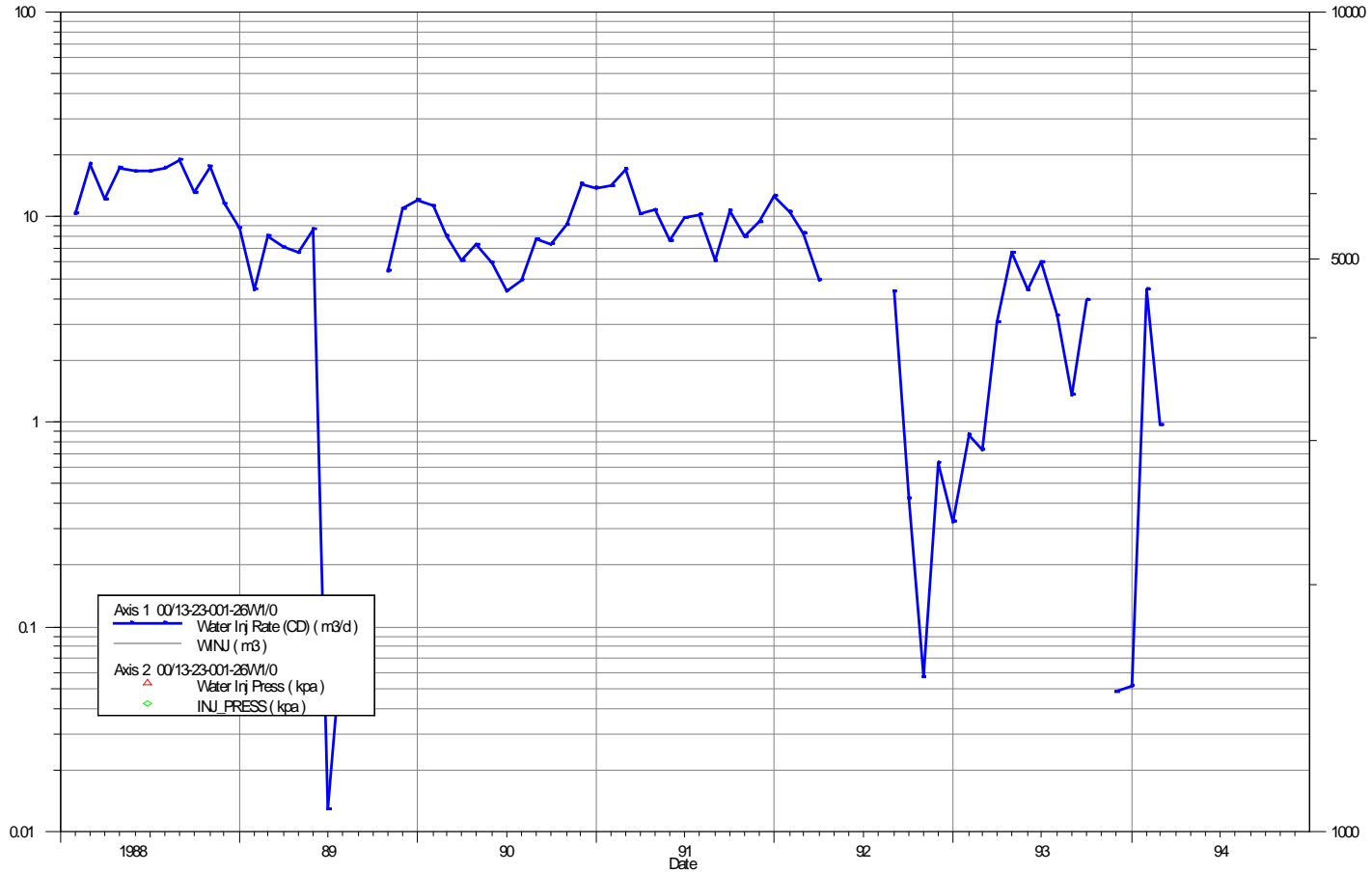
Cumulative Gas Inj : 0.00 MMscm

Cumulative Water Inj : 16.30 Mn3

Cumulative Water Prod : 22.33 Mn3

Cumulative Oil Prod : 1.44 Mn3

Cumulative Gas Prod : 0.00 MMscm



Status: ABD-OIL

Unit: WASKADA\_UNIT\_NO. 2 - PM\_58

Zone: LOWER\_AMARANTH\_A

Operator: OMEGA\_HYDROC Approval: Amaranth

