

# **WASKADA UNIT NO. 4**

## **WATERFLOOD PROGRESS REPORT**

**January 1, through December 31, 2010**

### **PennWest Exploration**

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## **INTRODUCTION**

The WASKADA UNIT NO.4 pressure maintenance project commenced water injection into the Lower Amaranth designed and in accordance with Manitoba Energy and Mines Approval No. PM 58.

PRESSURE MAINTENANCE: Governed by Board Order No. PM 58

### UNIT INFORMATION:

UNITIZED ZONE: Lower Amaranth

Original Unit, Jan.1, 1984 Board Order; Unitization Order No. 31

POOL: Waskada Lower Amaranth A (03 29A)

This report documents the performance of the Waskada Lower Amaranth pressure maintenance project for the period of January 1 to December 31, 2010.

Unit # 4 is part of main Waskada. 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 (W1PM).

The Waskada Fields produce light density crude (approximately 36° API), predominantly from the Lower Amaranth formation. The interlaminated, shallow marine to subtidal succession of sandstones, siltstones, 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 founded 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 meters 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.

### **UNIT HISTORY**

#### **Waskada Unit #4 (Unit History)**

| <b>Abbreviated Well ID</b> | <b>Date Well Spudded</b> | <b>On Prod YYYY/MM</b> | <b>Org Operator Name</b> | <b>Ground Elevation (m)</b> | <b>TVD (m)</b> |
|----------------------------|--------------------------|------------------------|--------------------------|-----------------------------|----------------|
| 00/16-11-001-26W1/0        | 7/11/1982                | 1982/08                | Omega Hydcbns Ltd        | 462.3                       | 946.0          |
| 00/14-12-001-26W1/0        | 3/6/1982                 | 1982/07                | Omega Hydcbns Ltd        | 465.6                       | 935.0          |
| 00/01-13-001-26W1/0        | 12/9/1981                | 1982/03                | Omega Hydcbns Ltd        | 466.2                       | 945.0          |
| 00/02-13-001-26W1/0        | 8/9/1982                 | 1982/10                | Omega Hydcbns Ltd        | 466.0                       | 953.0          |
| 00/03-13-001-26W1/0        | 8/13/1982                | 1982/10                | Omega Hydcbns Ltd        | 464.3                       | 949.0          |
| 00/04-13-001-26W1/0        | 7/24/1982                | 1982/09                | Omega Hydcbns Ltd        | 465.3                       | 955.0          |
| 00/05-13-001-26W1/0        | 7/20/1982                | 1982/09                | Omega Hydcbns Ltd        | 465.8                       | 953.5          |
| 00/06-13-001-26W1/0        | 6/15/1982                | 1982/07                | Omega Hydcbns Ltd        | 465.8                       | 951.0          |
| 00/07-13-001-26W1/0        | 8/5/1982                 | 1982/09                | Omega Hydcbns Ltd        | 466.5                       | 946.0          |
| 00/08-13-001-26W1/0        | 7/31/1982                | 1982/11                | Omega Hydcbns Ltd        | 466.7                       | 952.0          |
| 00/10-13-001-26W1/0        | 6/22/1982                | 1982/08                | Omega Hydcbns Ltd        | 465.7                       | 952.0          |
| 00/11-13-001-26W1/0        | 6/19/1982                | 1982/11                | Omega Hydcbns Ltd        | 464.2                       | 952.0          |
| 00/12-13-001-26W1/0        | 7/28/1982                | 1982/09                | Omega Hydcbns Ltd        | 465.6                       | 953.0          |
| 00/13-13-001-26W1/0        | 6/26/1982                | 1982/07                | Omega Hydcbns Ltd        | 467.8                       | 953.0          |
| 00/14-13-001-26W1/0        | 11/22/1981               | 1982/04                | Omega Hydcbns Ltd        | 464.5                       | 950.0          |
| 00/15-13-001-26W1/0        | 7/8/1981                 | 1981/11                | Omega Hydcbns Ltd        | 465.9                       | 954.0          |

| <b>Abbreviated Well ID</b> | <b>Date Well Spudded</b> | <b>On Prod YYYY/MM</b> | <b>Org Operator Name</b> | <b>Ground Elevation (m)</b> | <b>TVD (m)</b> |
|----------------------------|--------------------------|------------------------|--------------------------|-----------------------------|----------------|
| 00/08-14-001-26W1/0        | 6/10/1982                | 1982/08                | Omega Hydcbns Ltd        | 466.0                       | 944.6          |
| 00/09-14-001-26W1/0        | 8/16/1982                | 1982/11                | Omega Hydcbns Ltd        | 464.5                       | 948.0          |
| 00/10-14-001-26W1/0        | 9/6/1982                 | 1982/12                | Omega Hydcbns Ltd        | 464.6                       | 953.0          |
| 00/15-14-001-26W1/0        | 8/21/1982                | 1982/11                | Omega Hydcbns Ltd        | 465.2                       | 950.0          |
| 00/16-14-001-26W1/0        | 2/17/1982                | 1982/04                | Omega Hydcbns Ltd        | 462.9                       | 942.0          |
| 00/01-23-001-26W1/0        | 6/29/1982                | 1982/08                | Omega Hydcbns Ltd        | 466.3                       | 953.0          |
| 00/02-23-001-26W1/0        | 10/21/1982               | 1982/12                | Omega Hydcbns Ltd        | 463.8                       | 953.0          |
| 00/07-23-001-26W1/2        | 9/18/1982                |                        | NCE Petrofund Corp       | 466.4                       | 947.0          |
| 02/08-23-001-26W1/0        | 5/25/1983                | 1983/06                | Omega Hydcbns Ltd        | 465.9                       | 950.0          |
| A0/08-23-001-26W1/0        | 2/25/1991                | 1991/03                | Omega Hydcbns Ltd        | 463.8                       | 963.0          |
| 02/01-24-001-26W1/0        | 5/30/1983                | 1983/06                | Omega Hydcbns Ltd        | 464.5                       | 947.0          |
| 00/02-24-001-26W1/0        | 6/29/1982                | 1982/12                | Omega Hydcbns Ltd        | 464.4                       | 953.0          |
| B0/02-24-001-26W1/0        | 10/29/1997               | 1997/12                | NCE Rsrcs                | 465.5                       | 960.0          |
| 00/03-24-001-26W1/0        | 6/20/1983                | 1983/07                | Omega Hydcbns Ltd        | 467.1                       | 950.0          |
| C0/03-24-001-26W1/0        | 4/5/1991                 | 1991/04                | Omega Hydcbns Ltd        | 467.9                       | 965.0          |
| 00/04-24-001-26W1/0        | 6/24/1983                | 1983/07                | Omega Hydcbns Ltd        | 469.0                       | 950.0          |
| C0/04-24-001-26W1/0        | 3/2/1991                 | 1991/03                | Omega Hydcbns Ltd        | 465.7                       | 960.5          |
| 00/05-24-001-26W1/0        | 6/14/1983                | 1983/07                | Omega Hydcbns Ltd        | 465.1                       | 957.0          |
| 00/06-24-001-26W1/0        | 6/28/1983                | 1983/07                | Omega Hydcbns Ltd        | 467.1                       | 948.0          |
| A0/06-24-001-26W1/0        | 4/1/1991                 | 1991/04                | Omega Hydcbns Ltd        | 467.9                       | 960.0          |
| 00/07-24-001-26W1/0        | 9/24/1981                | 1981/11                | Omega Hydcbns Ltd        | 466.1                       | 961.0          |
| 02/08-24-001-26W1/0        | 7/30/1983                | 1983/08                | Omega Hydcbns Ltd        | 468.3                       | 930.0          |

## Waskada Unit #4 (Production & Injection History)

| Abbreviated Well ID | First Prod<br>YYYY/M<br>M | On Inject.<br>YYYY/M<br>M | Last Prod.<br>YYYY/M<br>M | Cumulative OIL<br>Prod.<br>(m3) | Cumulative WTR<br>Prod.<br>(m3) | First 12 mo.<br>Ave WC<br>% | Last Inject.<br>YYYY/M<br>M |
|---------------------|---------------------------|---------------------------|---------------------------|---------------------------------|---------------------------------|-----------------------------|-----------------------------|
| 00/16-11-001-26W1/0 | 1982/08                   | 1985/12                   | 1985/12                   | 474                             | 3,864                           | 85.0                        | 1989/04                     |
| 00/14-12-001-26W1/0 | 1982/07                   |                           | 1989/07                   | 1,010                           | 913                             | 62.7                        |                             |
| 00/01-13-001-26W1/0 | 1982/03                   |                           | 2010/12                   | 12,973                          | 11,743                          | 4.6                         |                             |
| 00/02-13-001-26W1/0 | 1982/10                   |                           | 2010/12                   | 11,919                          | 1,610                           | 14.2                        |                             |
| 00/03-13-001-26W1/0 | 1982/10                   |                           | 1997/01                   | 2,982                           | 1,142                           | 32.7                        |                             |
| 00/04-13-001-26W1/0 | 1982/09                   |                           | 1990/03                   | 1,842                           | 1,023                           | 42.8                        |                             |
| 00/05-13-001-26W1/0 | 1982/09                   | 1984/06                   | 1984/05                   | 792                             | 415                             | 40.0                        | 2006/11                     |
| 00/06-13-001-26W1/0 | 1982/07                   |                           | 1990/04                   | 6,436                           | 33,350                          | 74.7                        |                             |
| 00/07-13-001-26W1/0 | 1982/09                   | 1985/12                   | 1985/11                   | 2,006                           | 376                             | 17.3                        | 2010/12                     |
| 00/08-13-001-26W1/0 | 1982/11                   |                           | 1989/09                   | 2,456                           | 461                             | 17.5                        |                             |
| 00/10-13-001-26W1/0 | 1982/08                   |                           | 2010/12                   | 10,576                          | 1,660                           | 27.5                        |                             |
| 00/11-13-001-26W1/0 | 1982/11                   |                           | 2010/12                   | 5,200                           | 3,457                           | 32.7                        |                             |
| 00/12-13-001-26W1/0 | 1982/09                   |                           | 1997/09                   | 4,217                           | 2,102                           | 36.1                        |                             |
| 00/13-13-001-26W1/0 | 1982/07                   | 1984/06                   | 1984/05                   | 2,754                           | 1,905                           | 34.5                        | 2005/10                     |
| 00/14-13-001-26W1/0 | 1982/04                   |                           | 2010/12                   | 11,436                          | 6,650                           | 41.6                        |                             |
| 00/15-13-001-26W1/0 | 1981/11                   | 1984/06                   | 1984/05                   | 3,663                           | 633                             | 14.5                        | 2006/10                     |
| 00/08-14-001-26W1/0 | 1982/08                   |                           | 2000/06                   | 7,315                           | 12,918                          | 54.5                        |                             |
| 00/09-14-001-26W1/0 | 1982/11                   |                           | 1989/12                   | 3,892                           | 12,526                          | 60.4                        |                             |
| 00/10-14-001-26W1/0 | 1982/12                   |                           | 1986/06                   | 636                             | 10,533                          | 57.5                        |                             |
| 00/15-14-001-26W1/0 | 1982/11                   | 1984/06                   | 1984/05                   | 612                             | 4,790                           | 88.6                        | 2000/06                     |
| 00/16-14-001-26W1/0 | 1982/04                   |                           | 1991/01                   | 5,246                           | 1,745                           | 15.3                        |                             |
| 00/01-23-001-26W1/0 | 1982/08                   |                           | 2010/11                   | 15,309                          | 11,496                          | 41.2                        |                             |

| Abbreviated Well ID | First Prod<br>YYYY/M<br>M | On Inject.<br>YYYY/M<br>M | Last Prod.<br>YYYY/M<br>M | Cumulati<br>ve OIL<br>Prod.<br>(m3) | Cumulati<br>ve WTR<br>Prod.<br>(m3) | First<br>12<br>mo.<br>Ave<br>WC<br>% | Last<br>Inject.<br>YYYY/M<br>M |
|---------------------|---------------------------|---------------------------|---------------------------|-------------------------------------|-------------------------------------|--------------------------------------|--------------------------------|
| 00/02-23-001-26W1/0 | 1982/12                   |                           | 1990/03                   | 2,263                               | 34,836                              | 81.2                                 |                                |
| 00/07-23-001-26W1/2 |                           | 1984/08                   |                           |                                     |                                     |                                      | 2001/09                        |
| 02/08-23-001-26W1/0 | 1983/06                   |                           | 1996/06                   | 6,276                               | 27,059                              | 58.8                                 |                                |
| A0/08-23-001-26W1/0 | 1991/03                   |                           | 2010/12                   | 4,312                               | 1,256                               | 17.5                                 |                                |
| 02/01-24-001-26W1/0 | 1983/06                   |                           | 1996/05                   | 5,263                               | 3,369                               | 11.5                                 |                                |
| 00/02-24-001-26W1/0 | 1982/12                   |                           | 2008/04                   | 15,968                              | 14,767                              | 57.0                                 |                                |
| B0/02-24-001-26W1/0 | 1997/12                   |                           | 2010/12                   | 4,619                               | 297                                 | 10.2                                 |                                |
| 00/03-24-001-26W1/0 | 1983/07                   |                           | 2010/12                   | 19,361                              | 60,143                              | 42.1                                 |                                |
| C0/03-24-001-26W1/0 | 1991/04                   |                           | 2010/12                   | 2,421                               | 1,037                               | 23.8                                 |                                |
| 00/04-24-001-26W1/0 | 1983/07                   |                           | 2010/12                   | 29,994                              | 78,540                              | 64.0                                 |                                |
| C0/04-24-001-26W1/0 | 1991/03                   |                           | 2010/12                   | 3,507                               | 5,181                               | 45.7                                 |                                |
| 00/05-24-001-26W1/0 | 1983/07                   | 1984/06                   | 1984/05                   | 2,593                               | 2,027                               | 43.9                                 | 1993/04                        |
| 00/06-24-001-26W1/0 | 1983/07                   |                           | 2010/12                   | 12,026                              | 2,434                               | 16.0                                 |                                |
| A0/06-24-001-26W1/0 | 1991/04                   |                           | 2005/10                   | 2,658                               | 3,284                               | 23.0                                 |                                |
| 00/07-24-001-26W1/0 | 1981/11                   | 1984/06                   | 1984/05                   | 3,040                               | 290                                 | 7.3                                  | 2009/06                        |
| 02/08-24-001-26W1/0 | 1983/08                   |                           | 2010/12                   | 14,004                              | 10,366                              | 4.7                                  |                                |

## **DISCUSSION:**

### **Production Performance**

Production Response versus Injection: Since injection began, mid 1985, injection rates fluctuated to some degree amongst the injectors; it is difficult to link any production responses to any specific injector. Water breakthrough of certain producers could not be directly correlated with over injection in associated injectors. Some wells showed no change in oil rate when injection was ceased in 1989-90.

## **Voidage Replacement Ratio Calculation**

What could be described as very limited success, the waterflood was not maintained properly and injection rate dropped year after year in most cases. The cumulative VRR in the pool is about 1.08 and the current monthly VRR is about 0.8 for year 2010 (under injected). All of the injectors are shut in currently. PennWest has no plans to re-activate the old injectors (see Appendix C).

To understand the past performance of the Lower Amaranth waterflood, we are doing some reservoir engineering work to come up with potential solutions. One of our plans is to do a pilot program in section 2: The objective of the pilot is to:

1. See if we can continuously inject water into the Lower Amaranth Formation
  - i. Particle size less than 1 micron
  - ii. Total Suspended Solid (TSS) less than 10 ppm
  - iii. Oil less than 10 ppm
2. Inject below the frac pressure
3. Test the simulation model that we have built.

## **2011 Waskada Lower Amaranth Waterflood Pilot Location**

The pilot producer will be 102/12-01-02-26W1/00 (Ta horizontal well) and the injectors will be two vertical wells; 100/12-01-02-26W1 and 100/11-01-02-26 (need to be converted to injectors)

## **Corrosion and Scale Prevention Program**

We currently inject ScalCor down all the new horizontal wells. In addition to that, PennWest will be installing cathodic protection on the wells. Also, the new gathering system is Fiberglass and as such is not susceptible to corrosion.



## **SUMMARY AND RECOMMENDATIONS**

### **[Producers]**

#### **Current Producing Wells**

1. 00/03-26-001-26W1/0
2. 00/04-26-001-26W1/0
3. 00/06-26-001-26W1/0
4. 02/05-27-001-26W1/0

#### **Current Suspended Wells**

None

#### **Abandoned Wells**

1. 00/14-22-001-26W1/0 (since 1987/05)
2. 00/14-23-001-26W1/0 (since 1996/05)
3. 00/11-26-001-26W1/0 (since 1996/07)
4. 02/12-26-001-26W1/0 (since 1996/06)
5. 00/14-26-001-26W1/0 (since 1989/11)
6. 00/01-27-001-26W1/0 (since 1988/09)
7. 00/02-27-001-26W1/0 (since 1992/01)
8. 00/03-27-001-26W1/0 (since 1988/07)
9. 00/04-27-001-26W1/0 (since 1988/06)
10. 02/06-27-001-26W1/0 (since 1993/04)
11. 00/08-27-001-26W1/0 (since 1992/05)
12. 00/09-27-001-26W1/0 (since 1990/02)
13. 02/09-27-001-26W1/2 (since 1992/05)
14. 00/10-27-001-26W1/0 (since 1996/01)
15. 02/11-27-001-26W1/0 (since 1989/05)
16. 00/12-27-001-26W1/0 (since 1993/06)
17. 02/14-27-001-26W1/0 (since 1996/01)
18. 02/16-27-001-26W1/0 (since 1990/06)

- 19.00/02-34-001-26W1/2 (since 1990/04)
- 20.00/08-34-001-26W1/0 (since 1990/03)
- 21.00/02-35-001-26W1/0 (since 1989/03)
- 22.00/03-35-001-26W1/2 (since 1989/11)
- 23.00/06-35-001-26W1/0 (since 1991/05)
- 24.00/12-35-001-26W1/0 (since 1989/12)

### **[Injectors]**

#### **Current Injecting Wells**

None

#### **Current Suspended Wells**

1. 00/05-26-001-26W1/0 (since 2011/01)

#### **Abandoned Wells**

1. 00/16-22-001-26W1/0 (since 1988/03)
2. 00/13-23-001-26W1/0 (since 1994/04)
3. 00/13-26-001-26W1/0 (since 1987/04)
4. 00/05-27-001-26W1/0 (since 1987/04)
5. 00/07-27-001-26W1/0 (since 1999/04)
6. 02/13-27-001-26W1/0 (since 1987/01)
7. 02/15-27-001-26W1/0 (since 1988/01)
8. 00/05-35-001-26W1/0 (since 1992/11)

The behavior of a Waskada Unit 4 producers are indicated by examining the oil rate versus time plots (see Appendix B). Waskada Unit 4 exhibited relatively high initial oil productivity (most of the wells drilled in the past are verticals), rapidly declining to flat/low decline rates, with almost no discernible water flood response. This behavior can be explained by drop in the reservoir pressure from initial (approximately 8700 kPag) to above in some wells or below in others bubble point pressure (about 4200 kPag) followed

by solution gas breakout which adversely affected the relative permeability to oil. (see Table # 2)

Also, it is believed that fracture stimulation treatments, performed on these wells prior to initiation of water injection, “broke” through into the higher productivity Mississippian zone and that 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.

PennWest has no plan to drill any new well, in this unit, in year 2011, and no plans on reactivation of any old injectors either.

**TABLES****Waskada Unit #4****Table 1: Rates History**

| Date | OIL     |        | Water   |        | Inj Water |        |
|------|---------|--------|---------|--------|-----------|--------|
| Year | m3/year | m3/day | m3/year | m3/day | m3/year   | m3/day |
| 1981 | 891     | 2.44   | 154     | 0.42   | 0         | 0.00   |
| 1982 | 14,701  | 40.28  | 7,215   | 19.77  | 0         | 0.00   |
| 1983 | 37,397  | 102.46 | 34,057  | 93.31  | 0         | 0.00   |
| 1984 | 26,933  | 73.79  | 33,400  | 91.51  | 0         | 0.00   |
| 1985 | 19,314  | 52.91  | 34,523  | 94.58  | 73,162    | 200.44 |
| 1986 | 12,945  | 35.46  | 43,742  | 119.84 | 134,971   | 369.78 |
| 1987 | 15,258  | 41.80  | 28,894  | 79.16  | 86,108    | 235.91 |
| 1988 | 10,751  | 29.45  | 23,051  | 63.15  | 43,873    | 120.20 |
| 1989 | 7,954   | 21.79  | 22,723  | 62.26  | 4,701     | 12.88  |
| 1990 | 5,812   | 15.92  | 11,723  | 32.12  | 10,613    | 29.08  |
| 1991 | 8,956   | 24.54  | 10,018  | 27.45  | 36,491    | 99.97  |
| 1992 | 7,311   | 20.03  | 16,486  | 45.17  | 66,196    | 181.36 |
| 1993 | 7,060   | 19.34  | 18,650  | 51.10  | 56,746    | 155.47 |
| 1994 | 6,296   | 17.25  | 15,906  | 43.58  | 30,651    | 83.98  |
| 1995 | 7,691   | 21.07  | 15,621  | 42.80  | 22,900    | 62.74  |
| 1996 | 6,364   | 17.44  | 10,418  | 28.54  | 28,328    | 77.61  |
| 1997 | 5,288   | 14.49  | 6,833   | 18.72  | 21,899    | 60.00  |
| 1998 | 5,366   | 14.70  | 5,577   | 15.28  | 16,369    | 44.85  |
| 1999 | 4,174   | 11.44  | 4,629   | 12.68  | 18,559    | 50.85  |
| 2000 | 3,484   | 9.54   | 3,487   | 9.55   | 10,759    | 29.48  |
| 2001 | 3,016   | 8.26   | 2,747   | 7.53   | 9,240     | 25.32  |
| 2002 | 2,981   | 8.17   | 1,890   | 5.18   | 6,490     | 17.78  |
| 2003 | 2,536   | 6.95   | 1,517   | 4.15   | 7,229     | 19.81  |
| 2004 | 2,269   | 6.22   | 3,251   | 8.91   | 8,263     | 22.64  |
| 2005 | 1,789   | 4.90   | 2,915   | 7.99   | 9,895     | 27.11  |
| 2006 | 2,588   | 7.09   | 1,213   | 3.32   | 5,897     | 16.16  |
| 2007 | 2,395   | 6.56   | 1,809   | 4.96   | 1,296     | 3.55   |
| 2008 | 3,357   | 9.20   | 2,920   | 8.00   | 1,513     | 4.14   |
| 2009 | 3,676   | 10.07  | 2,132   | 5.84   | 4,100     | 11.23  |
| 2010 | 3,505   | 9.60   | 2,692   | 7.38   | 5,562     | 15.24  |

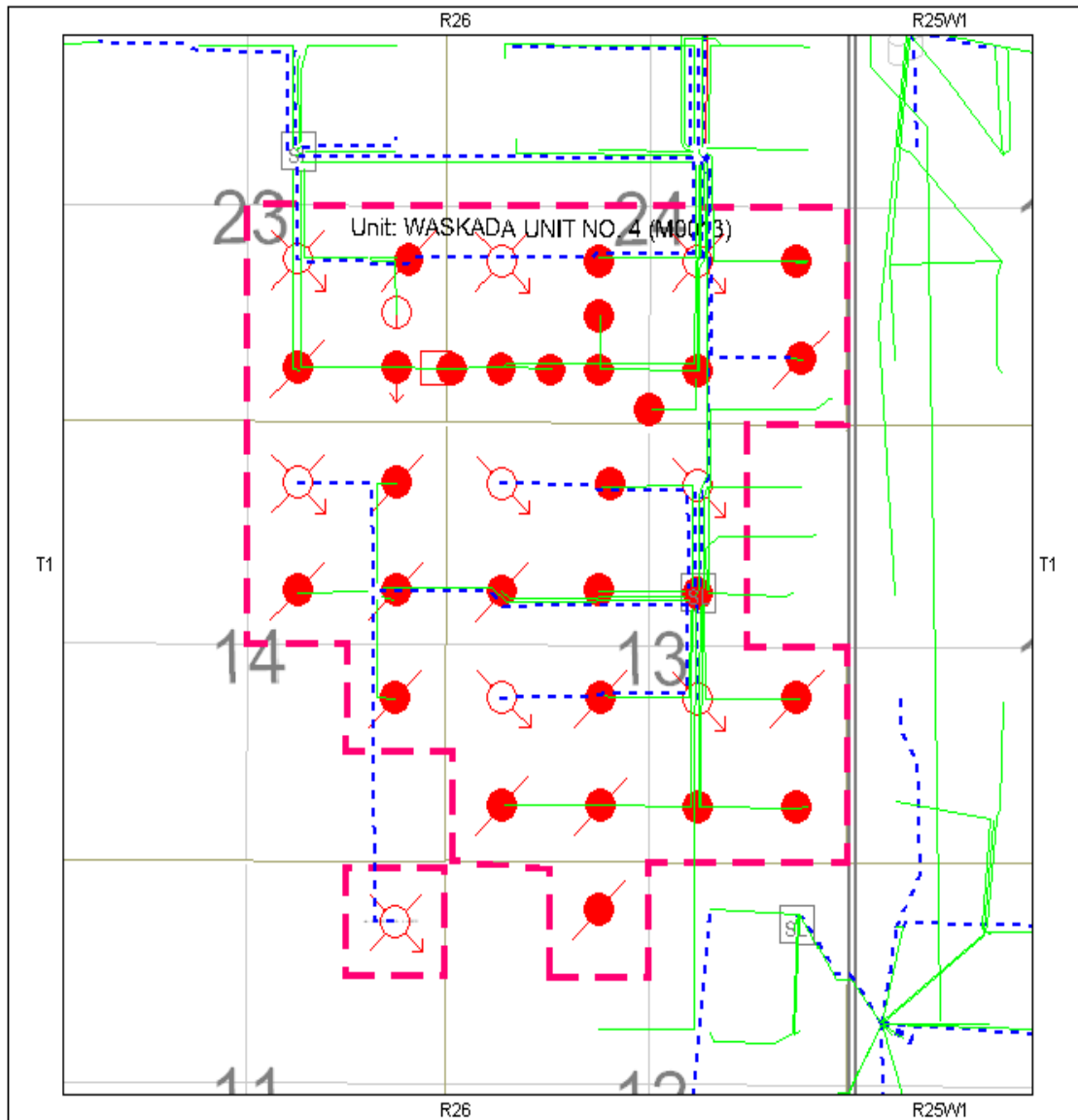
## Waskada Unit #4

**Table 2: Pressure Survey**


| <b>Location</b>     | <b>Shut In Date</b> | <b>Date of Survey</b> | <b>Type of Survey</b>             | <b>Pressure @ Datum Depth (kPa)</b> |
|---------------------|---------------------|-----------------------|-----------------------------------|-------------------------------------|
| 00/11-13-001-26W1/0 |                     | 2008                  | BHP, Assuming WC from Last Prod'n | 7150                                |
| 00/13-13-001-26W1/0 | Dec-89              | (469 days)            | Static Gradient                   | 9046                                |
| 00/15-13-001-26W1/0 | Dec-89              | (103 days)            | Static Gradient                   | 13899                               |
| 00/15-14-001-26W1/0 | Dec-89              | (39 days)             | Static Gradient                   | 10120                               |
| B0/02-24-001-26W1/0 |                     | 2008                  | BHP, Assuming WC from Last Prod'n | 1472                                |
| 00/03-24-001-26W1/0 | May-91              | (7 days)              | Static Gradient                   | 4281                                |
| 00/04-24-001-26W1/0 |                     | 2008                  | BHP, Assuming WC from Last Prod'n | 2104                                |
| 00/06-24-001-26W1/0 | May-91              | (7 days)              | Static Gradient                   | 3994                                |
| A0/06-24-001-26W1/0 |                     | 2008                  | BHP, Assuming WC from Last Prod'n | 8993                                |

