

Alberta Department of Energy

**Innovative Energy
Technologies Program**

BRINTNELL FIELD HORSETAIL POLYMER FLOOD PILOT PROJECT

Canadian Natural Resources Limited

Annual Report

June 25th, 2008



**Innovative Energy Technologies Program
Project Annual Report Requirements**

Summary

Canadian Natural Resources Limited has completed another successful year operation at the Brintnell polymer flood pilot. This year has provided CNRL with some additional data on the flood, operations at the pilot has been fairly consistent over the last 12 months. Continued results are still very positive.

The subject project is a pilot designed to evaluate the feasibility, both technical and economic, of polymer flooding in the Wabiskaw zone of the Brintnell Field within the Pelican Lake area. With the continued success throughout the year, the pilot has proven to be both a technical and economic success. Continued operation and reservoir experience have been gained throughout the year.

Currently there are two polymer injectors with three offset producers comprising the pilot pad. The two injectors have been on continuous injection since the start of the pilot. Since last report, oil production has varied, but has generally been flat for the last 12 months. Average water cuts have increased from approximately 40% to currently 50%. This increase though measurable, has not affected the oil rates, or caused any problems producing the wells. This continued slow breakthrough of the injected polymer has continued to exceed the initial prediction of rapid breakthrough. Increased polymer concentrations are being recorded at the producers, and are included within this annual report.

Chronological Report of Activities

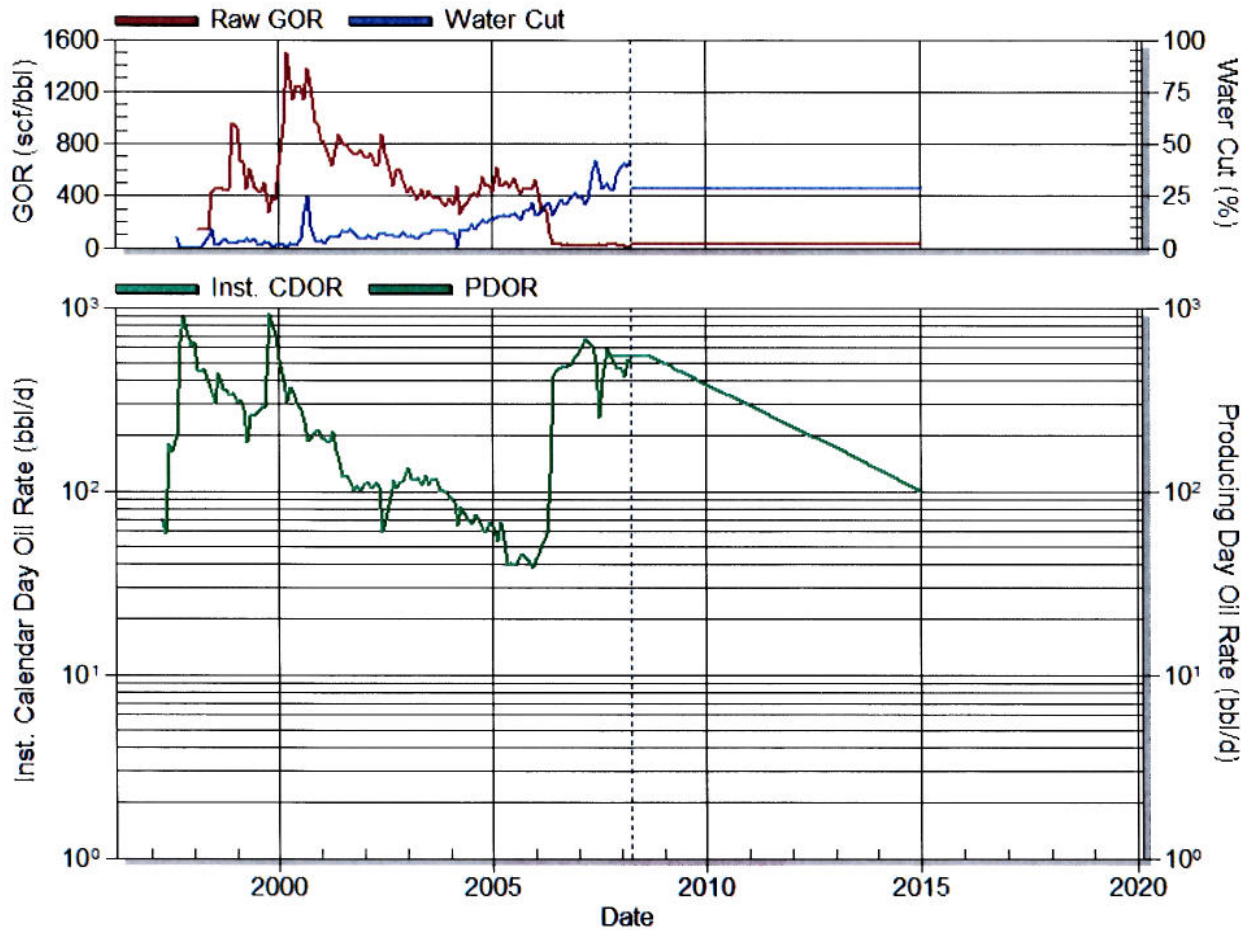
Since the commencement of polymer injection in May 2005 several operational changes have been made. The following is a listing of the date, operation, and impetus for each of the actions taken:

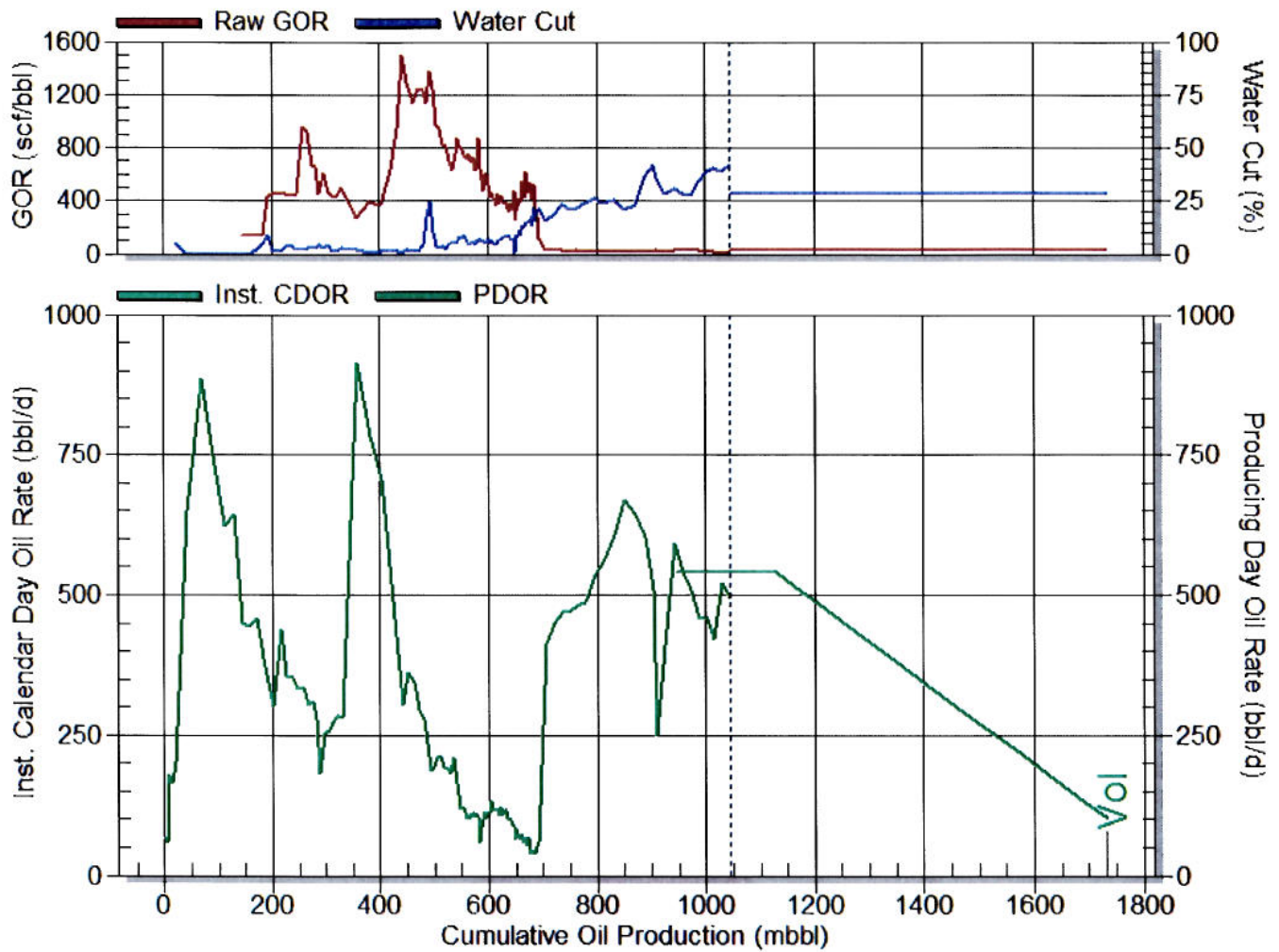
Date	Operation	Impetus
Late August 2005	Viscosity of Injected Polymer Reduced. Reduced from ~20cp to ~13cp.	Following original plan polymer concentration (i.e. viscosity) was reduced once a predetermined pressure response at wellhead was observed.
Sept 22 nd 2005	Received increase to Maximum Allowable Wellhead Injection Pressure (MAWIP) to 7650kPa	Applied for approval in anticipation of exceeding existing MAWIP of 3500kPa.
November 24 th 2005	Switched from higher molecular weight polymer to lower molecular weight polymer.	Pressure at injectors was rising faster than anticipated. Hypothesis was that there may be plugging of pore throats due to high molecular weight (and hence molecule size) of polymer. The switch to lower molecular weight polymer (12 Daltons vs. 20 Daltons) was an attempt to ensure skin damage was not a driving factor in developing pressure at the injection wellhead. Decreasing molecular weight necessitated an increased concentration of polymer to maintain viscosity.
April 20 th 2006	Pump Change at 00/15-34-081-22W4M.	Increasing fluid levels at this producer necessitated a larger downhole pump to move the fluid efficiently i.e. Production Response.