PENNVEST EXPLORATION

00/13-26-001-26W1/O

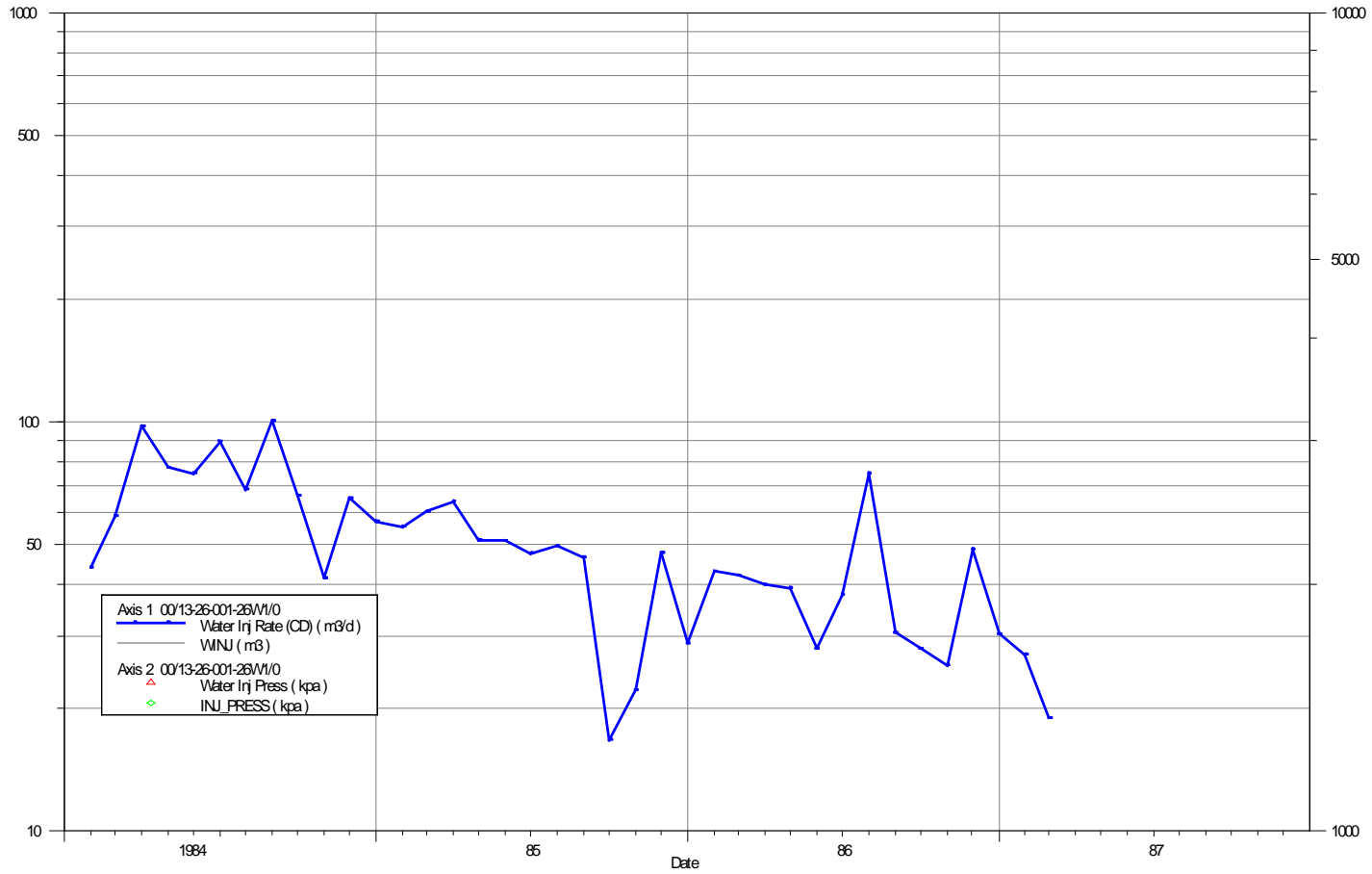
Cumulative Gas Inj : 0.00 MMscm

Cumulative Water Inj : 57.70 Mn3

Cumulative Water Prod : 3.11 Mn3

Cumulative Oil Prod : 0.46 Mn3

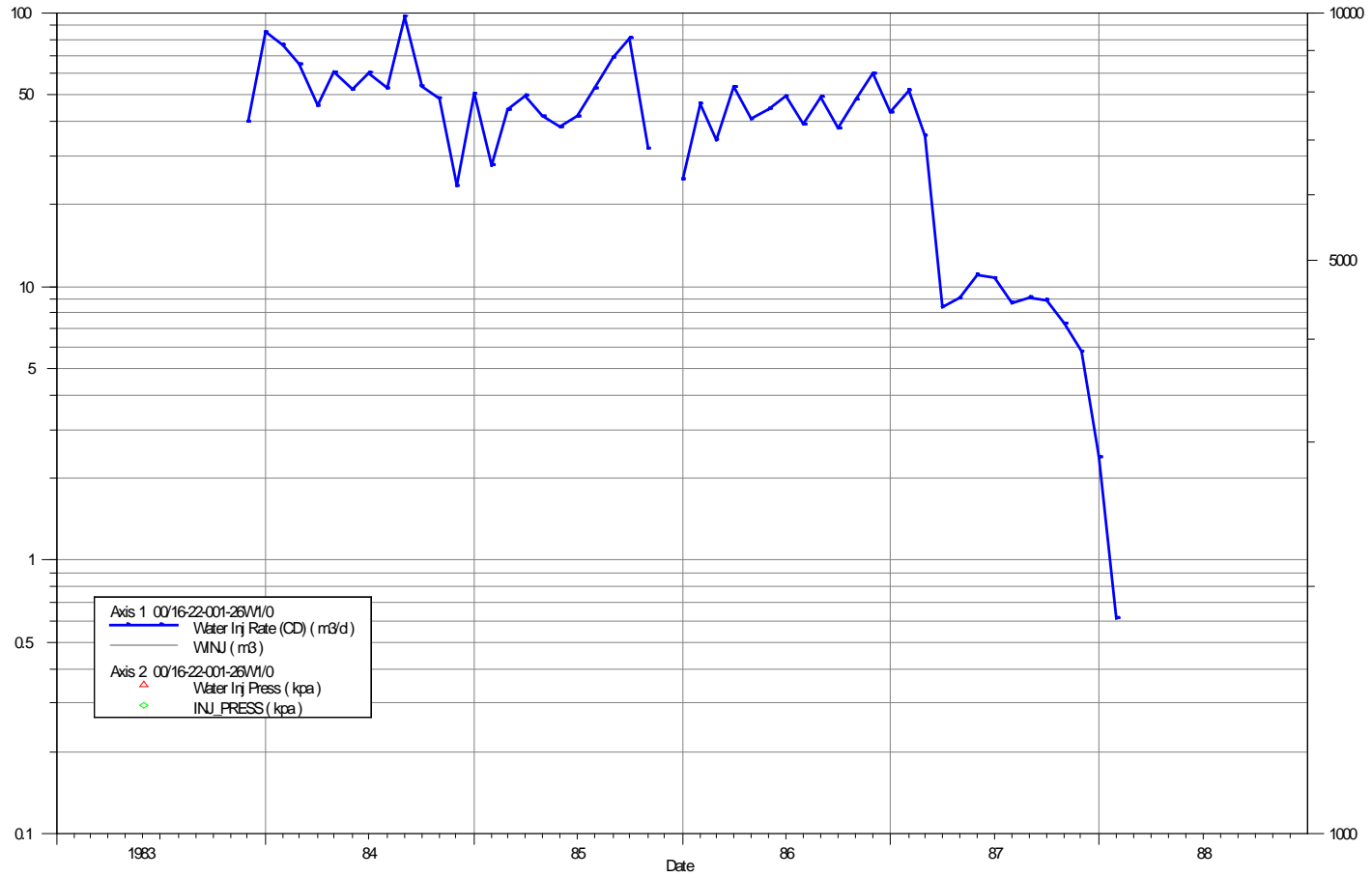
Cumulative Gas Prod : 0.00 MMscm



Status: ABD  
Unit: WASKADA\_UNIT\_NO\_2 - PM\_58  
Zone: LOWER\_AMARANTH\_A  
Operator: OMEGA\_HYDROC Approval: Amaranth

PENNAEST EXPLORATION  
00/16-22-001-26W1/0

Cumulative Gas Inj : 0.00 MMscm  
Cumulative Water Inj : 61.80 Mm3  
Cumulative Water Prod : \* Mm3  
Cumulative Oil Prod : \* Mm3  
Cumulative Gas Prod : \* MMscm



