

*Advancing Reservoir Performance*

# Heavy Oil Presentation for RDS Aberdeen

Thursday, May-05-11



# Heavy Oil Presentation for RDS Aberdeen

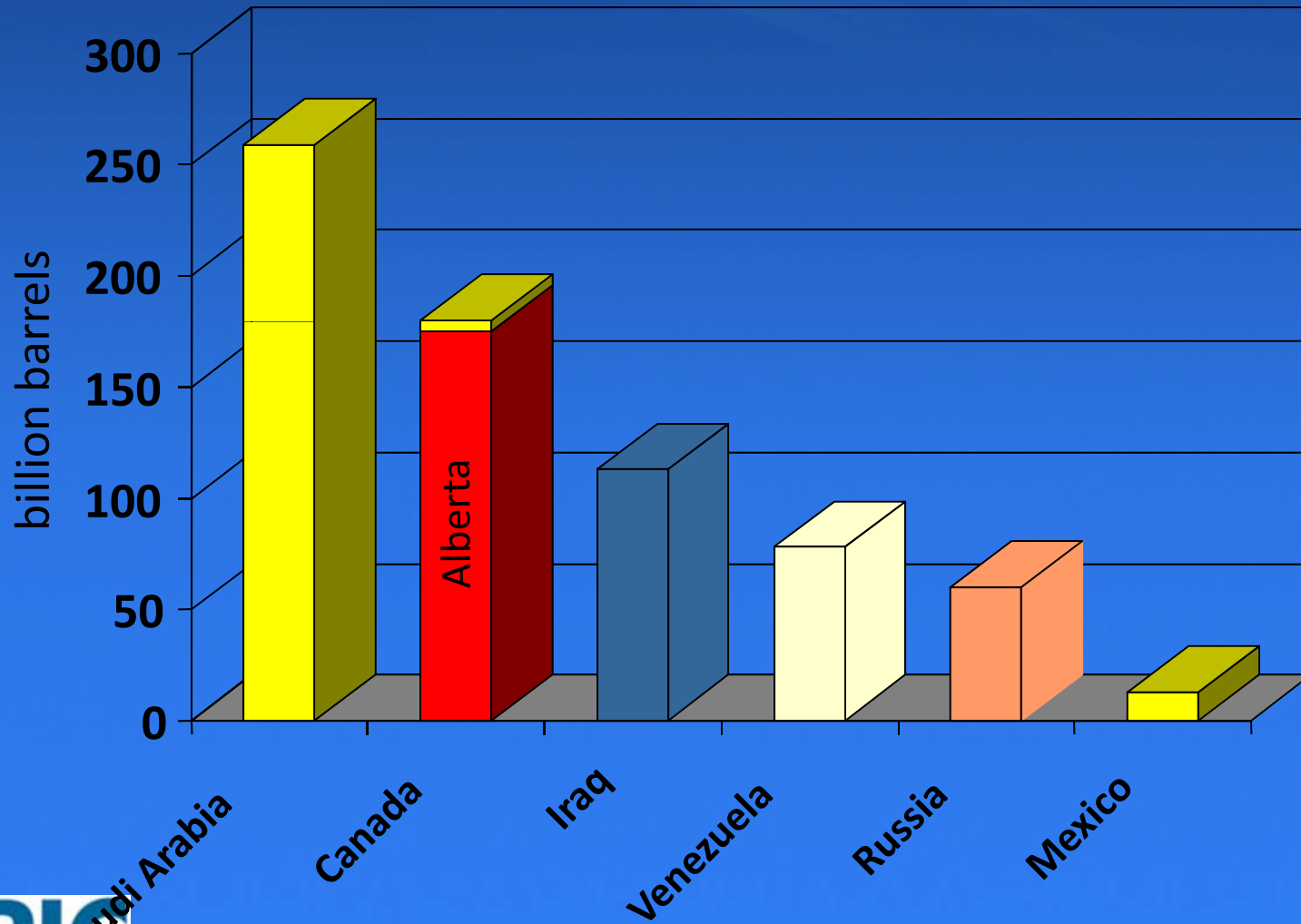
- Conclusions
- Overview of Heavy Oil Growth
- Reserves Growth in Heavy Oil
- What is applicable to North Sea Development?

# Conclusions

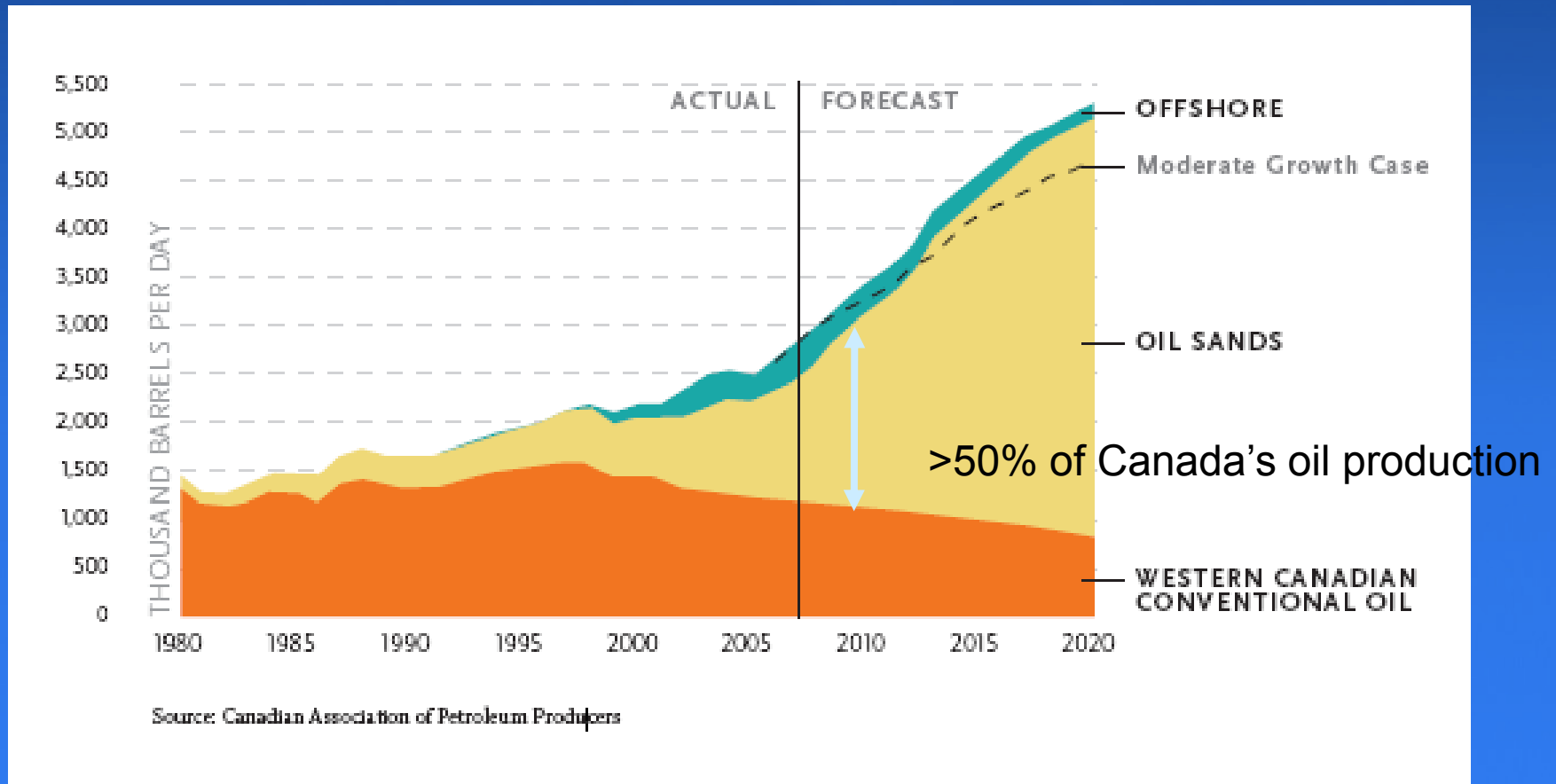
- Heavy Oil Reserves Growth is Critical Worldwide
- Heavy Oil reserve growth critically depends upon technology as well as price
- Heavy Oil Waterfloods and Polymer floods have been very successful (***above initial expectations***) but reservoir management is key
- North Sea Development will depend upon adaptation of technology for off shore environments such as ;
  - ICD (profile control, well intervention)
  - Waterfloods at higher water cuts



# World Reserves



# Canadian Oil Production

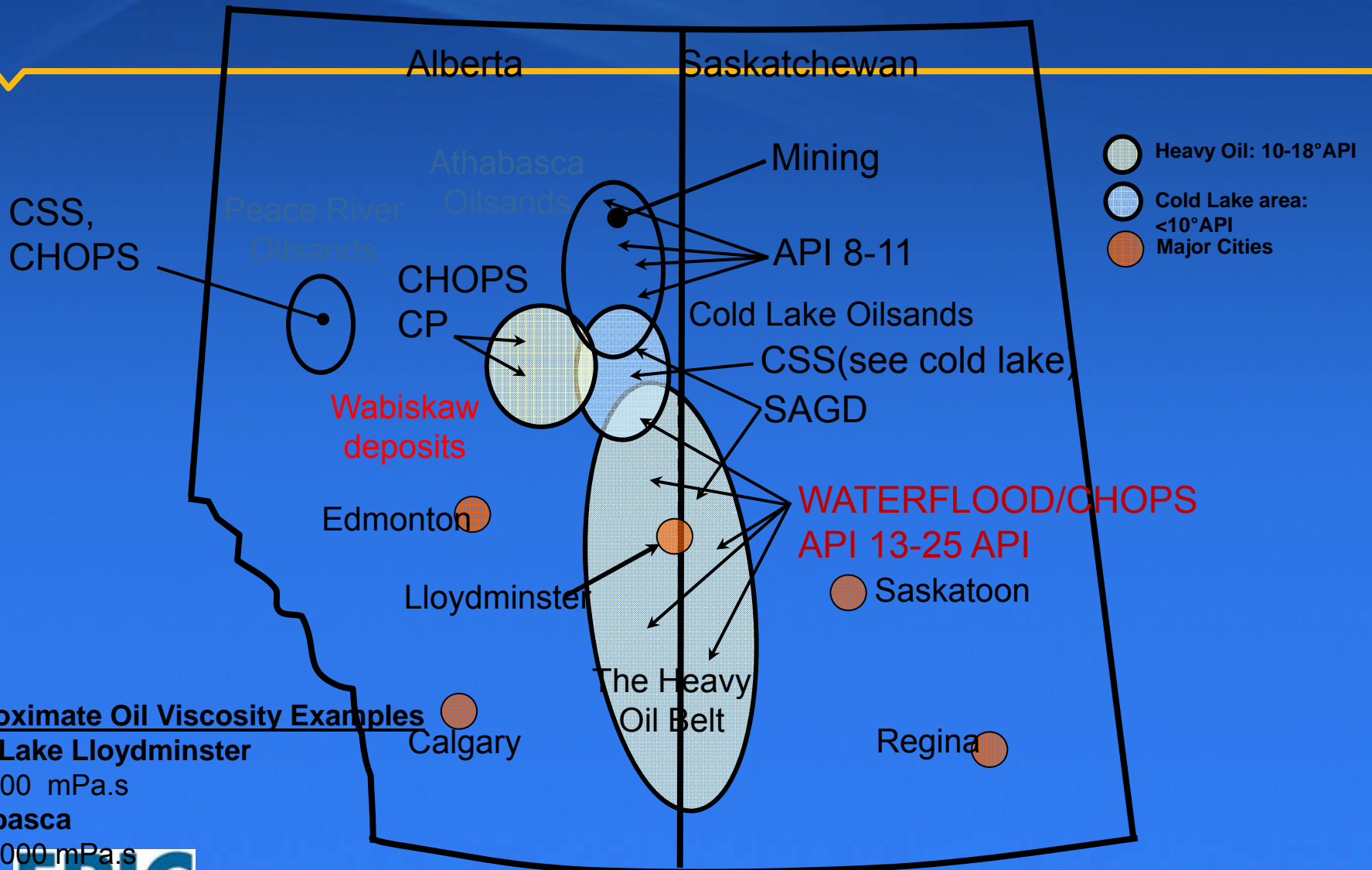


United States of America  
and Canada



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# Development Areas, Alberta/Saskatchewan



