MARCIT™ Gel Polymer Treatments in the Arbuckle – A Status Report

TORP Oil Recovery Conference

Bank of America Auditorium
Downtown Wichita, Kansas
Thursday, March 13, 2003

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University of Kansas

Acknowledgements

Wish to thank –

TIORCO and Gel-Tec for help in collecting treatment data and with operator contacts.

Those operators who have shared data.

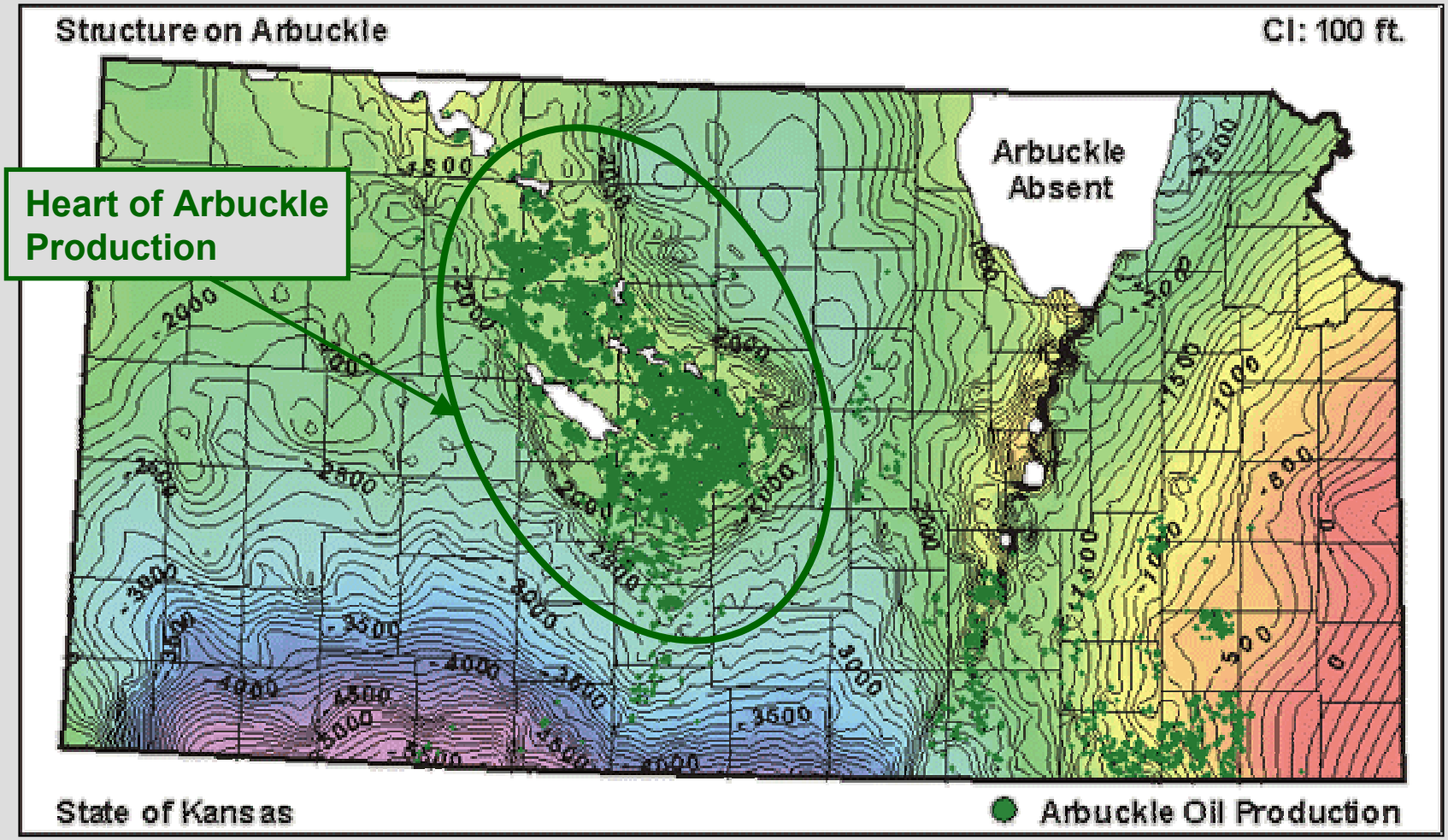
Especially Vess Oil and Murfin Drilling for help in collecting data and for permission to share that data.

Trilobite well testing for BHP surveys.

Presentation Outline

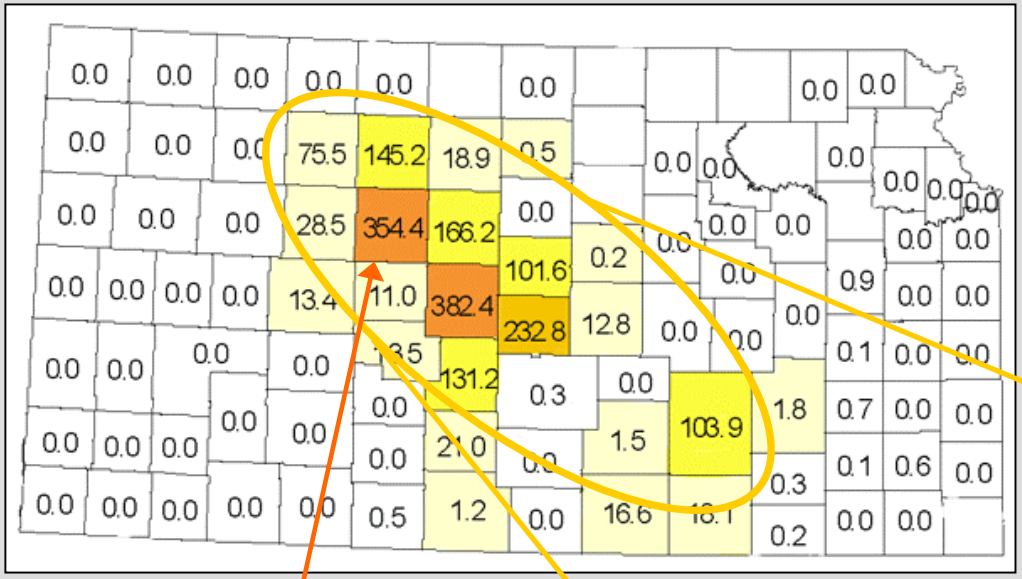
- **Review of Arbuckle Polymer Treatments**
- **TORP's Efforts in Evaluating Arbuckle Polymer Treatments**
- **Future TORP/PTTC Activities Related to Arbuckle Polymer Treatments**

Kansas Arbuckle Structure



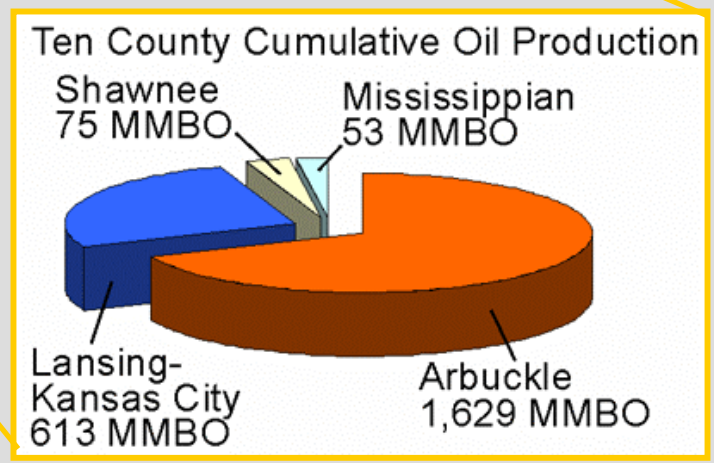
Courtesy of the Kansas Geological Survey

Kansas Arbuckle Production



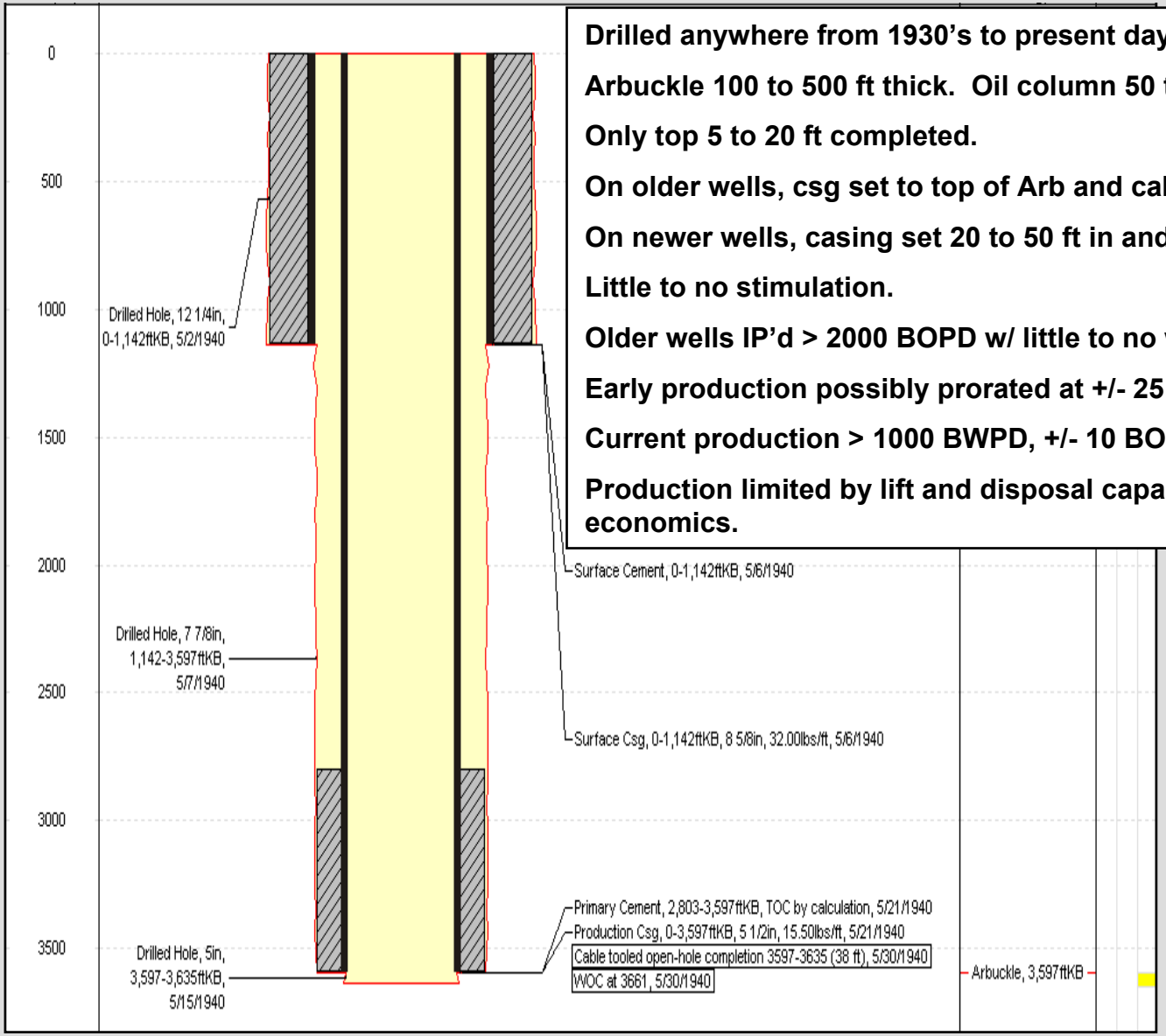
Over 1.6 billion bbls of oil produced from Arbuckle formation as of 1998.

Ellis County, Kansas



Courtesy of the Kansas Geological Survey

Typical Arbuckle Well



Drilled anywhere from 1930's to present day.

Arbuckle 100 to 500 ft thick. Oil column 50 to 100 ft.

Only top 5 to 20 ft completed.

On older wells, csg set to top of Arb and cable tooled in.

On newer wells, casing set 20 to 50 ft in and perforated.

Little to no stimulation.

Older wells IP'd > 2000 BOPD w/ little to no water.