## **APPENDIX A**

## Appendix A – Area Map



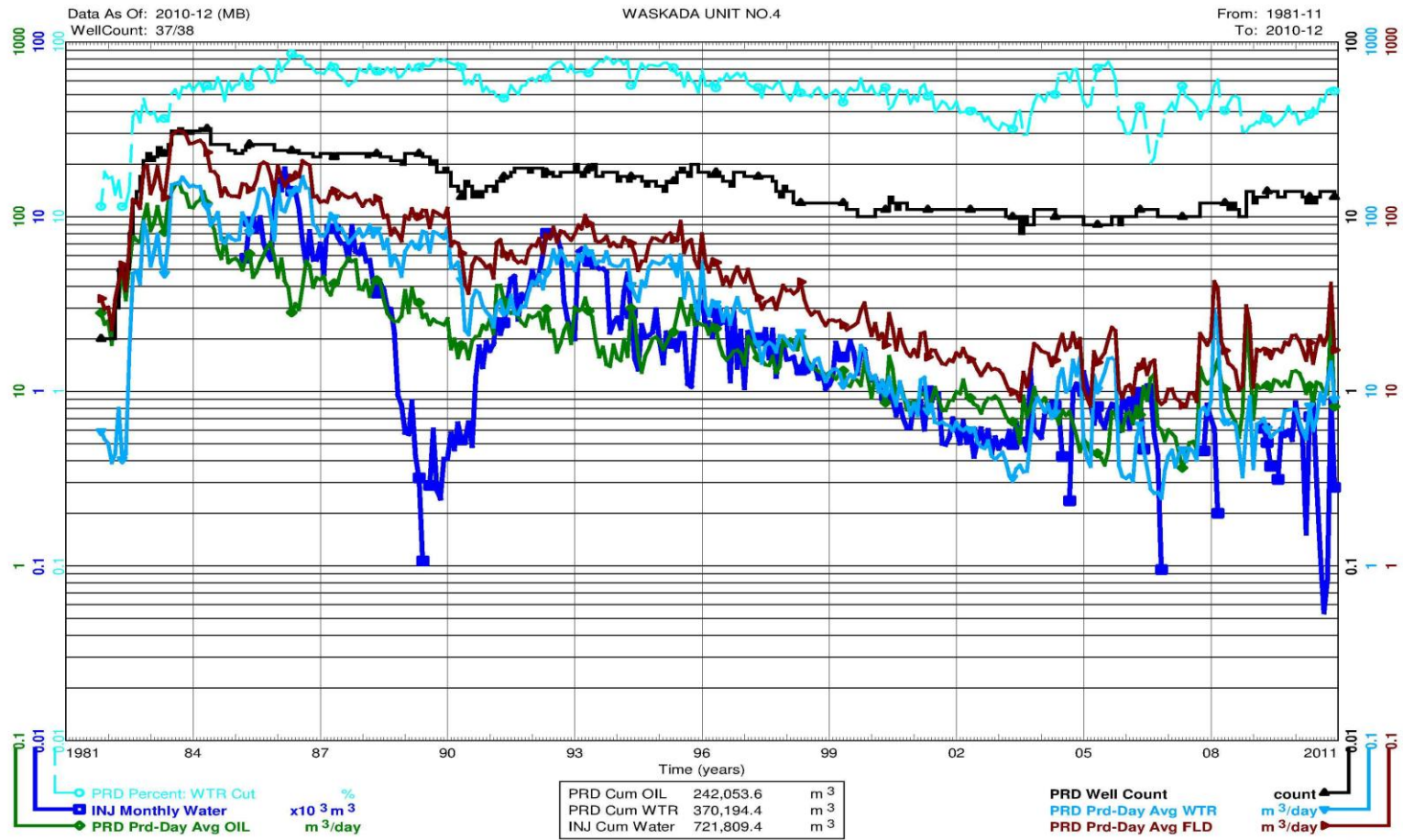
| WELL SYMBOLS |     |     |     |     |  |  |  |  |  |
|--------------|-----|-----|-----|-----|--|--|--|--|--|
| • OIL        | AO  | PTN | DSA | WI  |  |  |  |  |  |
| ○ LCT        | AWI | STN | CMM | DRL |  |  |  |  |  |
| ⊙ RDR        | WD  | AMS | AWD | SWI |  |  |  |  |  |
| ▲ SO         | WSC | JSA | SL  |     |  |  |  |  |  |

|   |                 |                   |
|---|-----------------|-------------------|
| <b>PennWest</b><br>Exploration  |                 |                   |
| Waskada Unit #4   |                 |                   |
|  | By :            | Date : 2011/04/14 |
|   | Scale = 1:21088 | Project : Waskada |

## **APPENDIX B**



## Appendix B – Production and Injection History plot

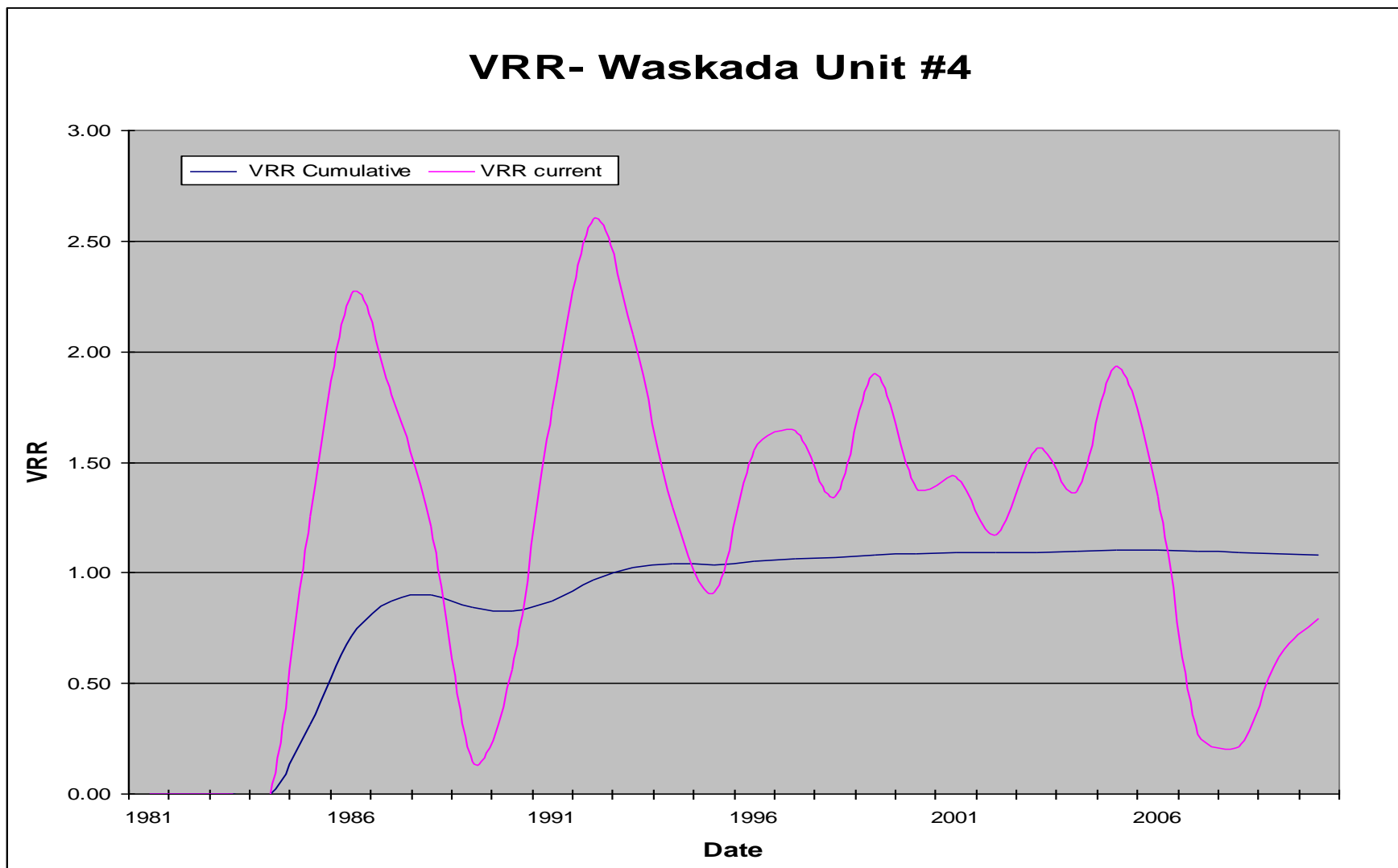


Thursday, March 31, 2011, 03:14 PM

geoSCOUT  
www.geologic.com

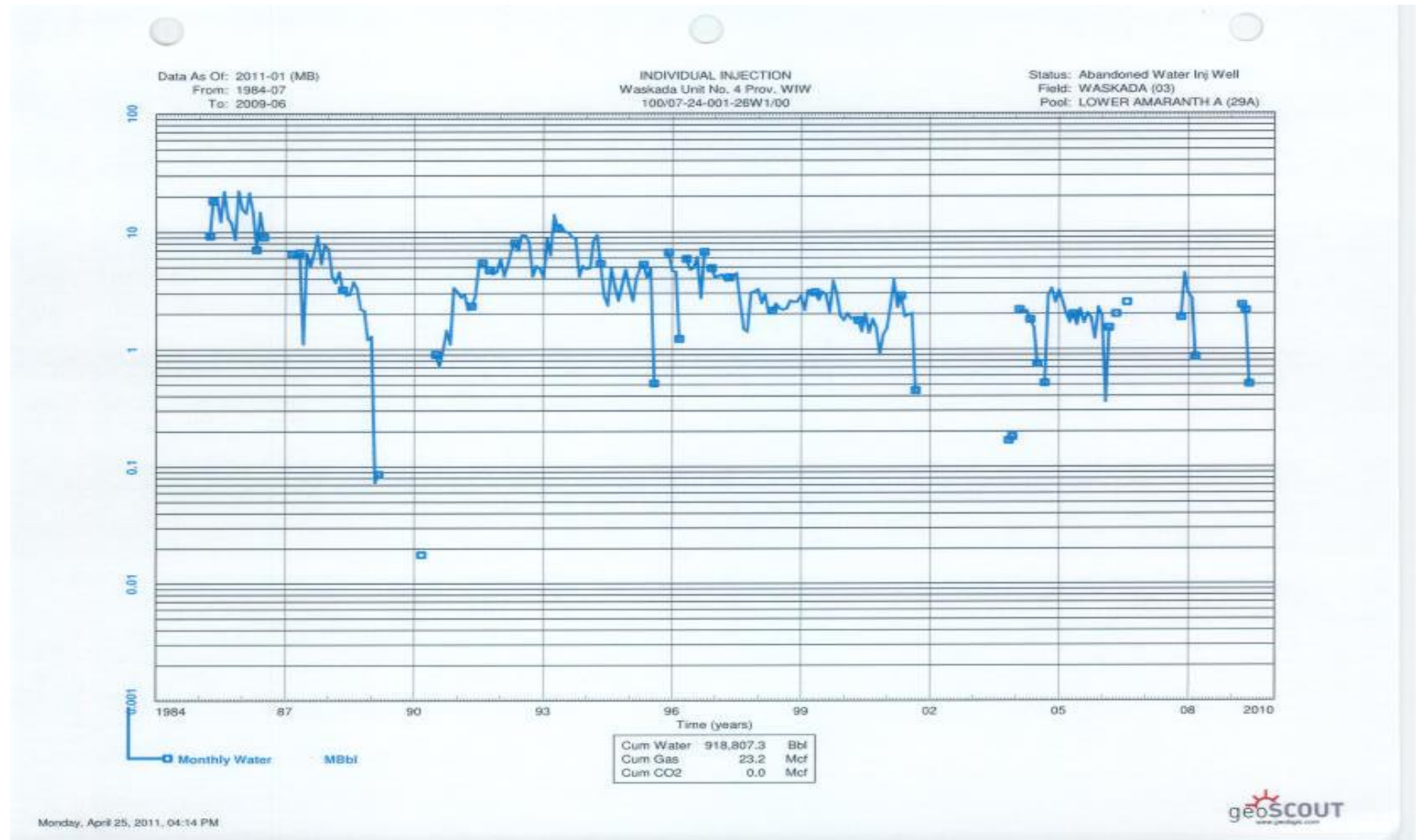
## **APPENDIX C**

Appendix C – Voidage Replacement Ratio VRR



## **APPENDIX D**

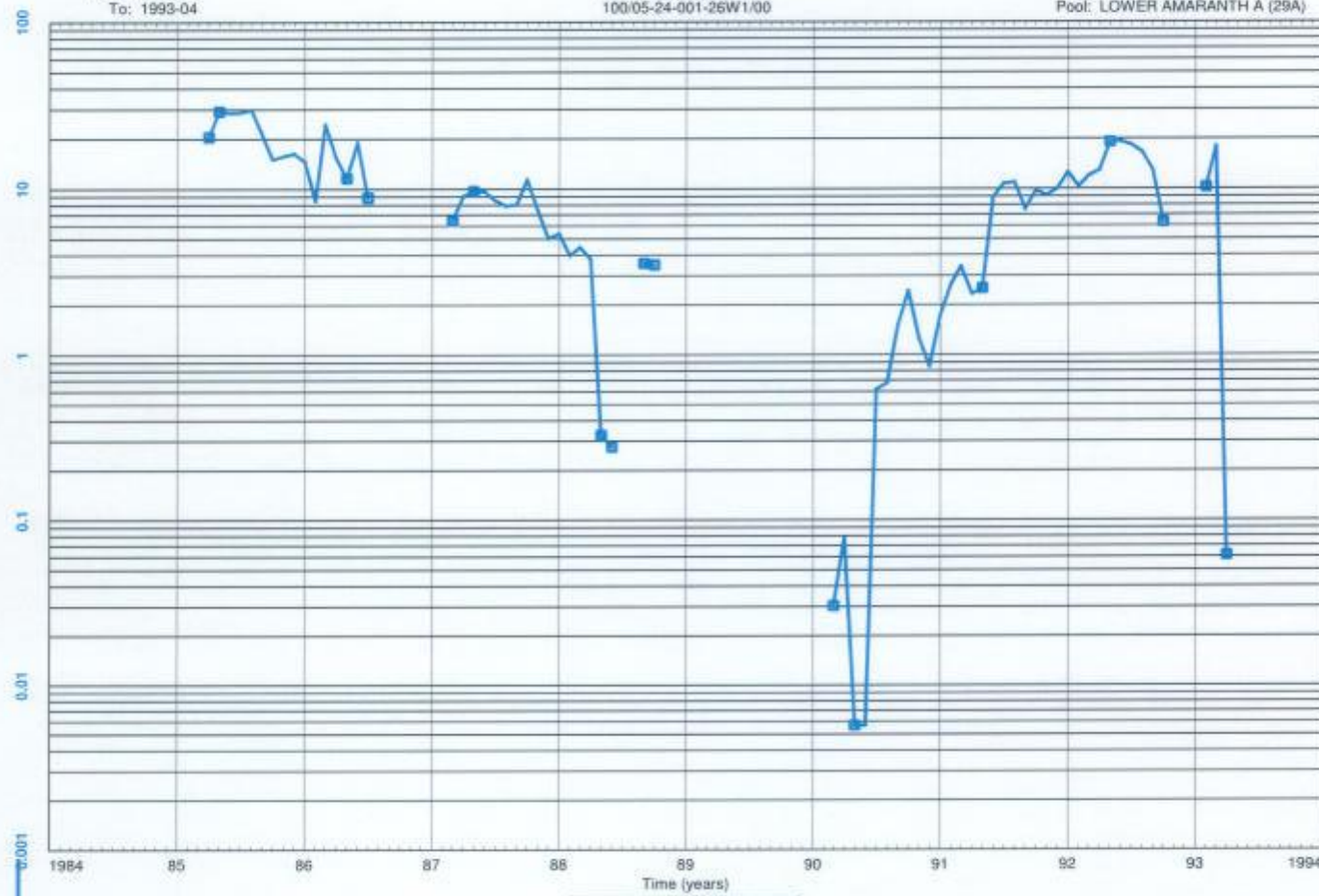
## Appendix D – Production and Injection Profiles (Individual wells)



Data As Of: 2011-01 (MB)  
 From: 1984-06  
 To: 1993-04

INDIVIDUAL INJECTION  
 Waskada Unit No. 4 WIW  
 100/05-24-001-26W1/00

Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Monthly Water MBbl

|           |           |     |
|-----------|-----------|-----|
| Cum Water | 668,988.5 | Bbl |
| Cum Gas   | 32.4      | Mcf |
| Cum CO2   | 0.0       | Mcf |

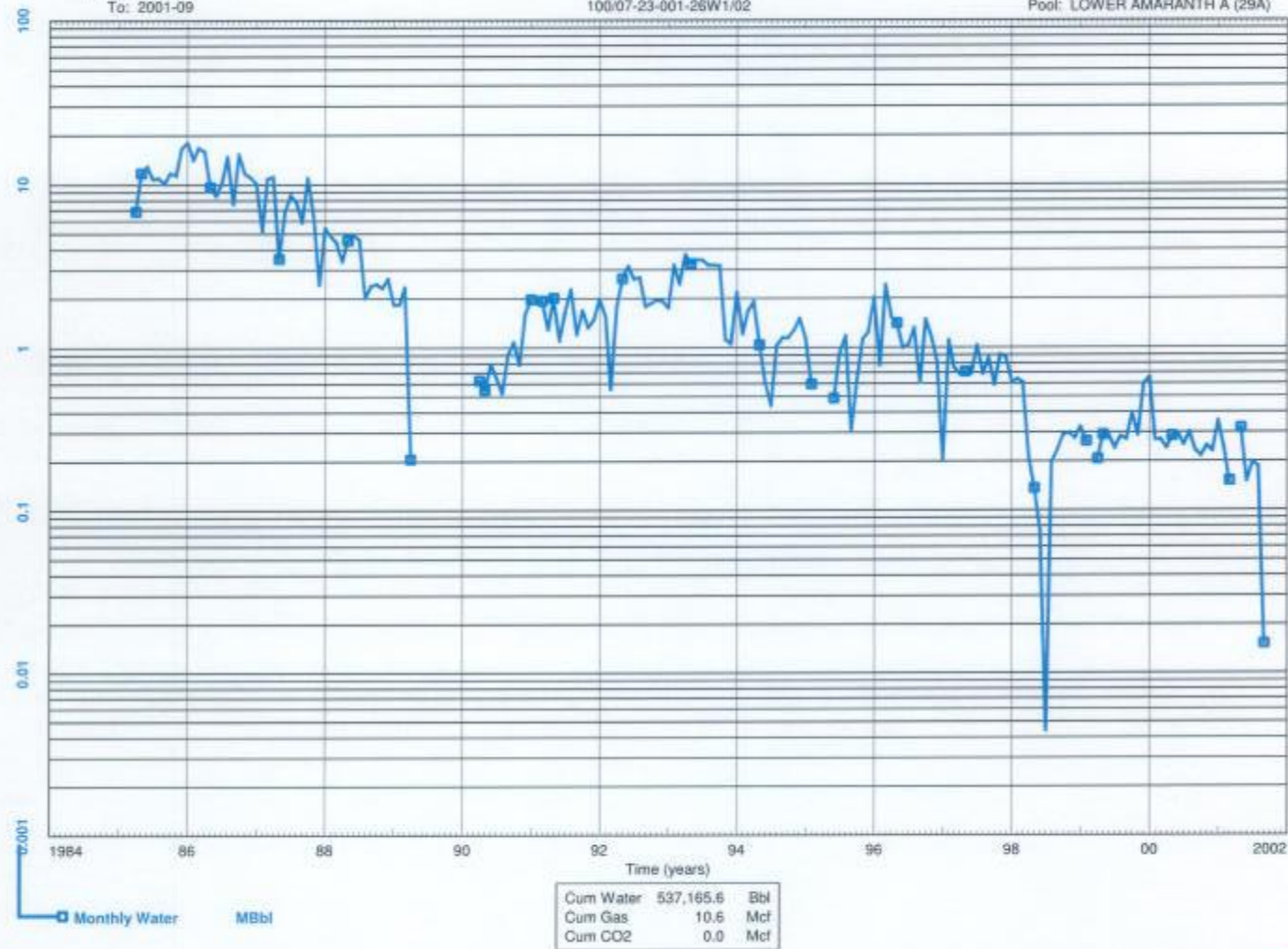
Monday, April 25, 2011, 04:14 PM



Data As Of: 2011-01 (MB)  
From: 1984-08  
To: 2001-09

INDIVIDUAL INJECTION  
Waskada Unit No. 4 WIW  
100/07-23-001-26W1/02

Status: Abandoned Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Monday, April 25, 2011, 04:13 PM

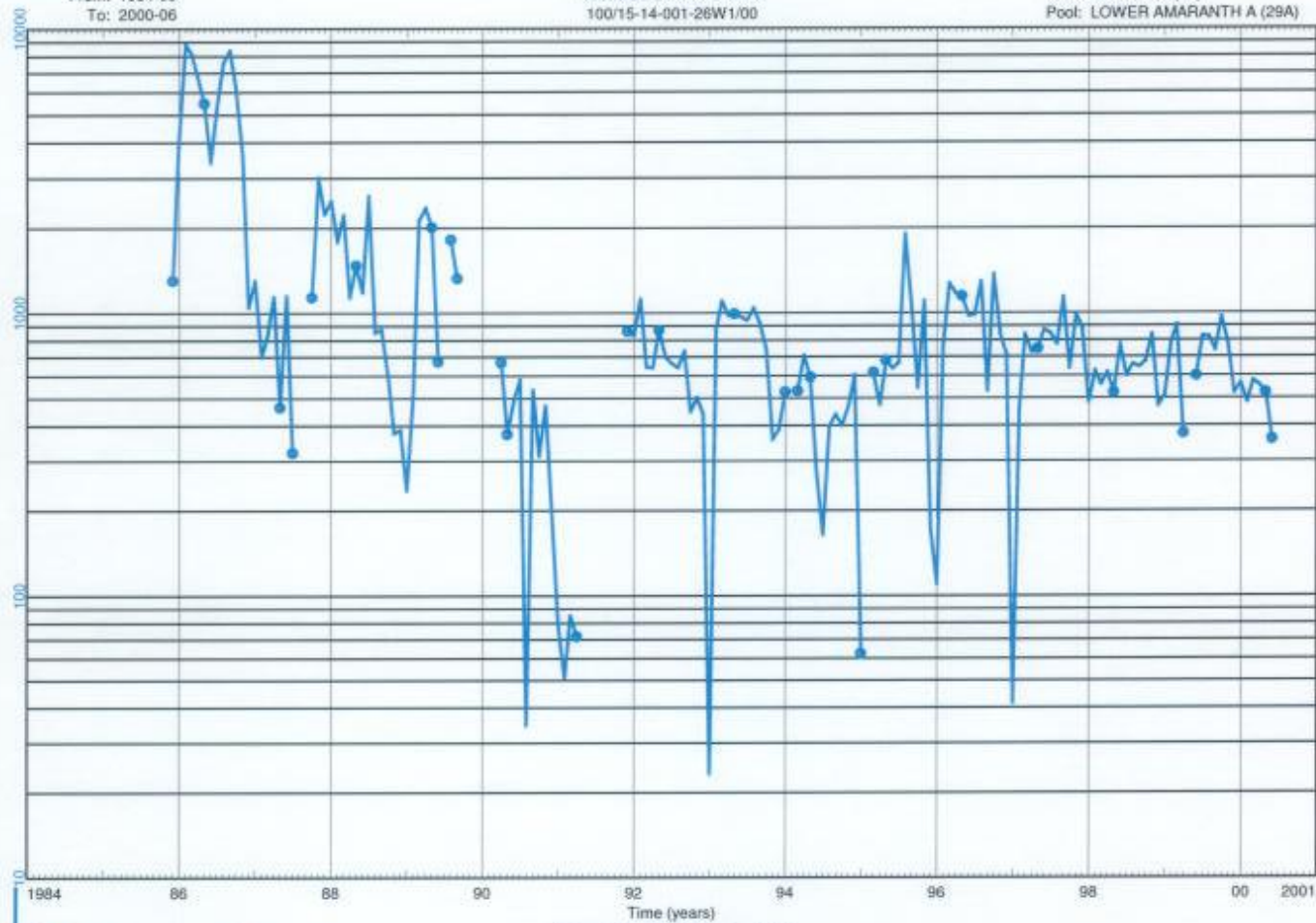
geoSCOUT  
www.geoscout.com



Data As Of: 2010-11 (MB)  
From: 1984-06  
To: 2000-06

INDIVIDUAL INJECTION  
Waskada Unit No. 4 WW  
100/15-14-001-26W1/00

Status: Abandoned Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Monthly Water Bbl

|           |           |     |
|-----------|-----------|-----|
| Cum Water | 183,316.7 | Bbl |
| Cum Gas   | 18.9      | Mcf |
| Cum CO2   | 0.0       | Mcf |