## Approximate Oil Viscosity Examples

**Cold Lake Lloydminster**

10-1000 mPa.s

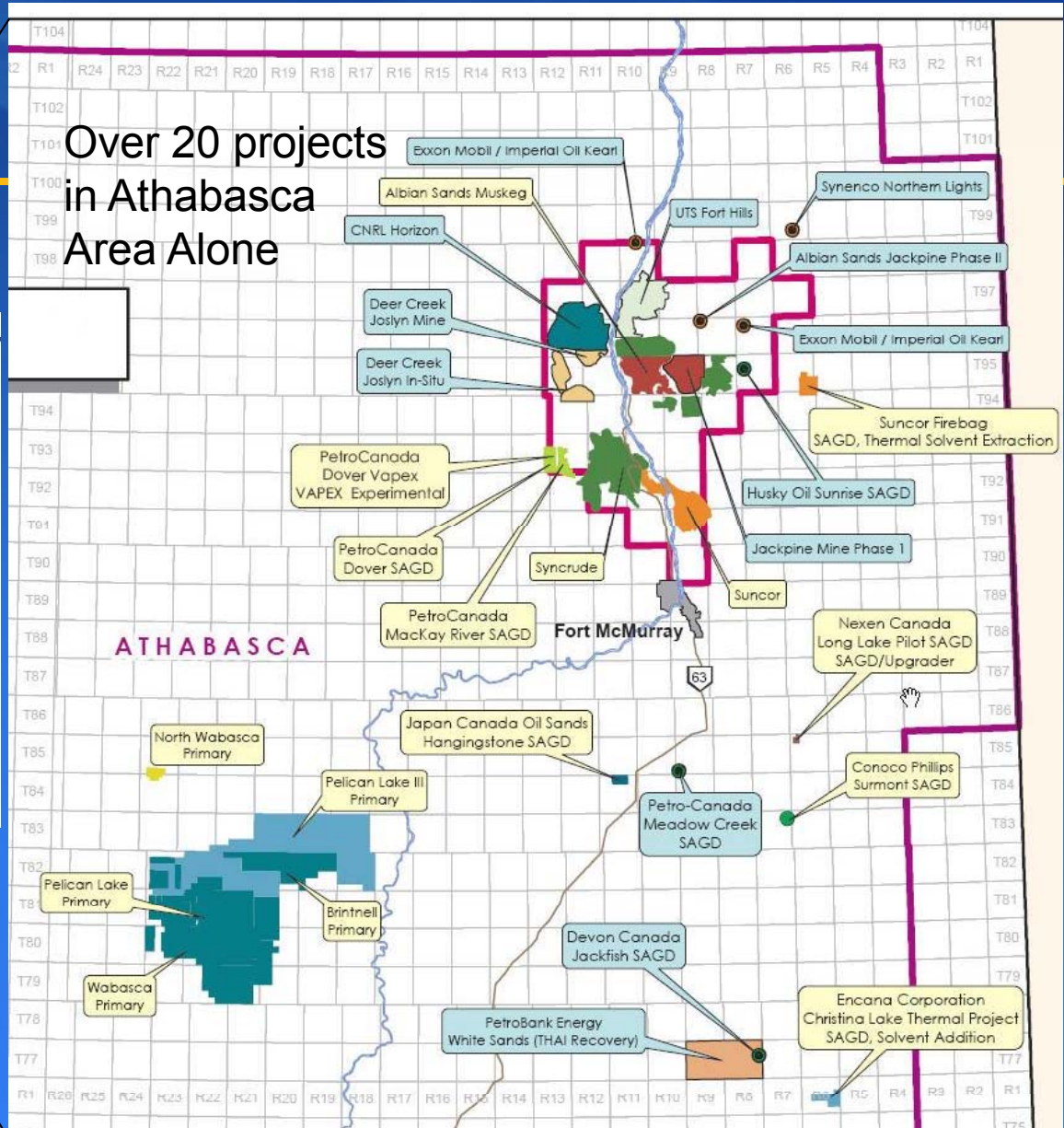
**Athabasca**

120-4000 mPa.s



# Athabasca Oil Sands

Over 20 projects  
in Athabasca  
Area Alone



Paris 2004, 66th EAGE Conference & Exhibition,  
Paris, France

SPE 84144

## Reserves Growth: Enigma, Expectation, or Fact?

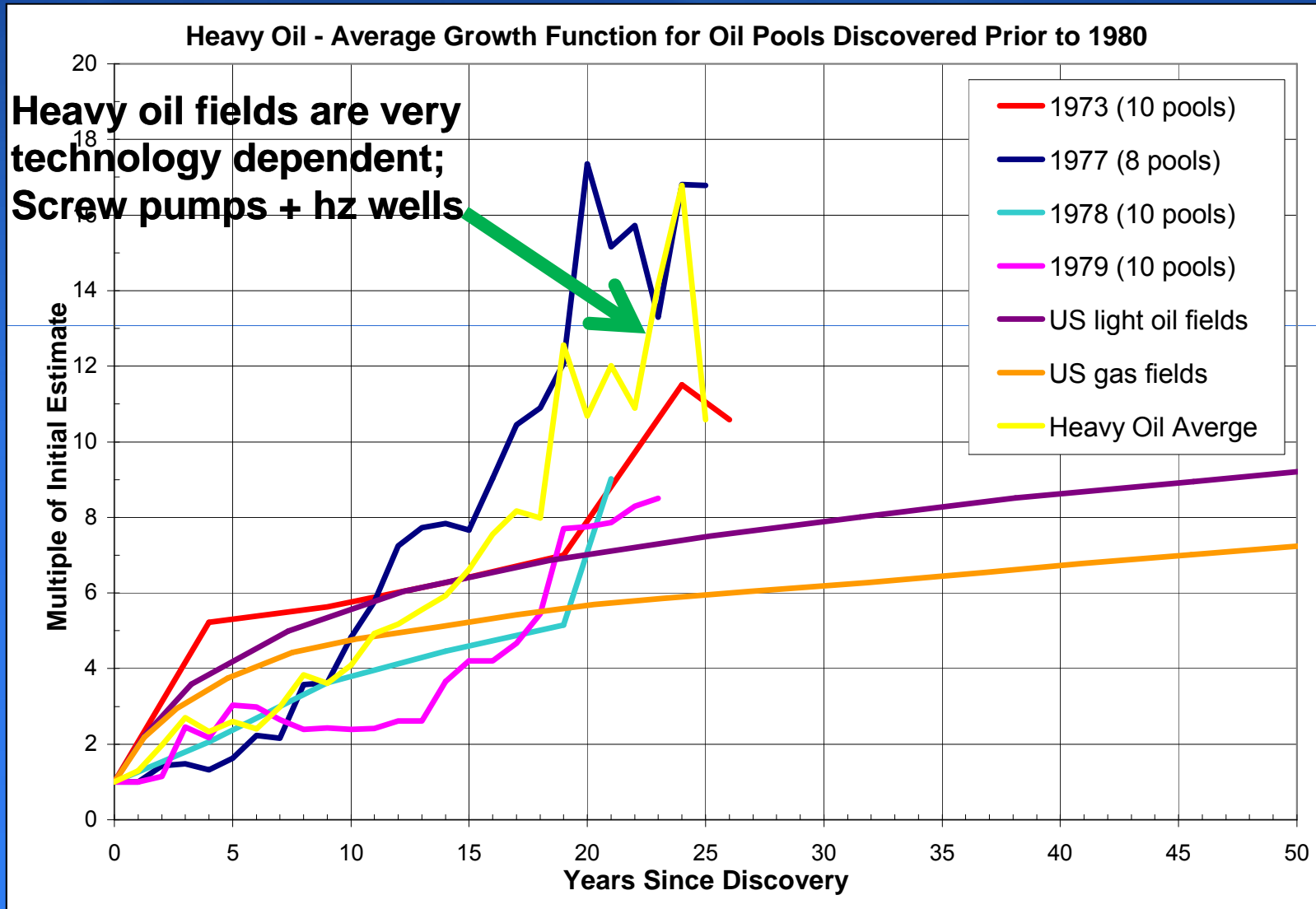
- Richard Baker and Dennis Beliveau
- June 8th, 2004



# Reserves Growth: Enigma, Expectation, or Fact?

- Growth in reserves from existing reservoirs has been the prime contributor to reserve additions in most mature basins.
- Out of 202 heavy oil fields 88% of those fields have reserve growth. The average reserves growth is 1,083%
- This reserve growth can be attributed to:
  - a) advances in technology,
  - b) multi-disciplinary reservoir studies,

# Focus on Heavy Oil (examined 38 pools)



# TECHNOLOGY LEVERAGES



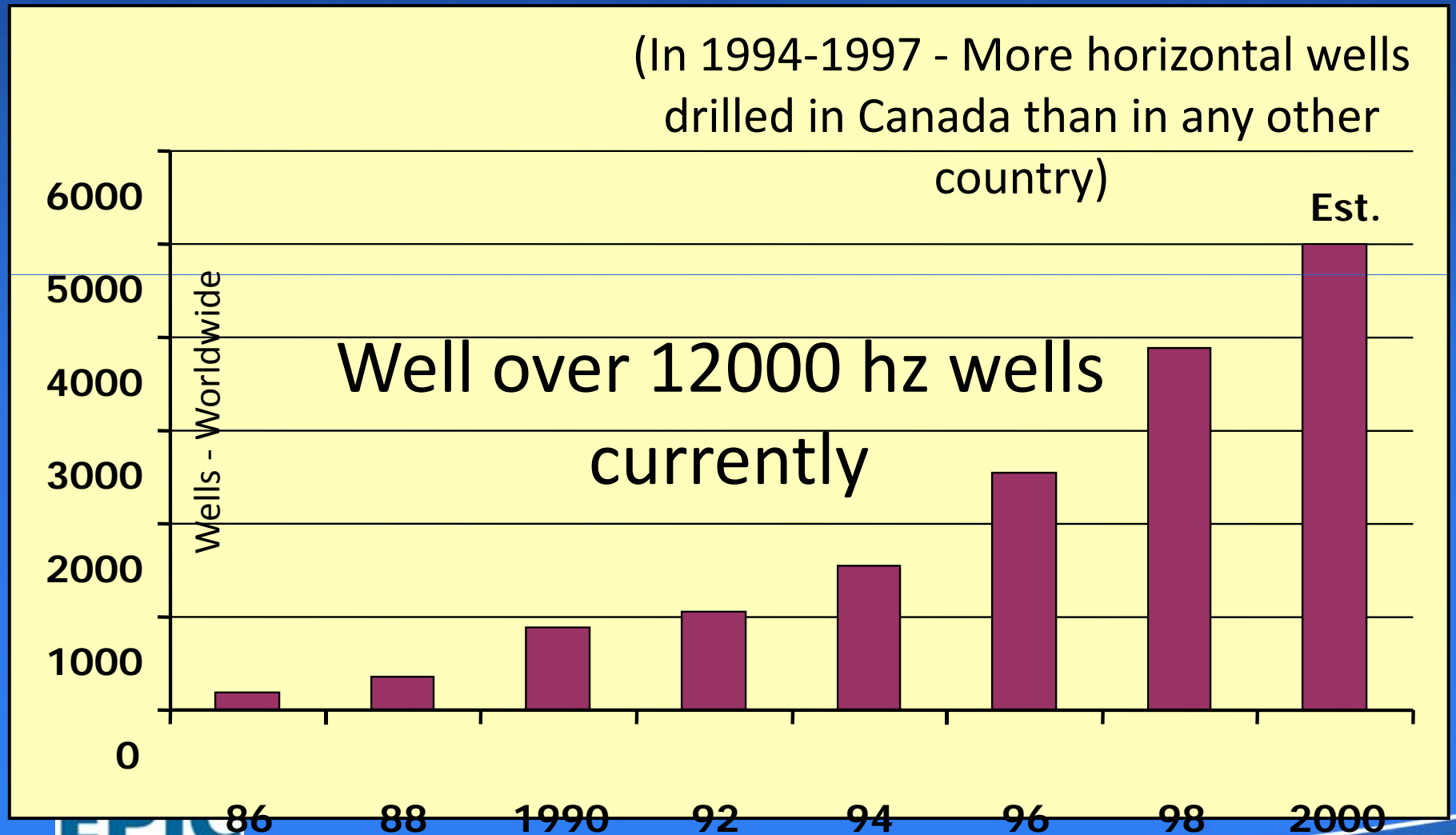
# Heavy Oil Technical Influences

- Horizontal/multilateral drilling
- EOR (thermal/non thermal)
- Screw pumps/pumping systems

*are tied to heavy oil reserves growth*

*Most reserve growth is not thermal in the last 15 years*

# Horizontal Wells, Worldwide



*Advancing Reservoir Performance*

# Heavy Oil Primary Production

Cold Heavy Oil Production(CHOPS), foamy oil  
production



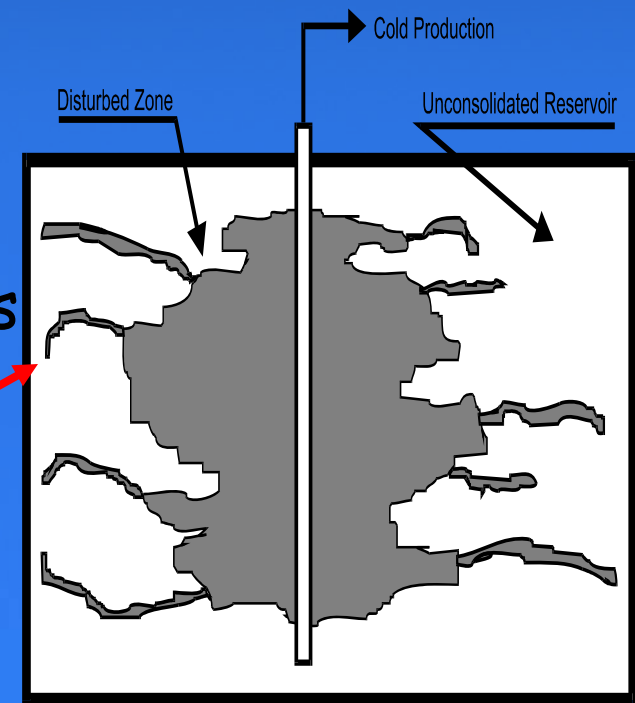
# Reservoir Mechanisms: Geo-mechanical Effects

## Sand Production

- enlarged drainage radius
  - wormholes
  - dilated zones
  - cavities
- sand grain flow
- liberation of pore blocking materials
- clean up of drilling damage