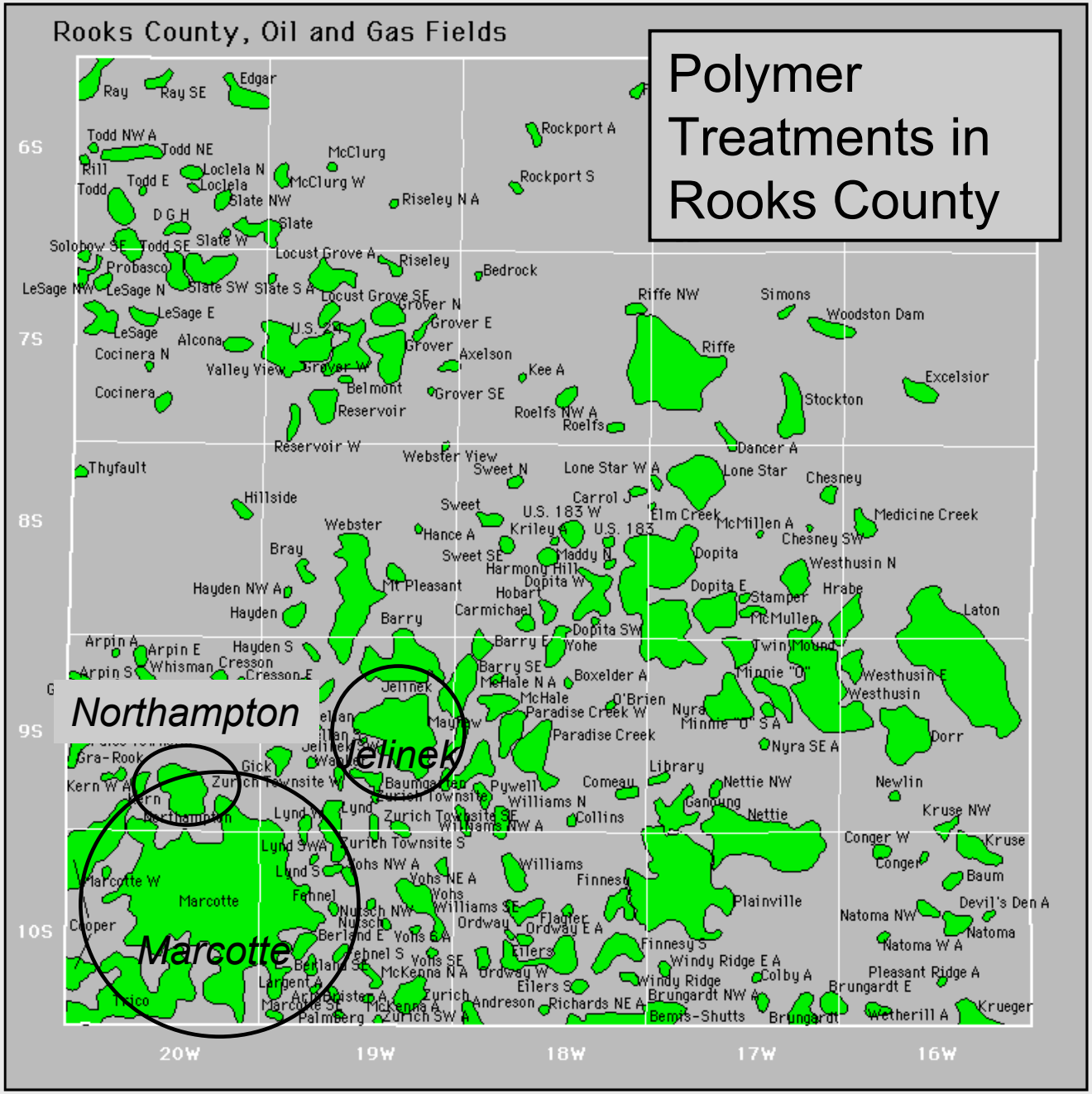
Early production possibly prorated at +/- 25 BOPD.

Current production > 1000 BWPD, +/- 10 BOPD.

Production limited by lift and disposal capacity and economics.

Review of Arbuckle Polymer Treatments

- **+/- 140 MARCIT technology polymer jobs pumped in the Arb. since 2000 (as of Feb ’03)**
  - **+/- 80 by TIORCO**
  - **+/- 60 by Gel-Tec**
- **Treatment locations**
  - **+/- 60 % of jobs pumped in Bemis-Shutts Field**
  - **Remainder pumped in Marcotte, Star Northwest, Northampton, Jelinek, Ogallah, Trapp, Geneseo-Edwards, and other fields**



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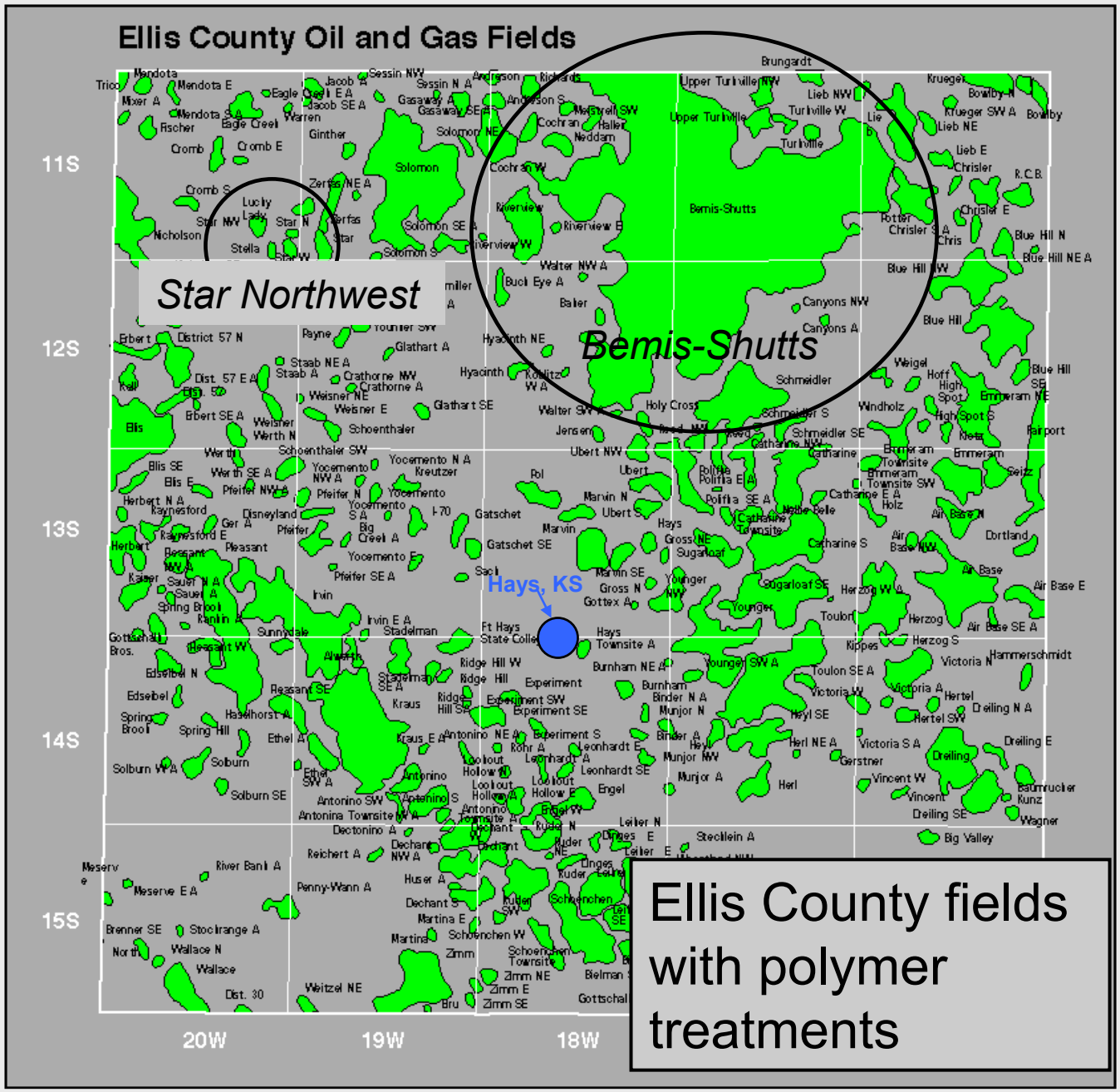
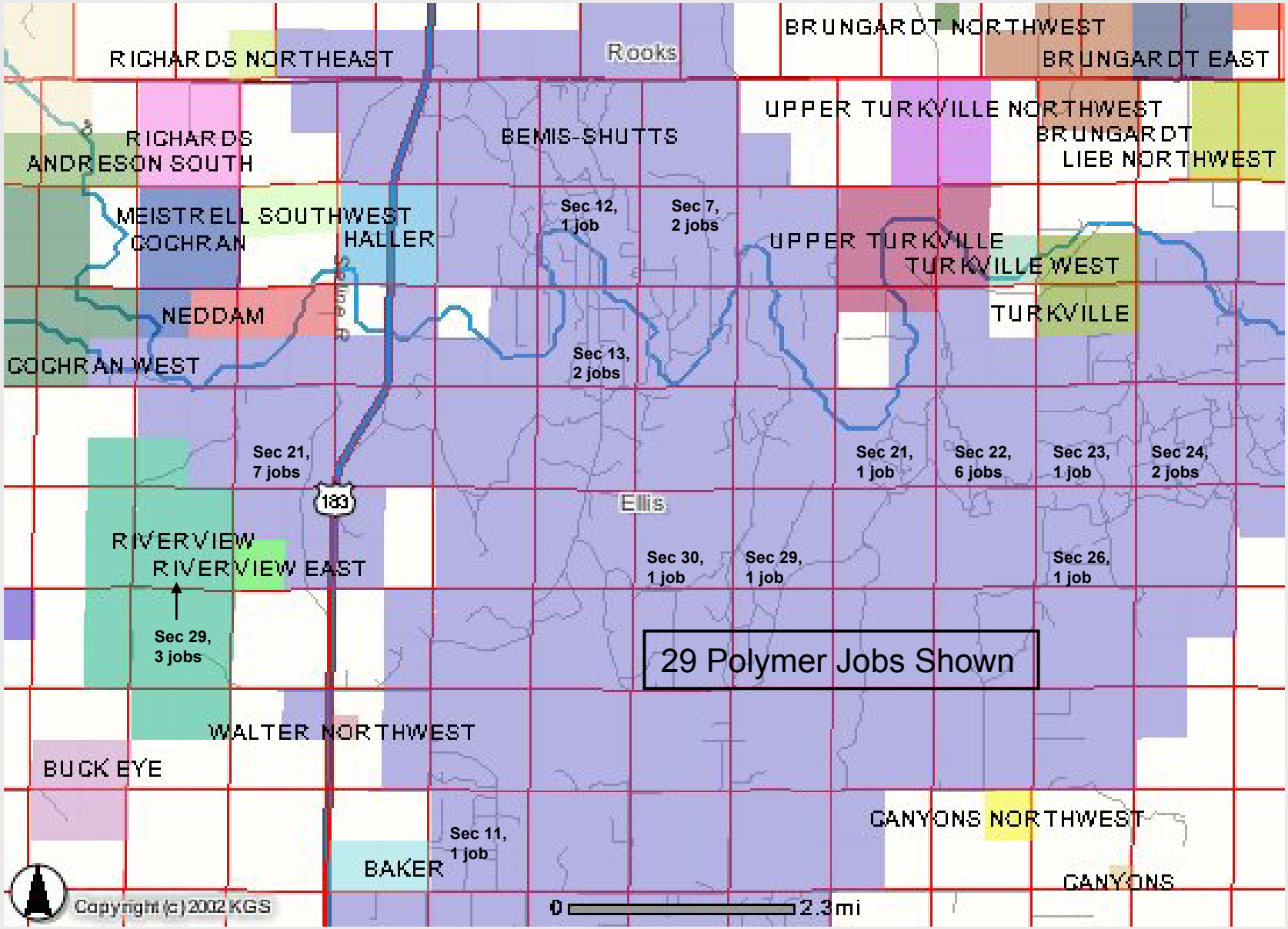