June 4 th 2006	Pump Change at 00/14-34-081-22W4M.	Increasing fluid levels at this producer necessitated a larger downhole pump to move the fluid efficiently i.e.
October 11 th 2006	Pump Change at 00/16-34-081-22W4M.	Increasing fluid levels at this producer necessitated a larger downhole pump to move the fluid efficiently i
July 2007	Production was shut in for 10-14 days	Problems at the central treating facility were being caused by polymer being produced from these wells. A treating chemical change was made and no problems have occurred since.

Updated Incremental Reserves and Production

The recent production has performed as expected as can be seen from the plots below.





With an additional year of production information, and rates that have met expectation, and the estimated ultimate recovery remains at 17% of OOIP.

Wabiskaw Reservoir Characterization – Horsetail Polymer Flood Pilot

The Wabiskaw member is the basal unit of the lower Cretaceous Clearwater Formation and is informally subdivided into three sands encountered downhole as the “A” sand, “B” sand, and “C” sand respectively. The three sands of the Wabiskaw represent a prograding shoreface-attached bar complex overlying the fluvial to restricted bay sediments of the McMurray Formation, and capped by the transgressive marine shale of the Clearwater Formation. The three coarsening-upward Wabiskaw sands are separated by shale and range in thickness, saturation, and permeability with the “A” sand being the thickest and most prolific reservoir in the Brintnell area. The “A” sand is a continuous and homogenous northeast-southwest trending body that ranges from 4-7 meters in the CNR Brintnell area with an average thickness of 5 meters.

Internally the “A” sand can be further divided into three locally mappable facies based on sedimentary and electric-log character as shown in the table below:

Geological Properties by Facies

	Facies 1	Facies 2	Facies 3
Thickness	0.1m	2.0 m	2.0 m
Porosity	25	31	27
Kh	878	2900	1500
Kv	*598	*1600	*750
Oil Sat.	41	65	55
Water Sat.	59	35	45