*Up to 400 m in length*

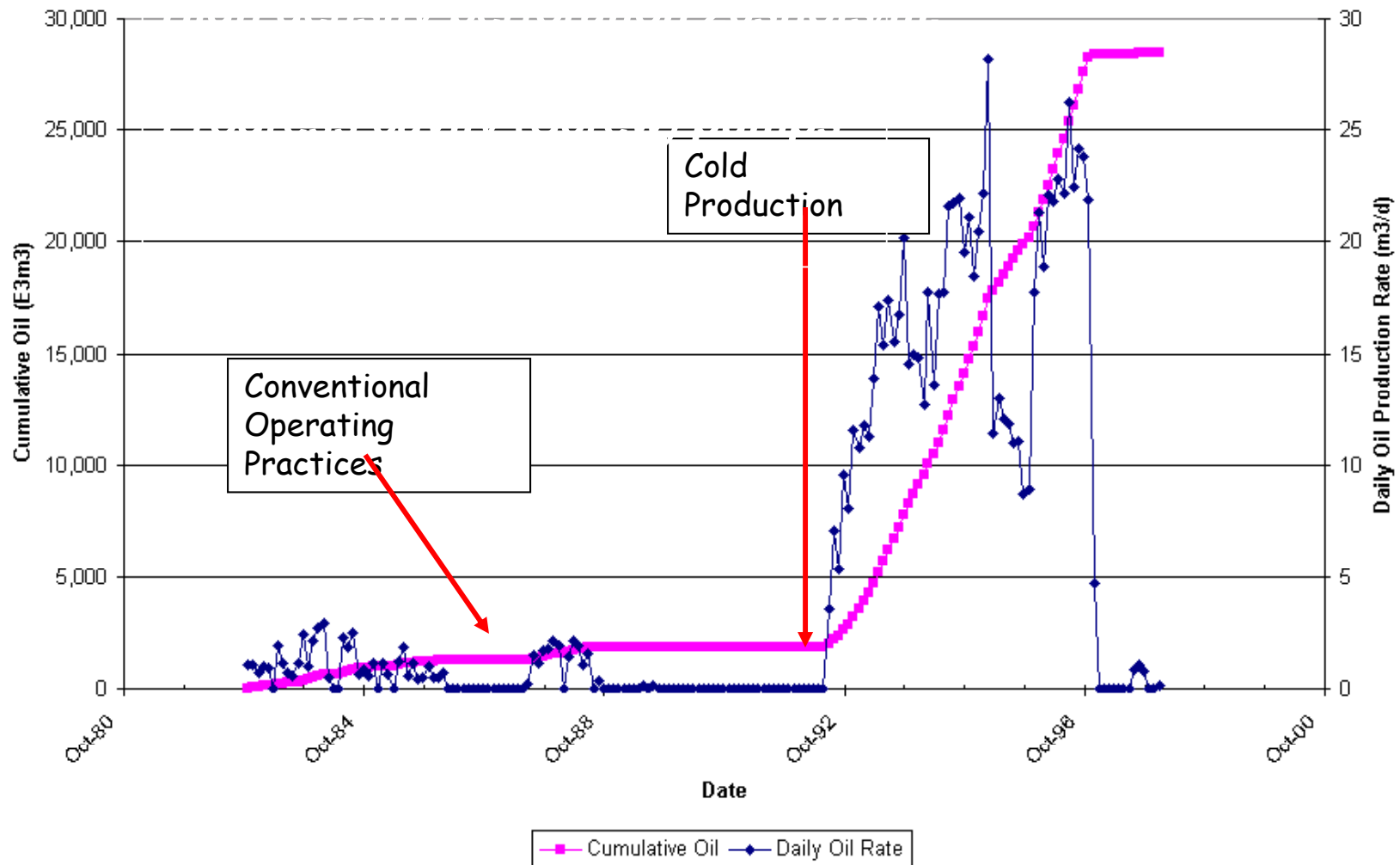
SAND DEFORMATION ENHANCES PERMEABILITY



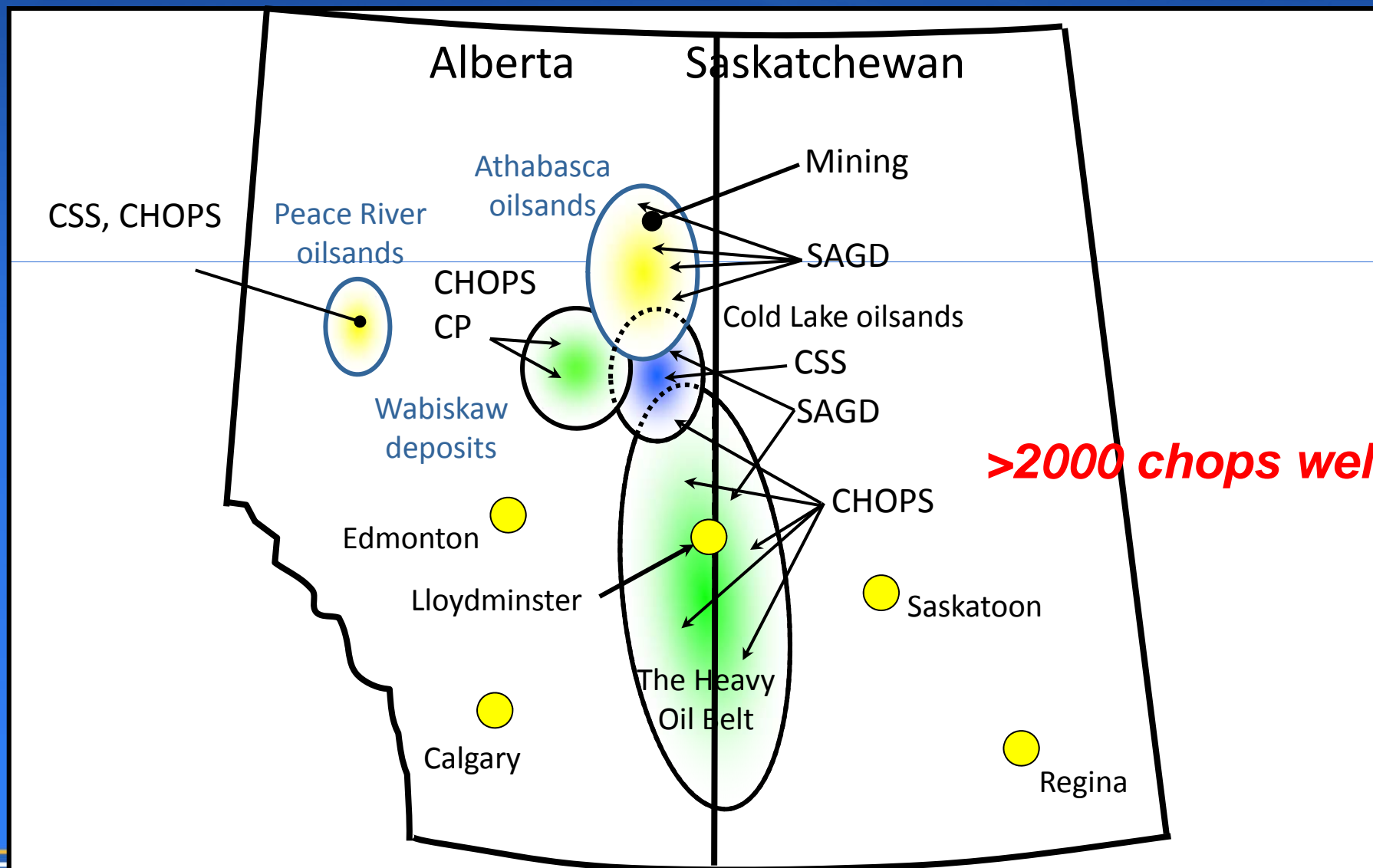
Vertical wellbore

# Cold Production - An Example

111/12-32-048-19W3/00



# Development Areas, Canada



**>2000 chops wells**

# Sand production – field horizontal wells example

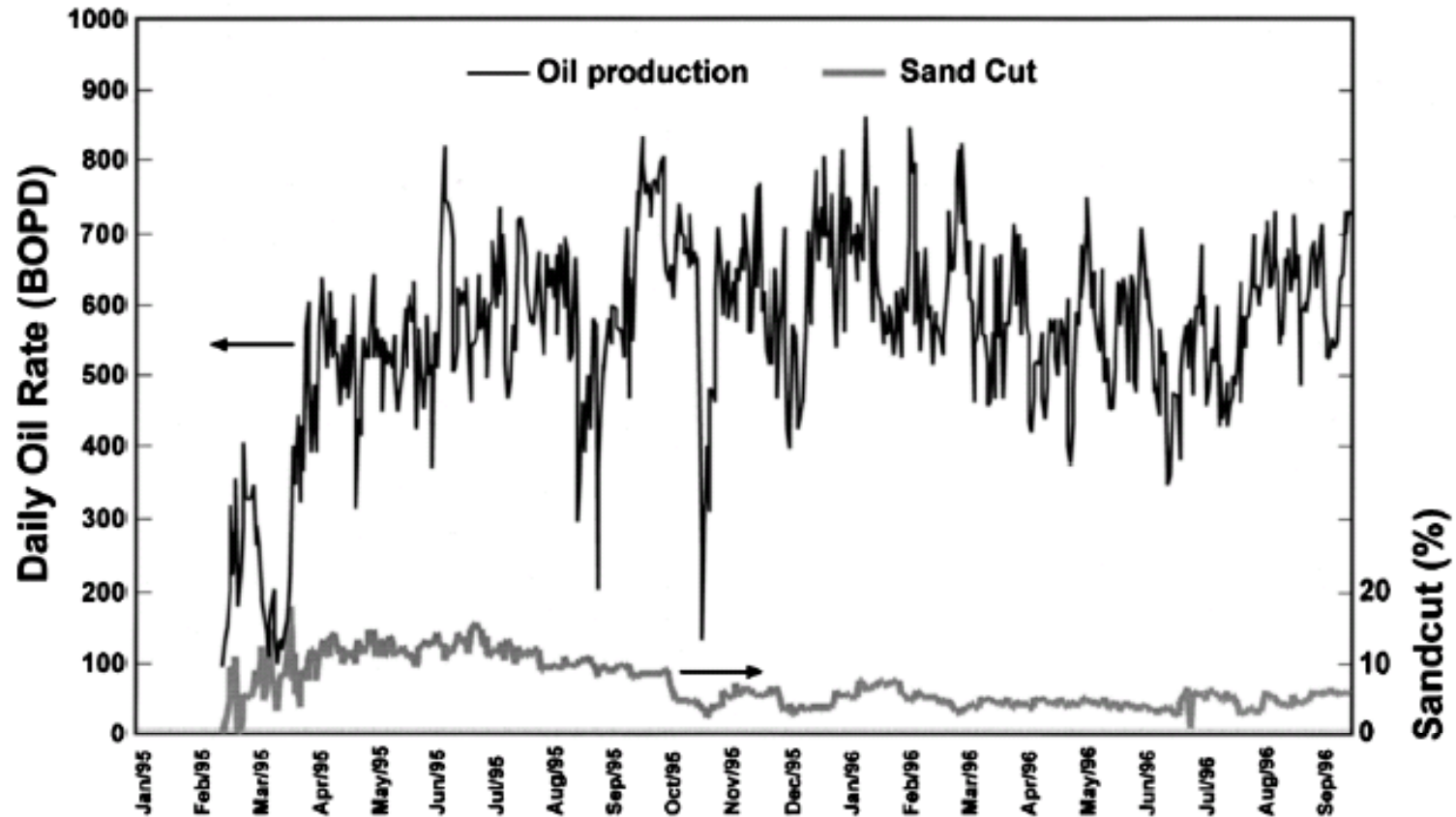


Fig. 8 – Production history of the 10-horizontal well Lower Waseca project in Frog Lake.

**EPIC**  
Energy Production Company

SPE 52636, Huang et al., SPE Res. Eng. & Eval., Dec. 1998

WALKER  
HUGHES

# HEAVY OIL WATERFLOODS/HORIZONTAL WELLS/HZ INJECTORS + POLYMER APPLICATION

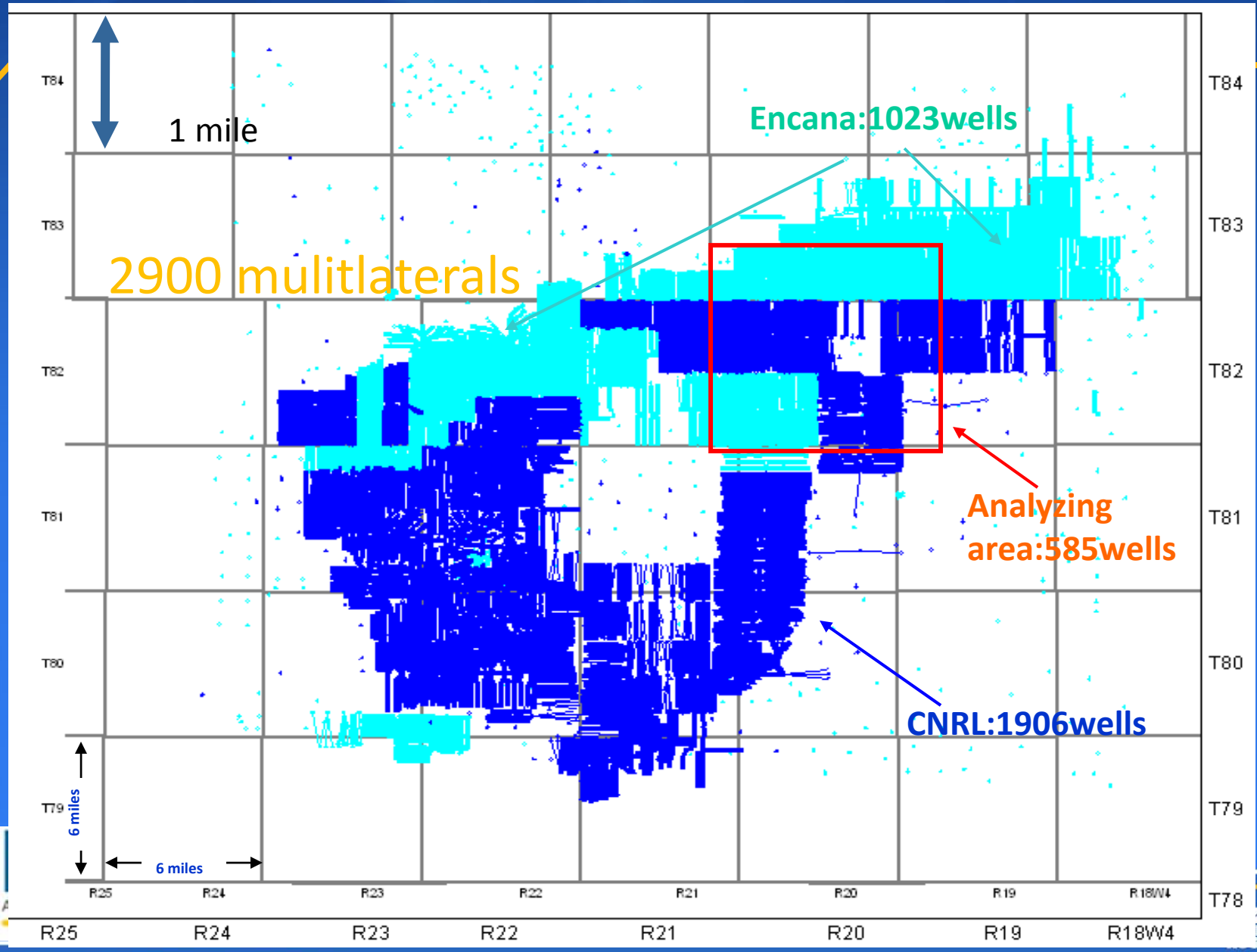


# Field Development Plan; Pelican Lake (Canada)

- Horizontal well development 2900 multilateral hz wells
- Primary with waterflood
- OOIP= 0.6 Bbbl
- 14 API oil gravity variation across field
- ~600 cp
- No substantial sand production
- 12 ft sand thickness
- $S_w \sim 15-30\%$
- $\phi > 30\%$
- $K = 500$  to  $1000 \text{ mD}$