Courtesy of the Kansas Geological Survey

Polymer Treatments in Bemis-Shutts



Courtesy of the Kansas Geological Survey

Review of Arbuckle Polymer Treatments

- **Well selection criteria**
  - **Well drilled up structure**
  - **Well originally had high, water-free IP**
  - **Well at its economic limit because of high WOR**
  - **Well has very high fluid level**
  - **Well has high calculated flow potential**

Review of Arbuckle Polymer Treatments

- **Treatment design criteria**

  <u>Vender 1</u>

  - **For high fluid level wells, pump 2x well's daily production, up to 4000 bbls.**
  - **For low fluid level wells, pump 1x well's daily production.**
  - **Surface treating pressure not to exceed 200 psig.**

  <u>Vender 2</u>

  - **Gel volume pumped to be near well's calculated maximum inflow, up to 4000 bbls.**
  - **Surface treating pressure to be between 200 and 400 psig.**

Review of Arbuckle Polymer Treatments

- **Typical treatment design**
  - **Pull pump & tbg. Sand pump well. RIH w/ tbg & packer. Set pkr +/- 100 ft above interval.**
  - **Acidize well w/ between 250 & 1500 gals 15% HCl.**
    - **Recent trend appears to be towards the larger, 1500 gal acid jobs.**
  - **Pump polymer down tbg.**
    - **Small job - 1000 to 1600 bbls.**
    - **Large job - 3000 to 4100 bbls.**
    - **Larger jobs are typically in Bemis.**
    - **Recent trend may be to pump even larger jobs.**

Review of Arbuckle Polymer Treatments

- **Typical treatment design (cont'd)**
  - **Pump polymer down tbg (cont'd).**
    - **Gel loadings increase in 3 to 4 stages – 3500, 4000, 5000, and 6500 ppm.**
    - **Recent trend appears to be to increase gel loading at end of job to 7500 or 8500 ppm.**
  - **Flush tbg w/ oil or water.**
    - **Typically 100 bbl water flush.**
    - **Typically 50 to 100 bbl oil flush.**
    - **Philosophy of oil or water flush varies among operators.**
  - **Shut-in well 7 to 14 days. Return well to production.**

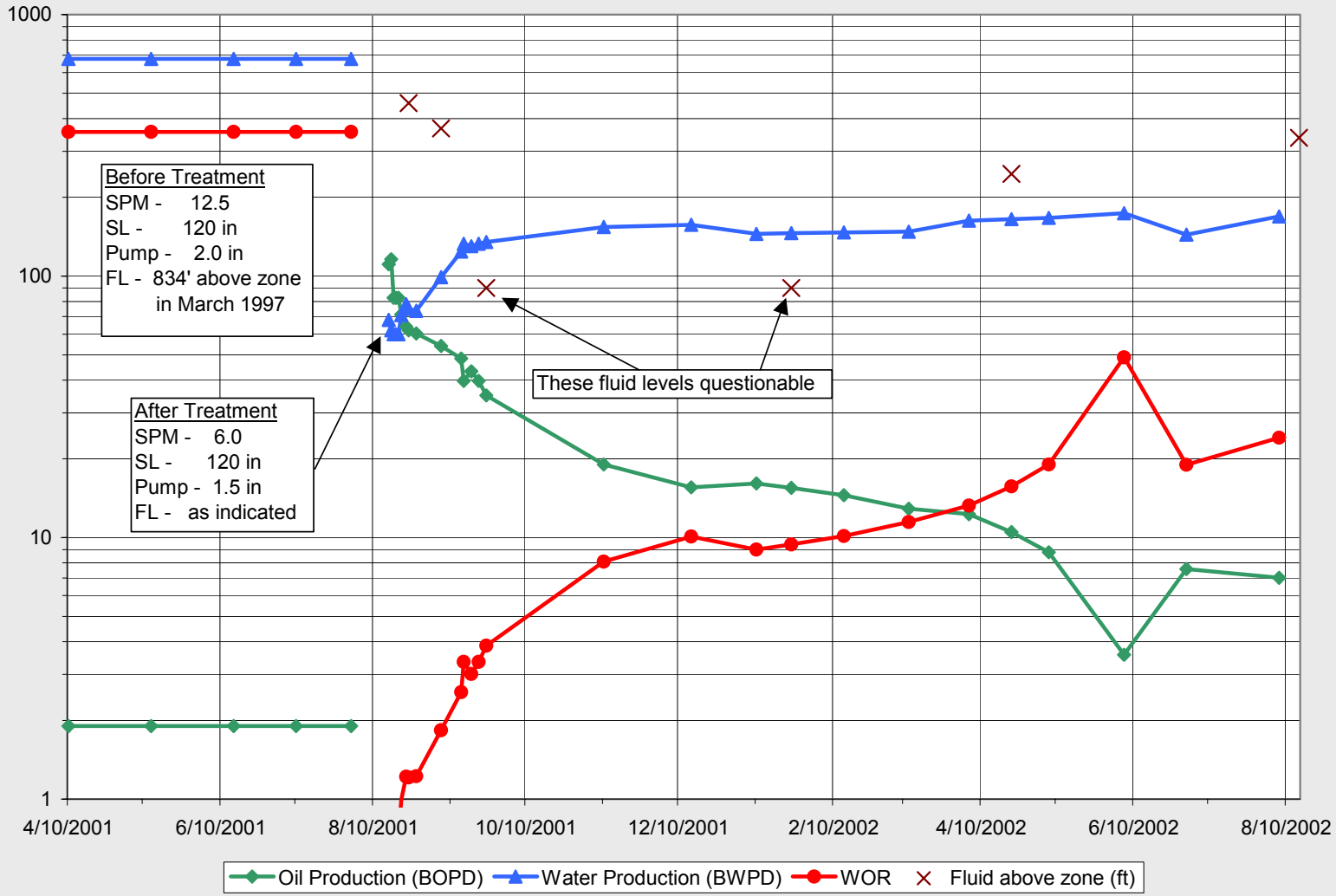
Review of Arbuckle Polymer Treatments

Polymer treatment examples –

Average to below average jobs

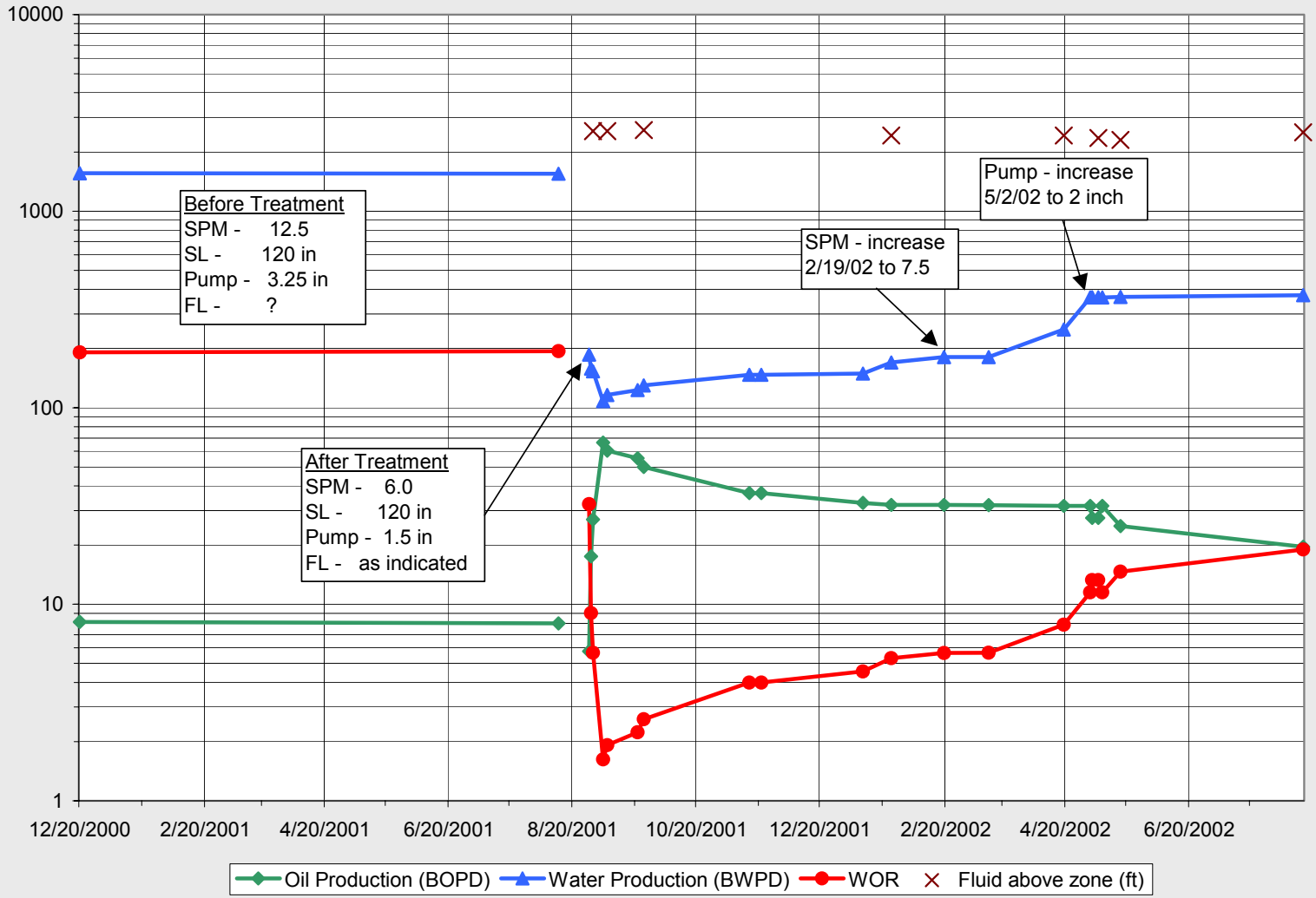
Example of Nice Initial Response

Murfin's Johnson B #3A Polymer Job
August 2-3, 2001
(1621 bbls gel, 97% of job treated on a vacuum, 51 psig max treating press)



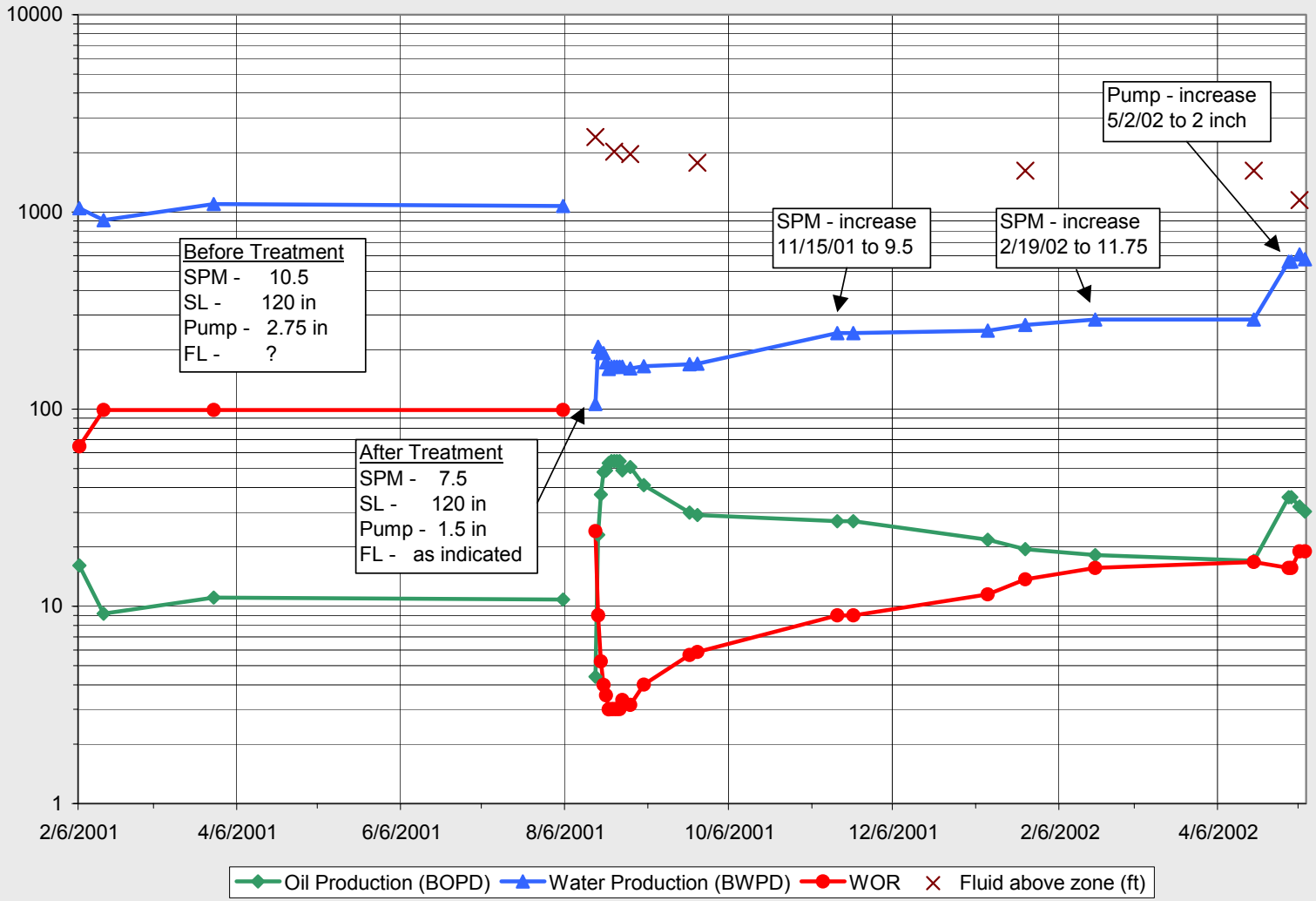
Example of Average to Good Response

Murfin's Hadley BC #10 Polymer Job
August 14-18, 2001
(3806 bbls gel, 100% of job treated on a vacuum, 0 psig max treating press)