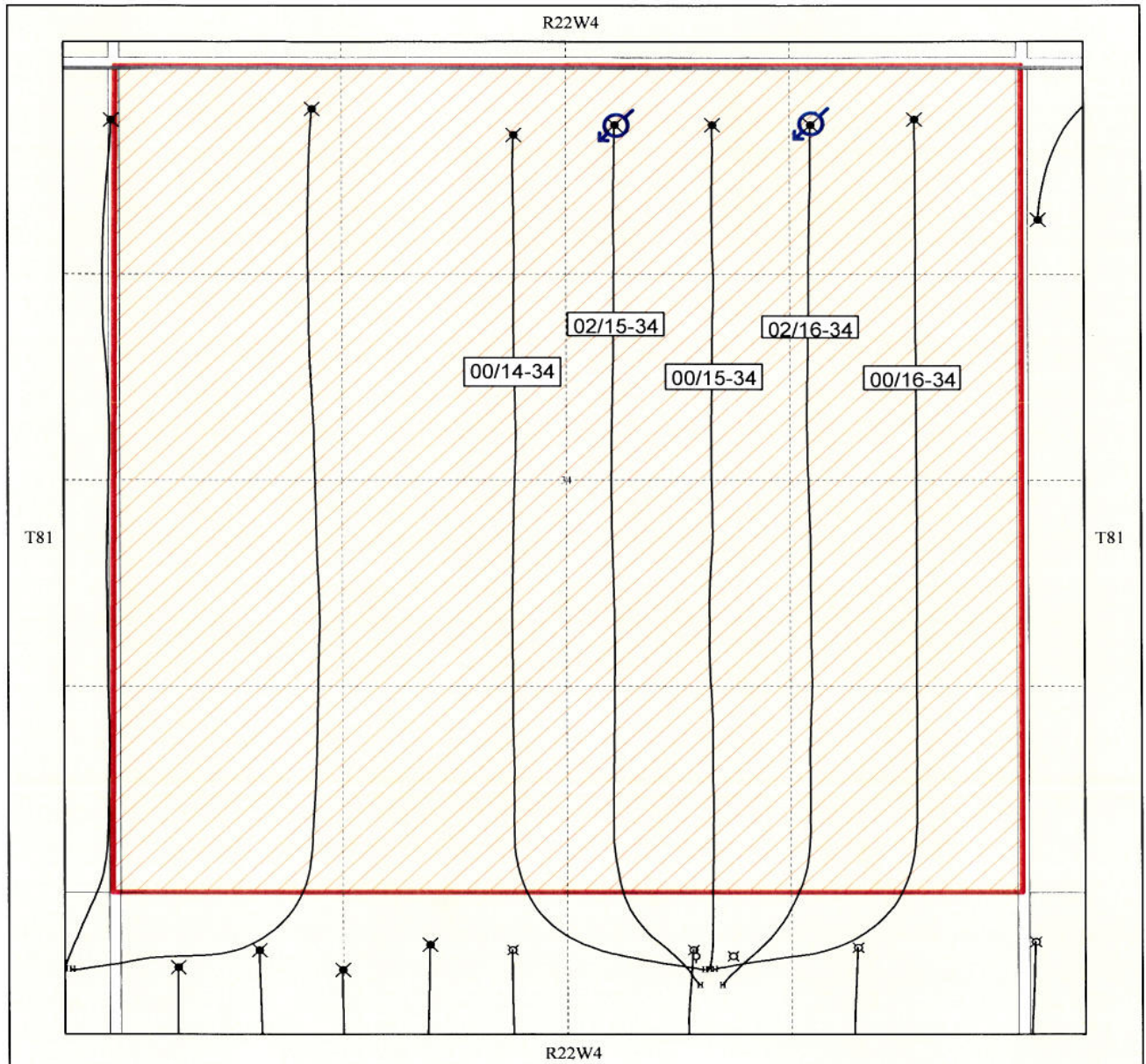
Core: 00/06-11-082-22W4 *Inferred from Kh/Kv ratios in nearby wells.

Facies 1 comprises the uppermost sediments in each well with an average thickness in the application area of 30 cm. Facies 2 is the main reservoir body, harboring the highest oil saturation, porosity, and permeability, with an average thickness of 2.5 meters in the application area. Facies 3 comprises the lower sediments of the Wabiskaw “A” sand at Brintnell with an average thickness of 2 meters and displays slightly lower saturation and permeability due to increased laminated and dispersed mud.

All three facies share a similar composition including a predominance of quartz grains and chert that appear subrounded to subangular and well-sorted. Glauconite is present in the Wabiskaw as well as fines consisting of Illite, Chlorite, Kaolinite, and Smectite. Facies 2 contains the most effectively sorted and coarsest sediment with an upper fine-grained sand. The matrix is unconsolidated sand with disseminated fines decreasing upwards through Facies 3 and Facies 2 before reappearing and decreasing pore space in Facies 1.

Structure in the pool dips slightly to the southwest with no bottom water present in the Brintnell area north of Township 78. Gas is present in small isolated pockets based on electric-log mapping. There are no known gas caps within the proposed injection patterns.