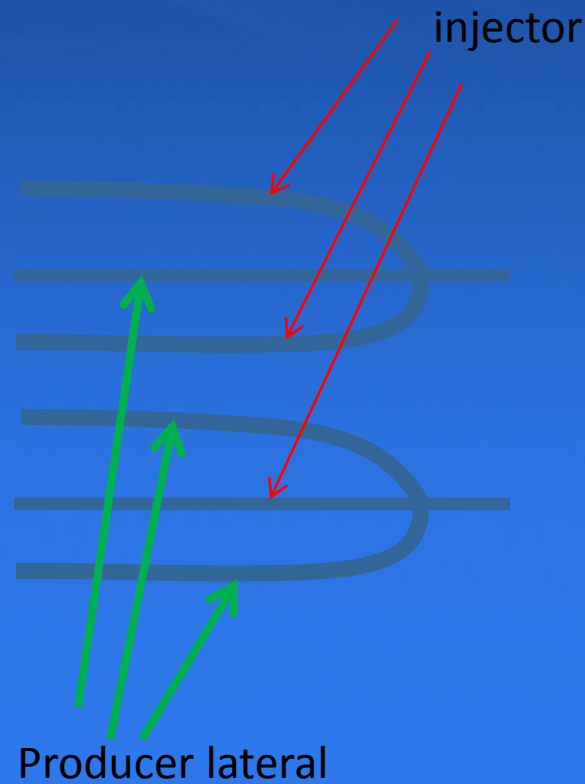


# Map of Pelican Lake Field 2008 Data

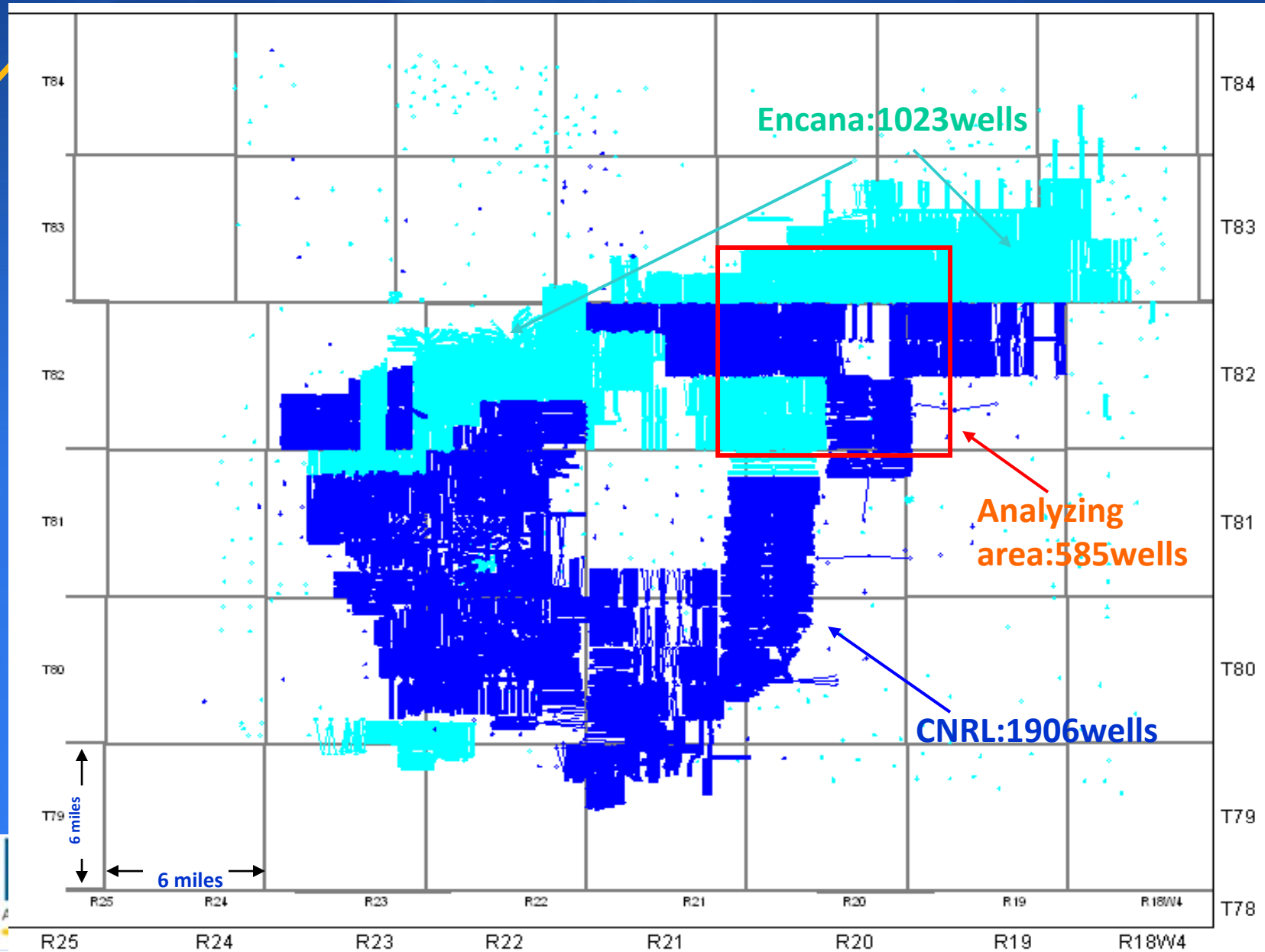


- Concept

Horizontal well development  
with waterflood  
14 API oil viscosity~600 cp

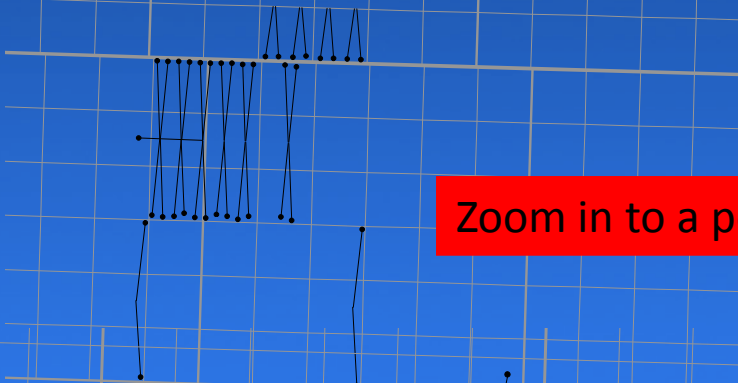


# Map of Pelican Lake Field



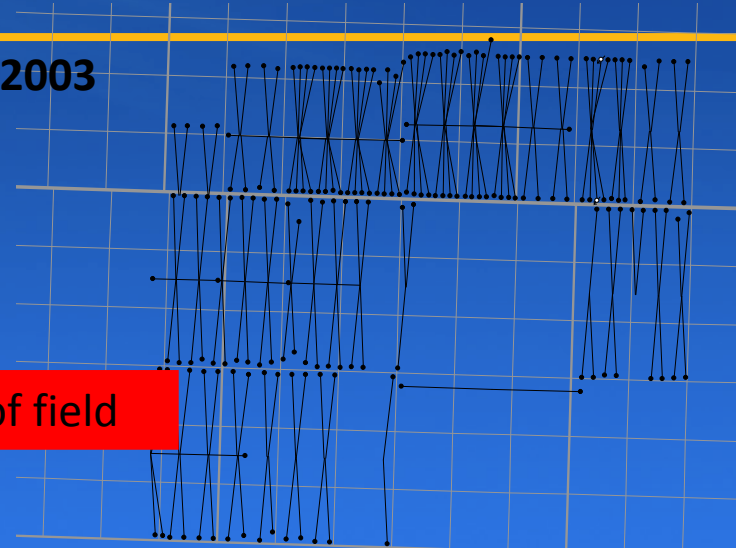
# Pelican Lake Field Development Time Lapse