Monday, February 14, 2011, 03:11 PM

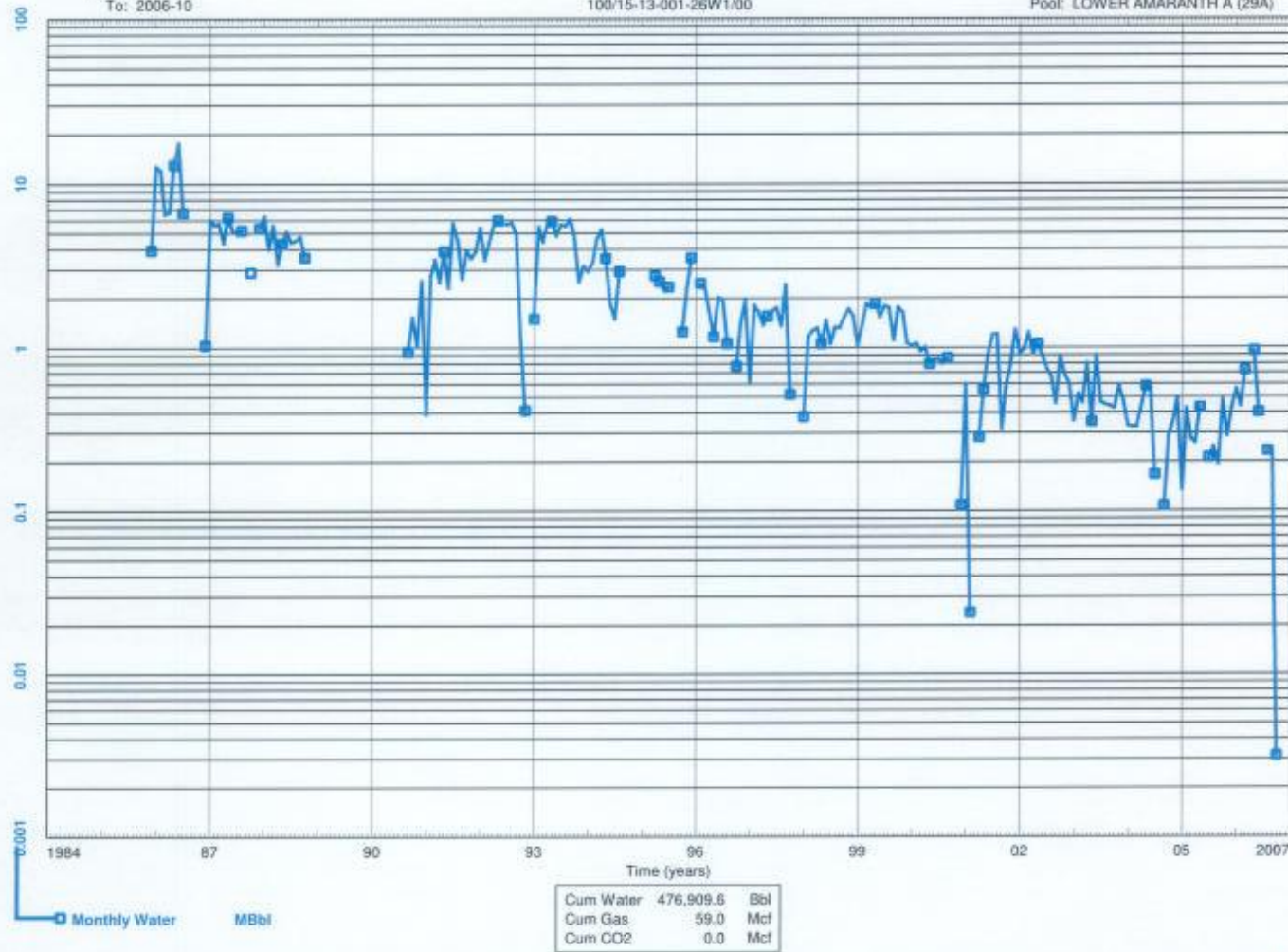
geoSCOUT  
www.geoscout.com



Data As Of: 2011-01 (MB)  
From: 1984-06  
To: 2006-10

INDIVIDUAL INJECTION  
Waskada Unit No. 4 WIW  
100/15-13-001-26W1/00

Status: Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



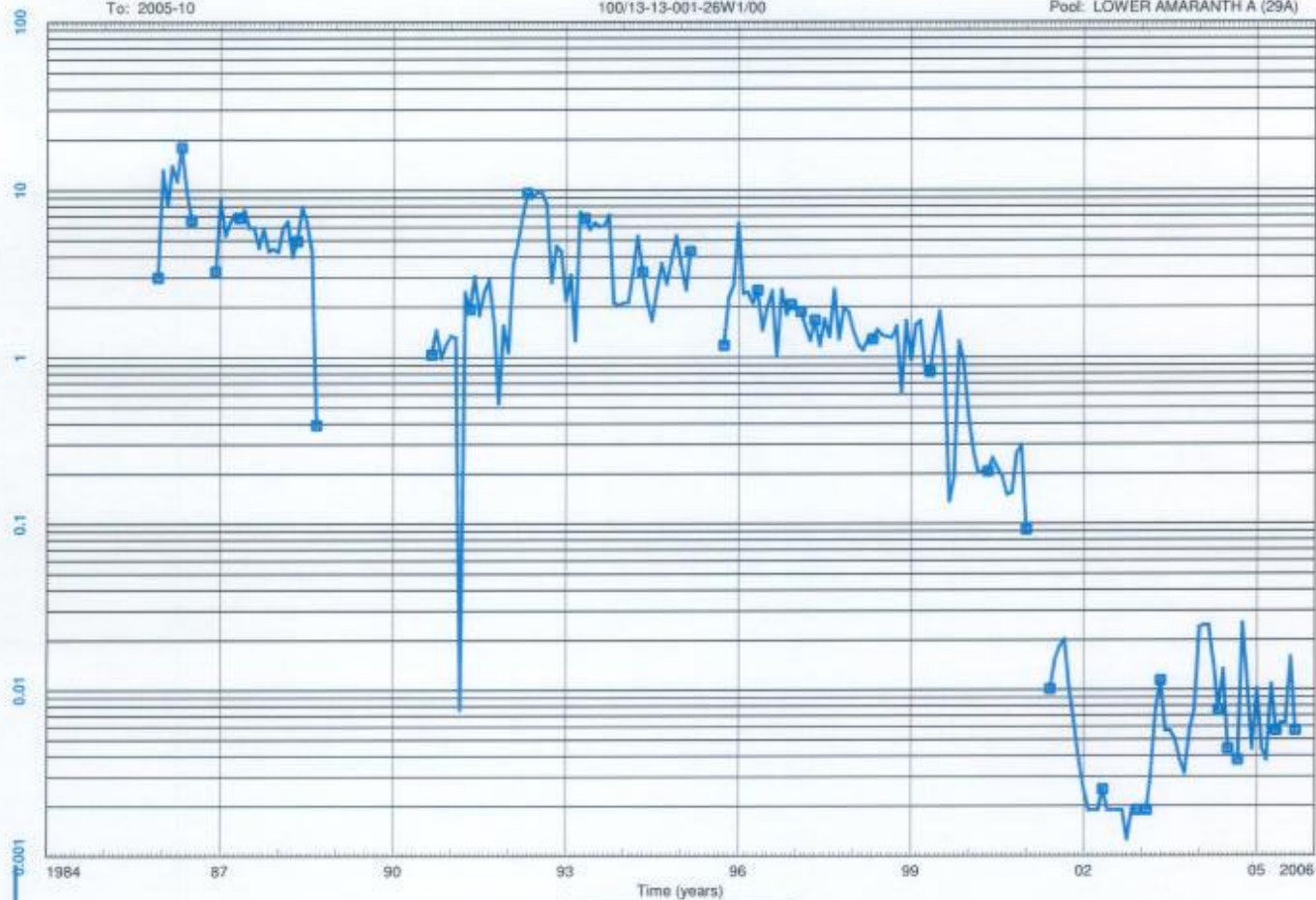
Monday, April 25, 2011, 04:12 PM

geoSCOUT  
www.geoscout.com

Data As Of: 2011-01 (MB)  
From: 1984-07  
To: 2005-10

INDIVIDUAL INJECTION  
Waskada Unit No. 4 WIW  
100/13-13-001-26W1/00

Status: Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Monthly Water MBbl

|           |           |     |
|-----------|-----------|-----|
| Cum Water | 493,029.2 | Bbl |
| Cum Gas   | 92.2      | Mcf |
| Cum CO2   | 0.0       | Mcf |

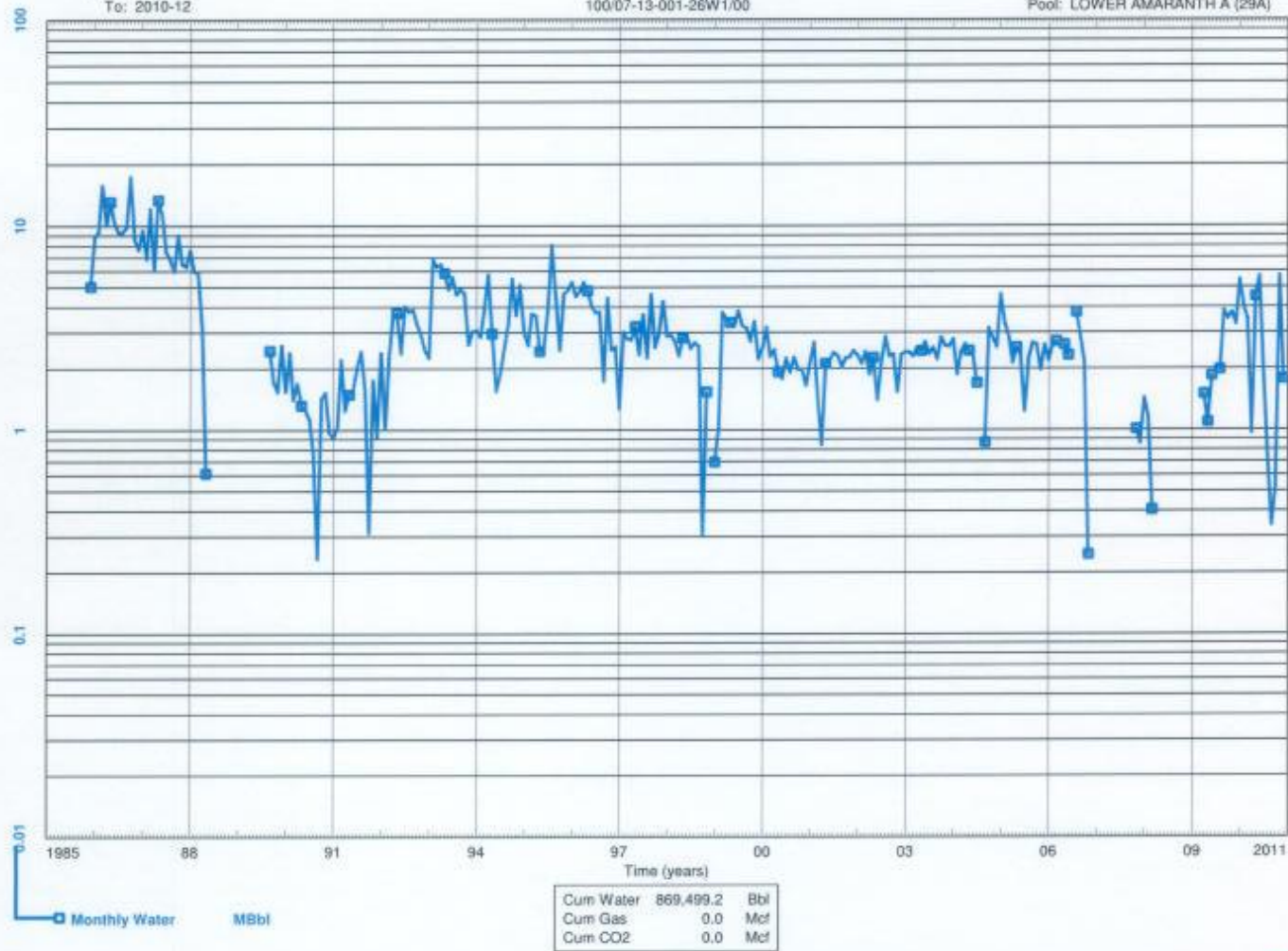
Monday, April 25, 2011, 04:12 PM

geoSCOUT  
www.geoscout.com

Data As Of: 2011-01 (MB)  
From: 1985-12  
To: 2010-12

INDIVIDUAL INJECTION  
Waskada Unit No. 4 WW  
100/07-13-001-26W1/00

Status: Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



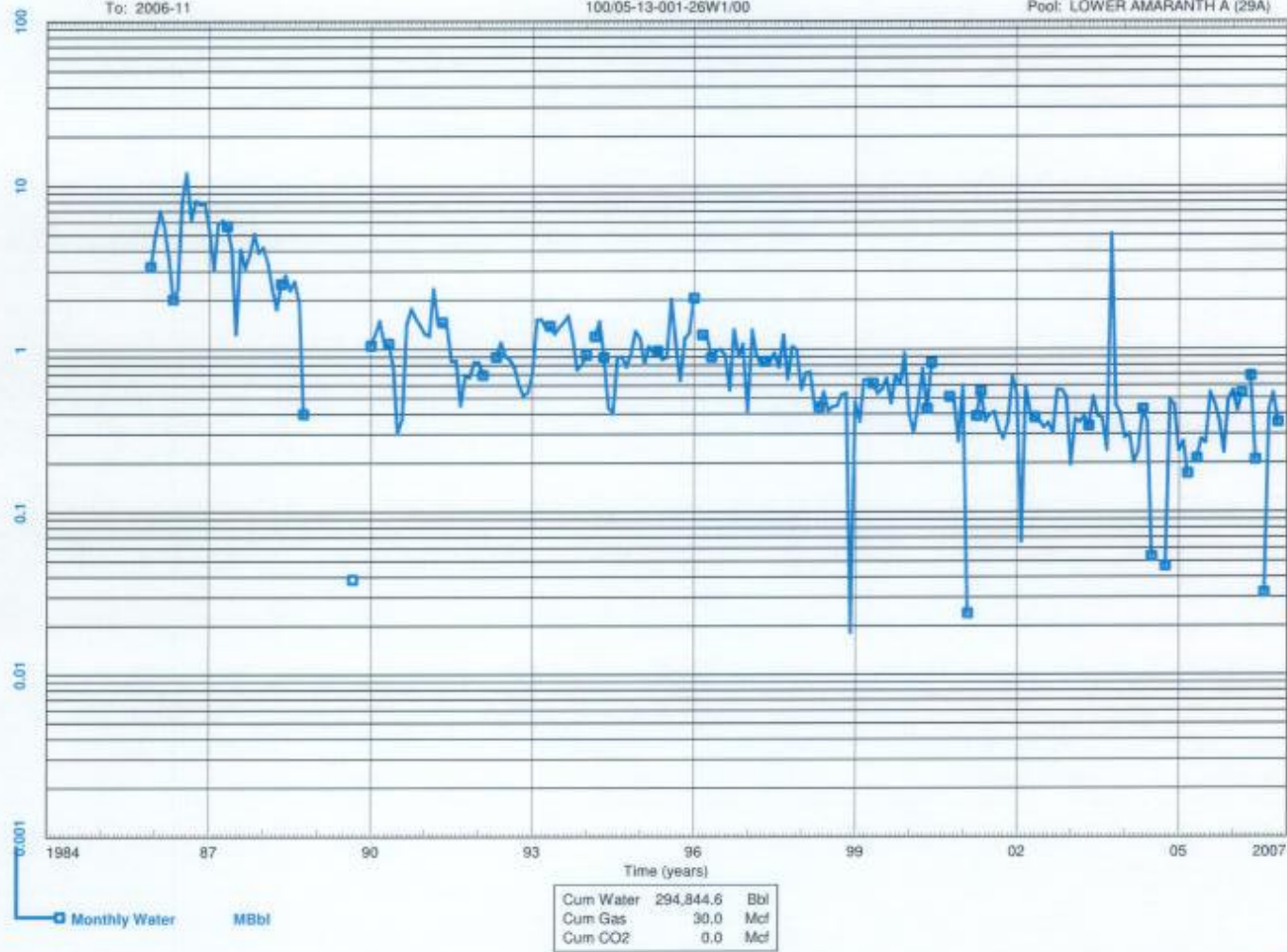
Monday, April 25, 2011, 04:11 PM

geoSCOUT  
www.geoscout.com

Data As Of: 2011-01 (MB)  
From: 1984-06  
To: 2006-11

INDIVIDUAL INJECTION  
Waskada Unit No. 4 WIW  
100/05-13-001-26W1/00

Status: Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Monday, April 25, 2011, 04:10 PM

geoSCOUT  
www.geoscout.com

Data As Of: 2011-01 (MB)  
From: 1985-12  
To: 1989-04

INDIVIDUAL INJECTION  
Omega-Waskada Prov. WW  
100/16-11-001-26W1/00

Status: Abandoned Water Inj Well  
Field: WASKADA (03)  
Pool: LOWER AMARANTH A (29A)



Monday, April 25, 2011, 04:10 PM

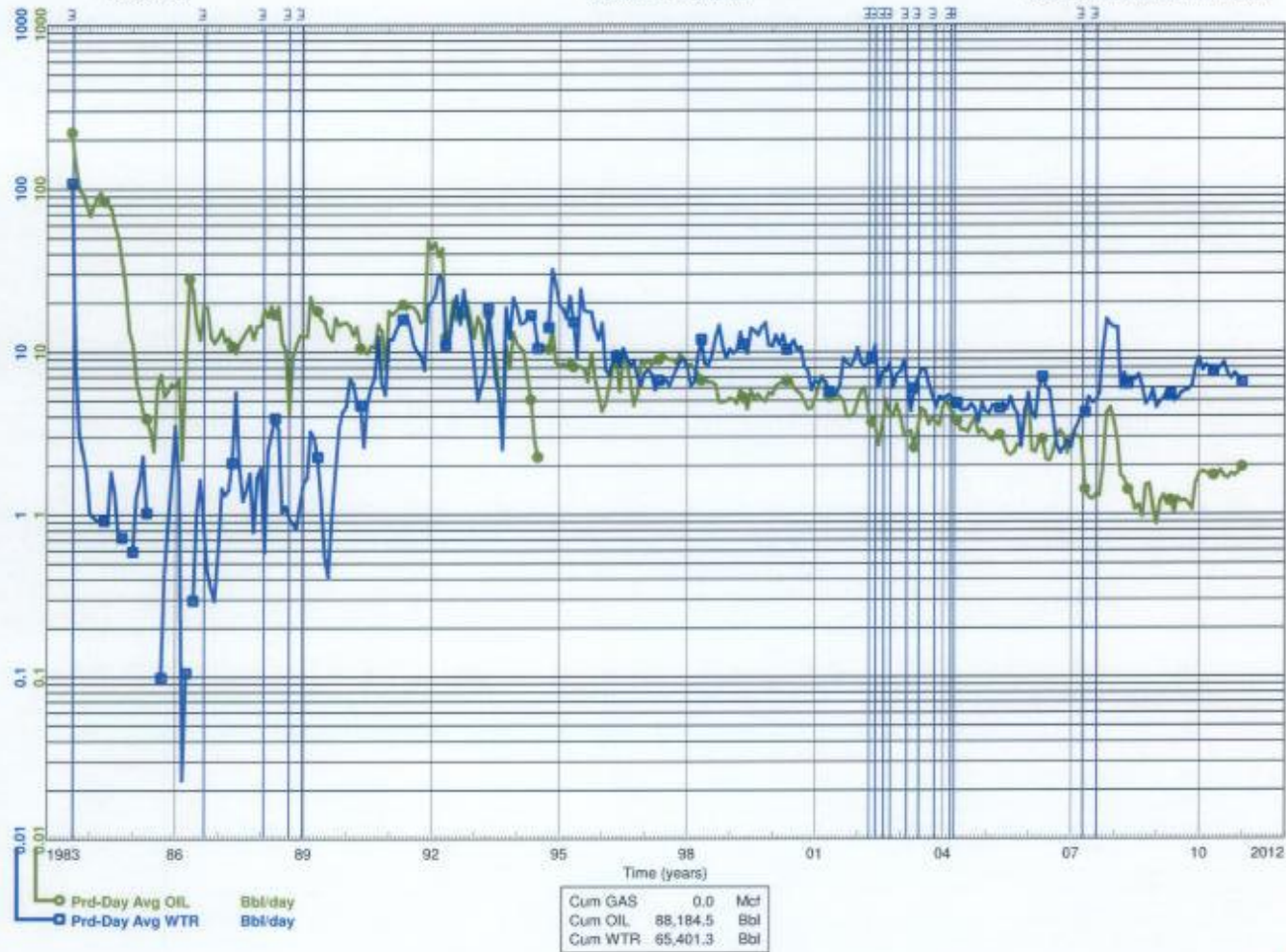
geoSCOUT  
www.geoscot.com



Data As Of: 2011-01 (MB)  
 From: 1983-08  
 To: 2011-01

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 Prov.  
 102/08-24-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



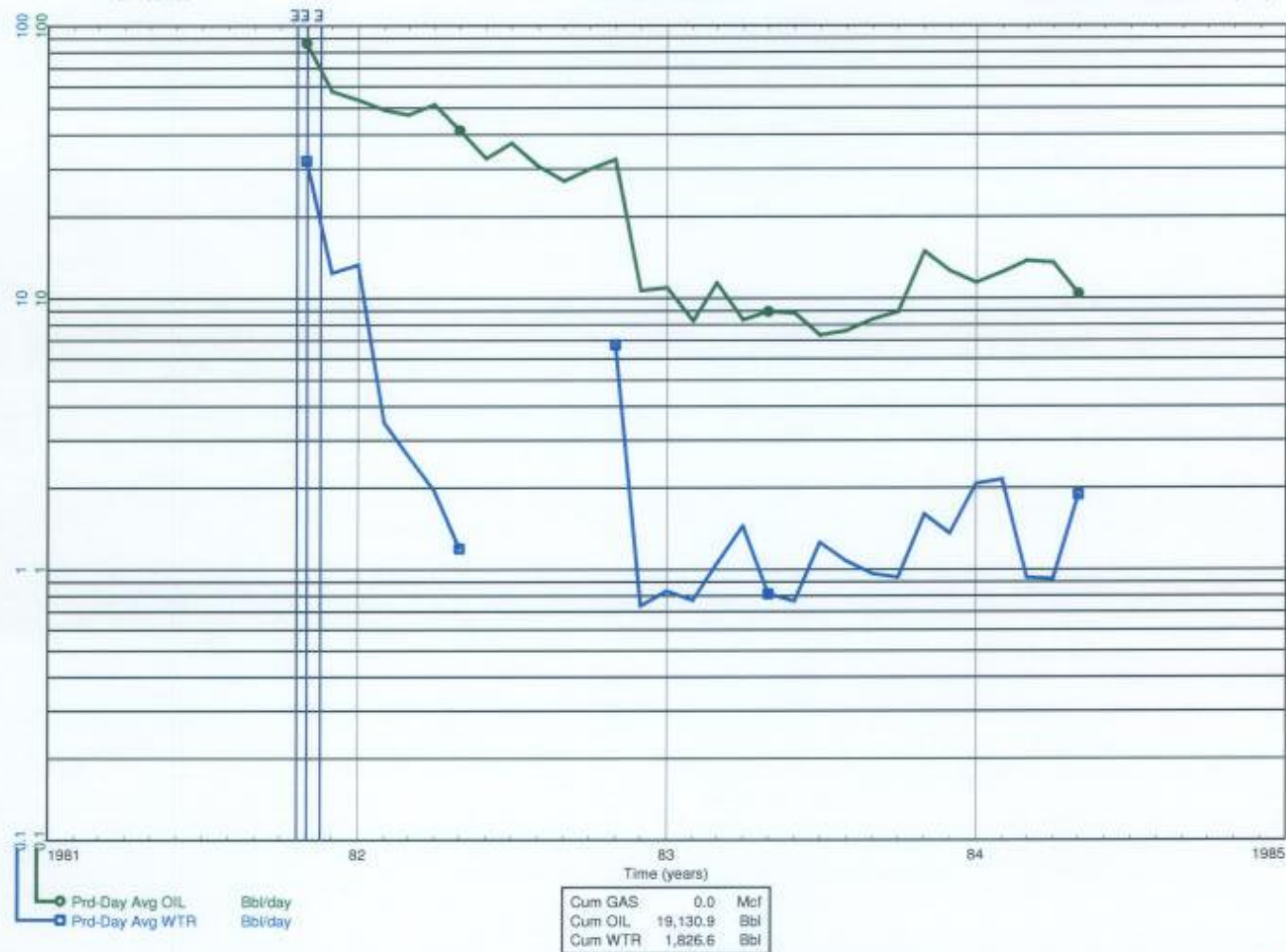
Thursday, April 21, 2011, 04:18 PM

geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)

Data As Of: 2010-11 (MB)  
 From: 1981-11  
 To: 1984-05

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 Prov. W/W  
 100/07-24-001-26W1/00

Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



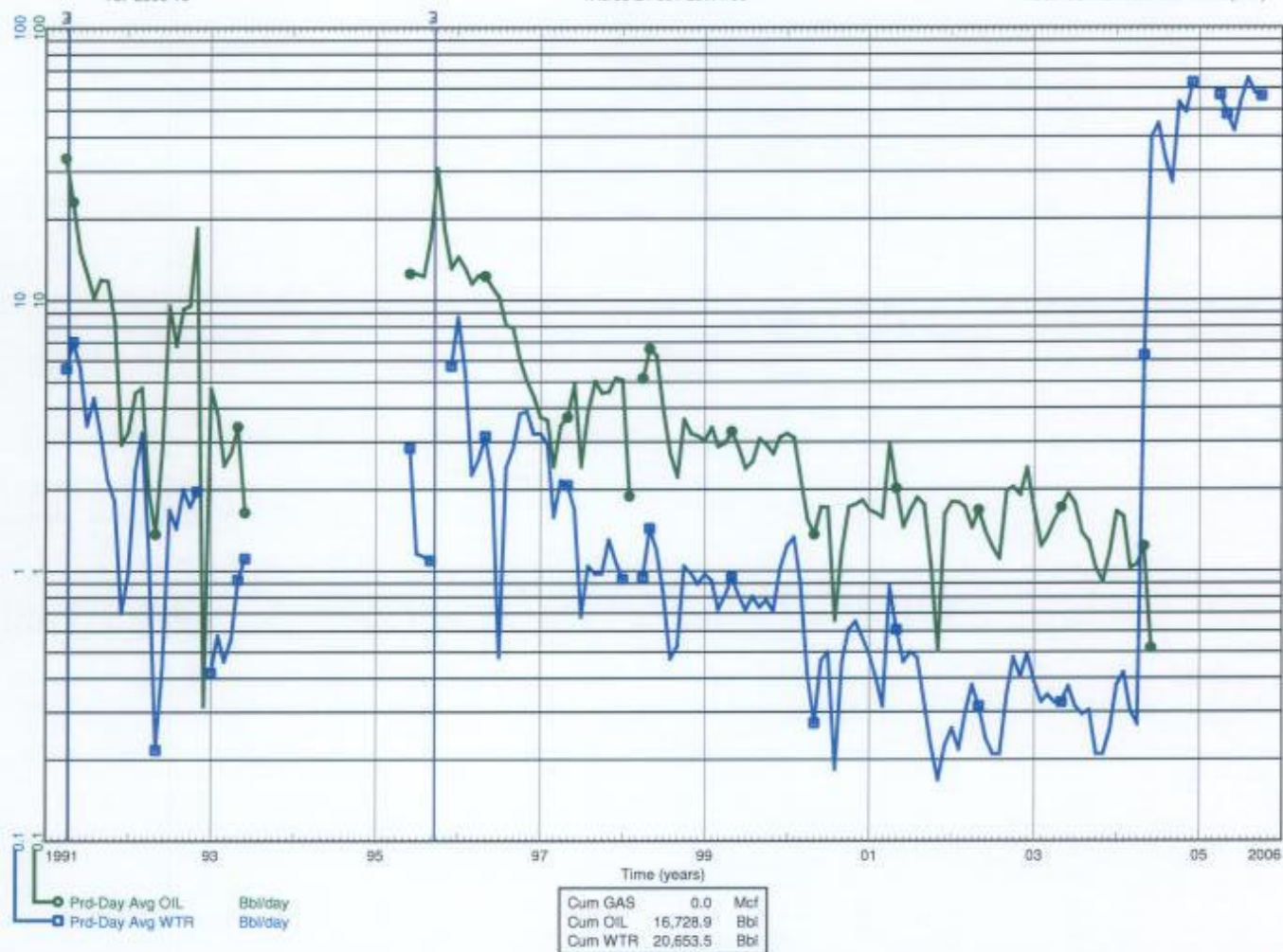
Friday, February 11, 2011, 03:29 PM

geoSCOUT  
 www.geoscout.com

Data As Of: 2010-11 (MB)  
 From: 1991-04  
 To: 2005-10

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 1A0/06-24-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Friday, February 11, 2011, 03:29 PM