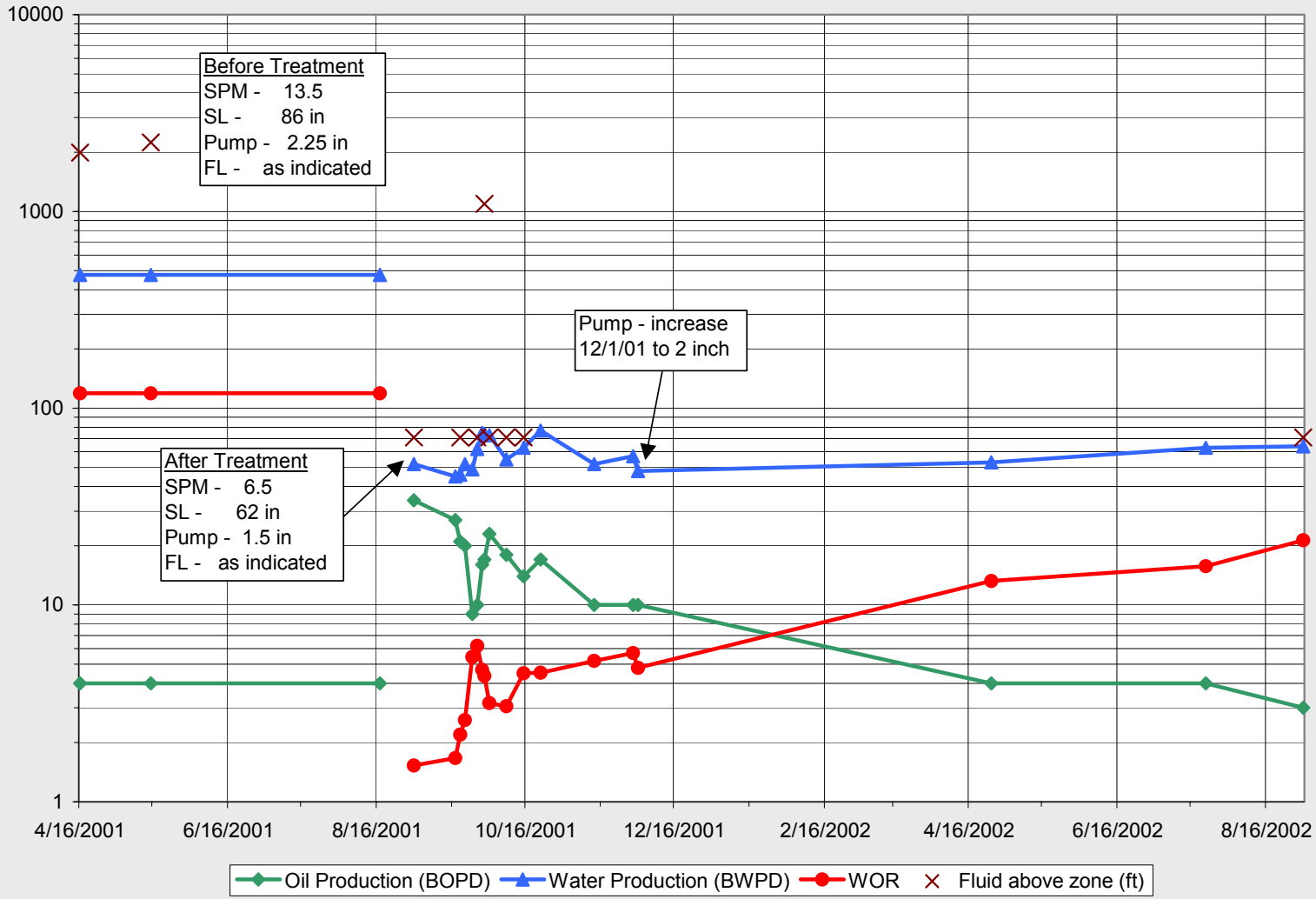
Example of Average to Good Response

Murfin's Jorgensen #4 Polymer Job
August 6-9, 2001
(3805 bbls gel, 58% of job treated on a vacuum, 102 psig max treating press)



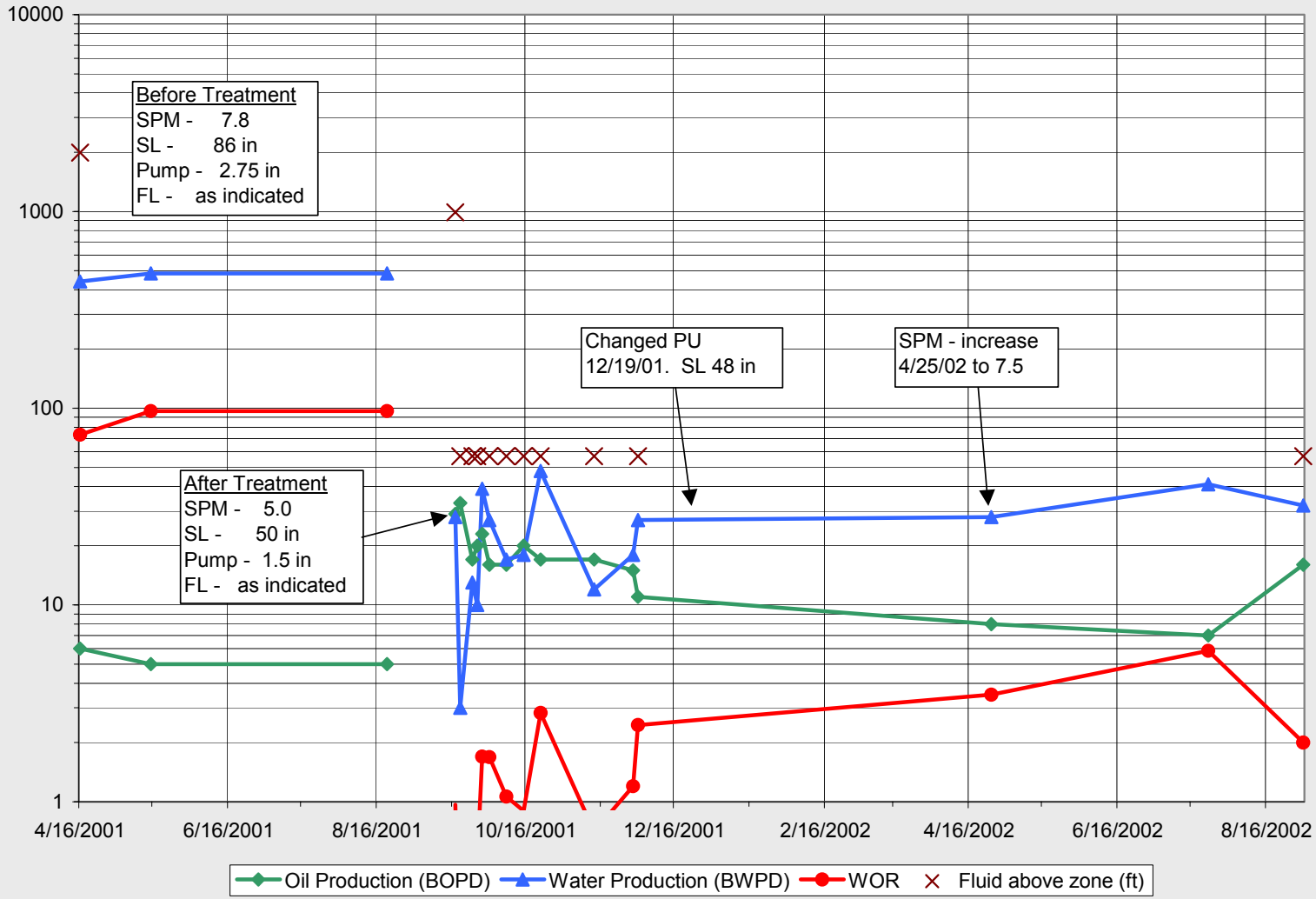
Example of Poorer Response

Vess's Colahan A #41 Polymer Job
August 18-21, 2001
(2988 bbls gel, 8.2% of job treated on a vacuum, 923 psig max treating press)



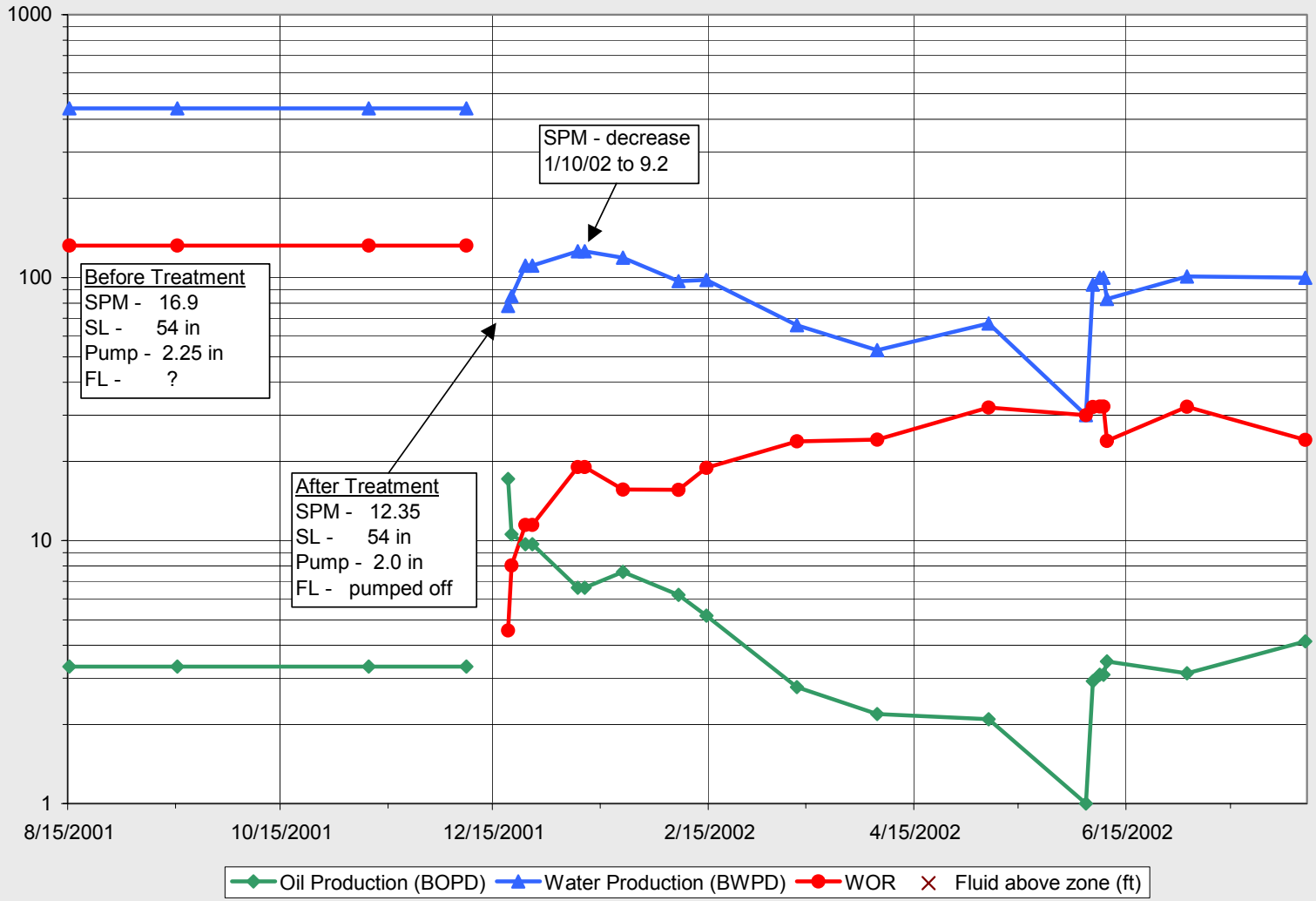
Example of Poorer Response

Vess's Colahan A #2 Polymer Job
August 26-30, 2001
(4093 bbls gel, 29% of job treated on a vacuum, 591 psig max treating press)