Status: ABD-OIL

Unit: WASKADA\_UNIT\_NO. 2 - PM\_58

Zone: LOWER\_AMARANTH\_A

Operator: PENN\_WEST Approval: Amaranth

PENNVEST EXPLORATION

02/13-27-001-26W1/O

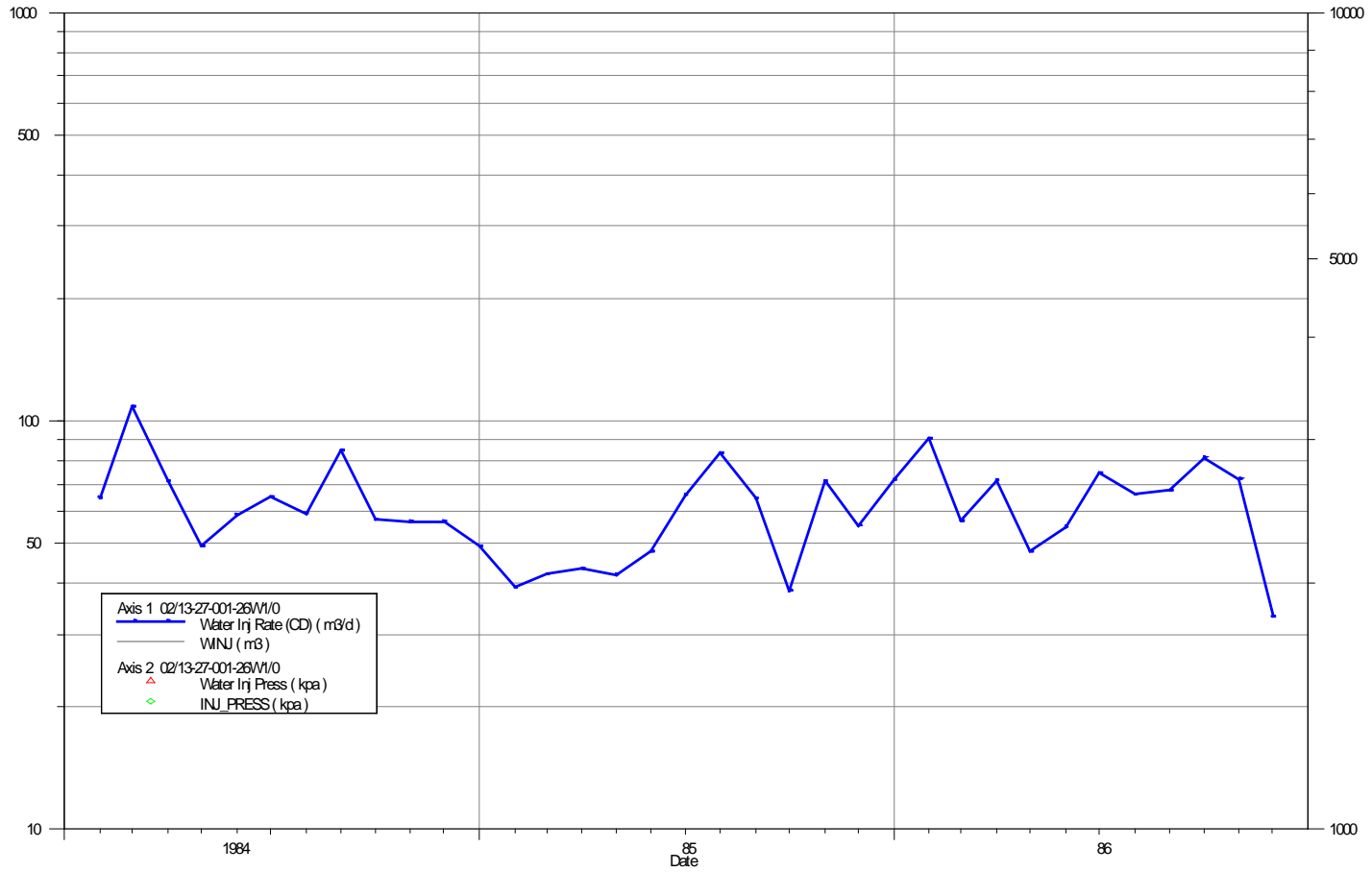
Cumulative Gas Inj : 0.00 MMscm

Cumulative Water Inj : 65.79 Mm3

Cumulative Water Prod : 1.35 Mm3

Cumulative Oil Prod : 1.43 Mm3

Cumulative Gas Prod : 0.00 MMscm



Status: ABD-OIL

Unit: WASKADA\_UNIT\_NO\_2\_-\_PM\_58

Zone: LOWER\_AMARANTH\_A

Operator: OMEGA\_HYDROC Approval: Amaranth

PENNAEST EXPLORATION

02/15-27-001-26W1/0

Cumulative Gas Inj : 0.00 MMscm

Cumulative Water Inj : 75.78 Mn3

Cumulative Water Prod : 0.38 Mn3

Cumulative Oil Prod : 1.83 Mn3

Cumulative Gas Prod : 0.00 MMscm