Jan 1999



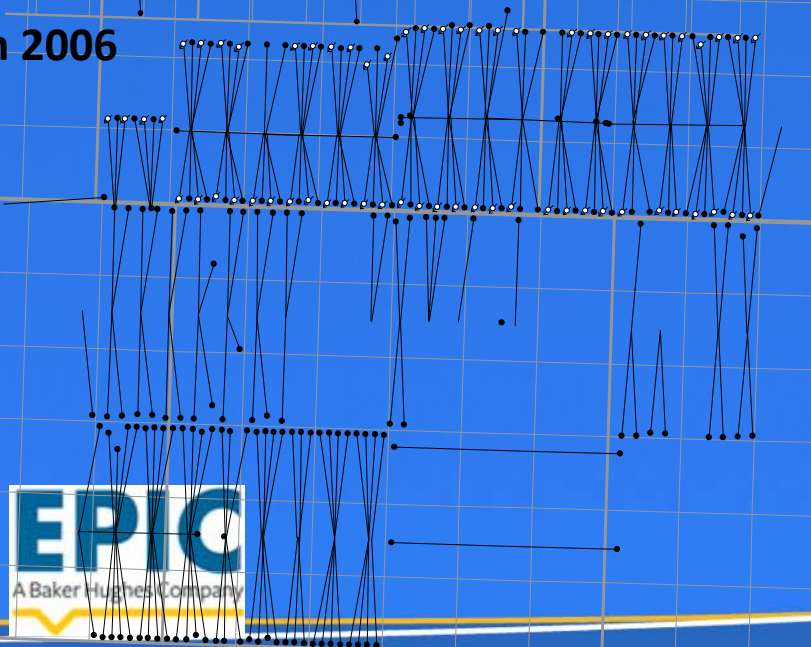
UNTITLED PROJECT  
DATE 1999-1

Jan 2003

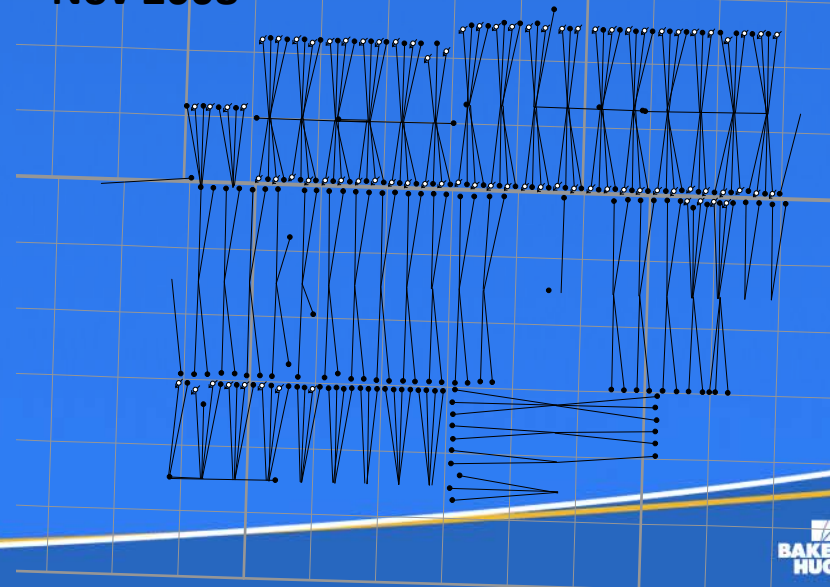


Zoom in to a portion of field

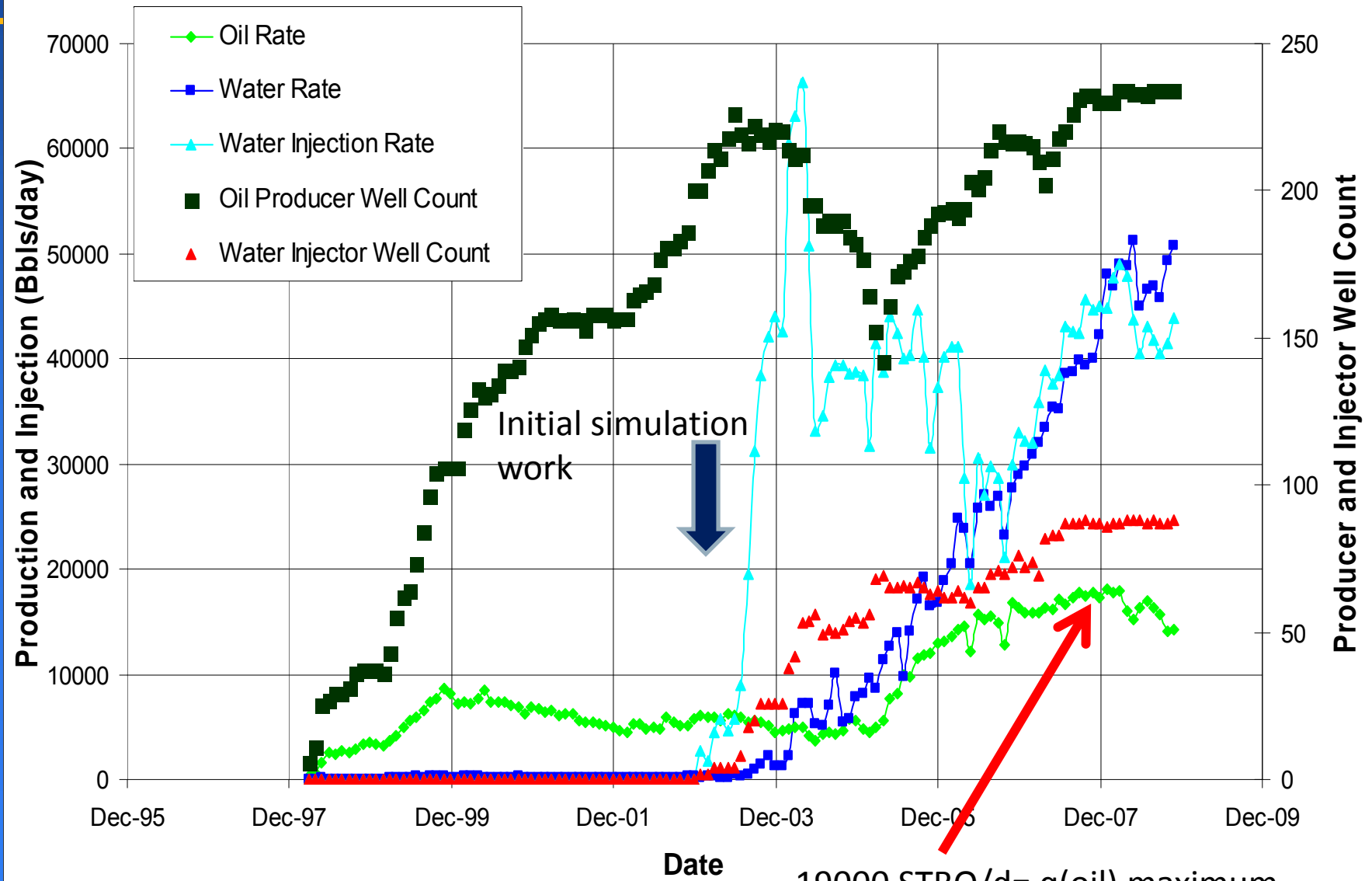
Jan 2006



Nov 2008

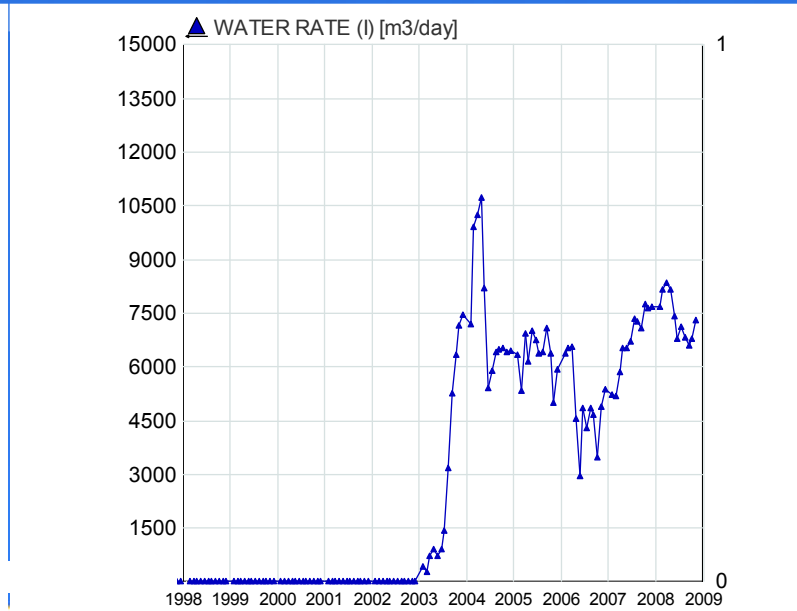
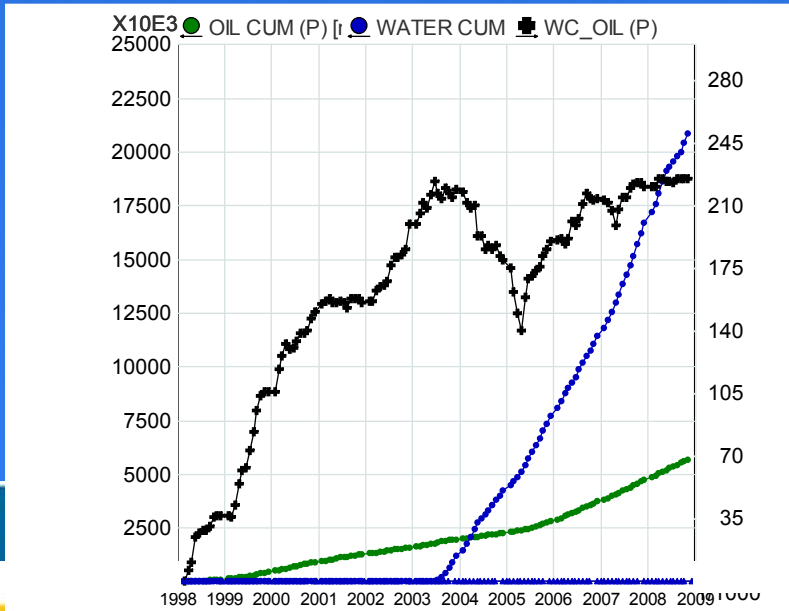
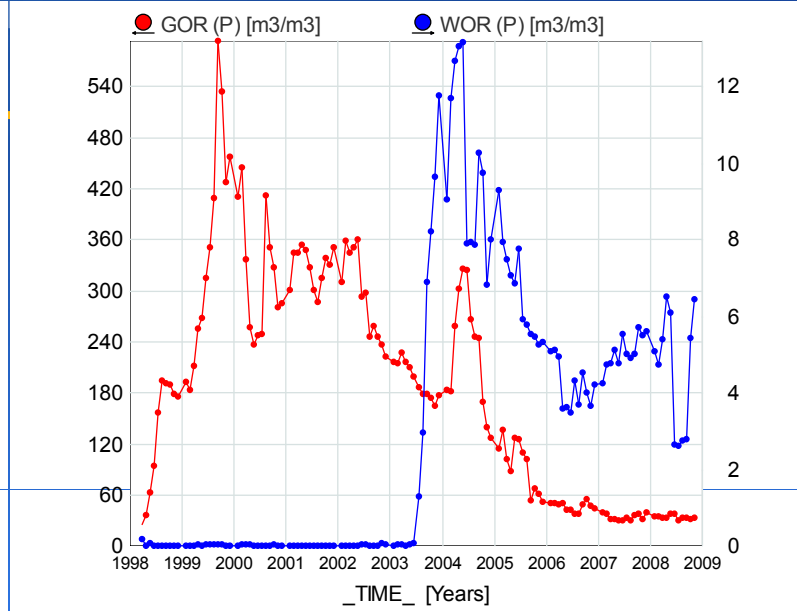
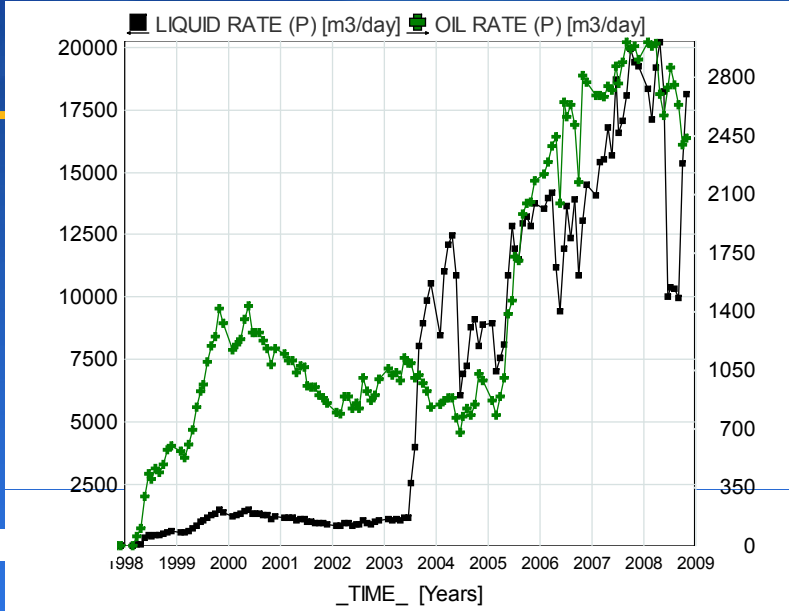


# Pelican Lake Section Production and Injection



19000 STBO/d =  $q(\text{oil})$  maximum  
 82 bbl/d/well

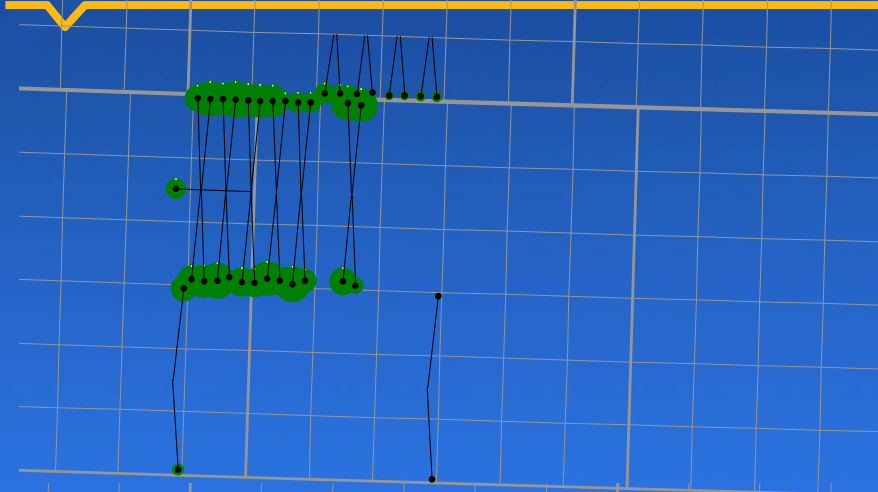
# Production Composite Plot for Pelican Lake Field



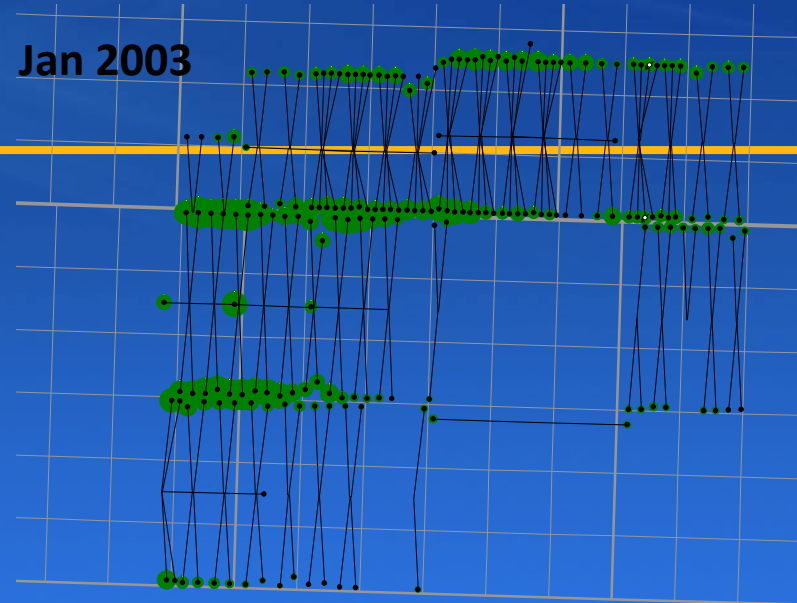
# Time Lapse Cum Oil Production Bubble Plots

Reservoir  
UNTITLED PROJECT  
DATE 1999-1  
OIL CUM (P)  
MAX: 100/03-24-082-21W4/00 (5815.7 m3)  
Multiplier=1

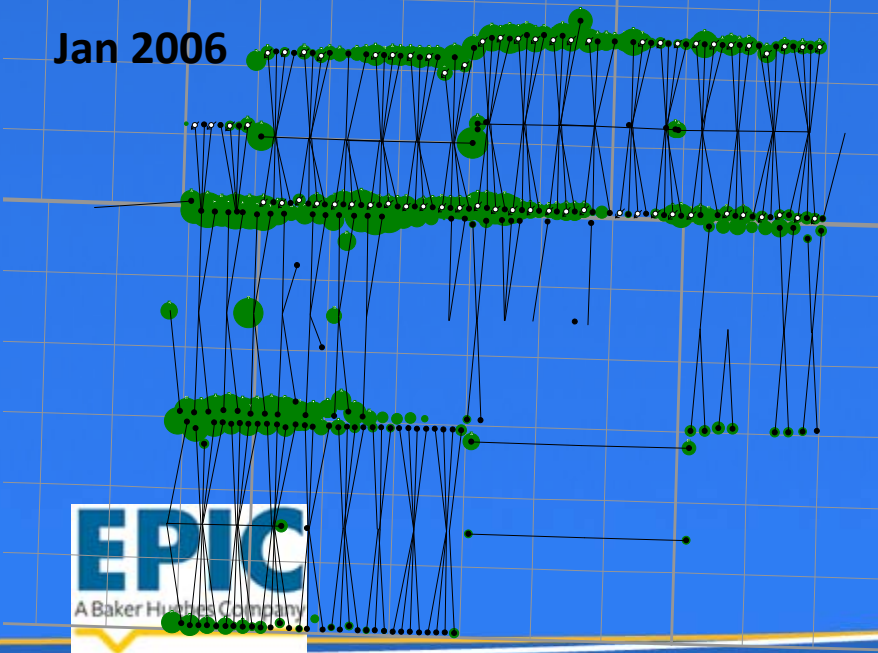
Jan 1999



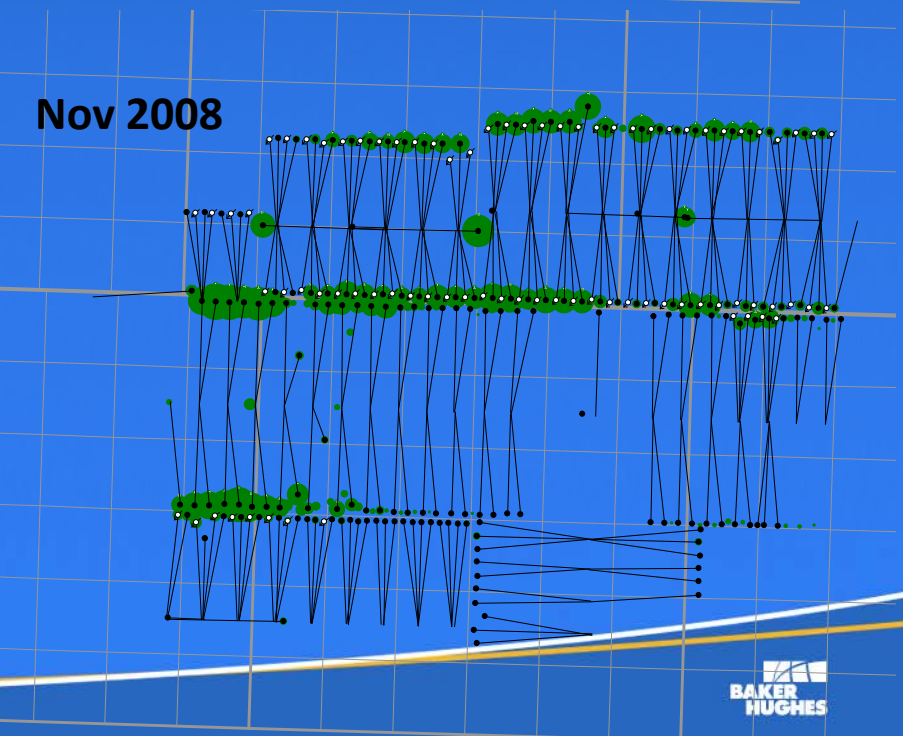
Jan 2003



Jan 2006



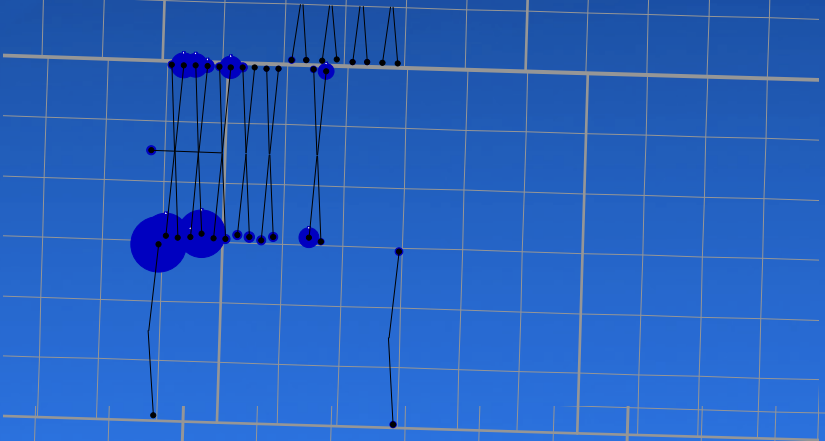
Nov 2008



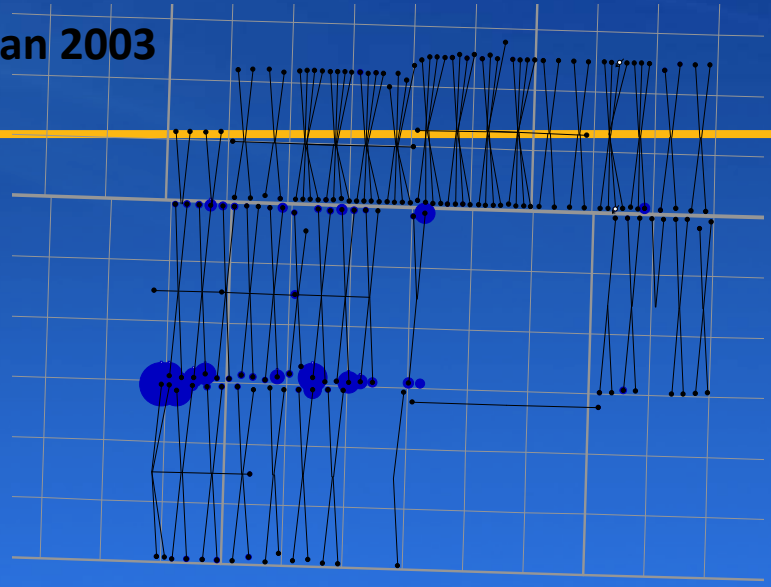
# Time Lapse Water Production Bubble Plots