Example of Poorest Response

Murfin's Glathart #1 Polymer Job
December 8-9, 2001
(1007 bbls gel, 0% of job treated on a vacuum, 200 psig max treating press)



Review of Arbuckle Polymer Treatments

- **Job costs**
  - **Gel cost**
    - **$35 M to $45 M for larger jobs (+/- 4,000 bbl)**
    - **$15 M to $20 M for smaller jobs (+/- 1,500 bbl)**
  - **Rig & acid costs**
    - **$5 M to $10 M depending on rig time & volume acid**
  - **Total costs**
    - **$40 to 55 M for large jobs**
    - **$20 to 30 M for small jobs**

Review of Arbuckle Polymer Treatments

- **Pay-out** *(based only on incremental oil recovery, water reduction savings not considered)*
  - ***3 to 6 month pay-out for average performing jobs***

    Assumptions
    - **+/- 18 BOPD/well incremental oil recovery for 6 months**
    - **$22/bbl oil price**
    - **$45 M job cost**

  - ***Poorest performing jobs did not pay-out***

    Assumptions
    - **+/- 6 BOPD/well incremental oil recovery for 6 months**
    - **$22/bbl oil price**
    - **$45 M job cost**

Murfin’s Hadley A #3 Polymer Job

TIORCO’s Polymer Injection Equipment

TIORCO's Polymer Mixing Hopper

Gel-Tec Polymer Job on an Elysium Well

Pumping into well

Tri-plex pump and crosslinker storage

Computer Monitors

Presentation Outline

- Review of Arbuckle Polymer Treatments
- **TORP's Efforts in Evaluating Arbuckle Polymer Treatments**
- Future TORP/PTTC Activities Related to Arbuckle Polymer Treatments

TORP's Efforts

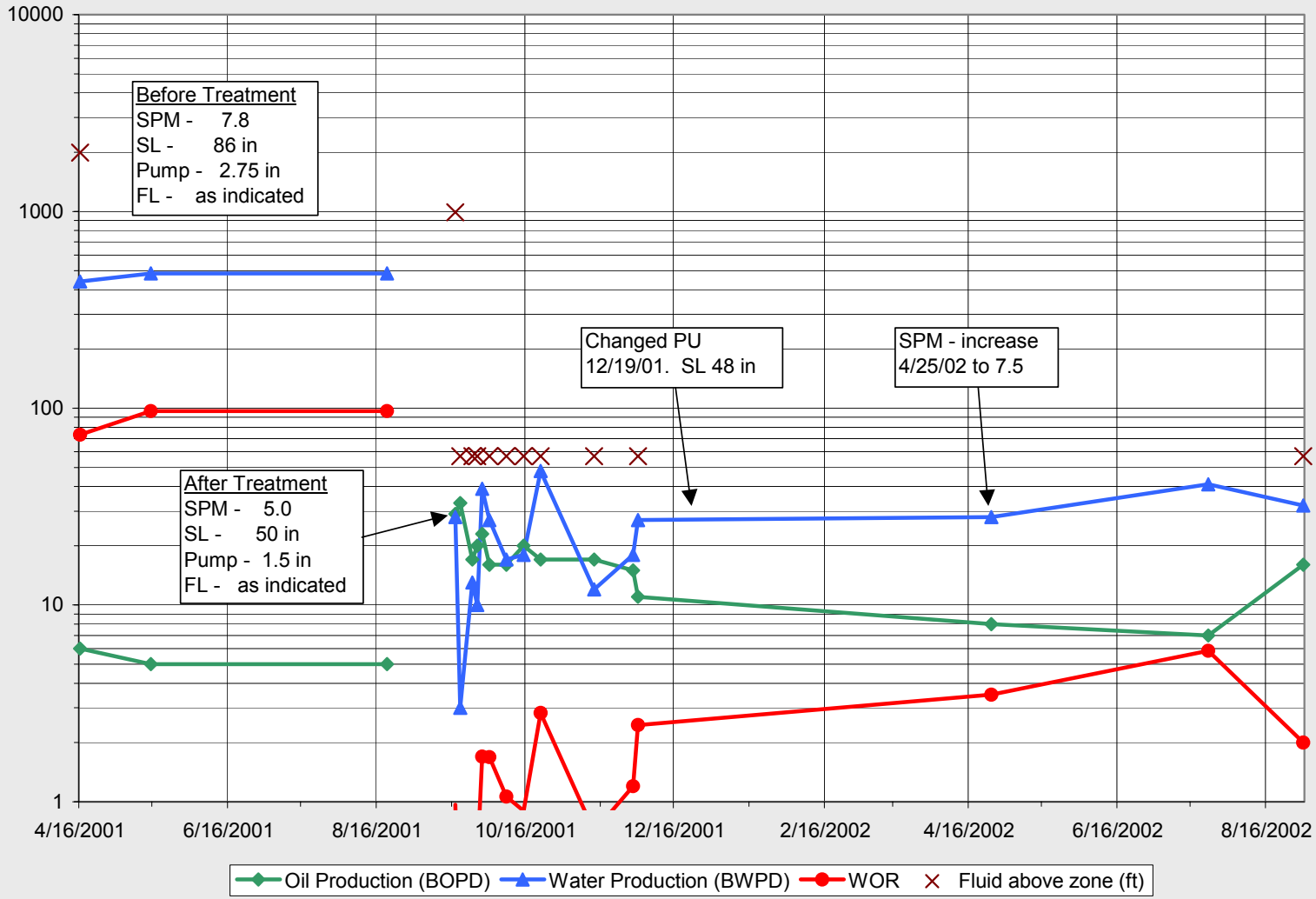
- **Objective – help operators maximize gel polymer treatment performance.**
- **1) Develop comprehensive database by which to compare all Arbuckle gel polymer treatments.**
  - **Hope to spot trends that lead to improved treatments.**
  - **Have contacted several operators requesting information on gel polymer treatments.**
  - **Getting some positive feedback and information.**

WE NEED MORE DATA!

- Names and locations of treated wells with pertinent well data.
- Details on pre-treatment acid job.
- Detailed treating report from vendor.
- Before and after water & oil production.
- Before and after fluid levels.
- Before and after production equipment.

Develop plot of job performance

Vess's Colahan A #2 Polymer Job
August 26-30, 2001
(4093 bbls gel, 29% of job treated on a vacuum, 591 psig max treating press)



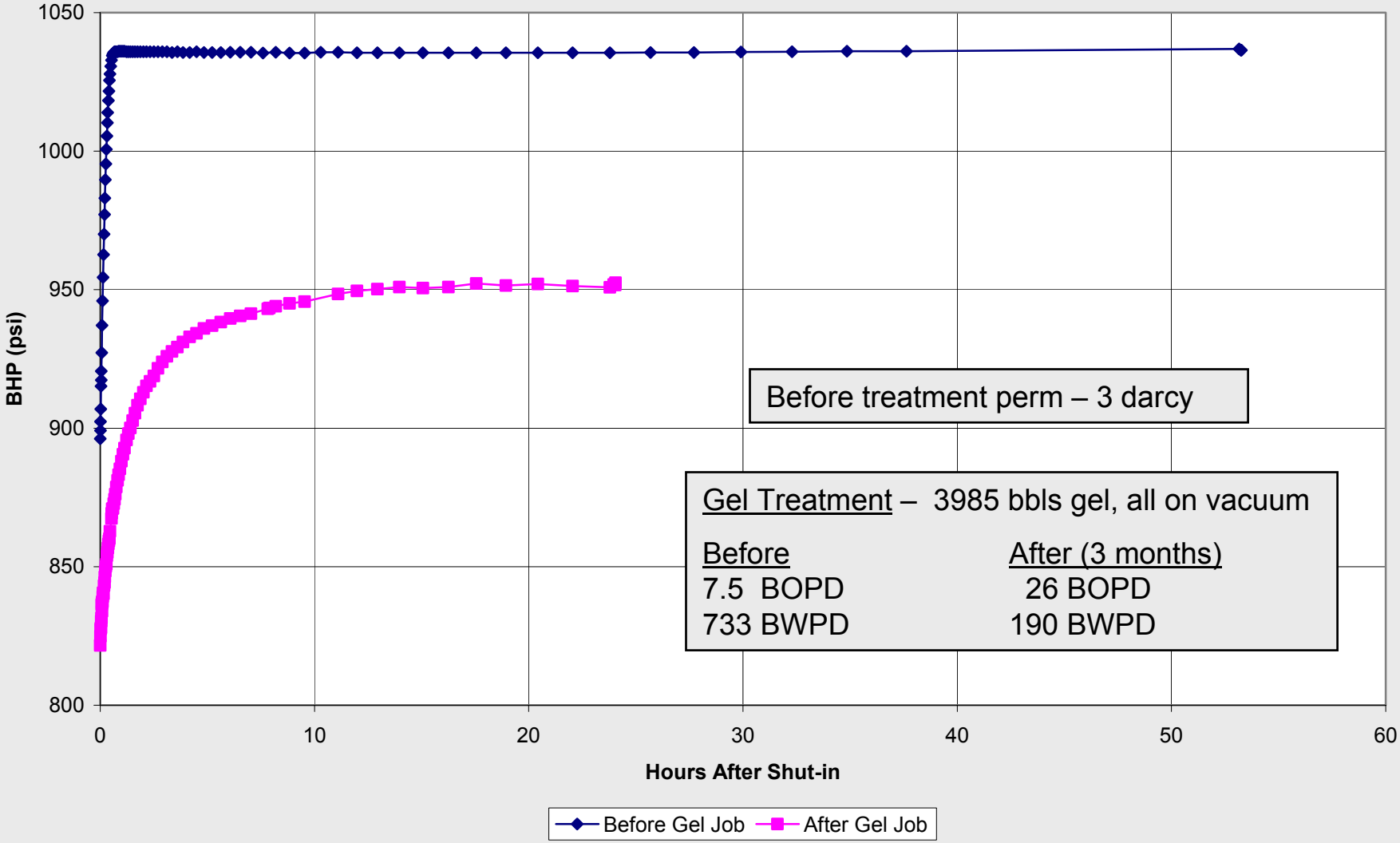
TORP's Efforts

- **2) Conduct and analyze pre and post-treatment build-up tests using TORP's computerized Echometer.**
  - **Measure formation kh and skin.**
  - **Determine if reservoir flow is linear (through fracture) or radial (through matrix).**
  - ***For pre-treatment build-ups, attempt to predict how much polymer a well will take.***
  - **Have performed pre-treatment build-ups on 7 Arbuckle wells (5 in Bemis-Shutts 2 in Geneseo-Edwards)**
  - **Have performed post-treatment build-ups on 6 Arbuckle wells (5 in Bemis-Shutts 1 in Geneseo-Edwards)**