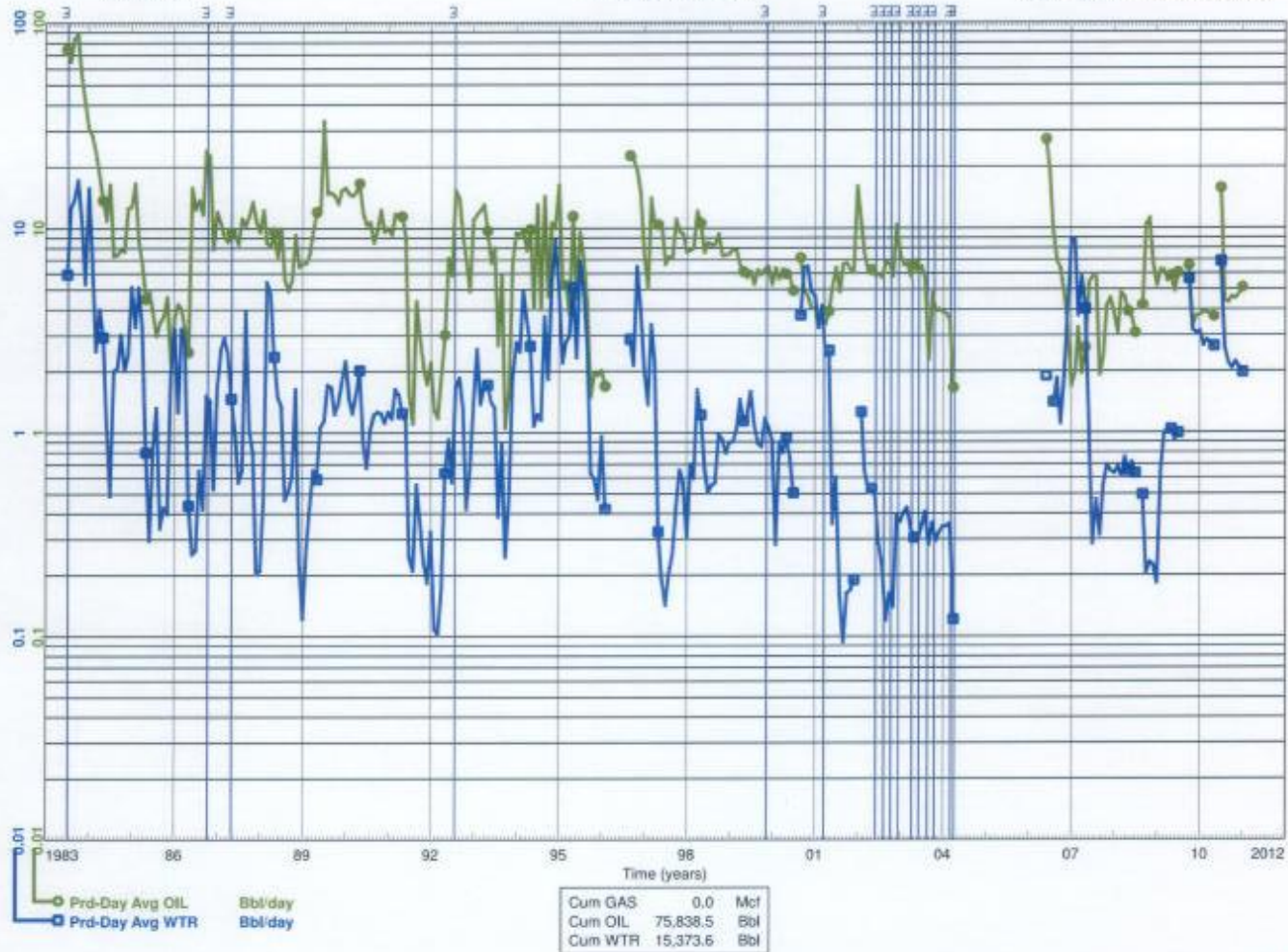
geoSCOUT  
 www.geoscot.com



Data As Of: 2011-01 (MB)  
 From: 1983-07  
 To: 2011-01

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/06-24-001-26W1/00

Status: Capable Of Oil Prod.  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



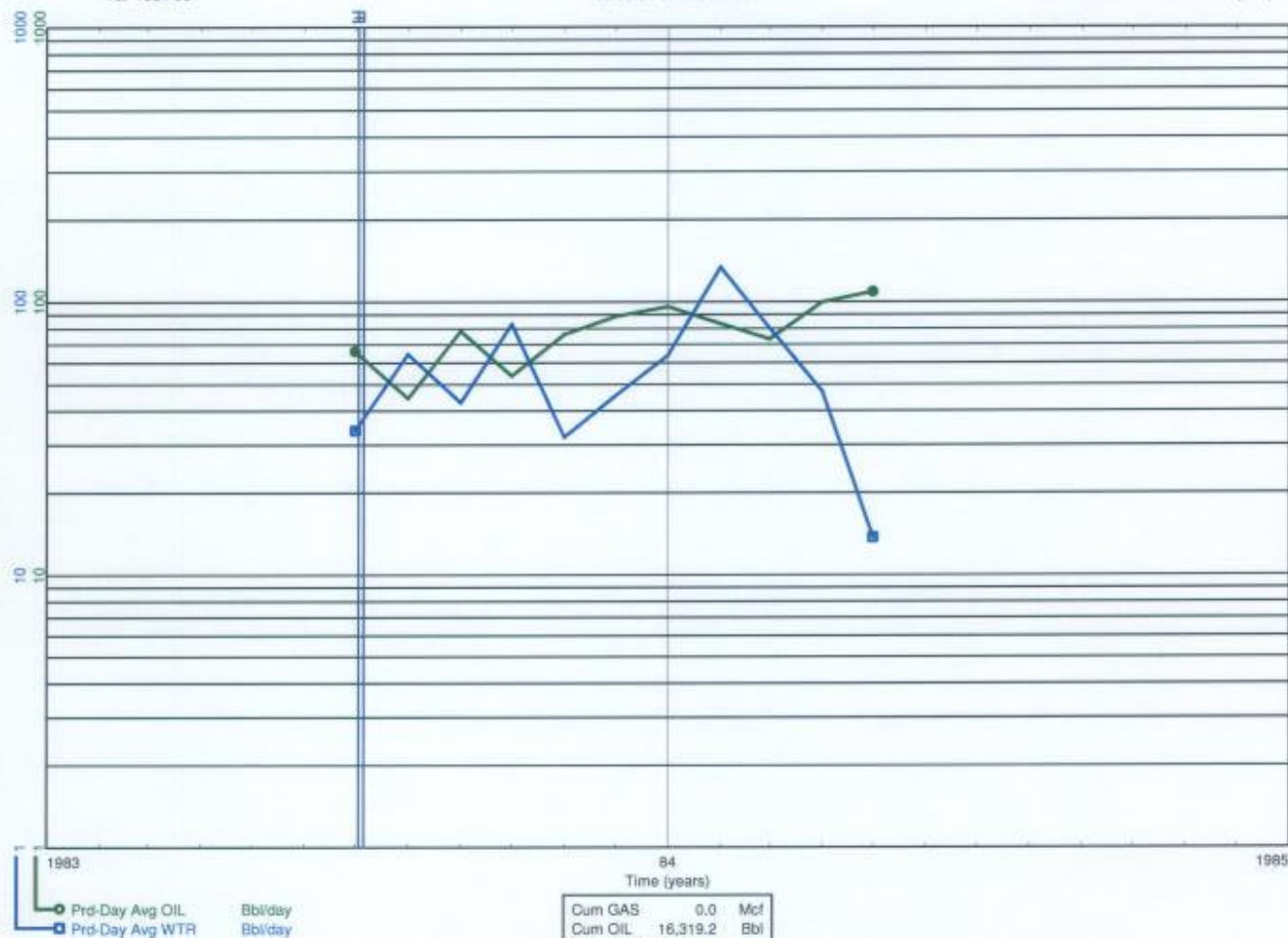
Thursday, April 21, 2011, 04:17 PM

geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)

Data As Of: 2010-11 (MB)  
 From: 1983-07  
 To: 1984-05

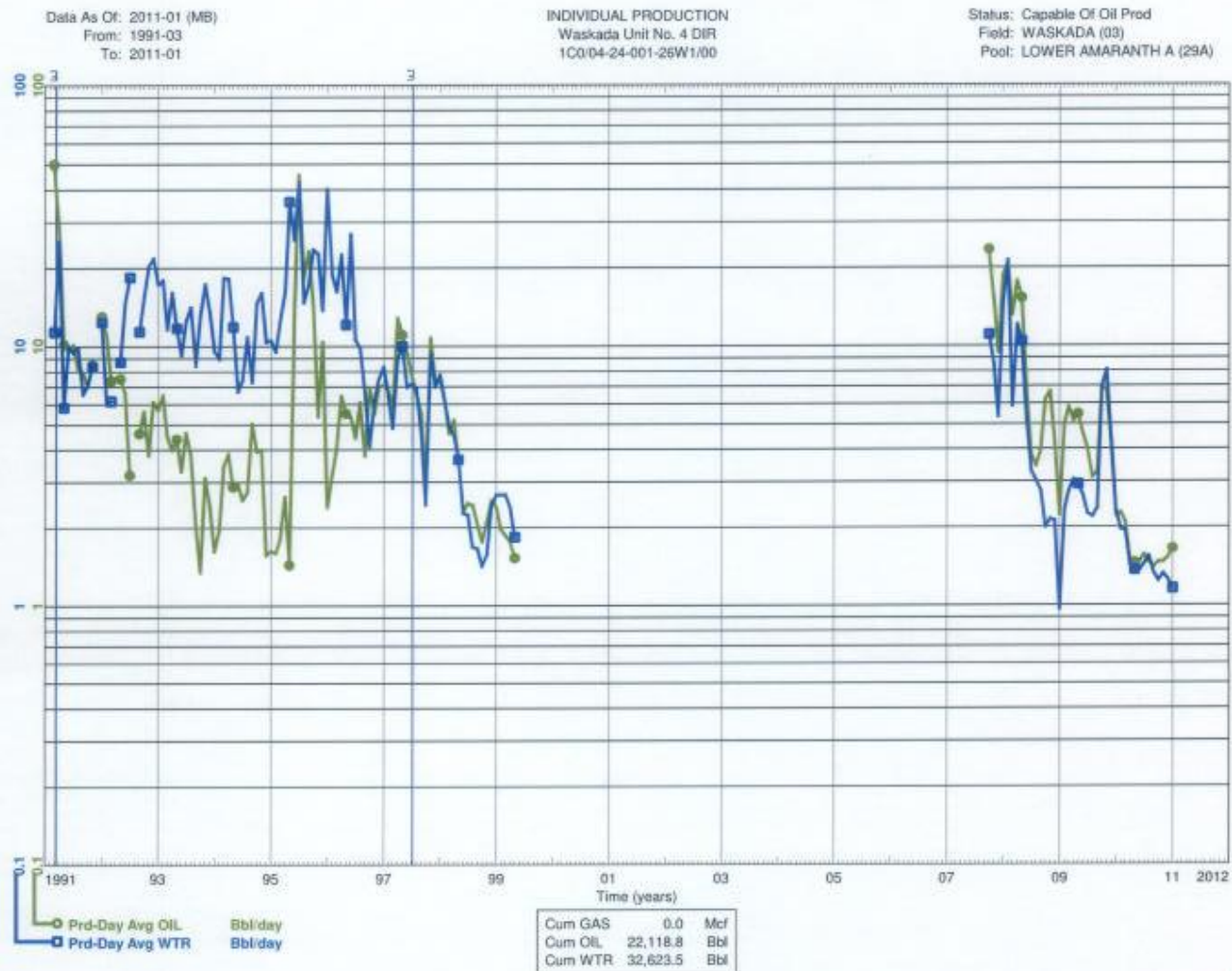
INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 WIW  
 100/05-24-001-26W1/00

Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



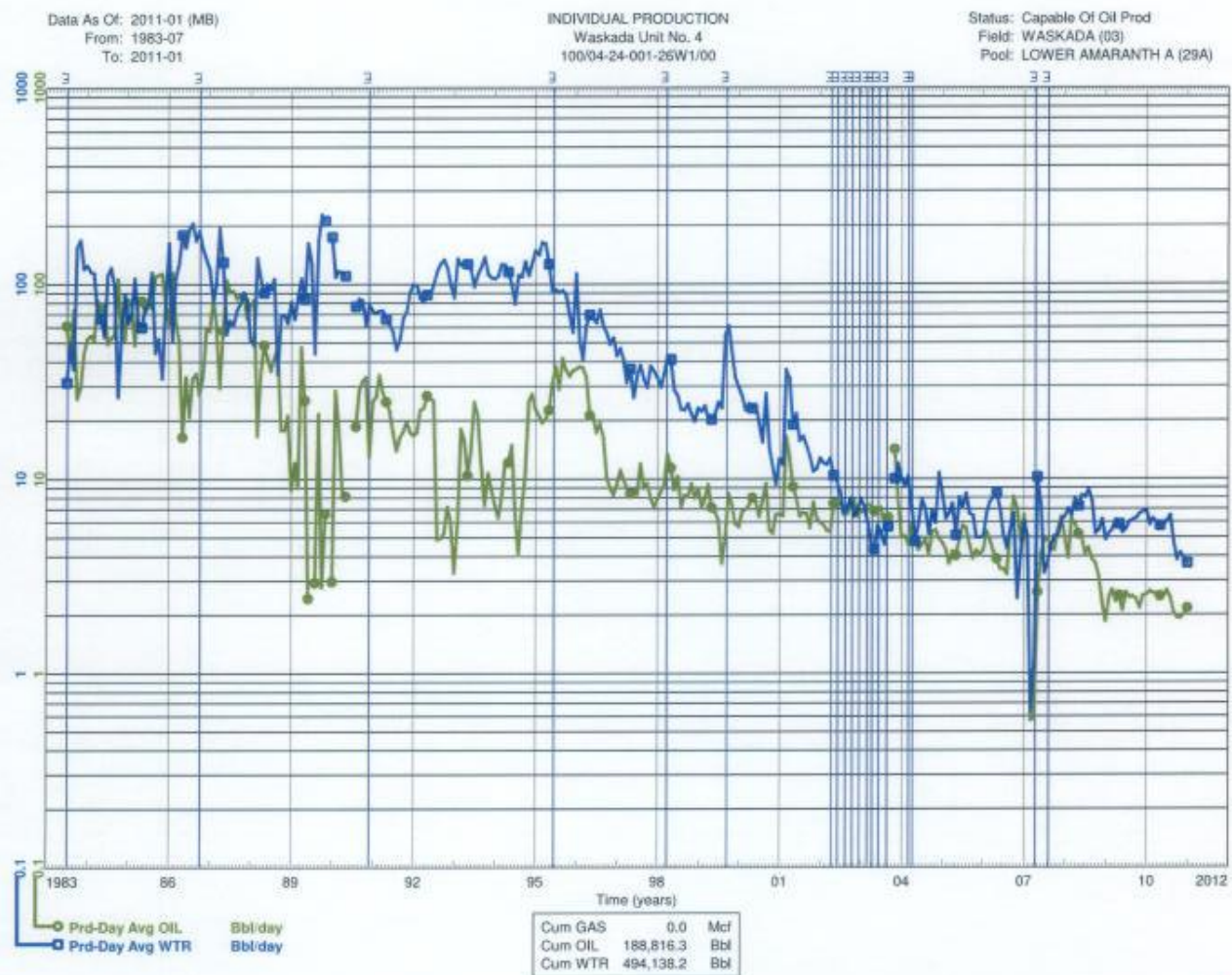
Friday, February 11, 2011, 03:29 PM

geoSCOUT  
 www.geoscot.com



Thursday, April 21, 2011, 04:16 PM

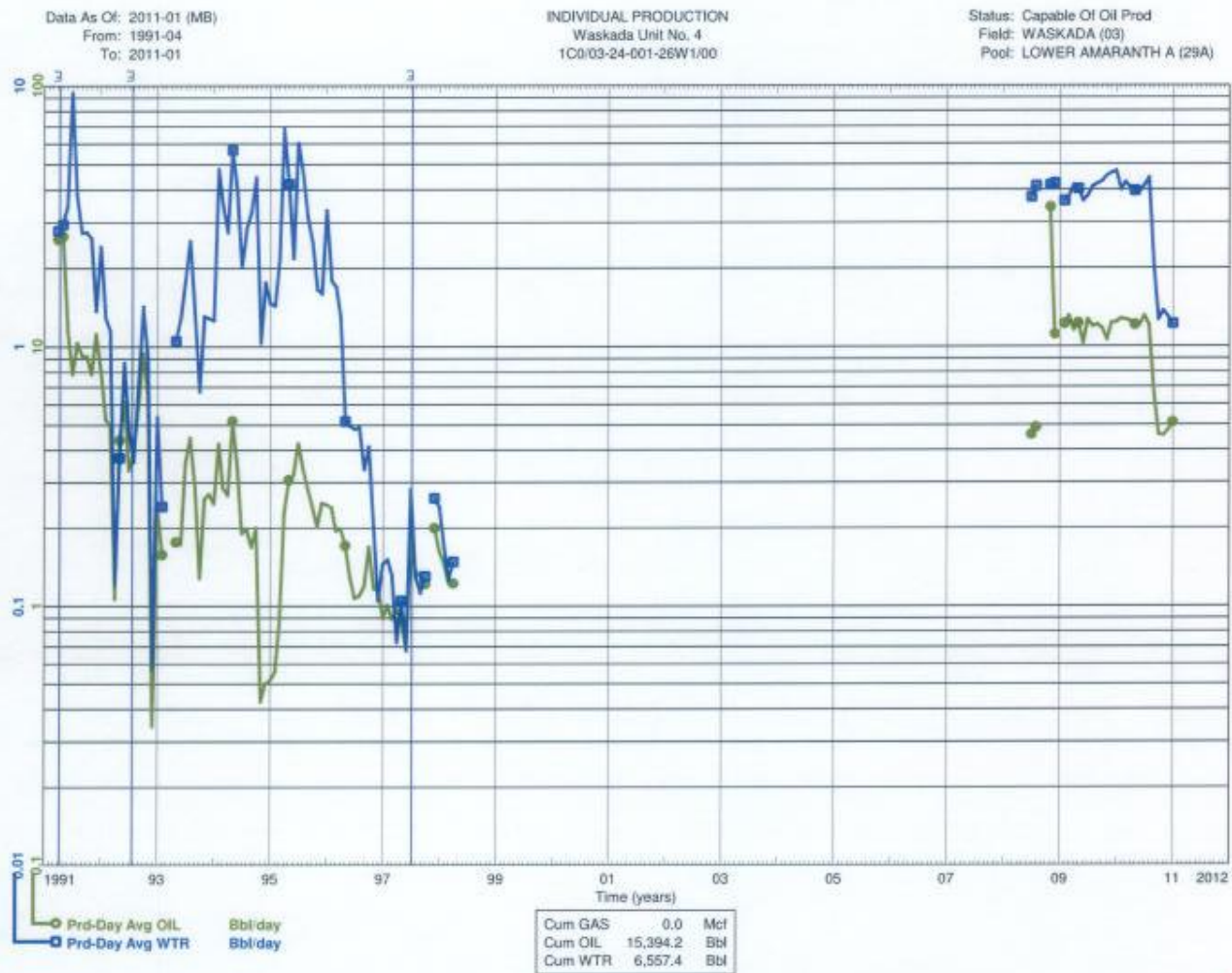
geoSCOUT  
www.geoscout.com



Thursday, April 21, 2011, 04:16 PM

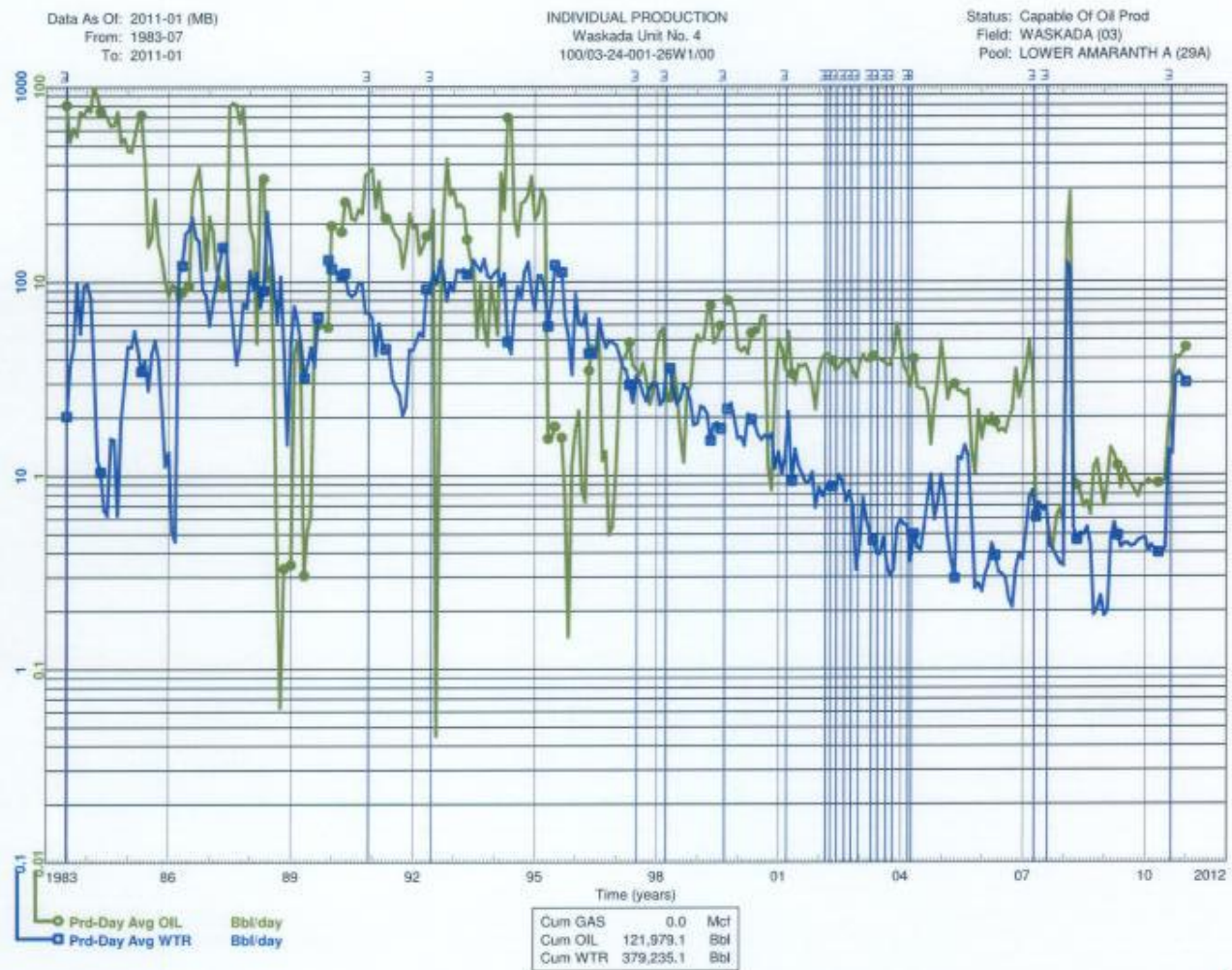
geoSCOUT  
www.geoscout.com





Monday, April 25, 2011, 04:00 PM

geoSCOUT  
www.geoscot.com



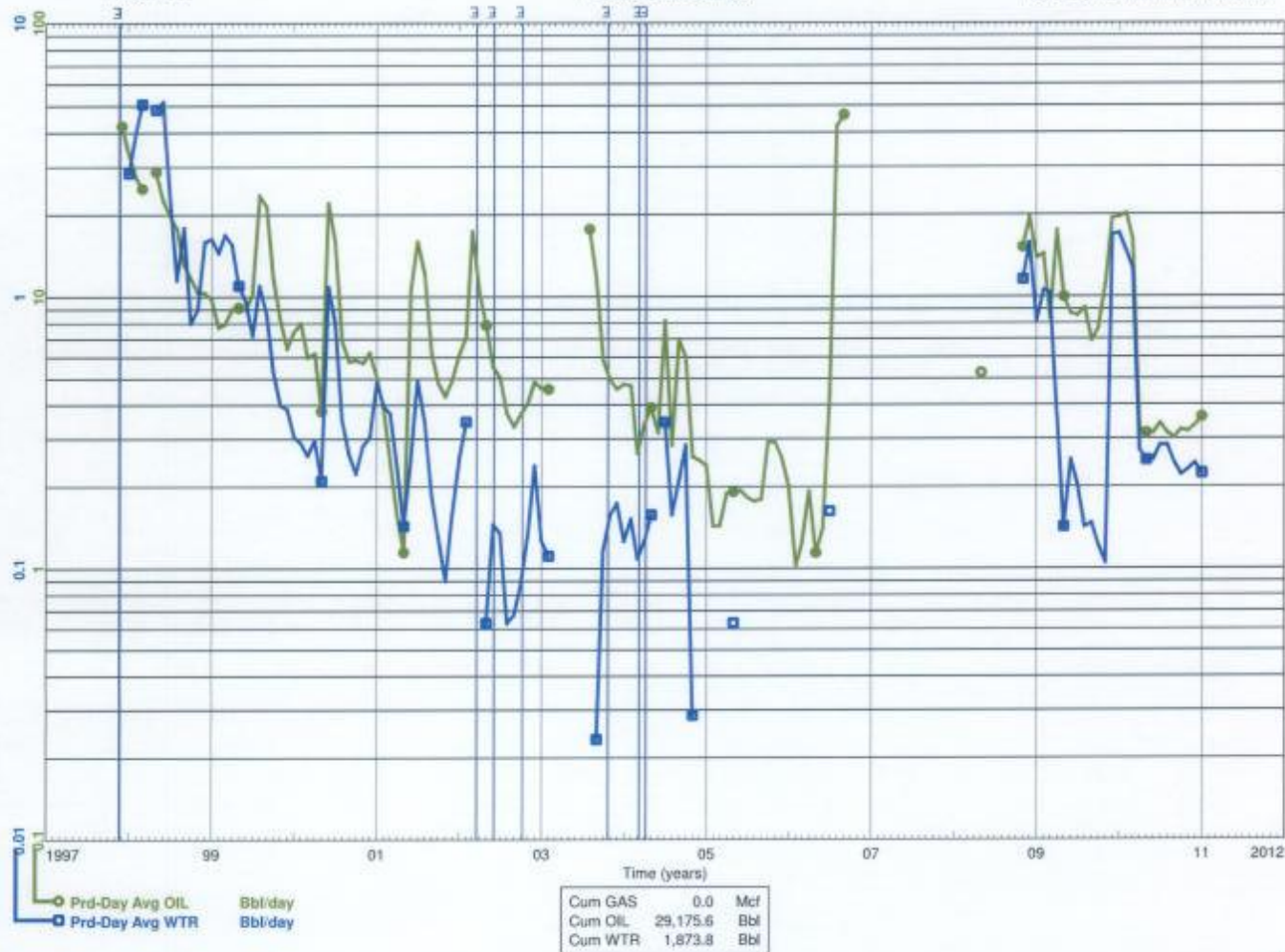
Thursday, April 21, 2011, 04:15 PM

geoSCOUT  
www.geoscout.com

Data As Of: 2011-01 (MB)  
 From: 1997-12  
 To: 2011-01

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 Prov.  
 1B0/02-24-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