UNTITLED PROJECT  
DATE 1999-1  
\*WATER CUM (P)  
MAX: 100/16-14-082-21W4/00 (431.5 m3)  
Multiplier=1

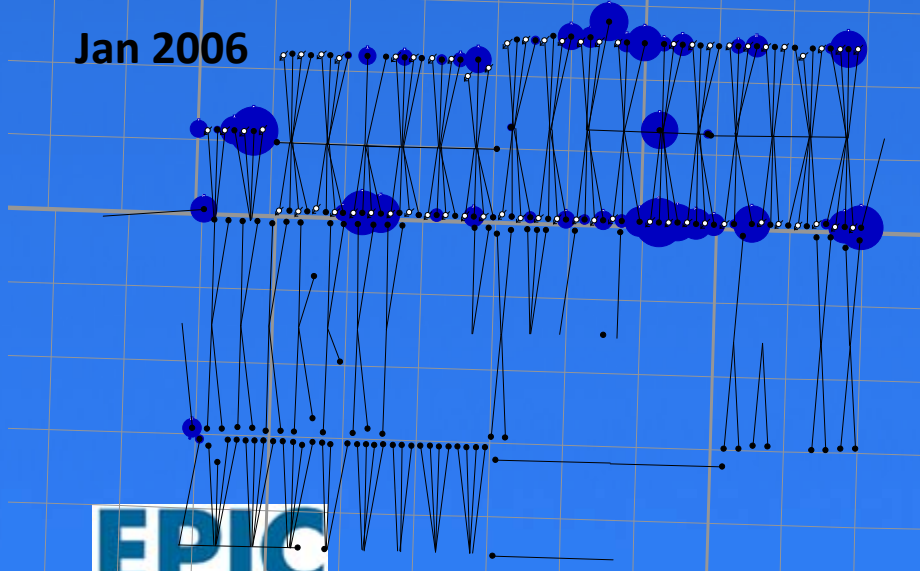
Jan 1999



Jan 2003



Jan 2006



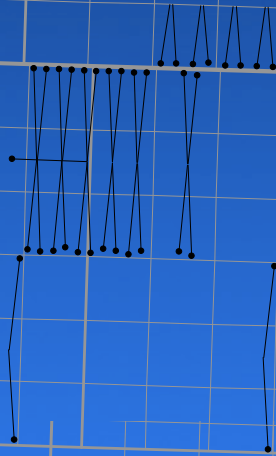
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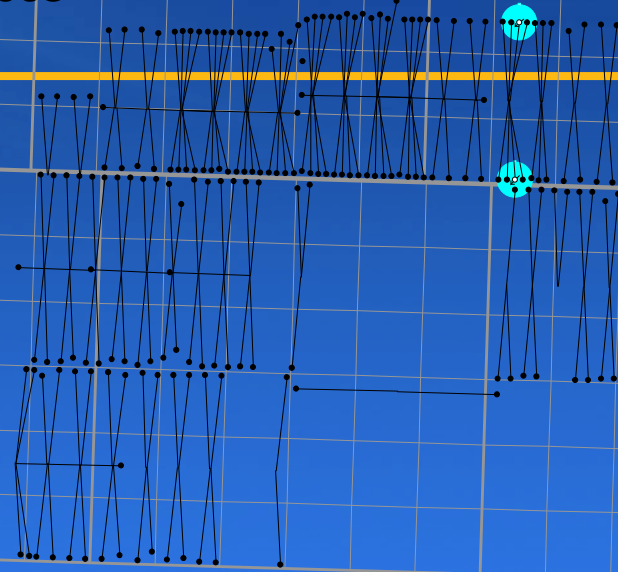
# Time Lapse Water Injection Bubble Plots

Reservoir  
UNTITLED PROJECT  
DATE 1999-1  
WATER CUM (I)  
Multiplier=1

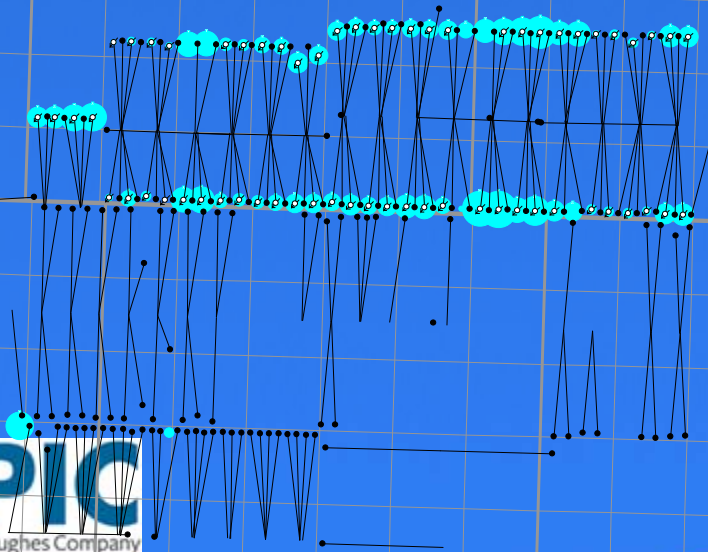
Jan 1999



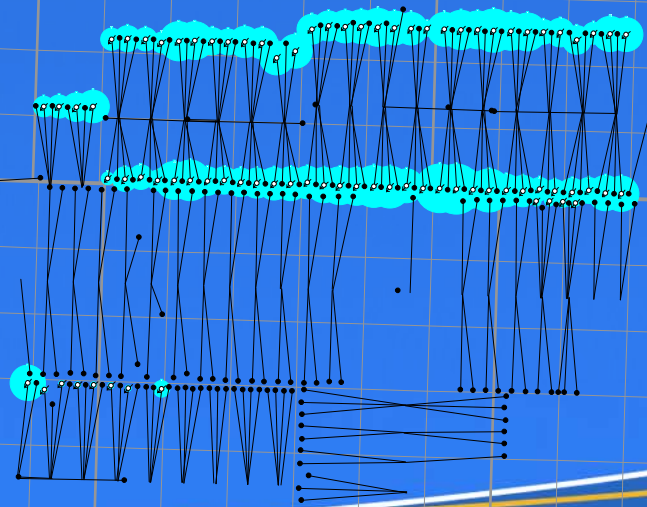
Jan 2003



Jan 2006



Nov 2008



# Chauvin South-Mannville MU #1

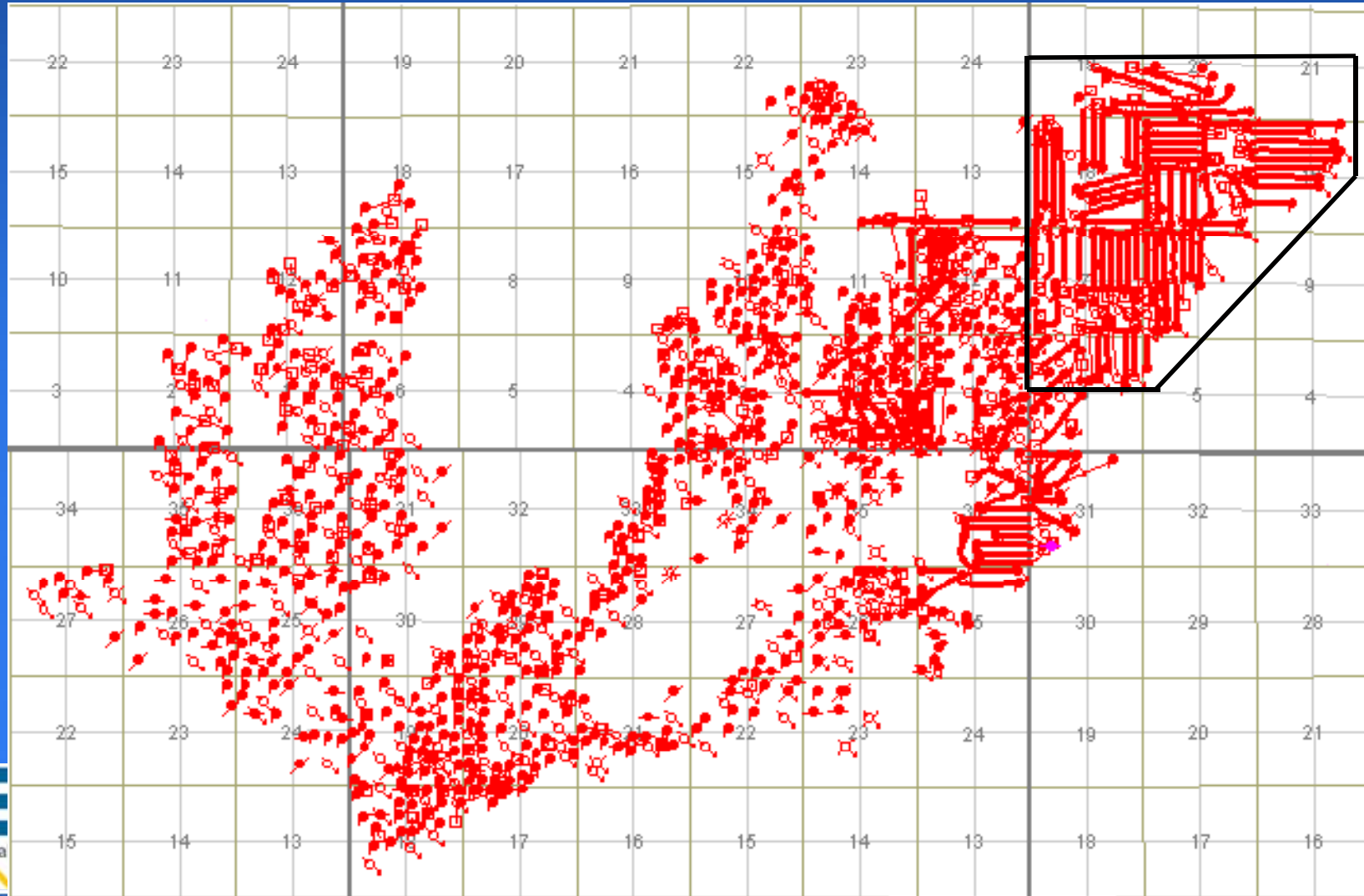
R3

R2

R1W4

T43

T42



# Pool Data for Dina PP pool not Chauvin

- **OOIP = 2.09 e6m3 (from ERCB)**
- **OGIP (soln') = 71 e6m3**
- **Production**
  - **Oil: 1.27 e6m3**
  - **Water: 24.94 e6m3**
  - **Gas : 42.87 e6m3**
- **Current Oil RF = 60.8%**
- **Injection**
  - **Water in**



## ■ Reservoir Properties

- **Area = 350 ha**
- **h = 3.2 m**
- **$\phi = 25\%$**
- **$S_{wi} = 23\%$**
- **$B_{oi} = 1.031$**
- **$P_i = 5778$  kPa**
- **$P_b = 3116$  kPa (Standing correlation)**
- **Oil gravity = 29.3 °API**
- **$\mu_{oil} = 15.1$  mpa.s**
- **$R_{H} = 20$  m3/m3**
- **Fm. Temp = 28 °C**
- **First production: 1988**
- **Total production wells: 63**
- **Currently active wells : 48**

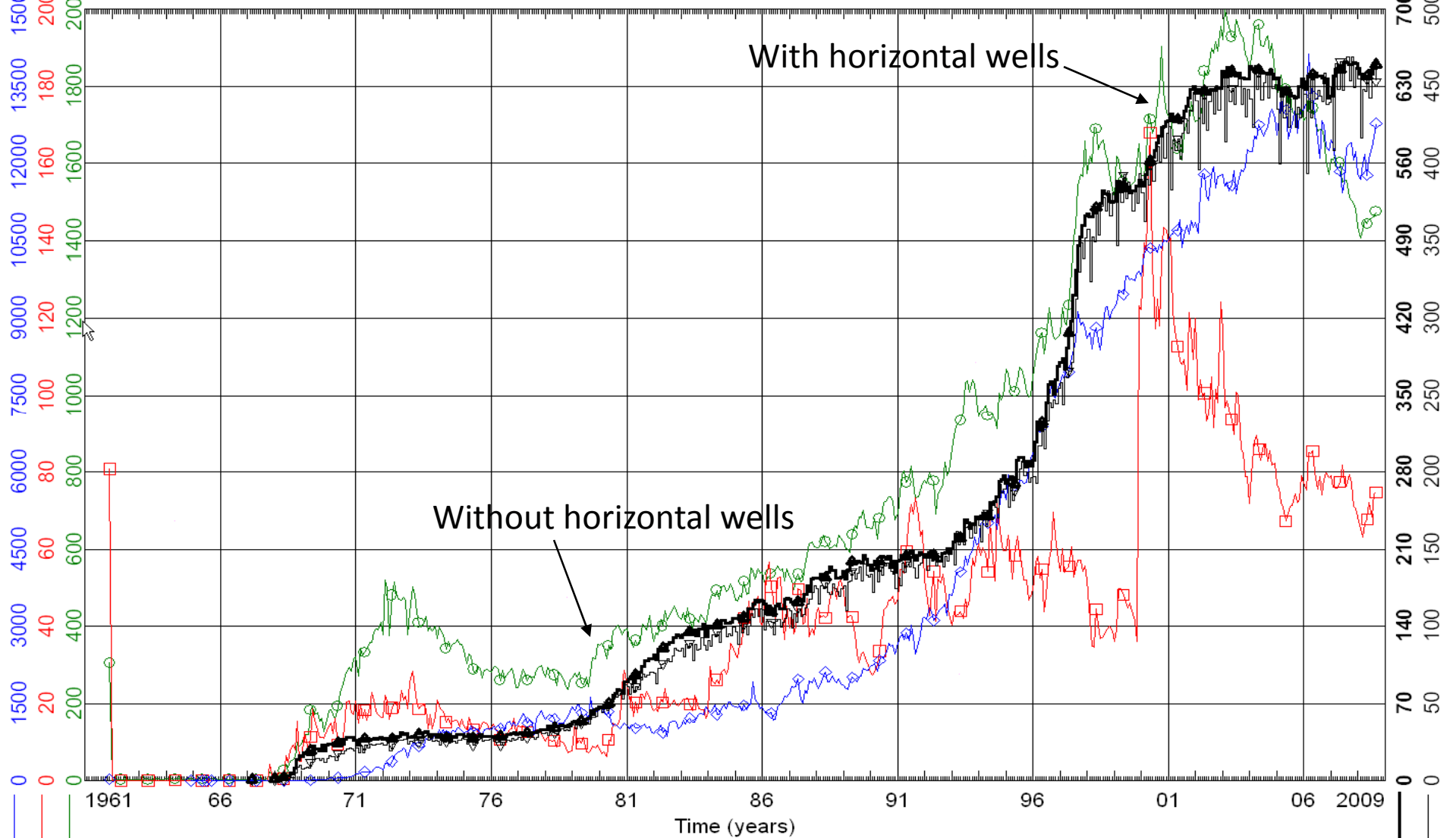
Data As Of: 2008-09 (AB)