Build-up Test on Vess Oil's McCord A #4

Before & After Build-ups

Hadley A #3 Build-up Data

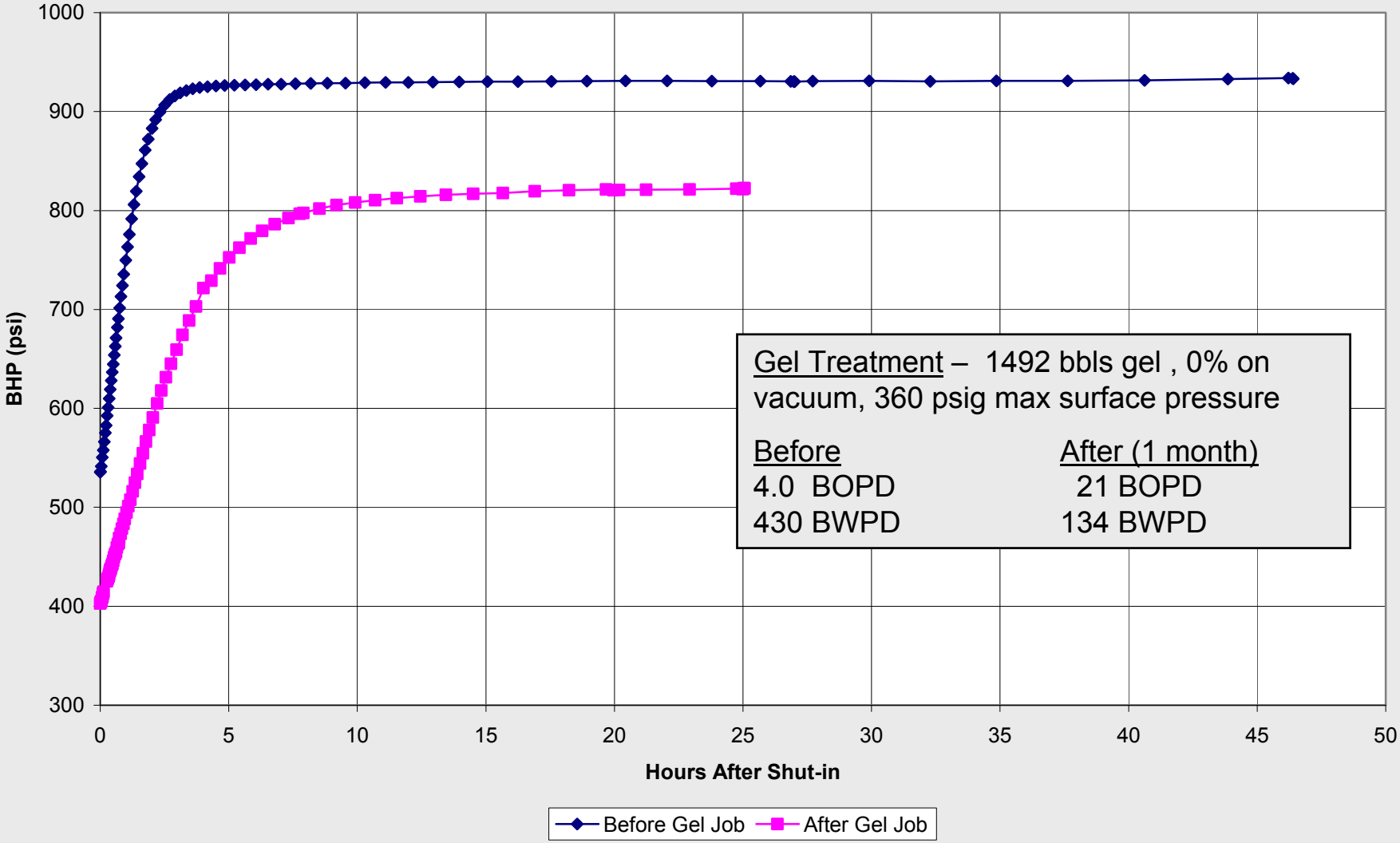


Before & After Build-ups

McCord A #4 Build-up Data

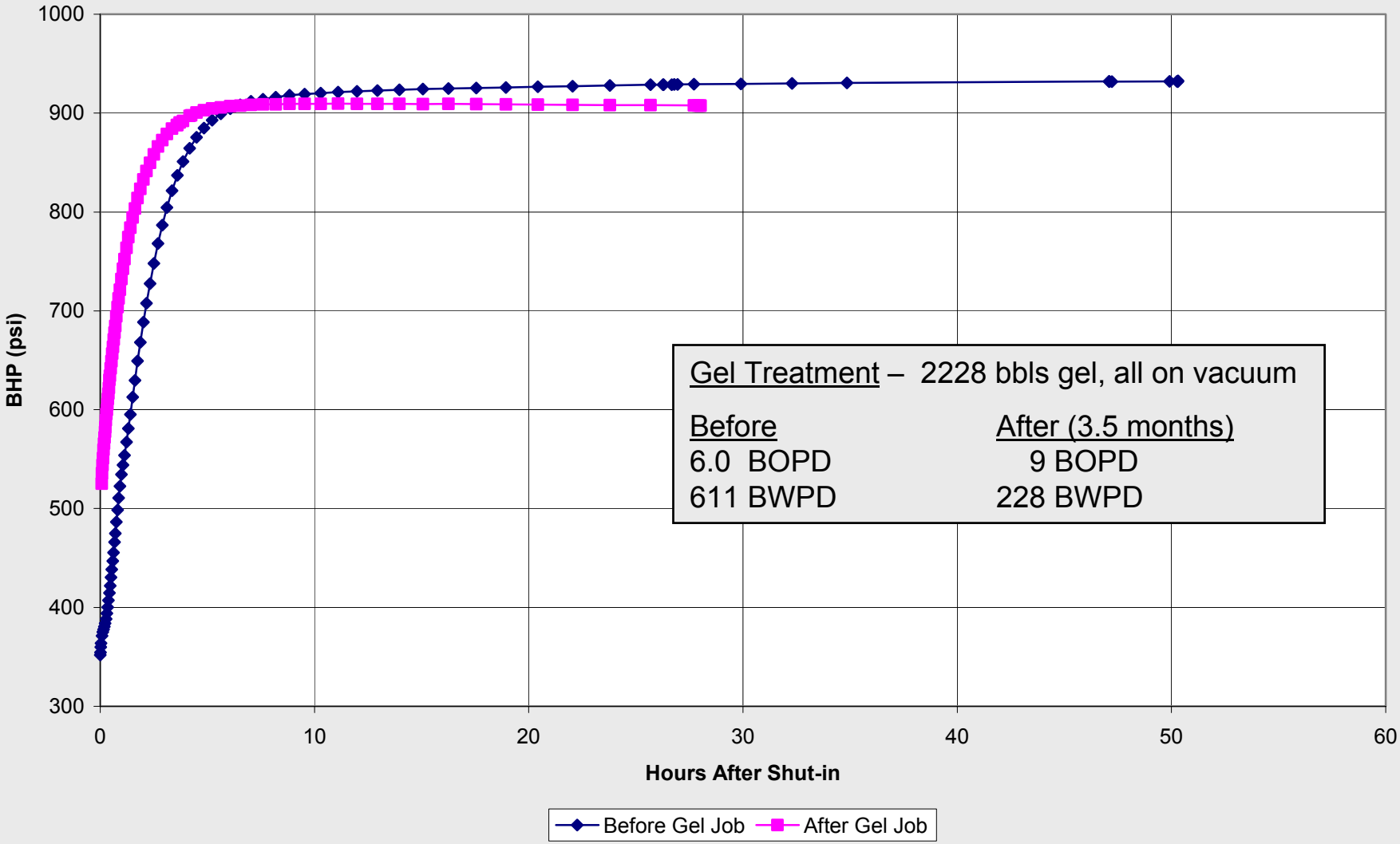
Before & After Build-ups

Colahan A #8 Build-up Data



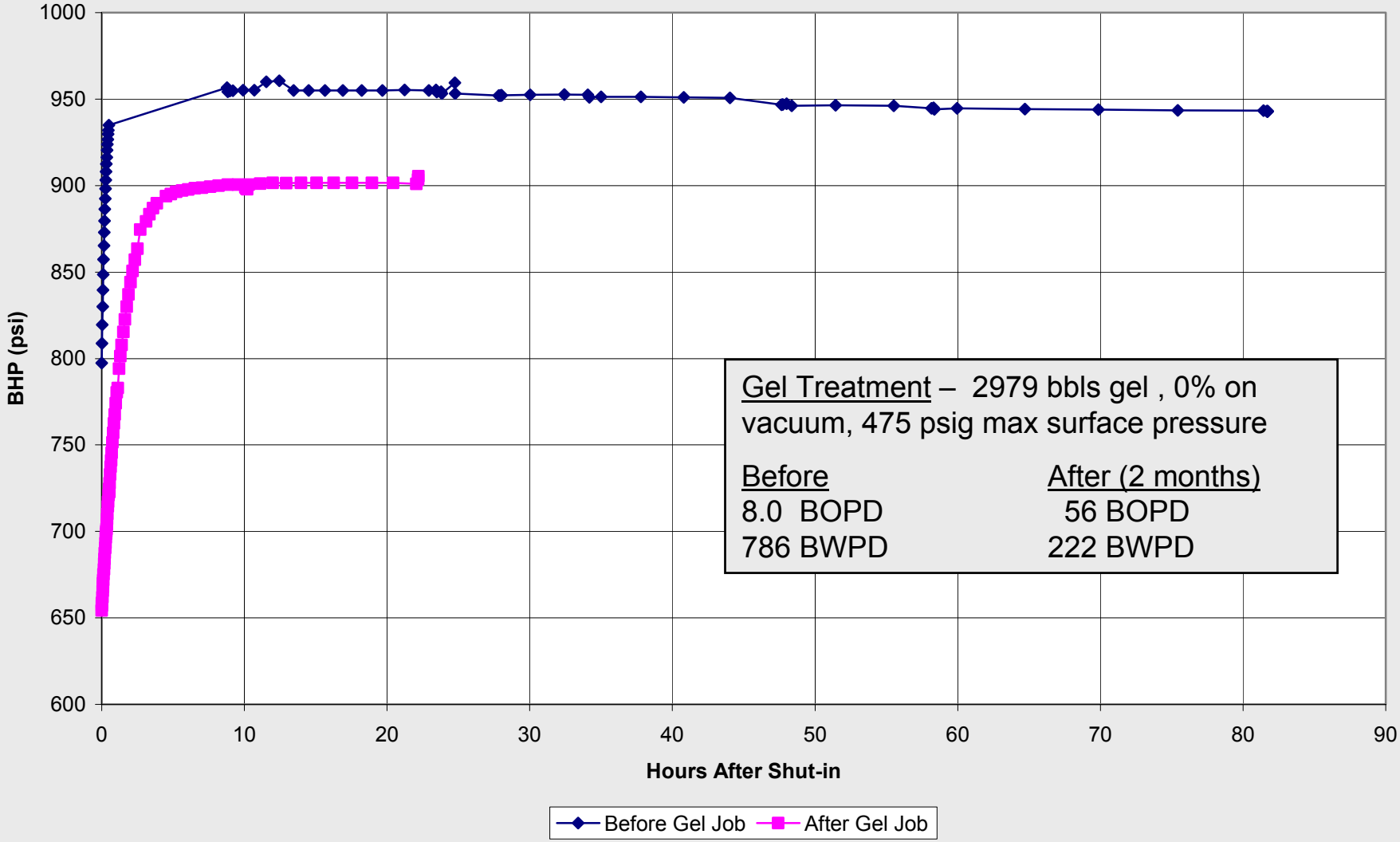
Before & After Build-ups

Hall B #4 Build-up Data



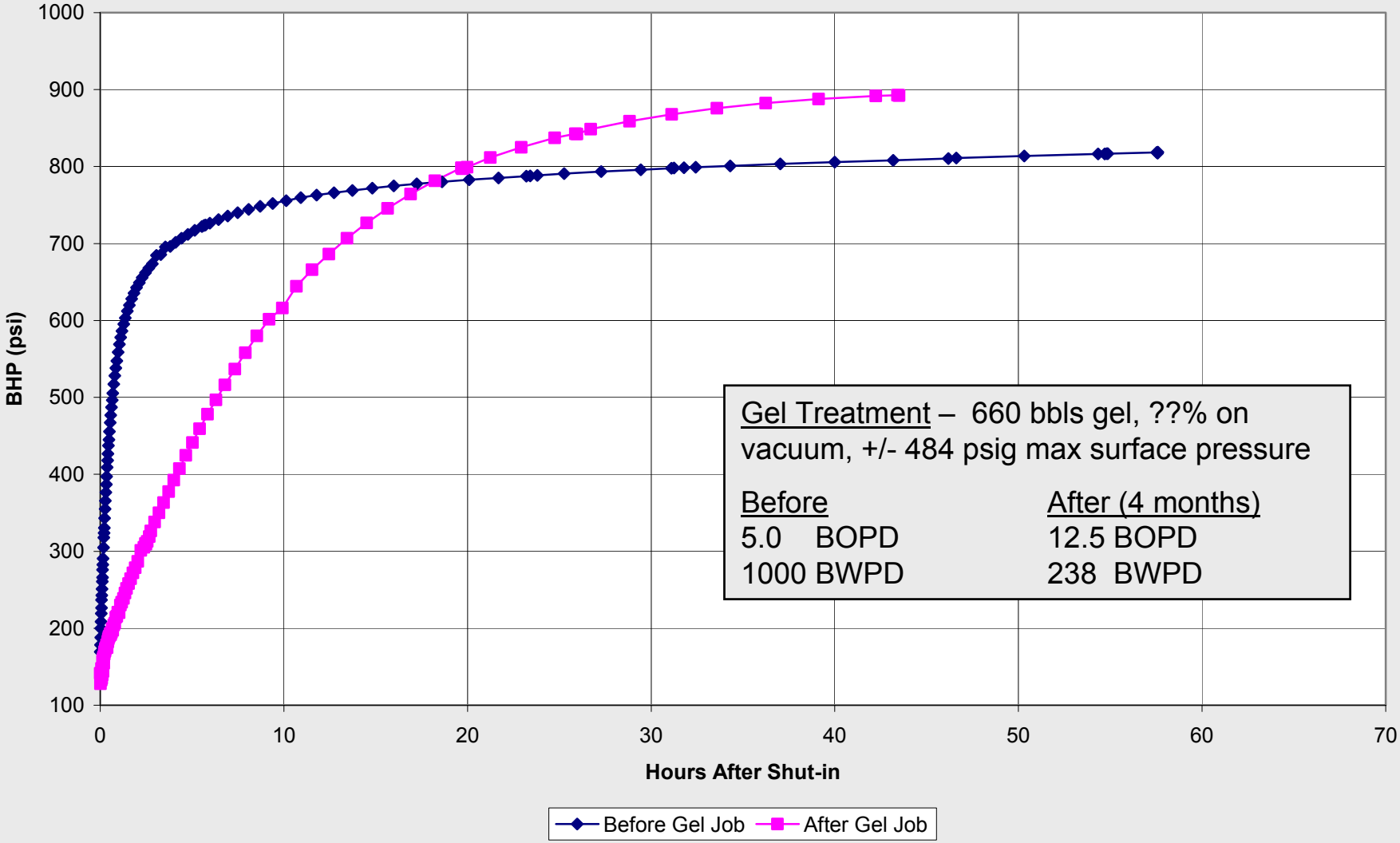
Before & After Build-ups

Jennie Johansen #8 Build-up Data



Before & After Build-ups

Fuller 11-28 Build-up Data



TORP's Efforts *

- **3) Analyze bottom-hole pressure (BHP) surveys run on 6 wells.**