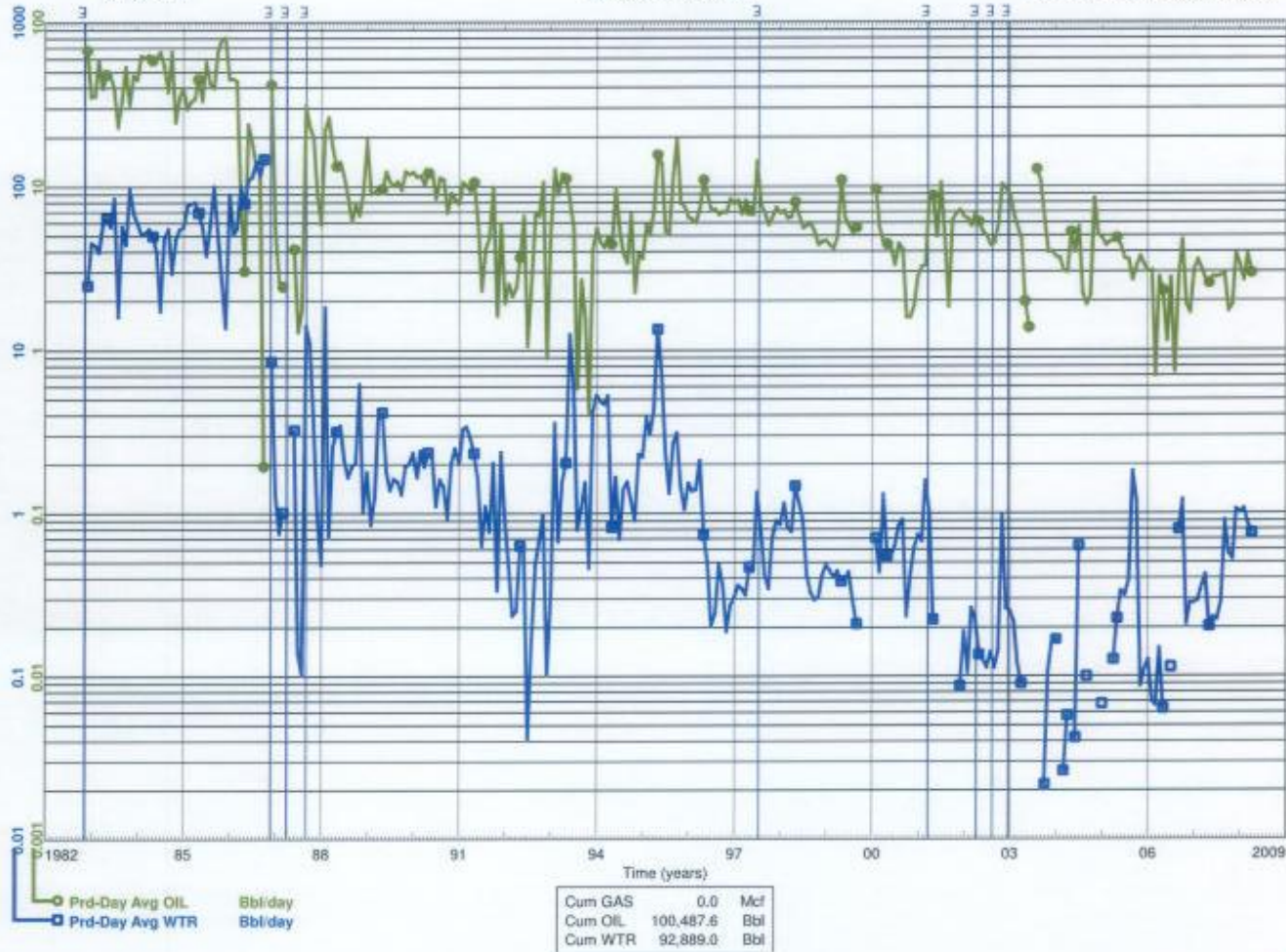
Thursday, April 21, 2011, 04:14 PM



Data As Of: 2011-01 (MB)  
 From: 1982-12  
 To: 2008-04

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 Prov.  
 100/02-24-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 04:14 PM

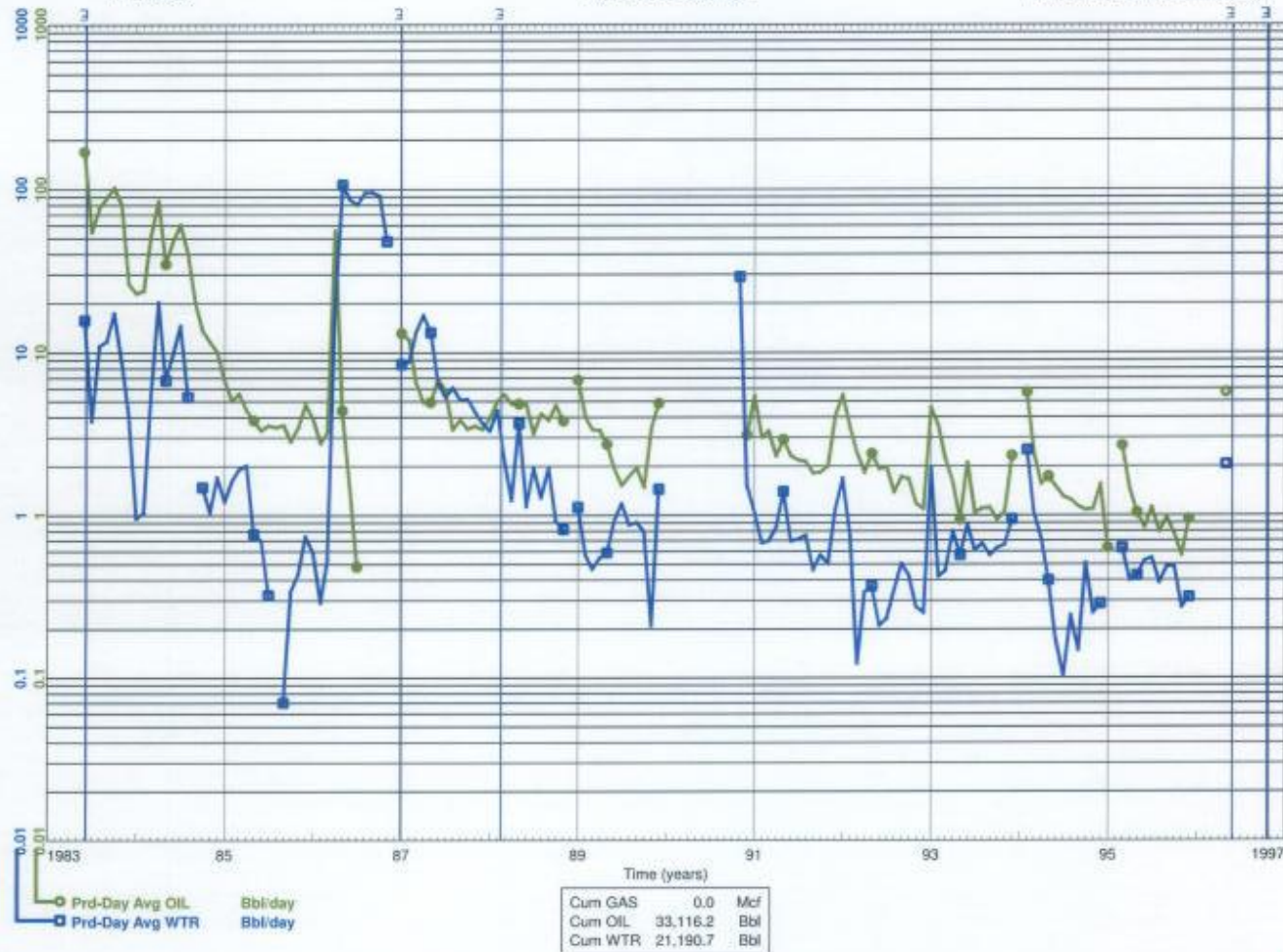
geoSCOUT  
 www.geoscout.com



Data As Of: 2011-01 (MB)  
 From: 1983-06  
 To: 1996-05

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 Prov.  
 102/01-24-001-26W1/00

Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)

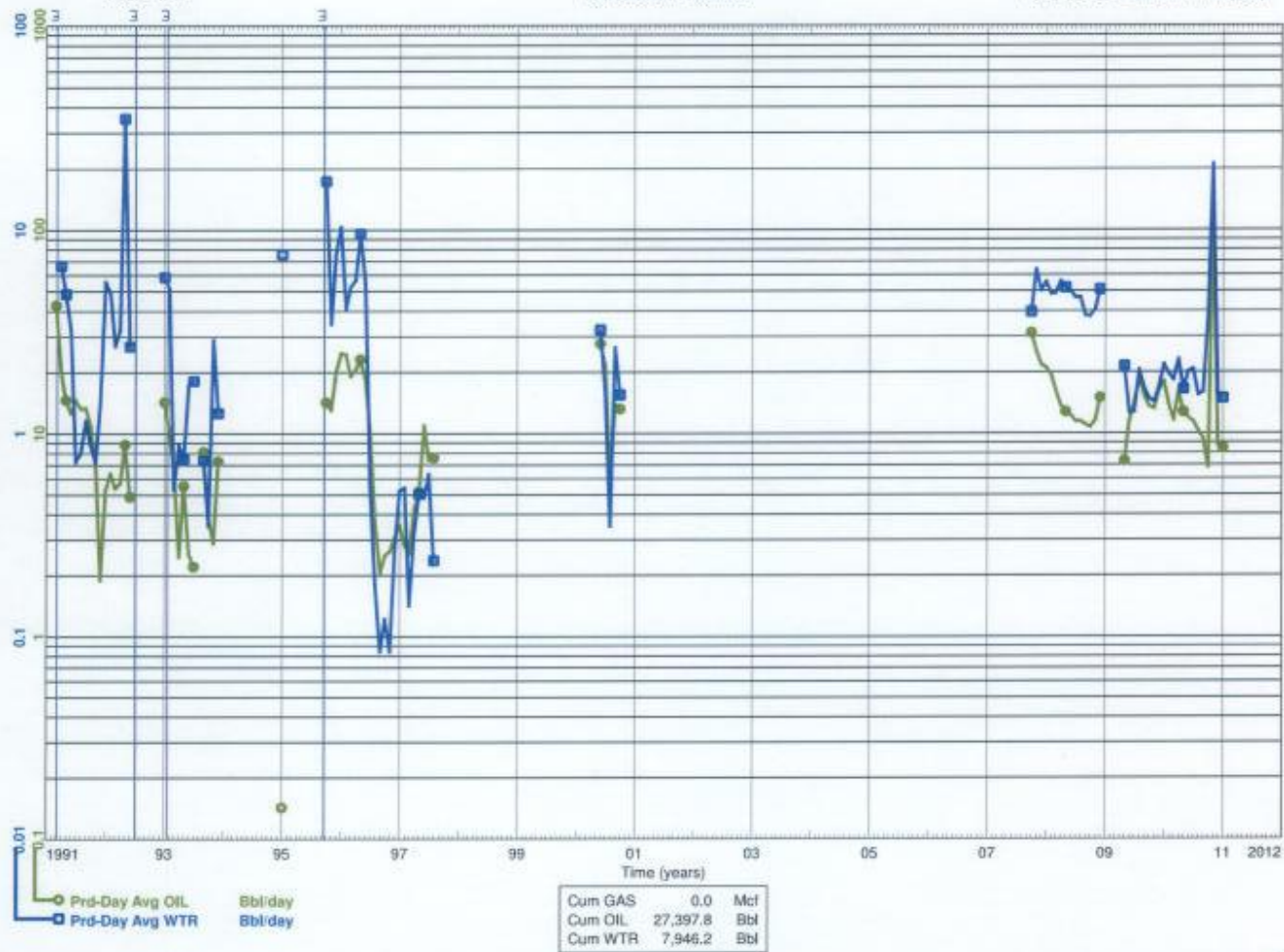


Thursday, April 21, 2011, 04:13 PM

Data As Of: 2011-01 (MB)  
 From: 1991-03  
 To: 2011-01

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 1A0/08-23-001-26W1/00

Status: RESUMED COOP  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



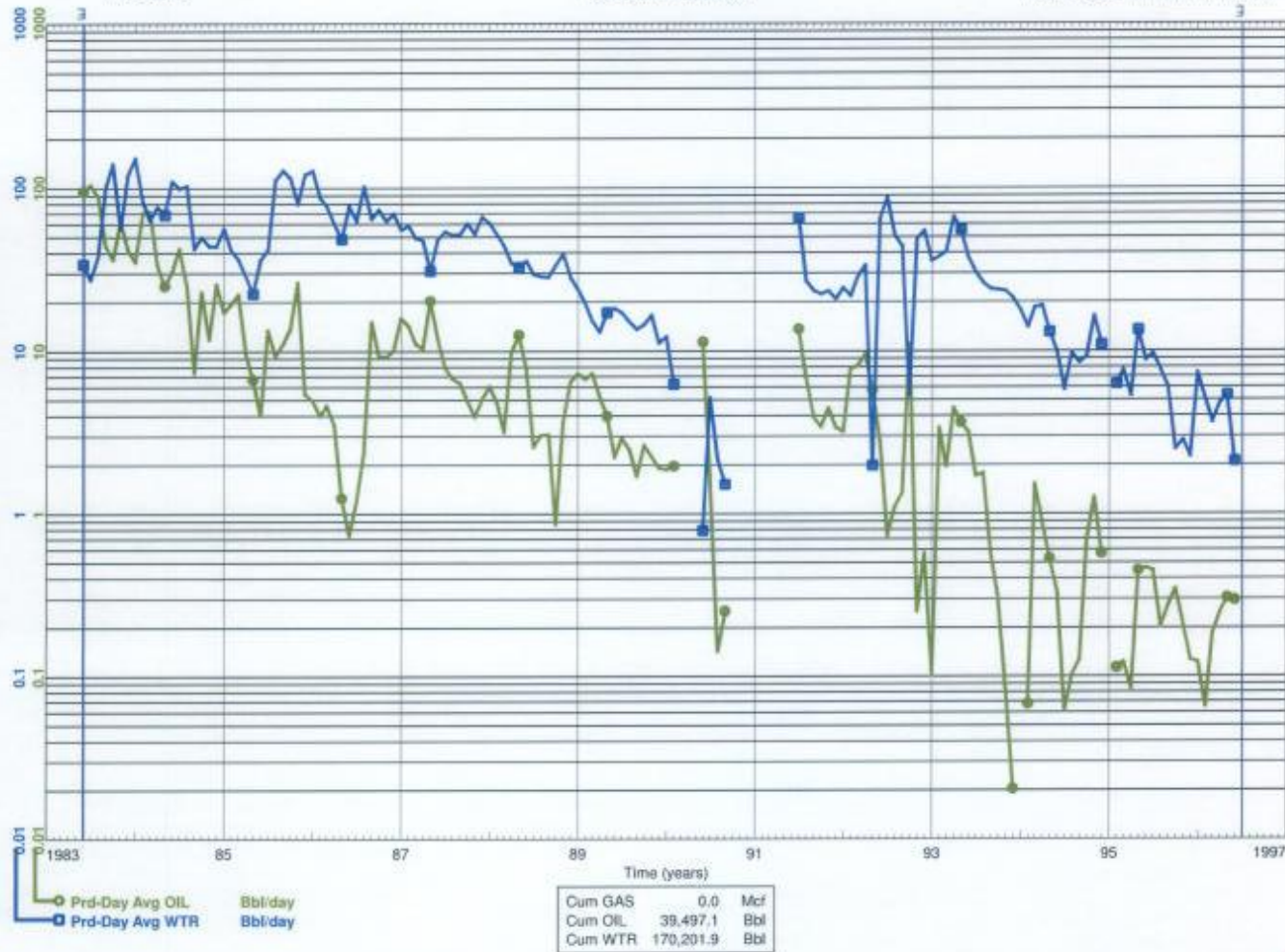
Monday, April 25, 2011, 03:56 PM

geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)

Data As Of: 2011-01 (MB)  
 From: 1983-06  
 To: 1996-06

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 102/08-23-001-26W1/00

Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 04:12 PM

geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)

Data As Of: 2010-11 (MB)

From: 1982-12

To: 1990-03

# INDIVIDUAL PRODUCTION

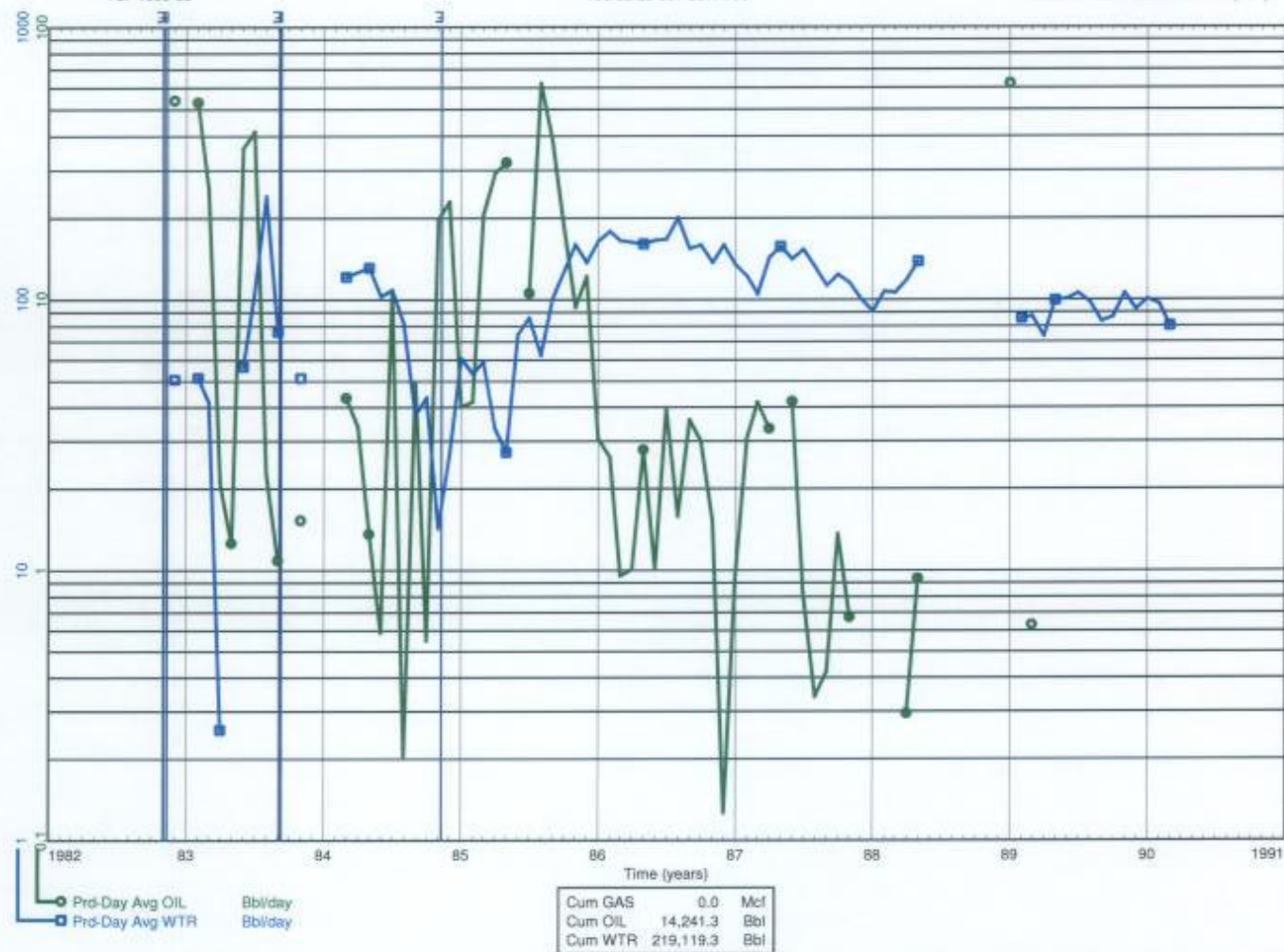
Waskada Unit No. 4

100/02-23-001-26W1/00

Status: Abandoned Producer

Field: WASKADA (03)

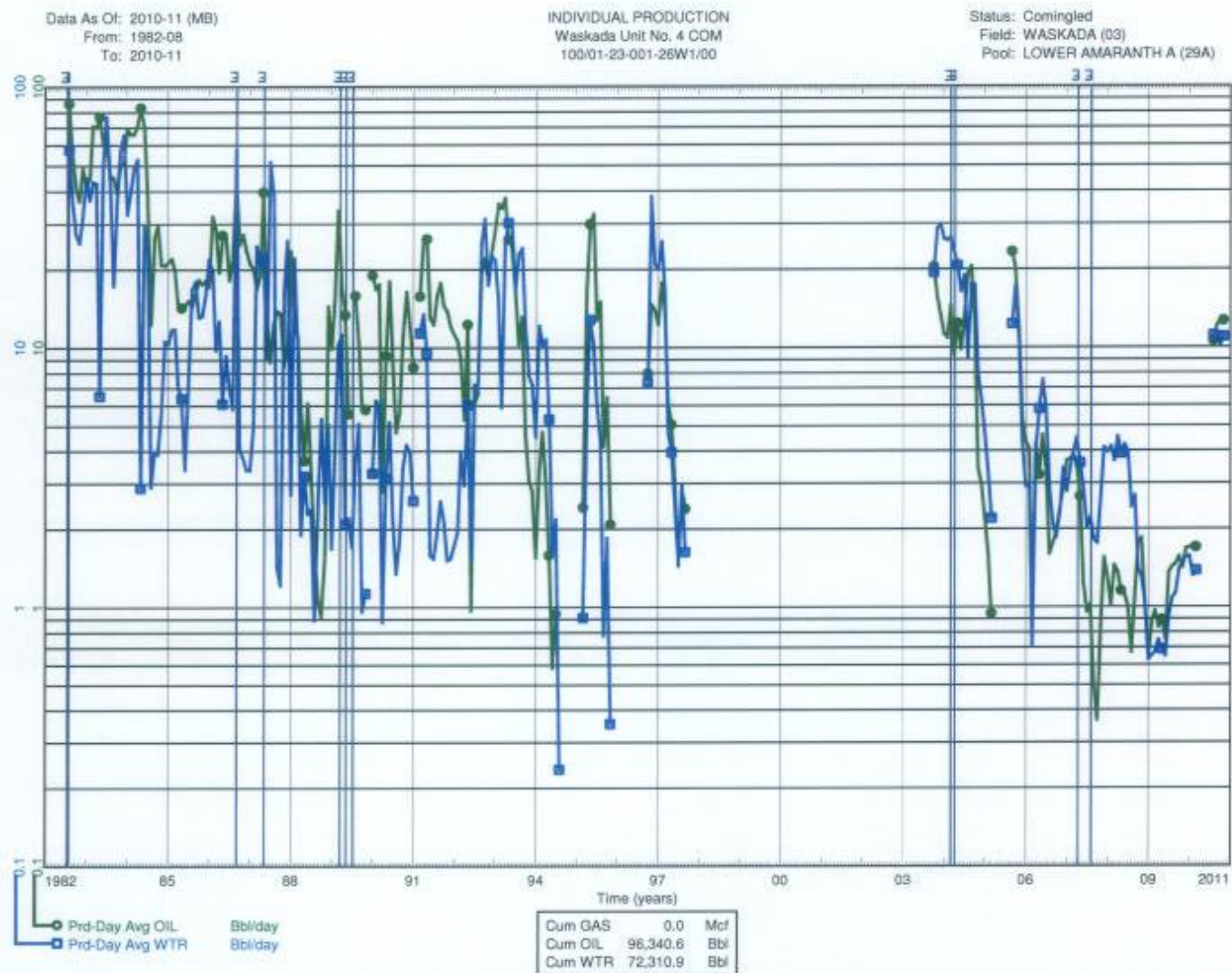
Pool: LOWER AMARANTH A (29A)