### SELECTED WELLS PRODUCTION

From: 1961-12

WellCount: 1048/1194

To: 2008-09



Without horizontal wells

With horizontal wells

Cum GAS	663,792.1	$\times 10^3$	$m^3$
Cum OIL	12,590,032.9		$m^3$
Cum WTR	67,218,410.8		$m^3$

Well Count  $\blacktriangle$   
Monthly Hours  $\nabla$   $\times 10^3$  hrs

- Cal-Day Avg OIL  $m^3/day$
- Cal-Day Avg GAS  $\times 10^3 m^3/day$
- ◇ Cal-Day Avg WTR  $m^3/day$

# Polymerflood of heavy oil

- In 1994, IFP recommended the application of polymerflood in the **Pelican Lake** heavy oil field (12 API, 900 to 40,000 cp) operated by CS Resources
- Horizontal wells
- First pilot implemented in 1996-97 failed because of field operational issues

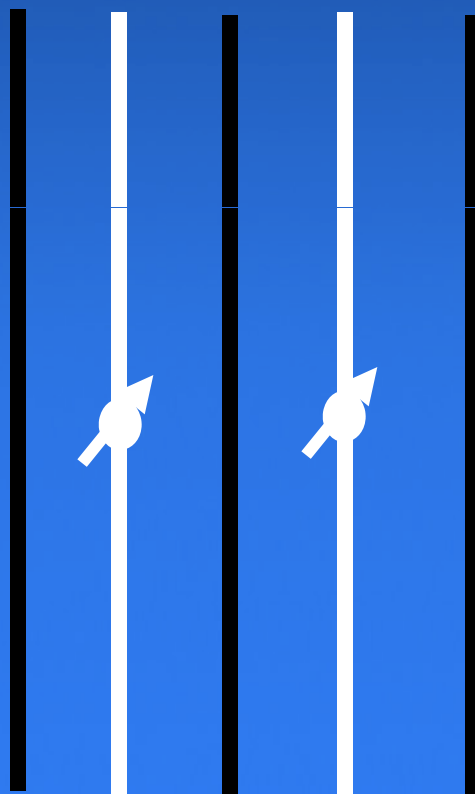


- New pilot implemented in 2005 by CNRL highly successful

From Poweltec

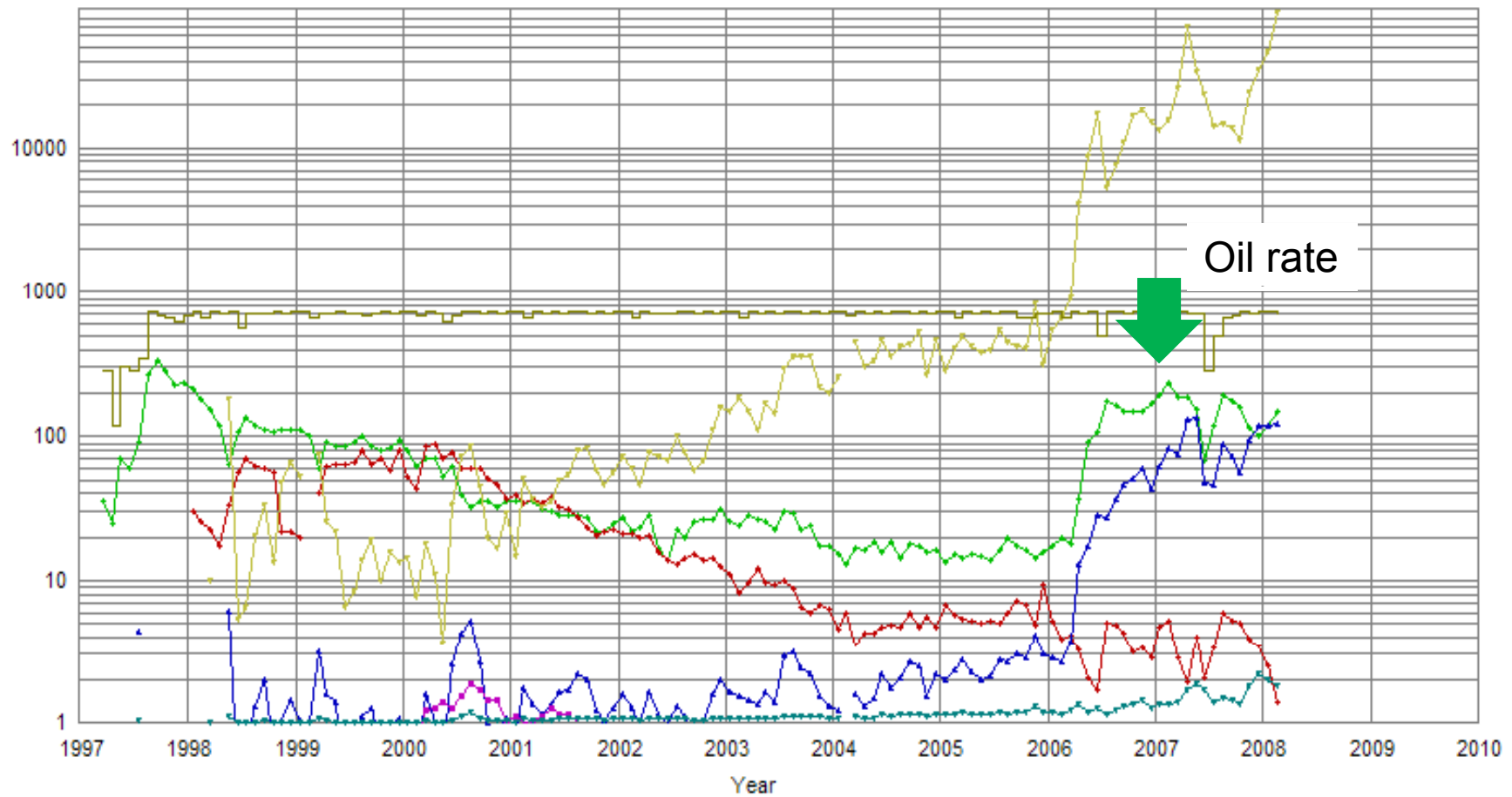


# Second polymer pilot



1500 m long horizontals  
200 m spacing

Field: BRINTNELL Pool: WABISKAW-MCMURRAY UNDEFINED



Oil (Bbl/Cal Day) Cum: 291 MBbl  
WOR+1

Gas (Mcf/Cal Day) Cum: 85 MMcf  
WGR (Bbl/MMcf)

Water (Bbl/Cal Day) Cum: 53 MBbl  
Cond (Bbl/Cal Day) Cum: 0 MBbl

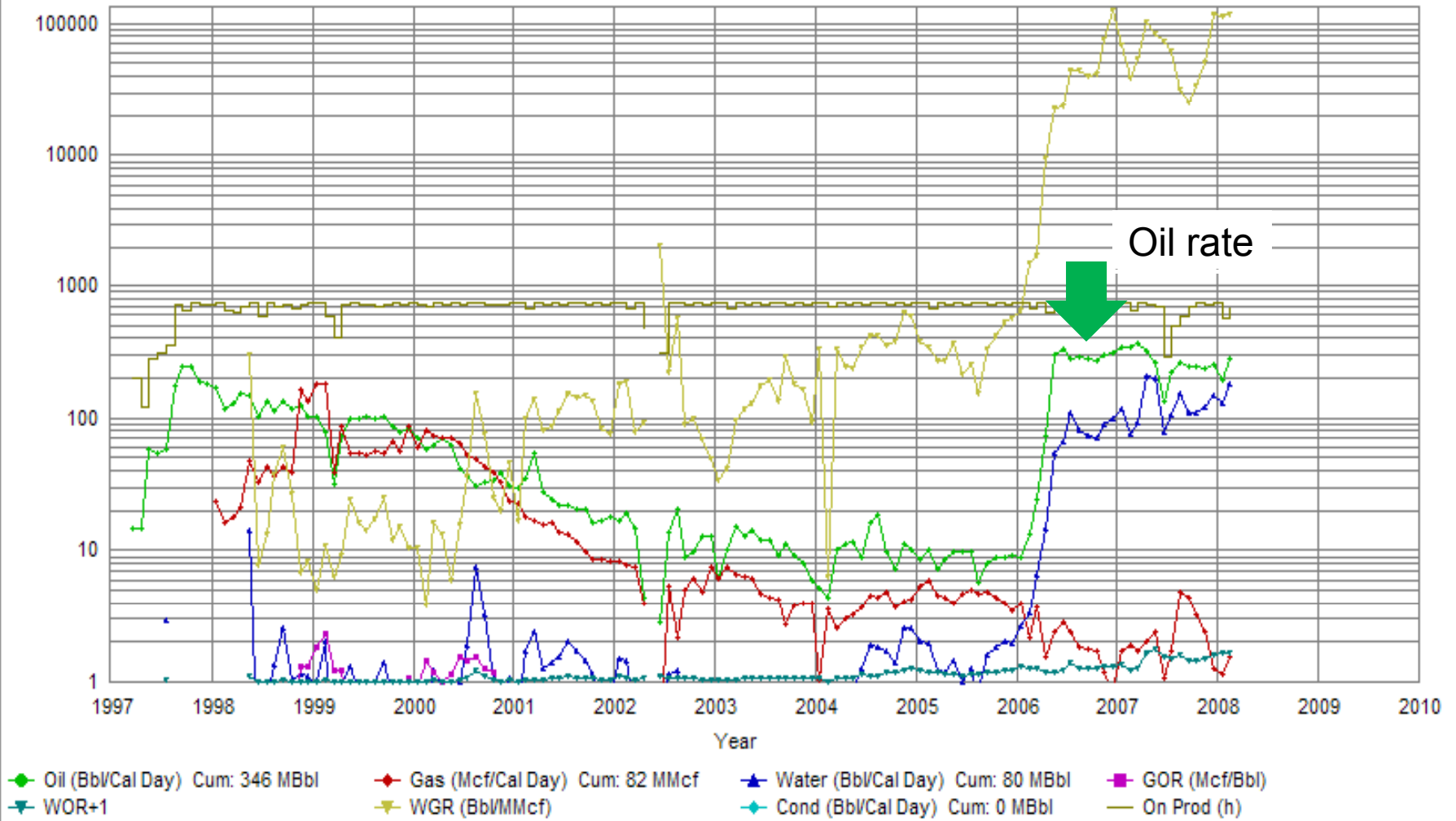
GOR (Mcf/Bbl)  
On Prod (h)