  - **Bottom-hole pressure measured (via pressure bomb on slickline) before, during, and after gel treatment.**
  - **Hope to gain insights into the gel/rock interface, which should help in sizing treatments and setting maximum treating pressures.**
  - **Hope to determine a friction coefficient for pumping gel down tubing.**

* ***With financial assistance from vendors and oil companies***

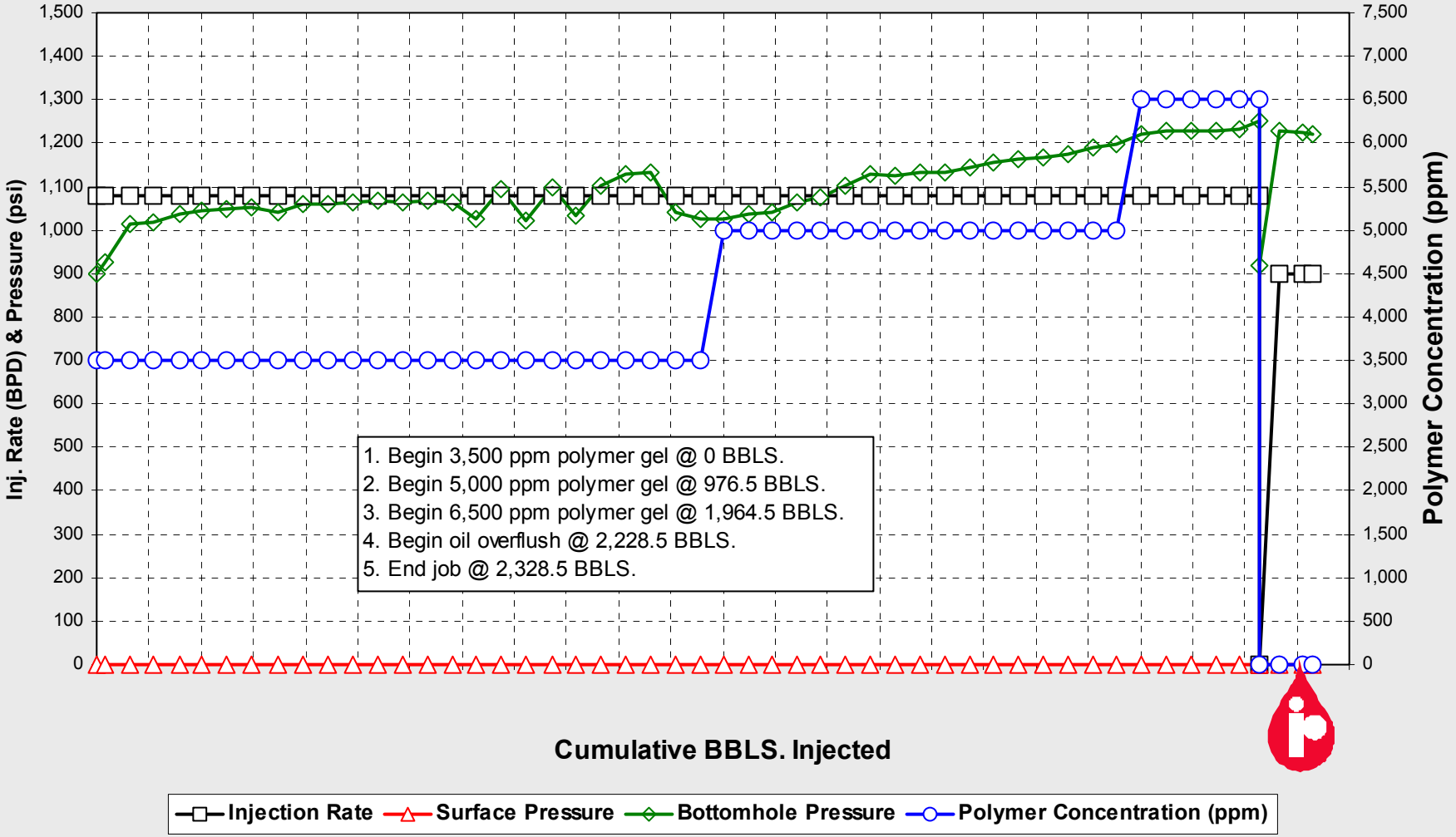
Trilobite Testing's Slickline Trailer at Vess Oil's Hall B #4

Surface & Bottom-hole Pressure Plot

VESS OIL CORPORATION - HALL B #4 PRODUCING WELL - ARBUCKLE FORMATION

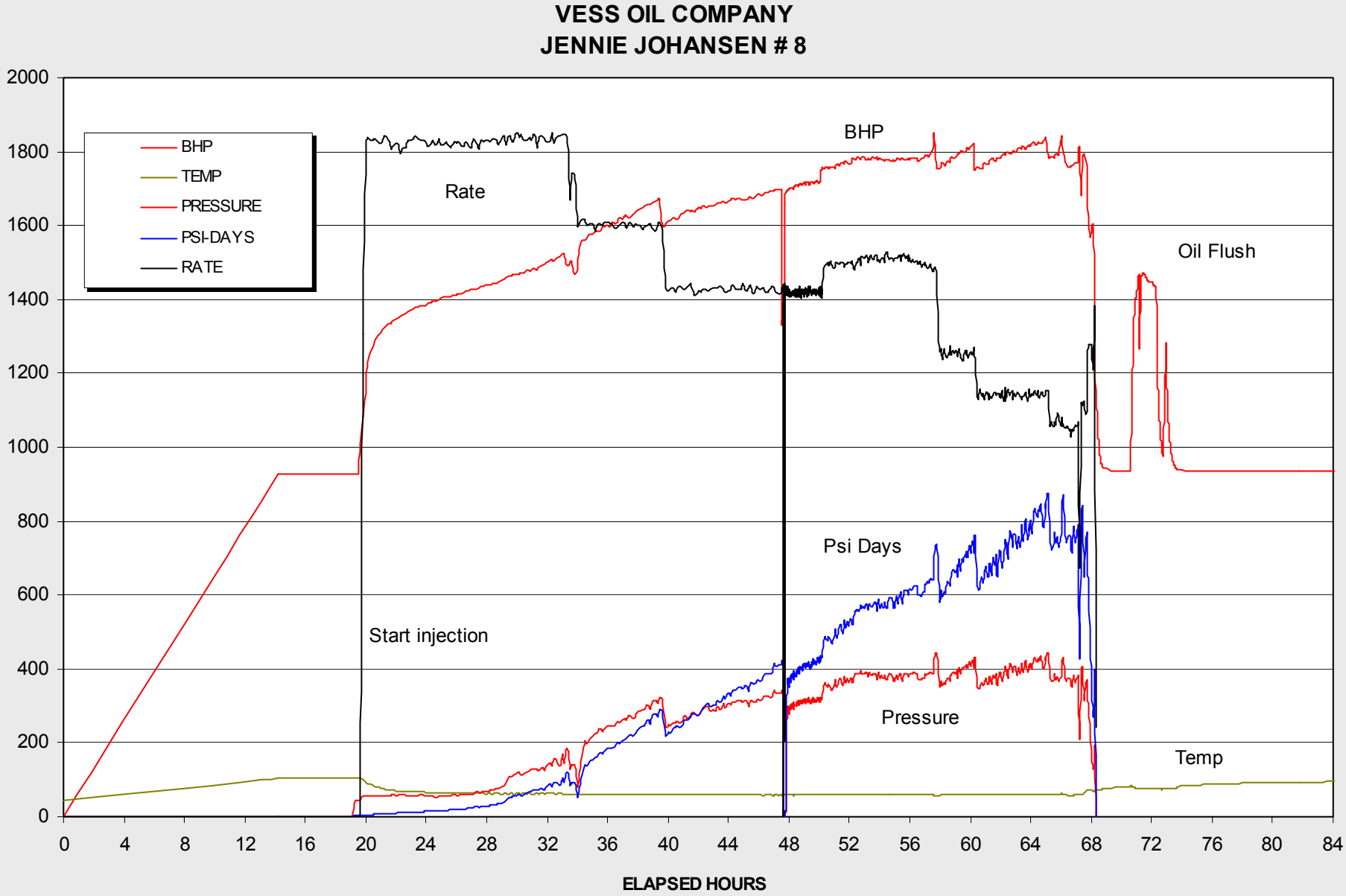
MARCIT[sm] Polymer Gel Treatment Rate vs. Pressure