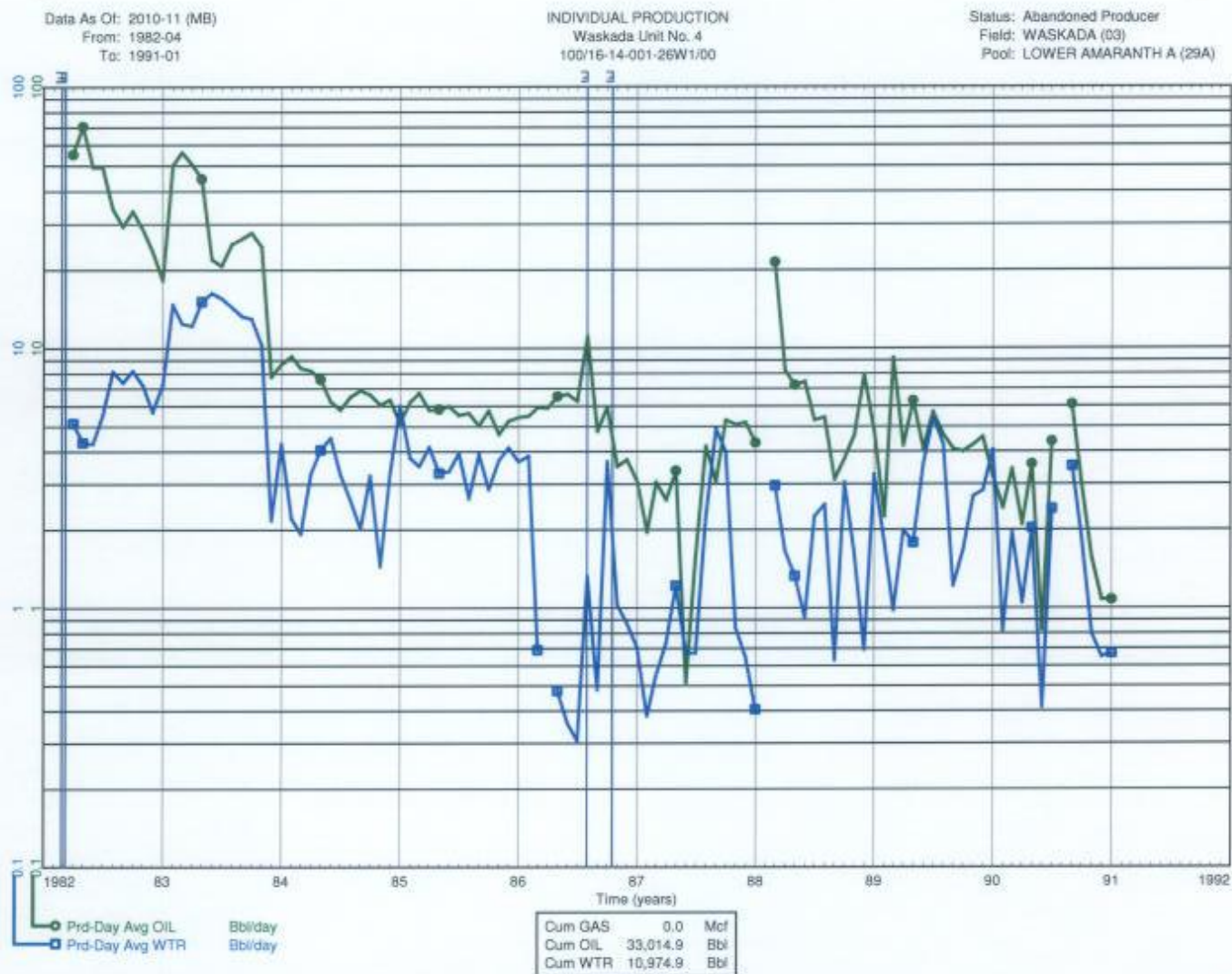
Friday, February 11, 2011, 03:25 PM

geoSCOUT  
www.geoscout.com





Friday, February 11, 2011, 03:25 PM

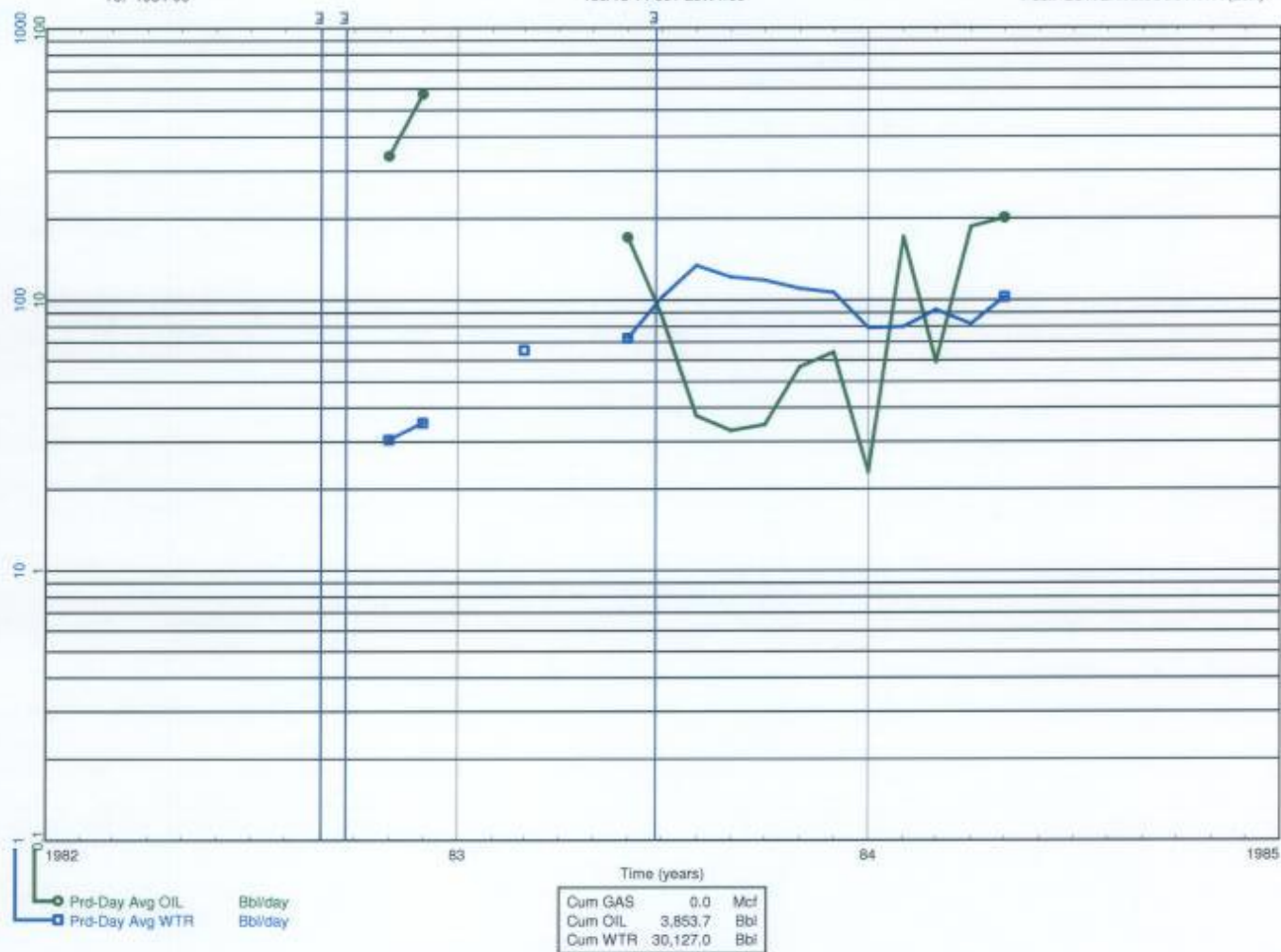


Friday, February 11, 2011, 03:24 PM

Data As Of: 2010-11 (MB)  
 From: 1982-11  
 To: 1984-05

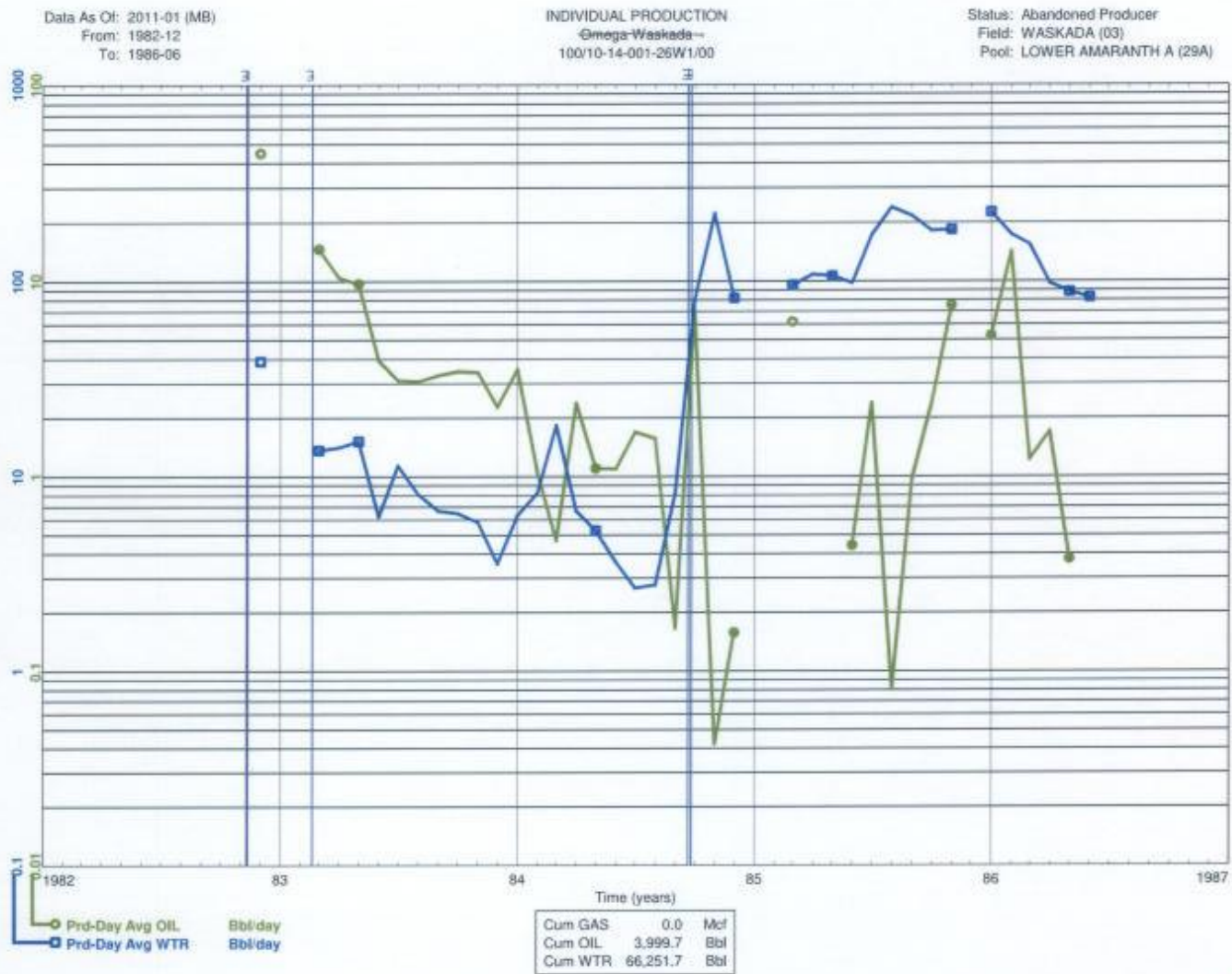
INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 WIW  
 100/15-14-001-26W1/00

Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Friday, February 11, 2011, 03:24 PM

geoSCOUT  
 www.geologic.com



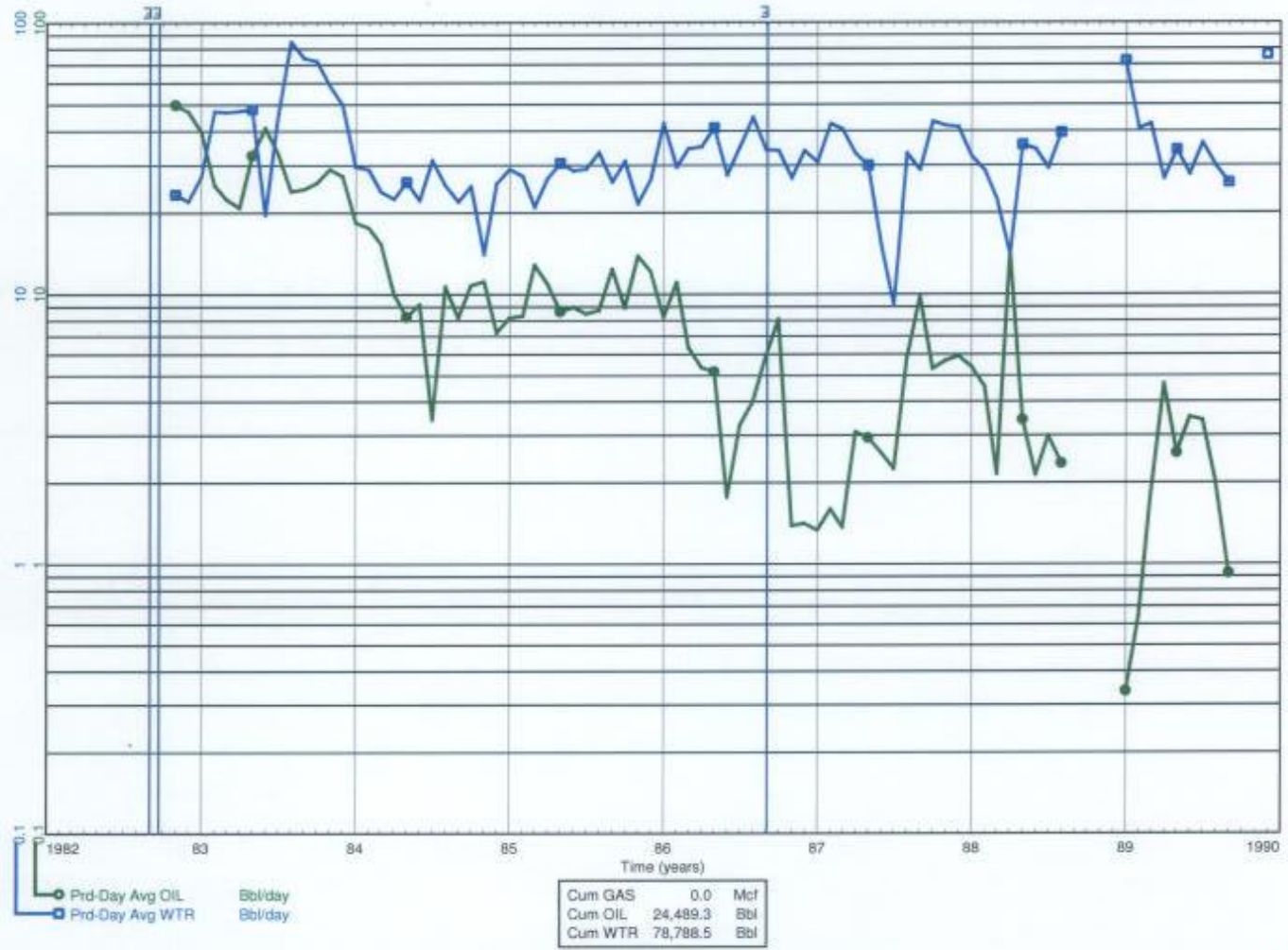
Thursday, April 21, 2011, 04:09 PM



Data As Of: 2010-11 (MB)  
 From: 1982-11  
 To: 1989-12

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/09-14-001-26W1/00

Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Friday, February 11, 2011, 03:23 PM



Data As Of: 2010-11 (MB)

From: 1982-08

To: 2000-06

# INDIVIDUAL PRODUCTION

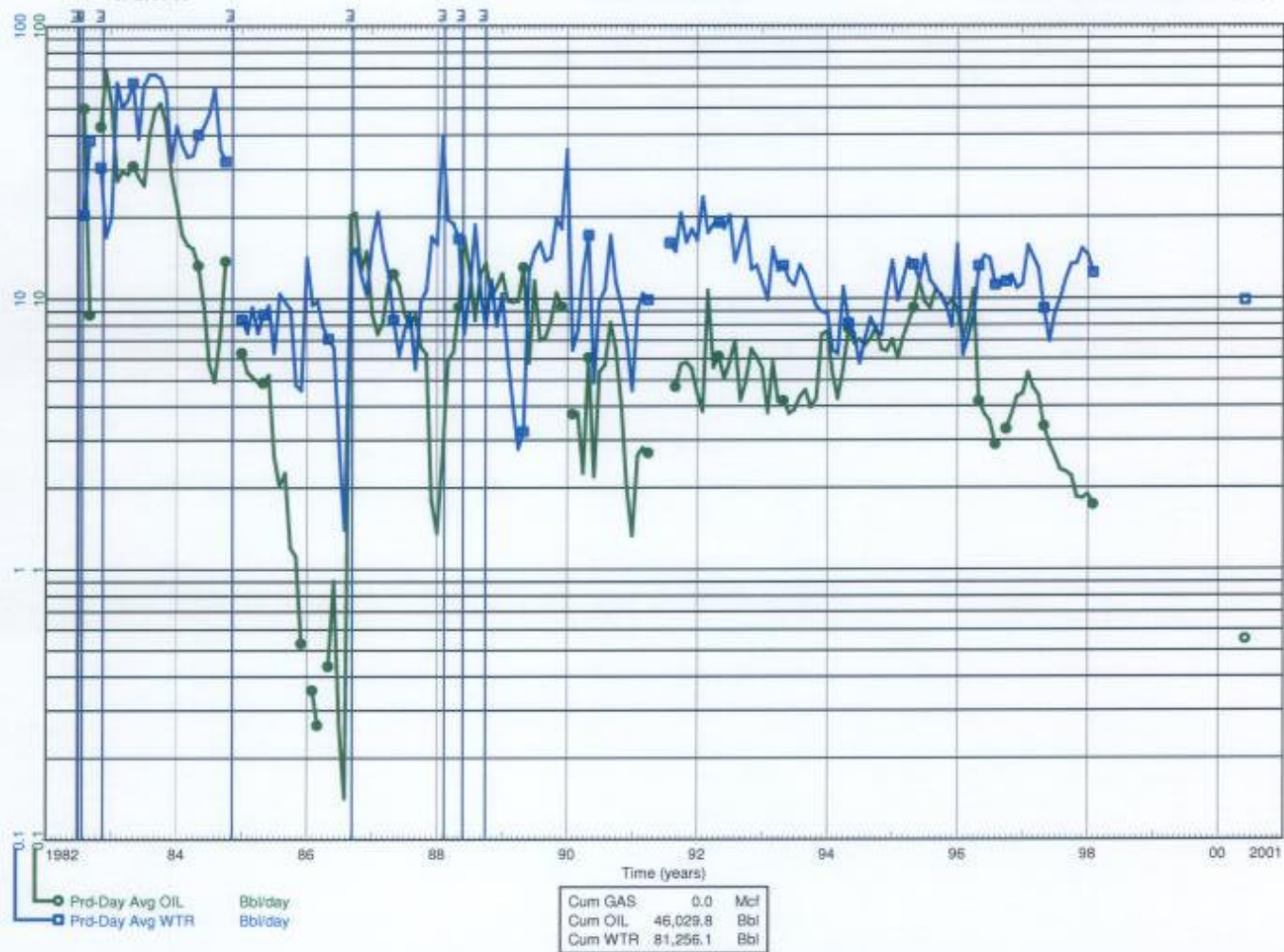
Waskada Unit No. 4

100/08-14-001-26W1/00

Status: Abandoned Producer

Field: WASKADA (03)

Pool: LOWER AMARANTH A (29A)



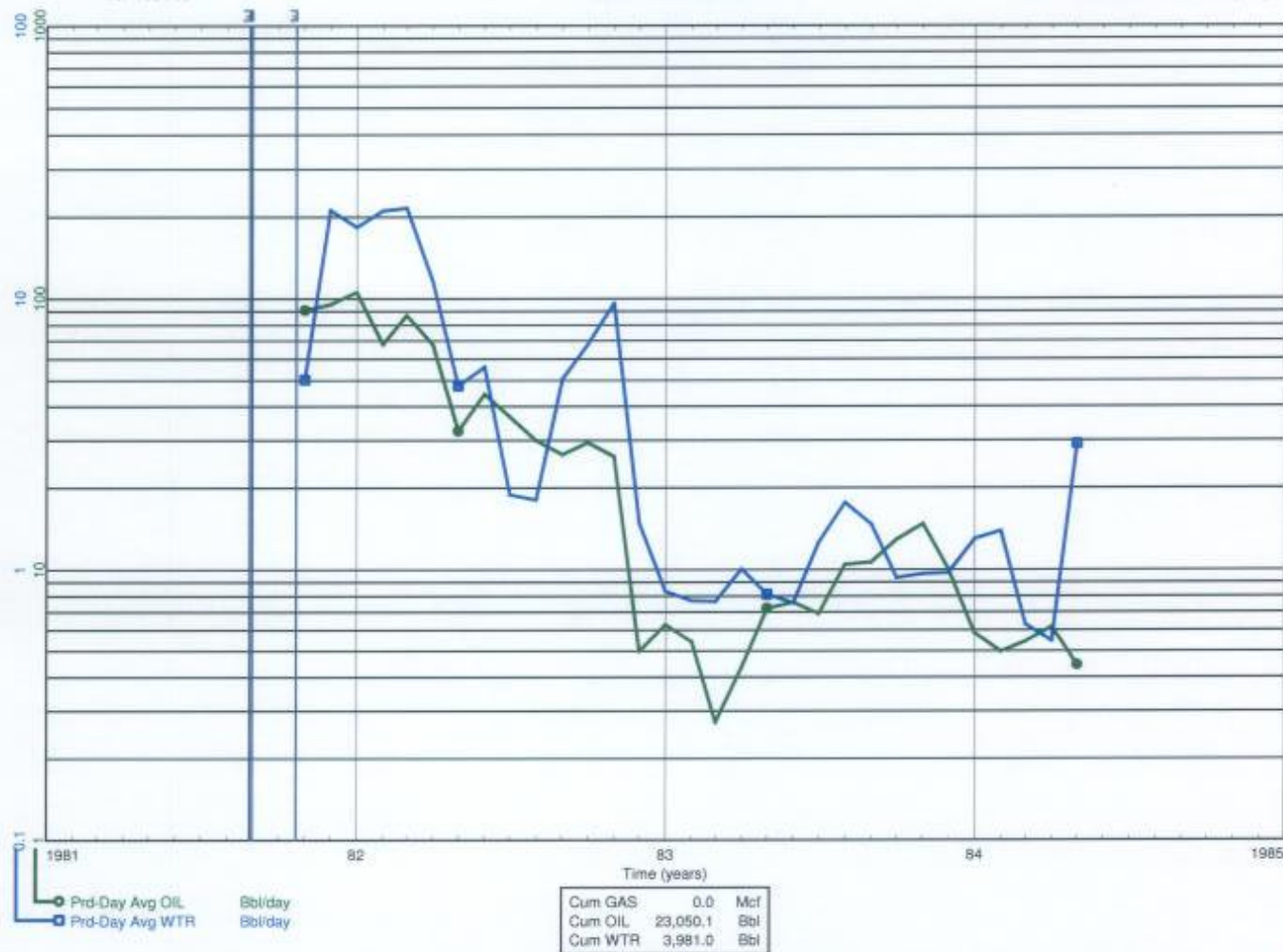
Friday, February 11, 2011, 03:23 PM

geoSCOUT  
www.geoscout.com

Data As Of: 2010-11 (MB)  
 From: 1981-11  
 To: 1984-05

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 WIW  
 100/15-13-001-26W1/00

Status: Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



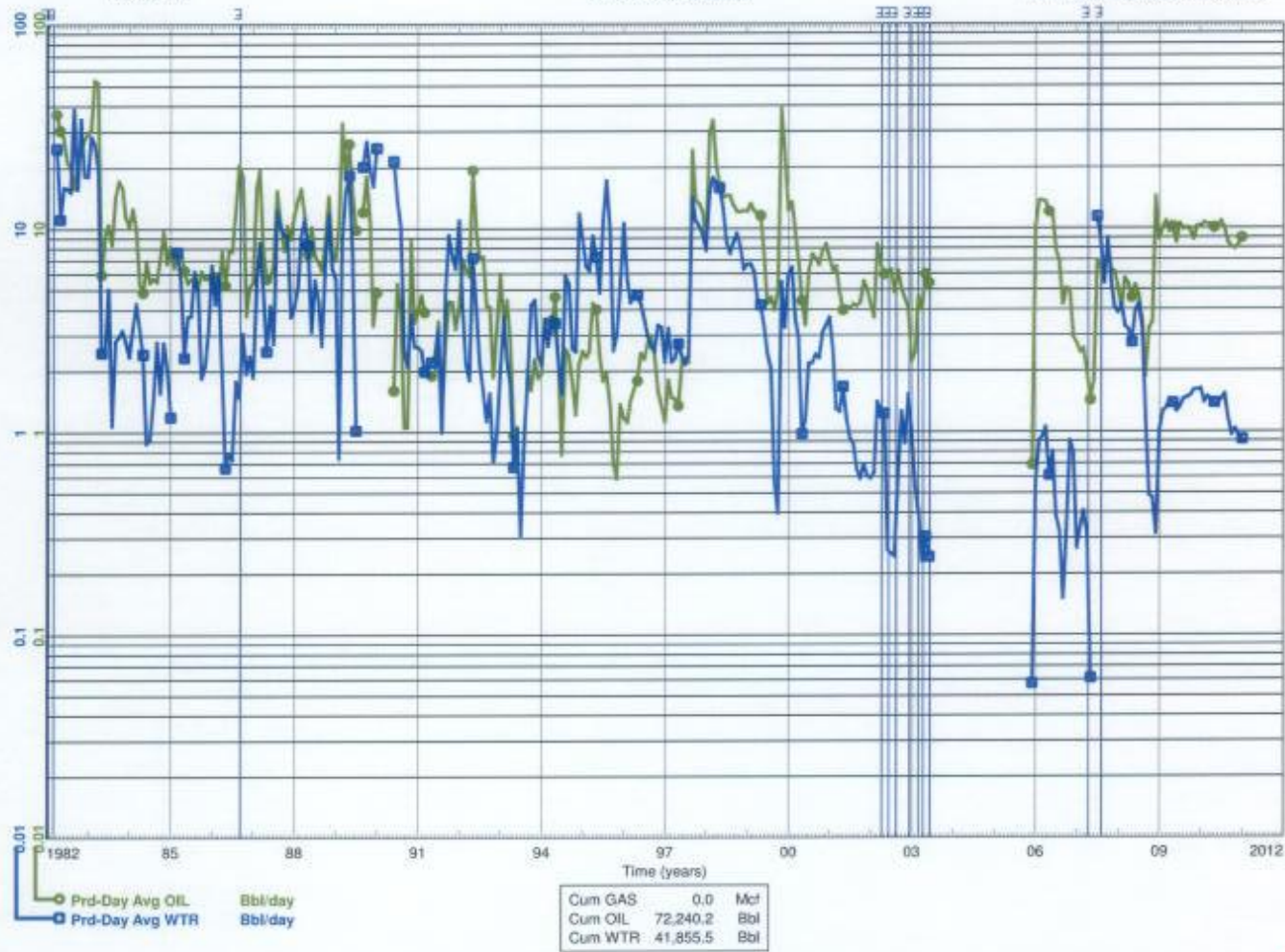
Friday, February 11, 2011, 03:23 PM

geoSCOUT  
 www.geoscout.com

Data As Of: 2011-01 (MB)  
 From: 1982-04  
 To: 2011-01

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/14-13-001-25W1/00

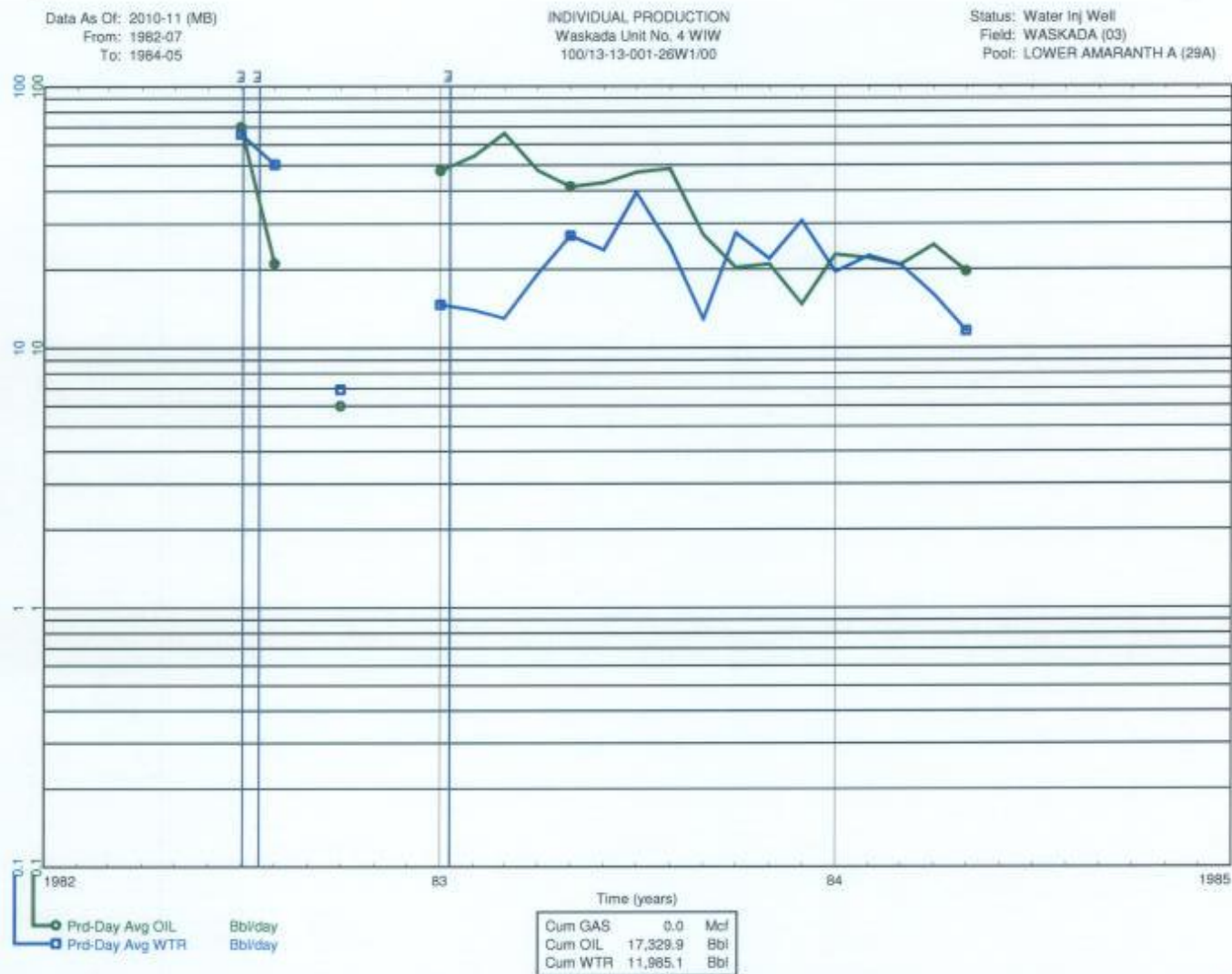
Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 04:06 PM

geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)