From **Poweltec**

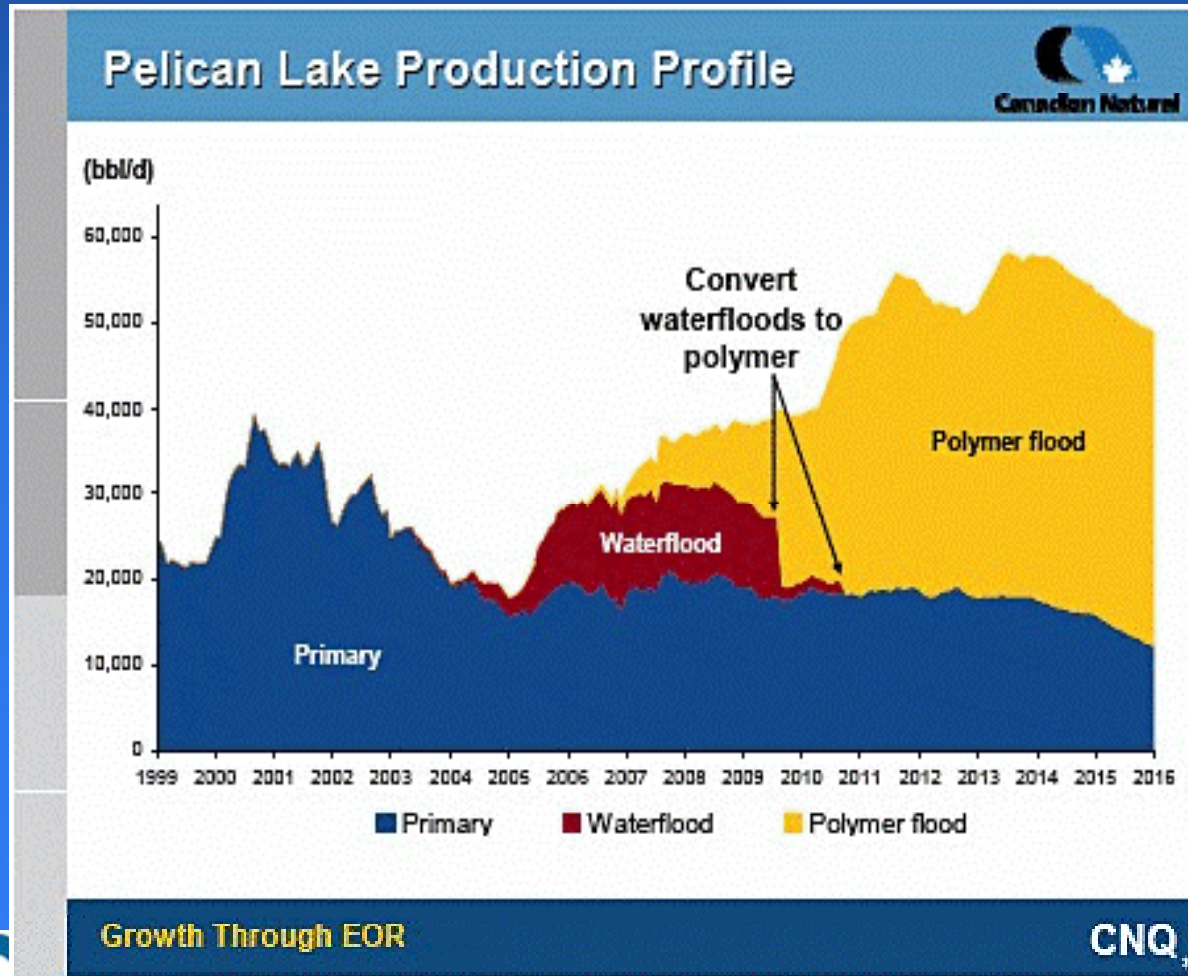


Field: BRINTNELL Pool: WABISKAW-MCMURRAY UNDEFINED



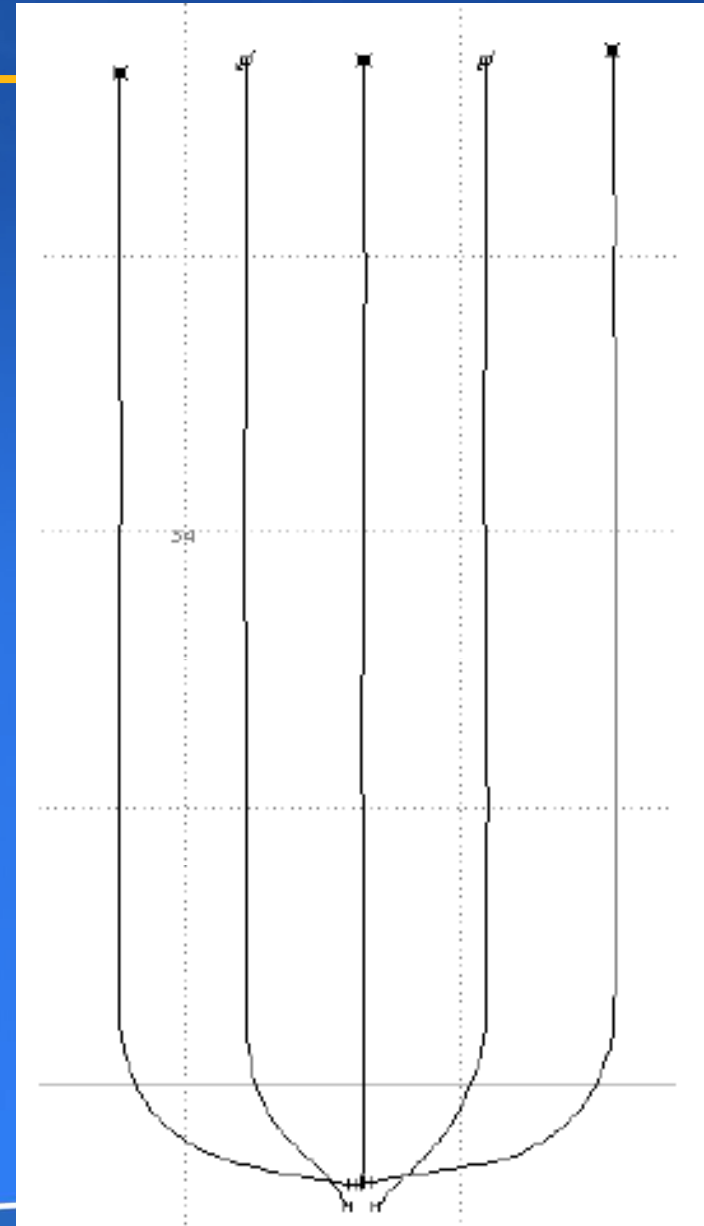
# Polymer Flood in Pelican Lake:

## ✓ Full Field Implementation

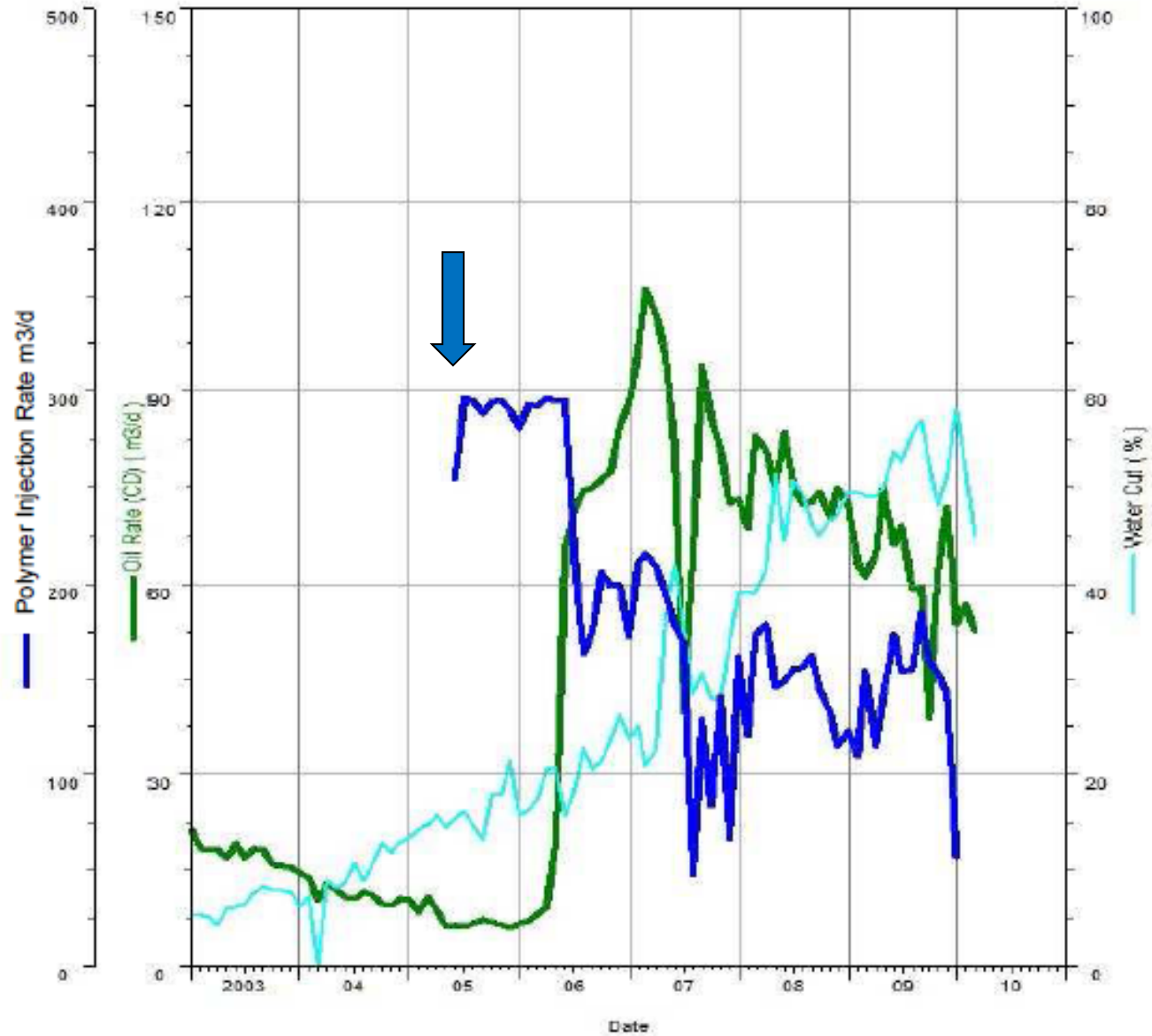


# HTLP 6 Polymer Pilot Schematic

- 2 injectors, 3 producers
- 1400m long lined horizontals
- 175m inter-well spacing
- Injection commenced May 2005



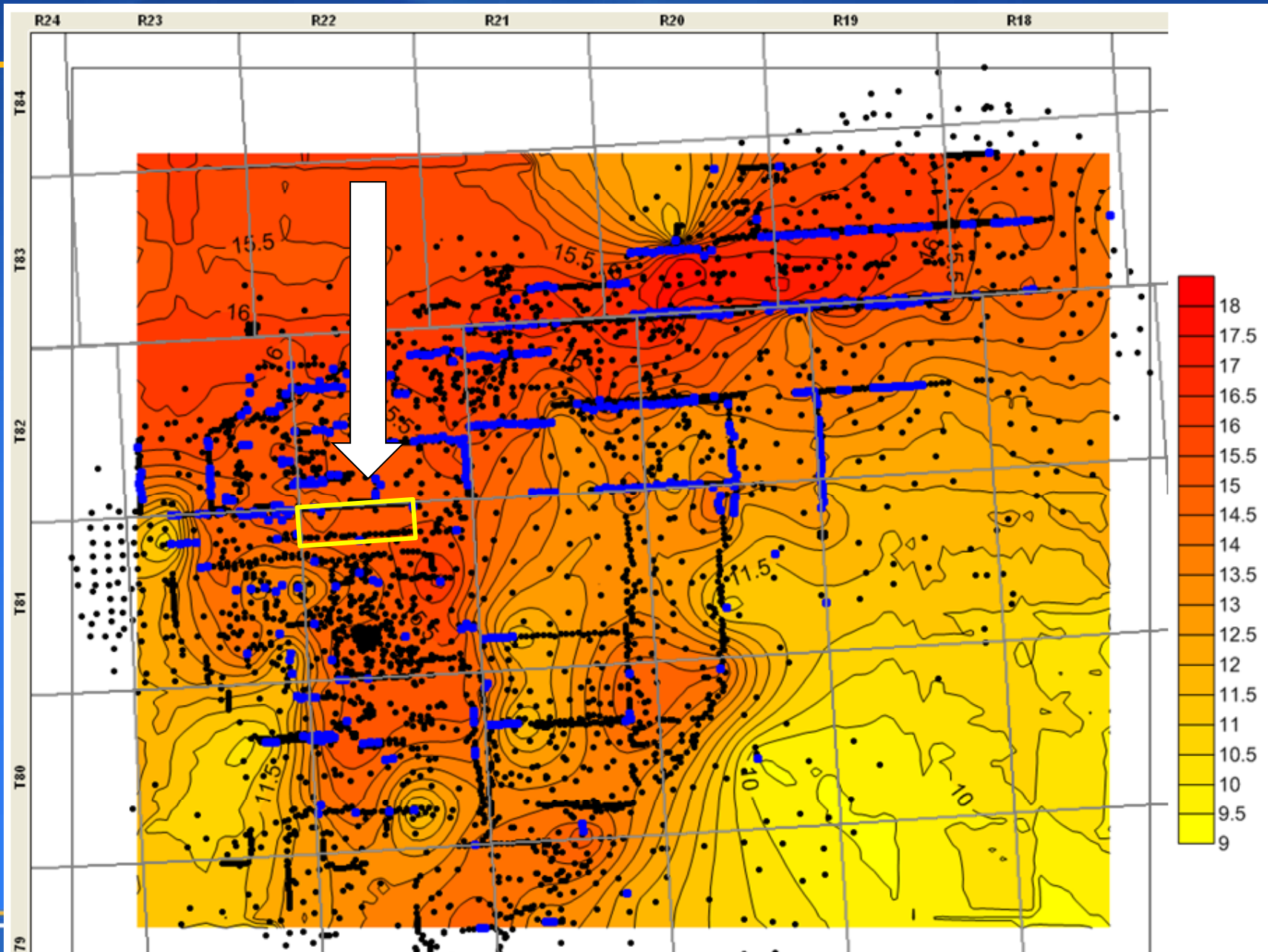
# HTLP 6 Total Pilot Production



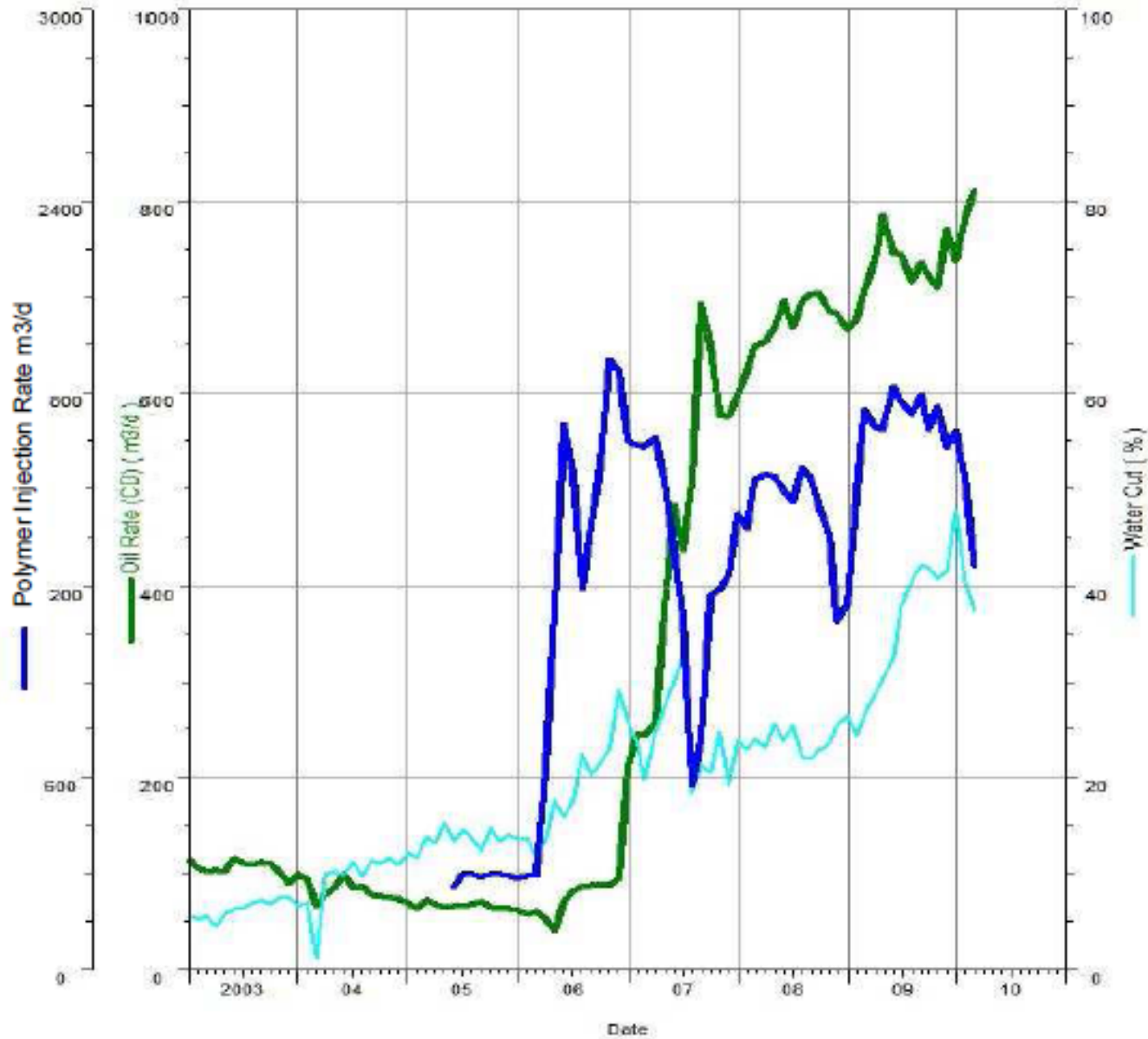
# HTLP 6 Pilot Discussion

- First Polymer Injection in May 2005
- Polymer Response March 2006
- Average watercuts increased, but remain less than 60%
- All previous simulation work had predicted substantial polymer breakthrough by now
- Primary recovery factor was 7.5%, latest incremental polymer flood recovery factor estimate is 15-21%

# Approval 10147 – Expansion of Pilot



# Approval 10147 Flood Area



# Conclusions

- Heavy Oil Reserves Growth is Critical Worldwide
- Heavy Oil reserve growth critically depends upon technology as well as price
- Heavy Oil Waterfloods and Polymer floods have been very successful (***above initial expectations***) but reservoir management is key
- North Sea Development will depend upon adaptation of technology for off shore environments such as ;
  - ICD (profile control, well intervention)
  - Waterfloods at higher water cuts