Treatment Date: October 21-23, 2002



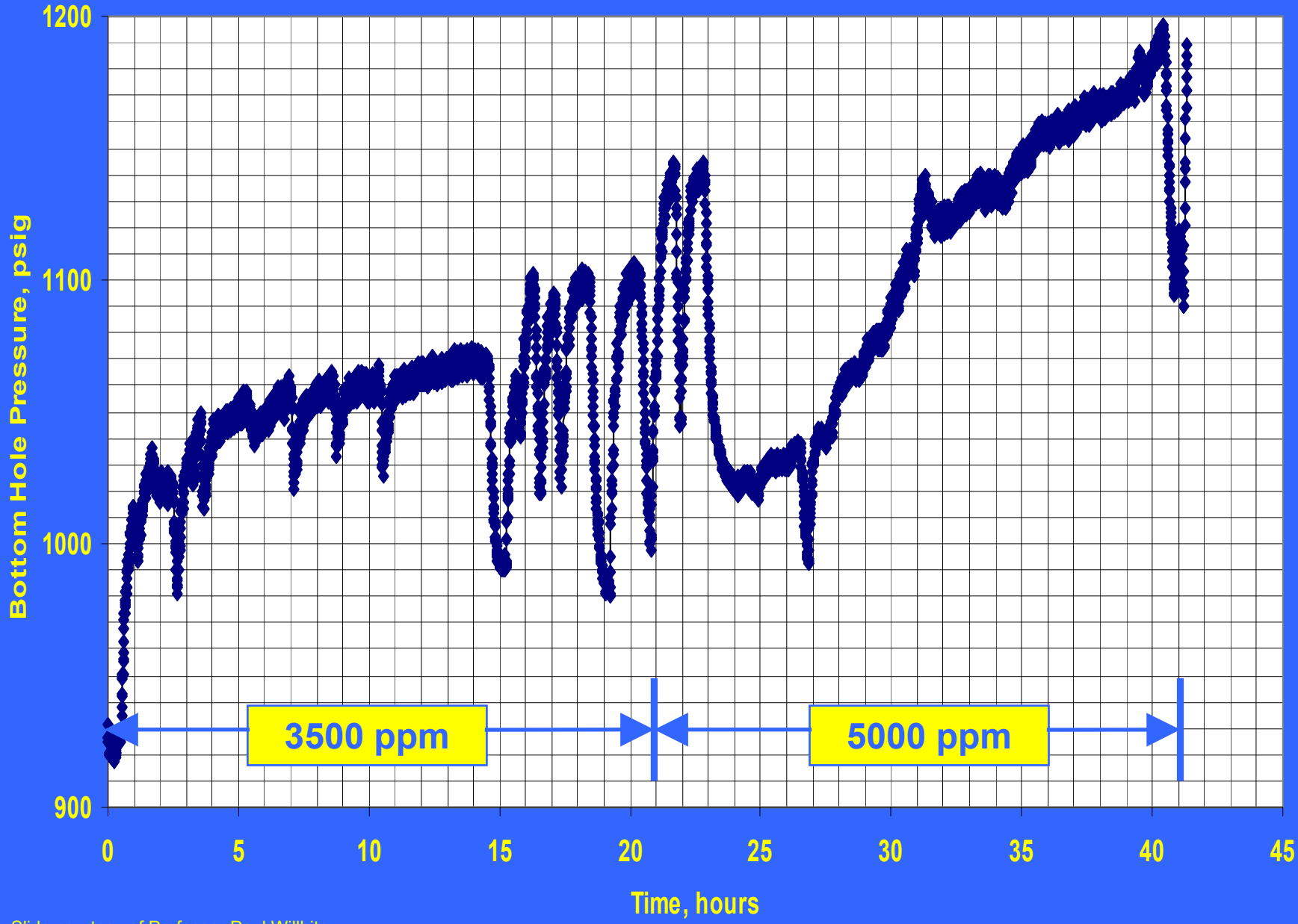
Courtesy of TIORCO

Surface & Bottom-hole Pressure Plot



Courtesy of Gel-Tec

BHP Data – Hall B #4



Slide courtesy of Professor Paul Willhite

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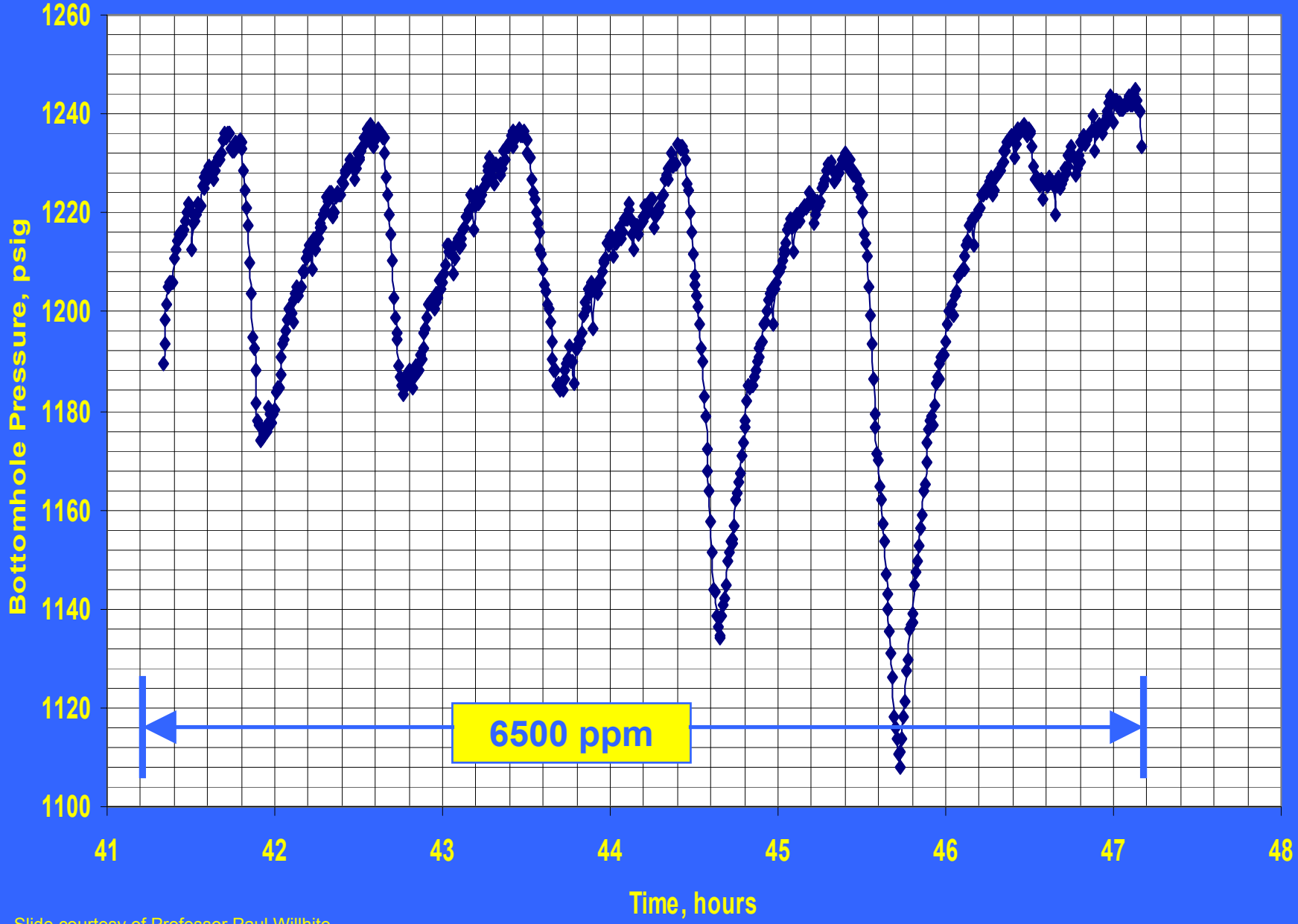

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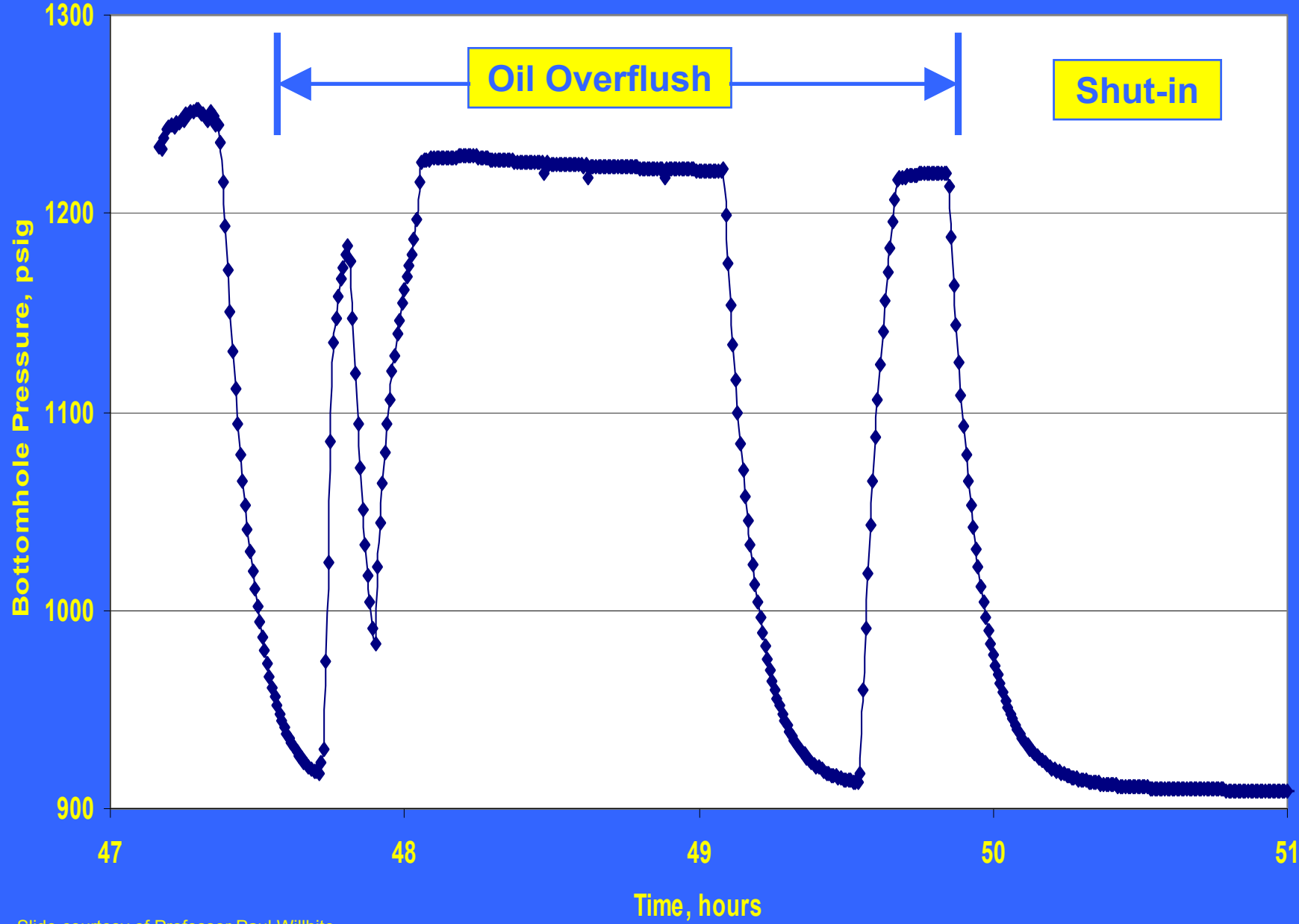

Slide courtesy of Professor Paul Willhite

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Future TORP/PTTC Activities

- Finish post-treatment build-ups – hope to document how reservoir changes after treatments.
- Sponsor operator for[illegible]se operators who have pumped jo[illegible] February 4, 2003.
- PTTC to conduct gel polymer workshop – Summer 2003.
- Publish case studies relative to gel polymer treatments – Fall 2003.
- Put gel polymer database online – Fall 2003.

Completed