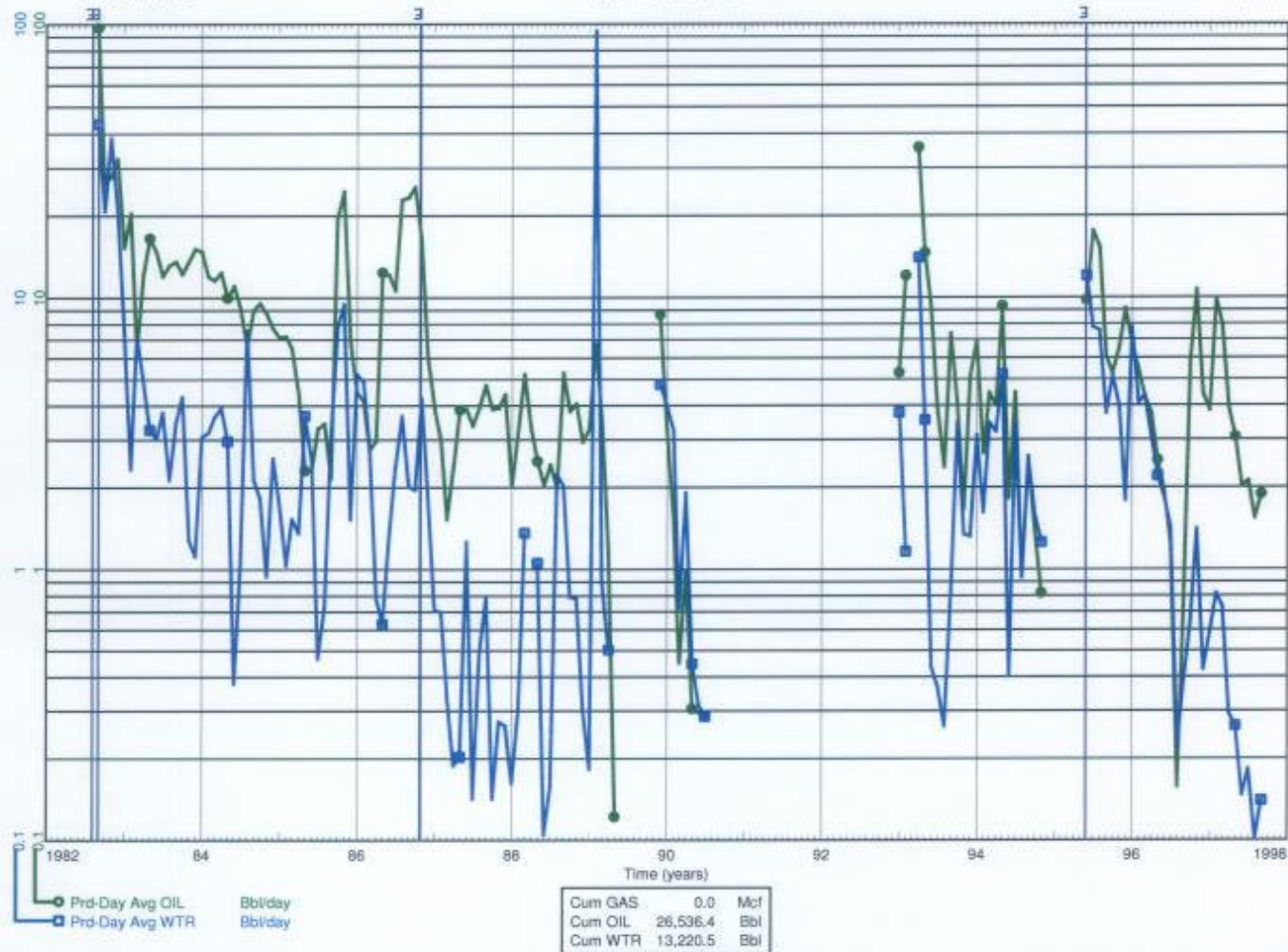


Friday, February 11, 2011, 03:22 PM

Data As Of: 2010-11 (MB)  
 From: 1982-09  
 To: 1997-09

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/12-13-001-26W1/00

Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



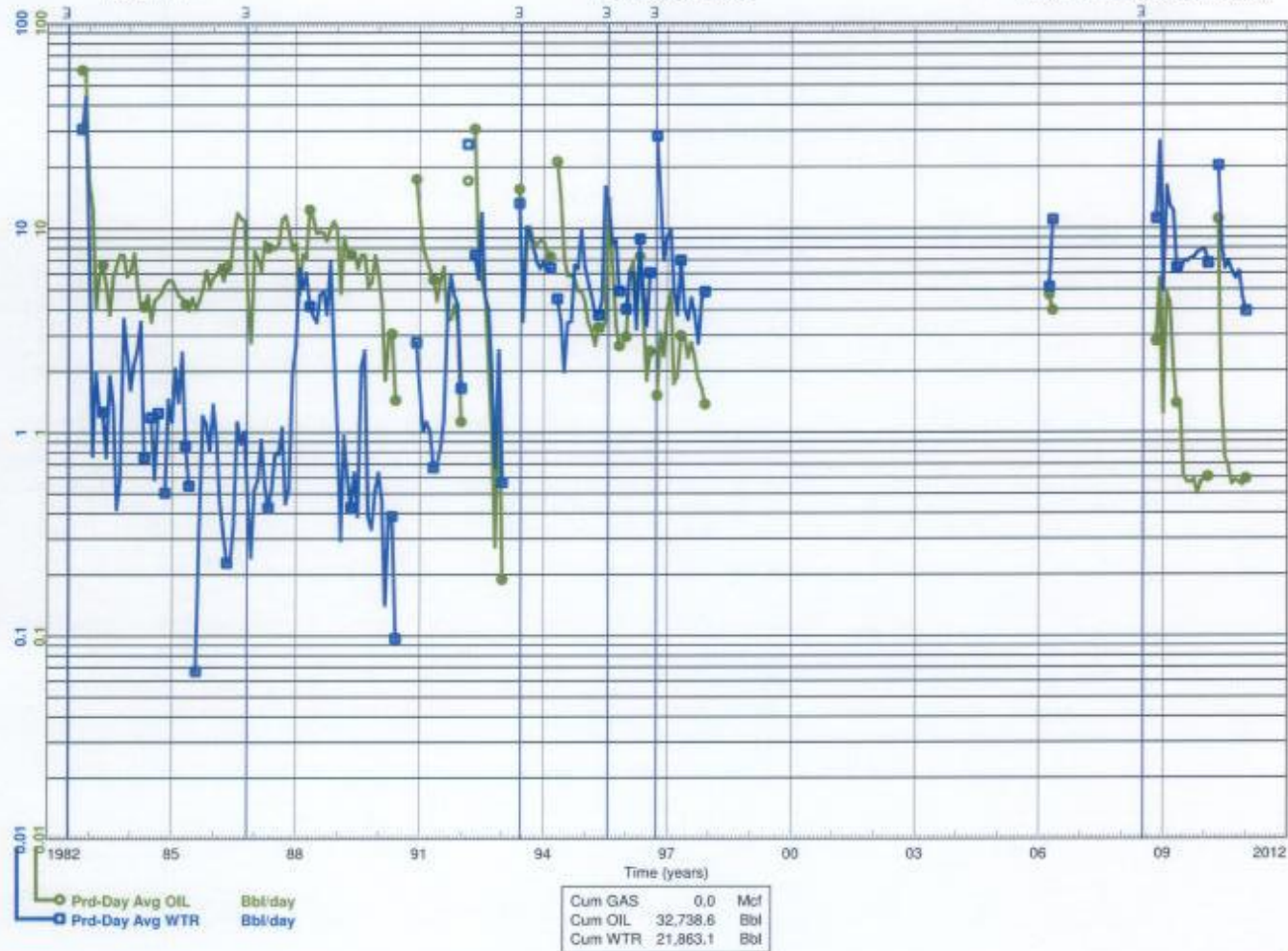
Friday, February 11, 2011, 03:22 PM

geoSCOUT  
 www.geoscot.com

Data As Of: 2011-01 (MB)  
 From: 1982-11  
 To: 2011-01

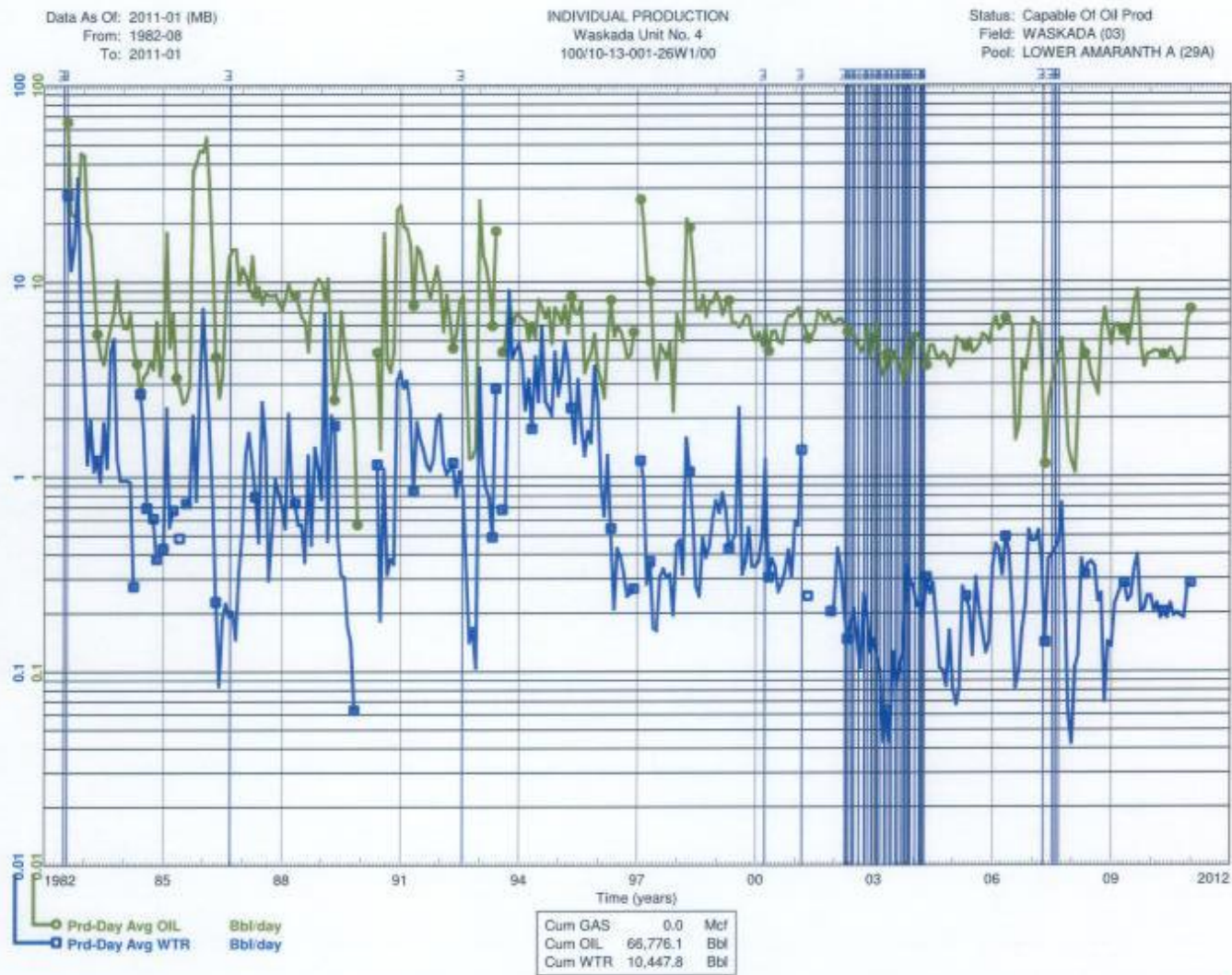
INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/11-13-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 04:05 PM

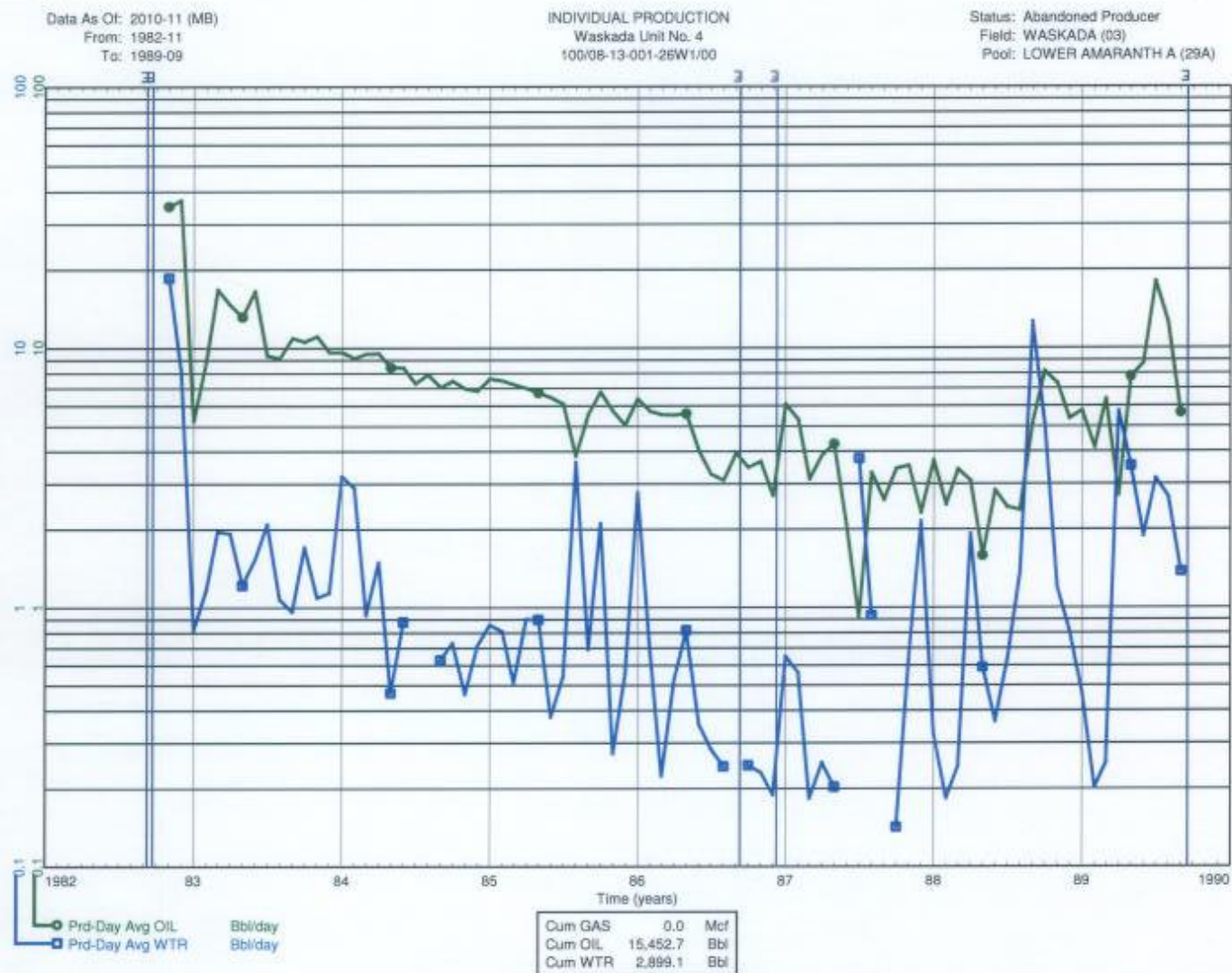




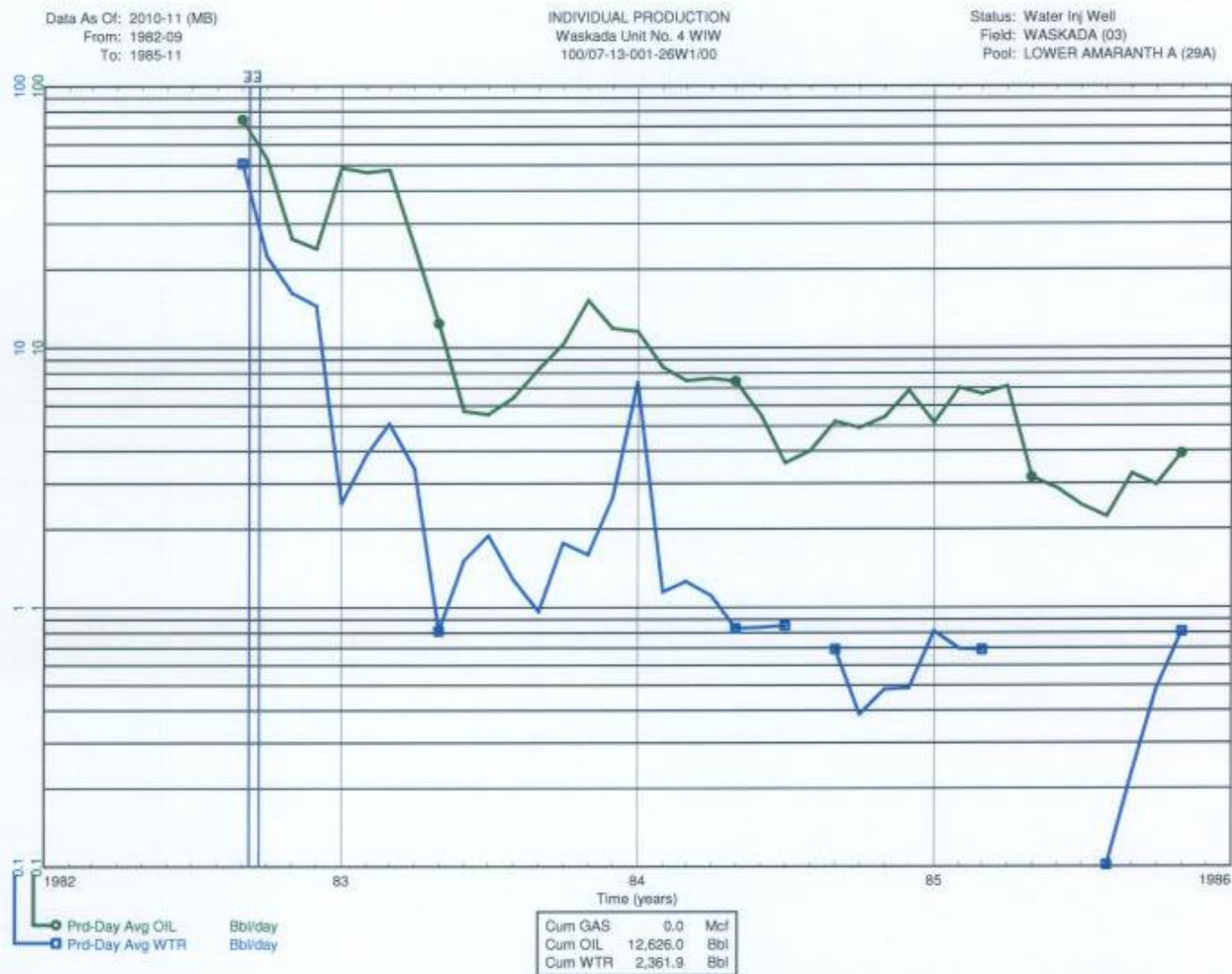
Thursday, April 21, 2011, 04:04 PM

geoSCOUT  
www.geoscout.com



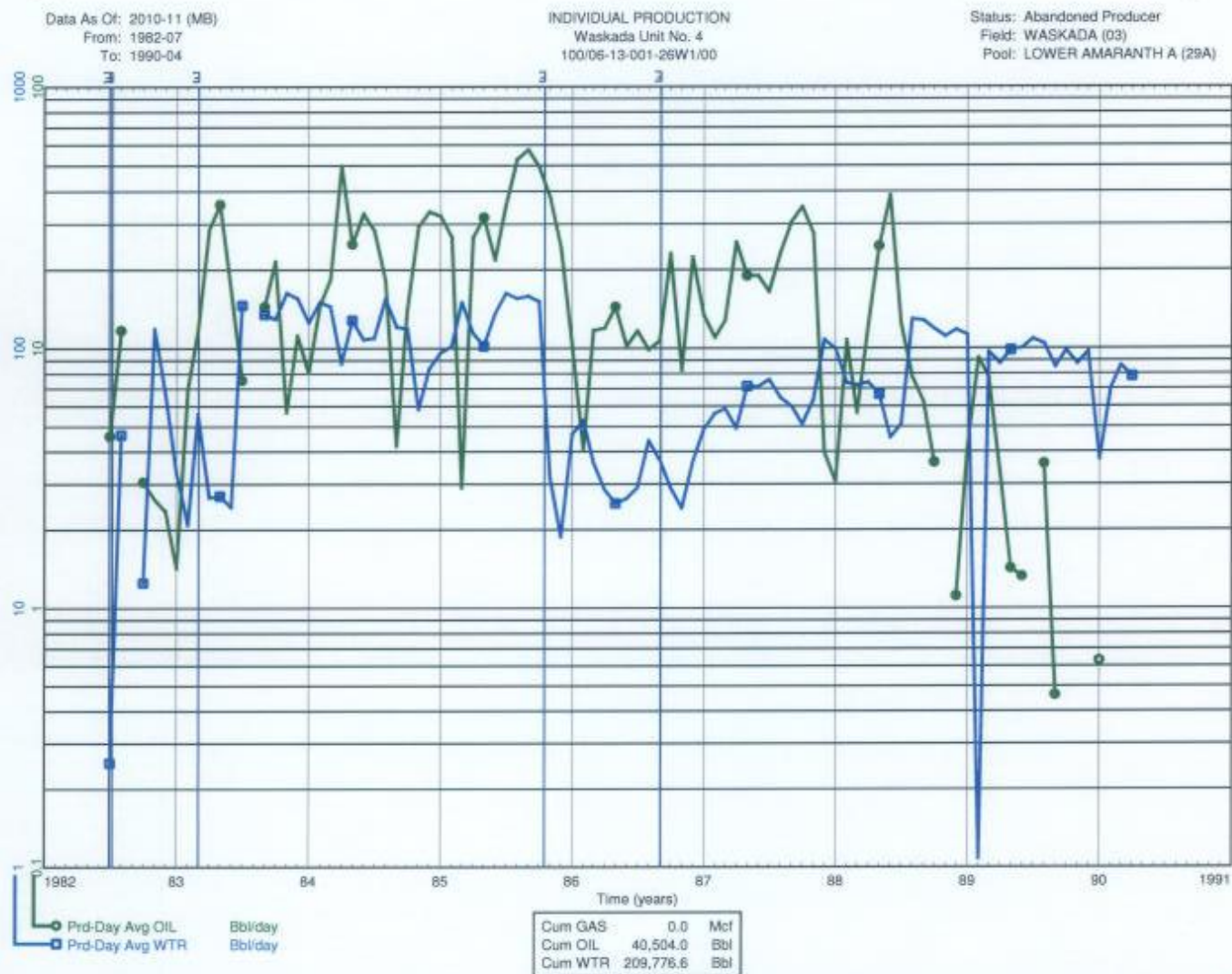


Friday, February 11, 2011, 03:21 PM



Friday, February 11, 2011, 03:21 PM

geoSCOUT  
www.geoSCOUT.com

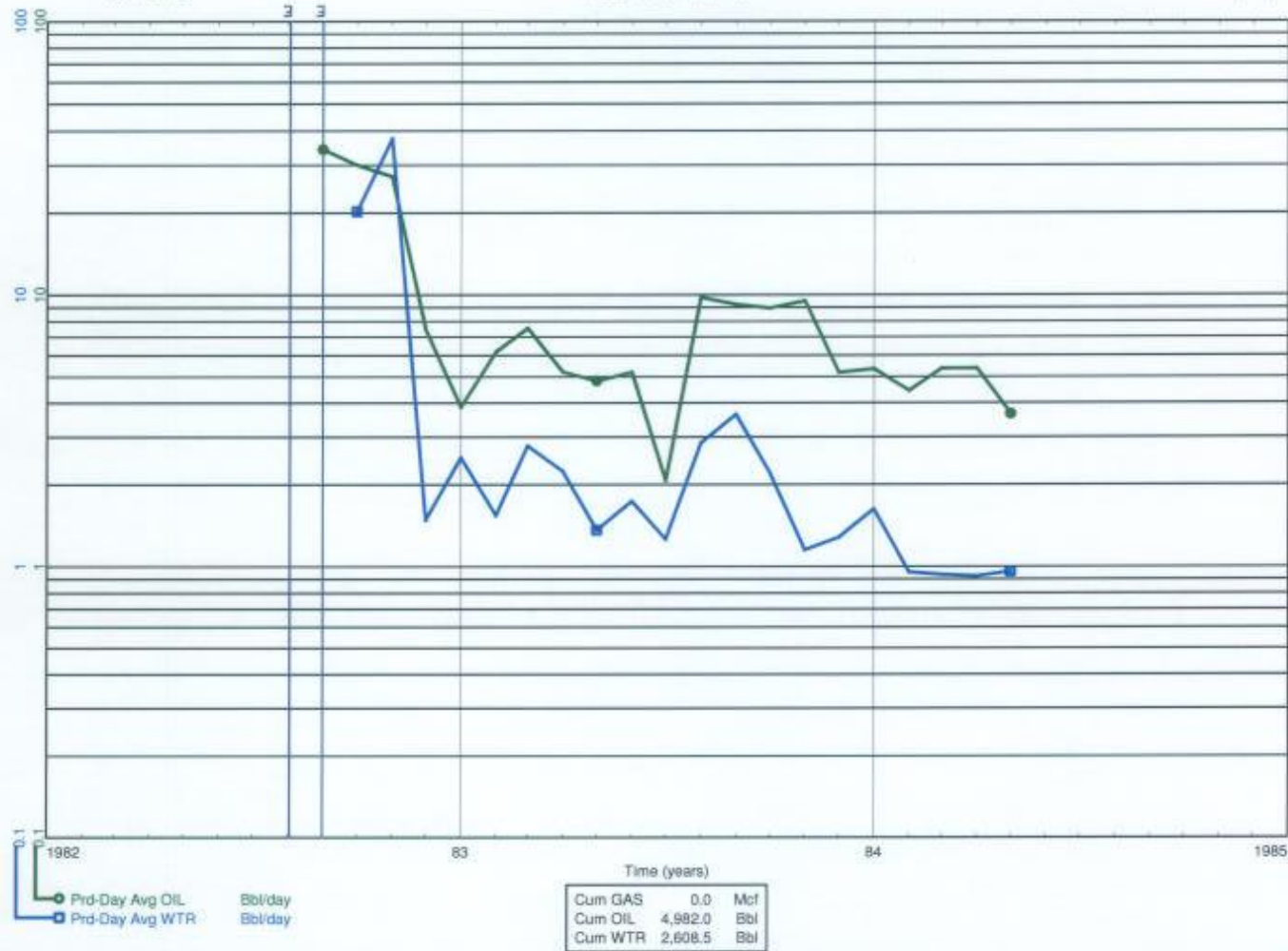


Friday, February 11, 2011, 03:21 PM

Data As Of: 2010-11 (MB)  
 From: 1982-09  
 To: 1984-05

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4 W/W  
 100/05-13-001-26W1/00

Status: Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Friday, February 11, 2011, 03:21 PM

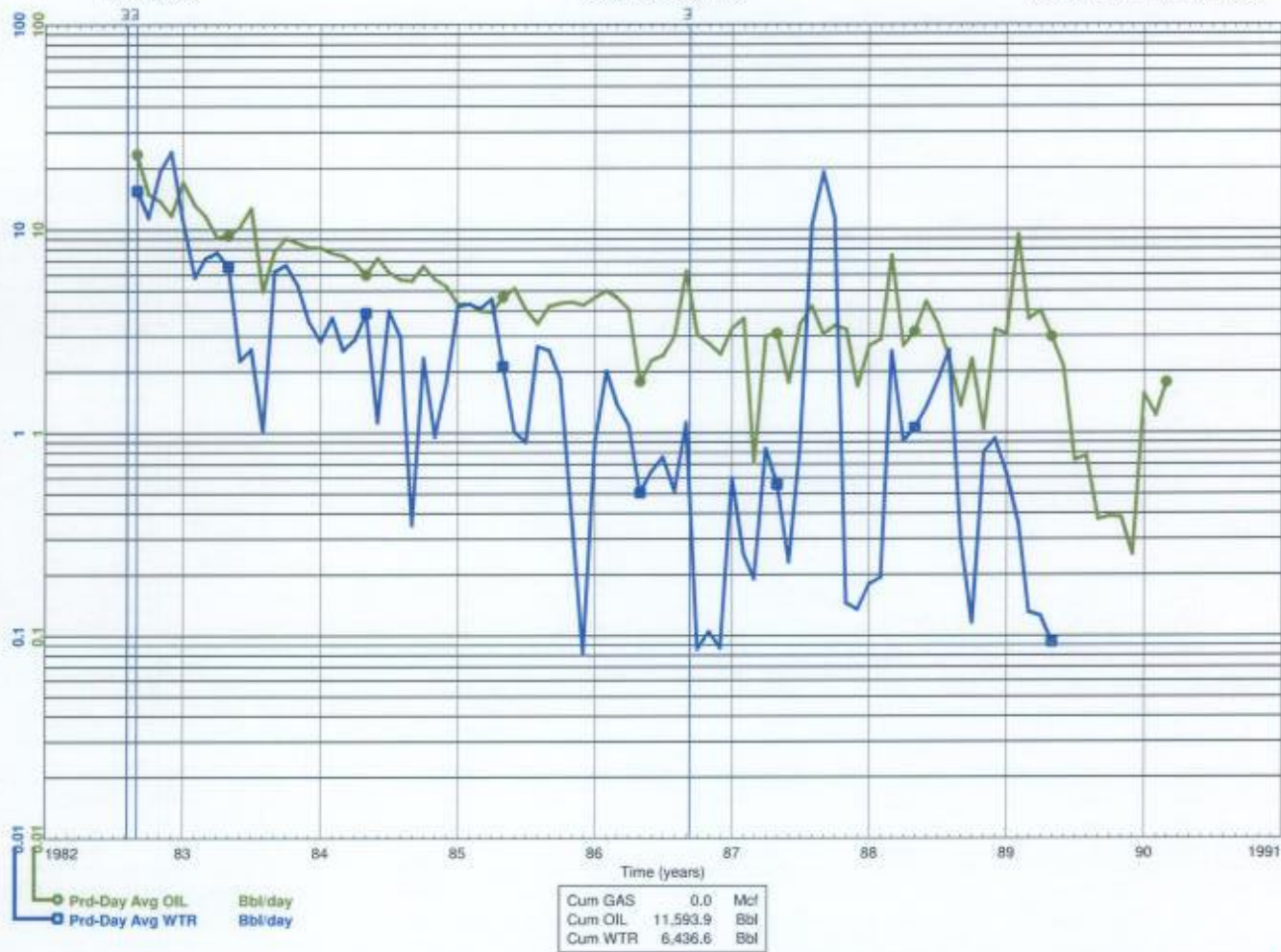
geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)



Data As Of: 2011-01 (MB)  
 From: 1982-09  
 To: 1990-03

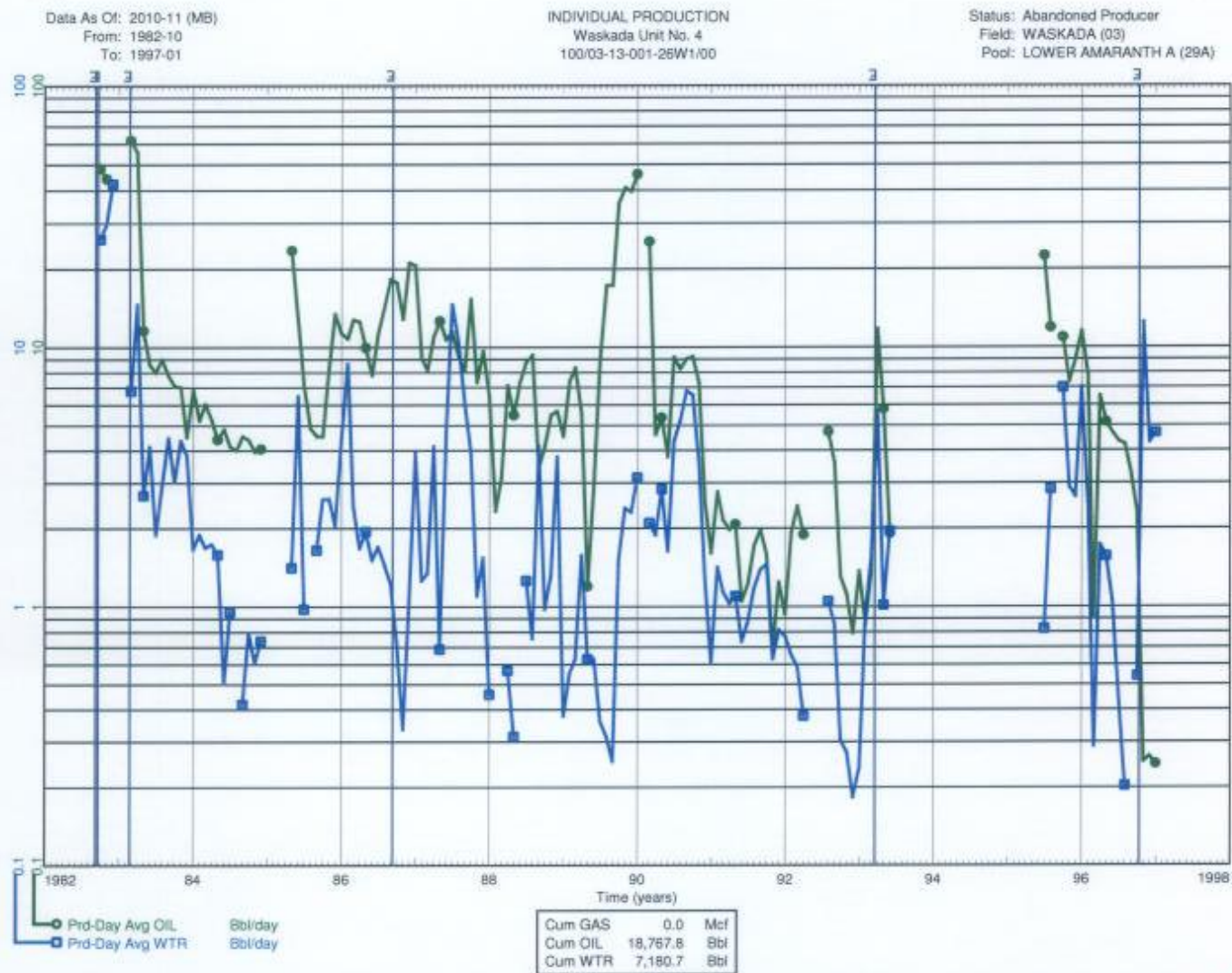
INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/04-13-001-26W1/00

Status: Abandoned Producer  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 04:00 PM



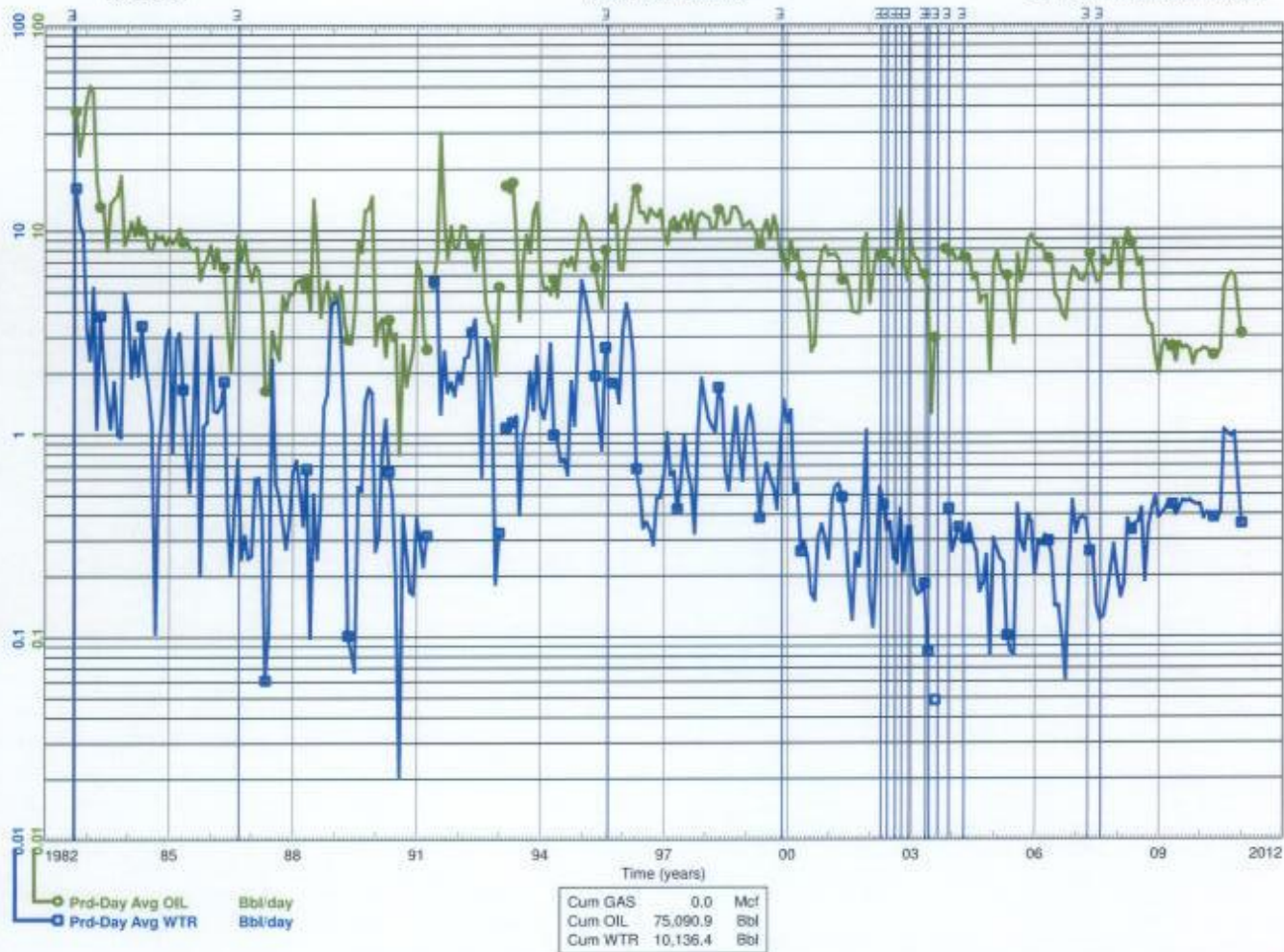


Friday, February 11, 2011, 03:26 PM

Data As Of: 2011-01 (MB)  
 From: 1982-10  
 To: 2011-01

INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/02-13-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 03:59 PM

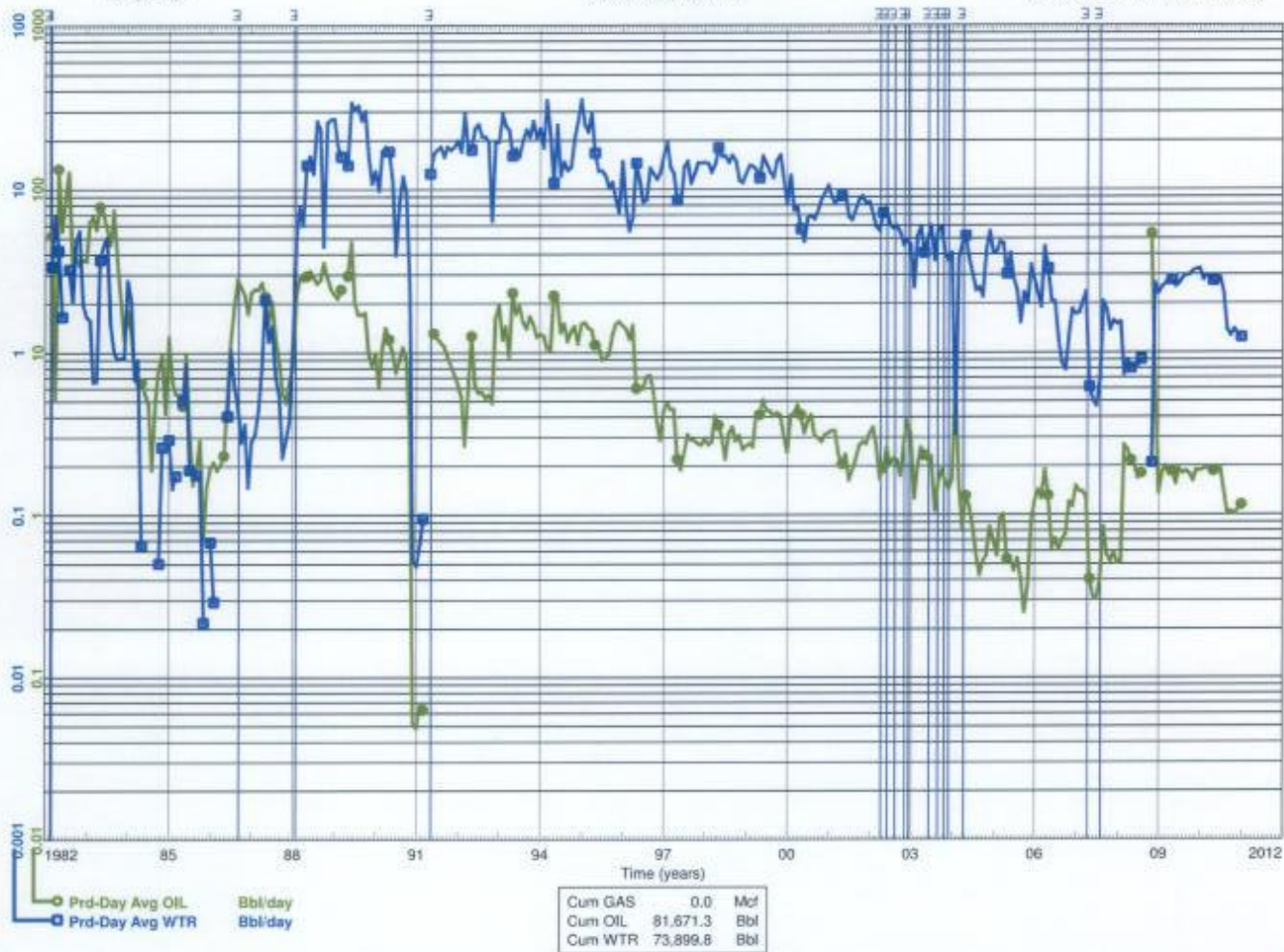
geoSCOUT  
 www.geologic.com



Data As Of: 2011-01 (MB)  
 From: 1982-03  
 To: 2011-01

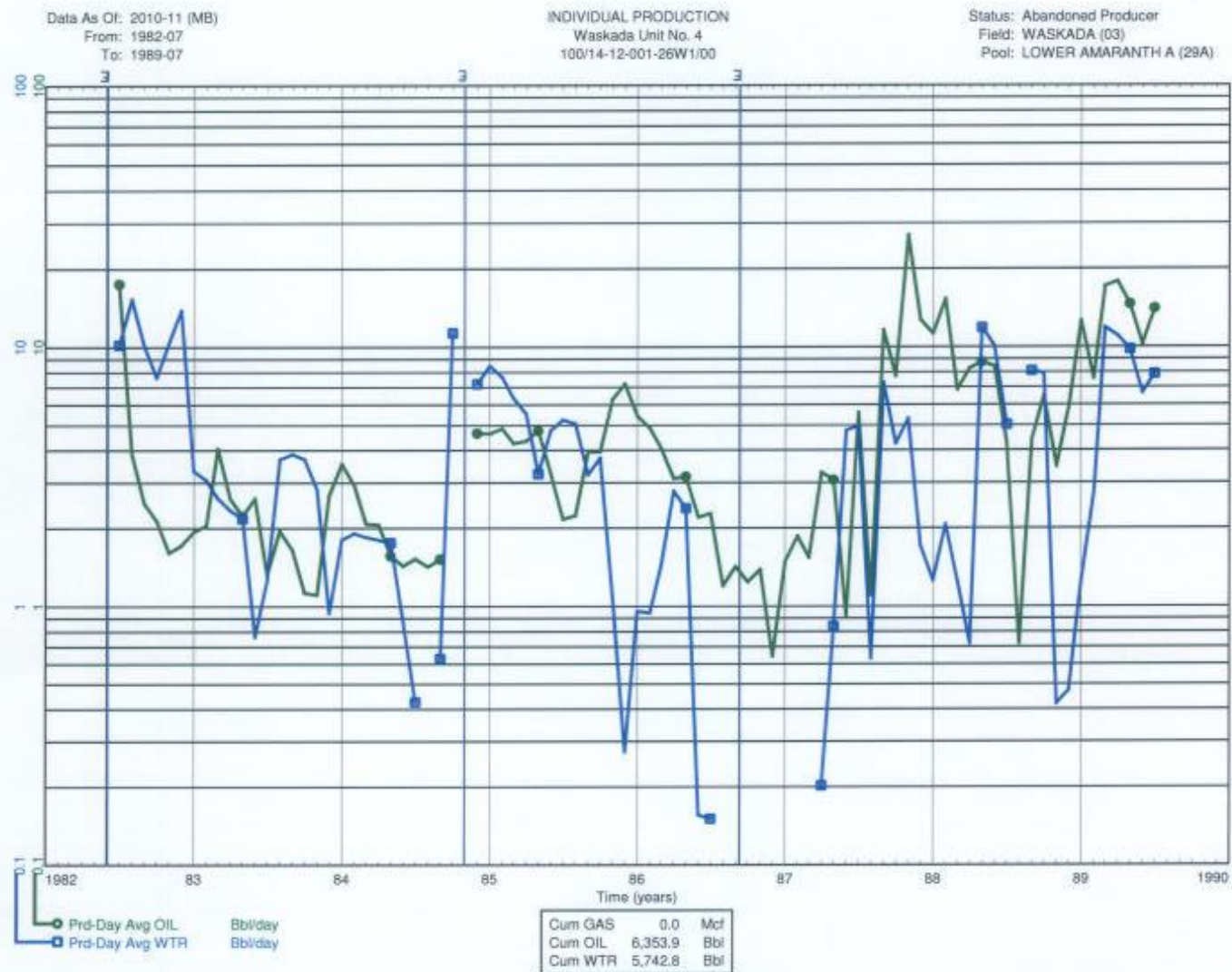
INDIVIDUAL PRODUCTION  
 Waskada Unit No. 4  
 100/01-13-001-26W1/00

Status: Capable Of Oil Prod  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 03:05 PM

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[www.geoscout.com](http://www.geoscout.com)

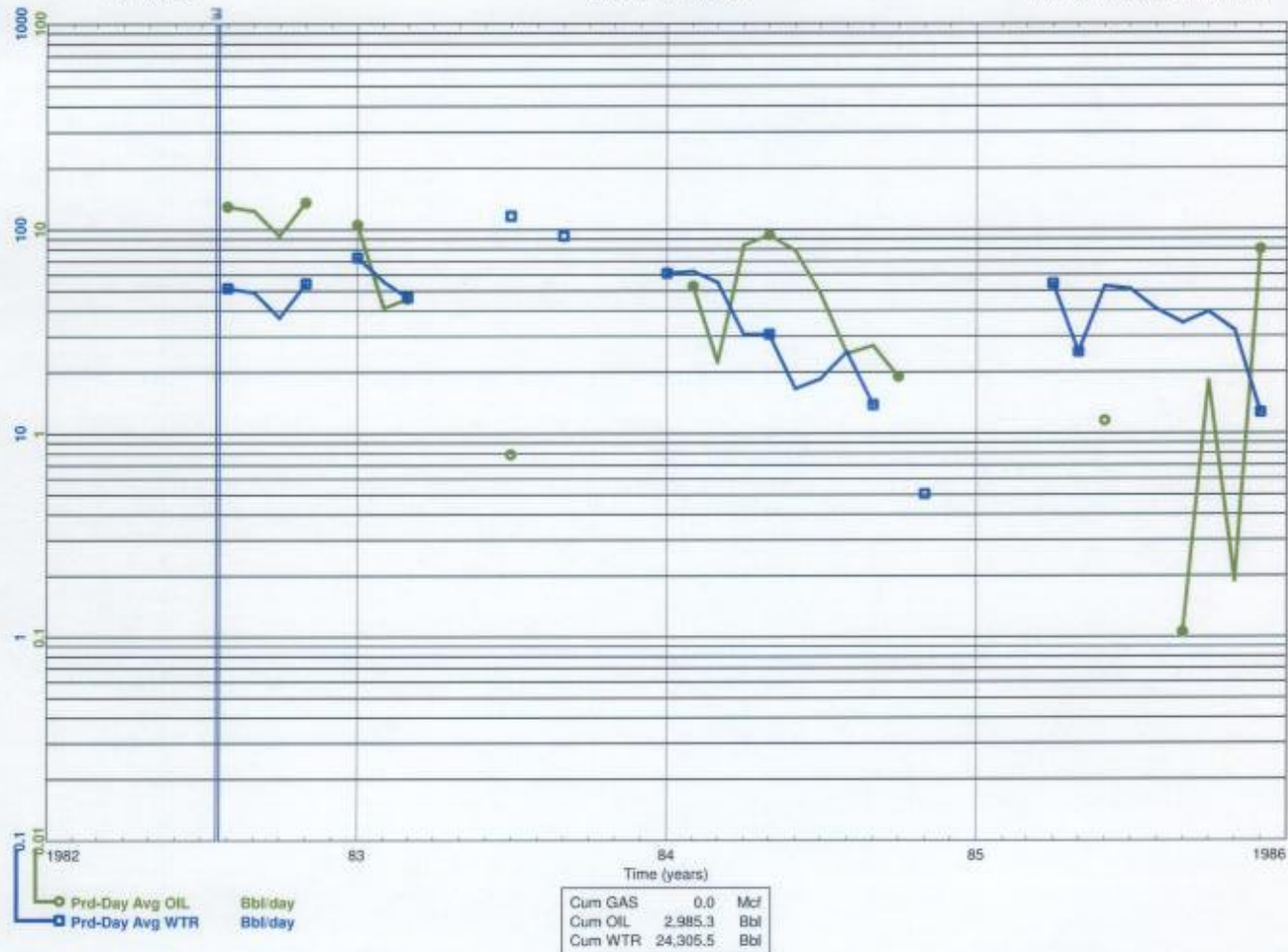


Friday, February 11, 2011, 03:19 PM

Data As Of: 2011-01 (MB)  
 From: 1982-08  
 To: 1985-12

INDIVIDUAL PRODUCTION  
 -Omega-Waskada Prov. WW-  
 100/16-11-001-26W1/00

Status: Abandoned Water Inj Well  
 Field: WASKADA (03)  
 Pool: LOWER AMARANTH A (29A)



Thursday, April 21, 2011, 02:56 PM

geoSCOUT  
[www.geoscout.com](http://www.geoscout.com)