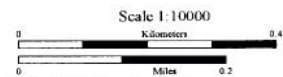
Well Layout



WELL LEGEND	
Bottom Hole Locations:	
◇ Suspended	▣ Service or Drain
⊗ Heavy Oil	

PROPRIETARY DATA LEGEND	
Regions:	
▨	CNRL Proprietary Land
■	Solid

Canadian Natural Resources	
HORSETAIL POLYMER PILOT	
Figure 3- Injector Pattern	
<small>Created in AccuMap™ Product of IHS Energy Edition: NA03.27 Vol. 15 No. 03, Mar. 2 2005 (403) 770-8566</small>	<small>Author: RZ Date: March 24, 2005 File: Injector plan for AE.MAP Scale: 1 : 10000</small>



The wells shown above are offset 175m in the East-West direction and are approximately 1375m in lateral length. Patterns are inferred to be centered on each injector with the centre well (00/15-34) contributing 50% of it's production to each injector and the two outside producers allocated 100% to the nearest offset injector.

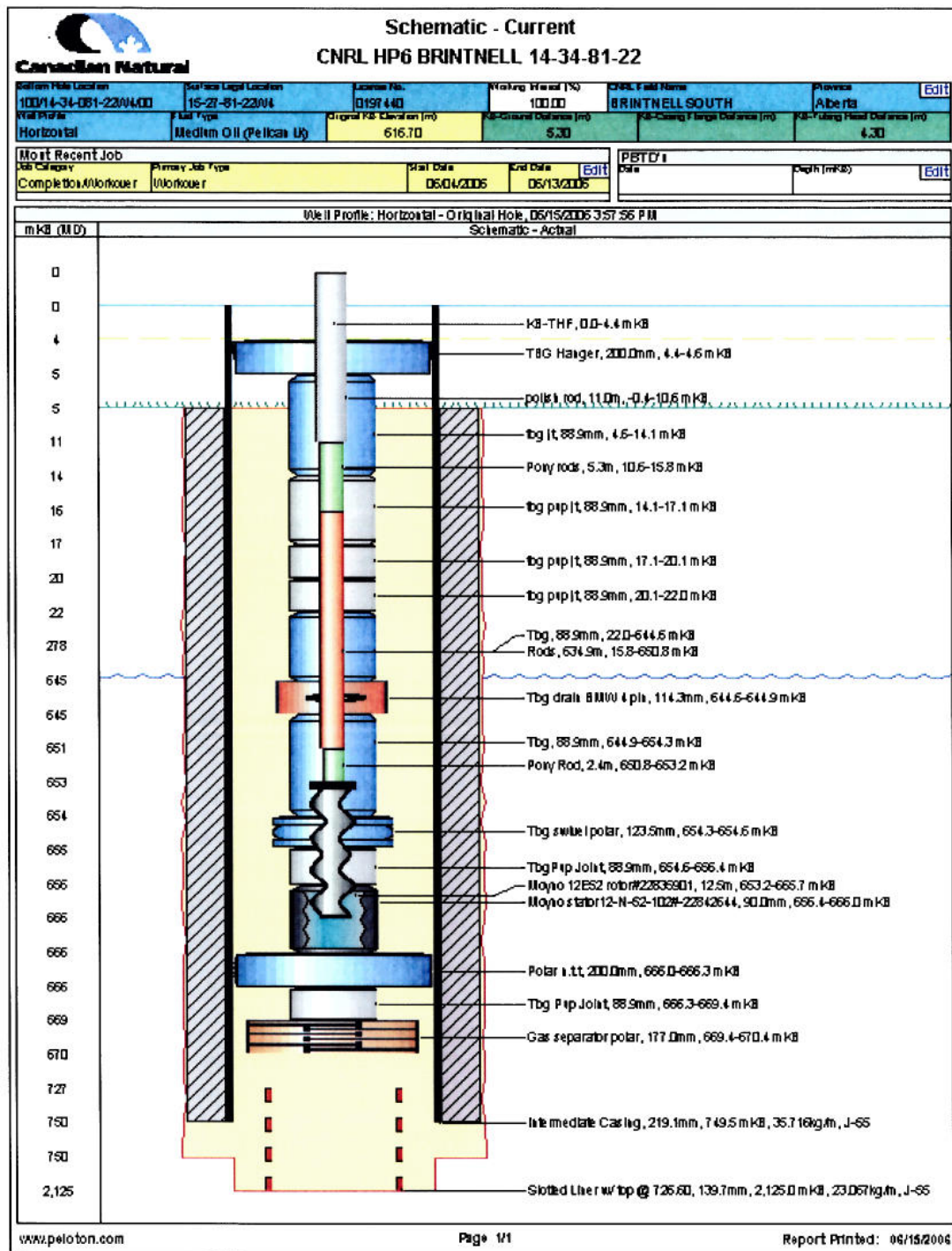
Well List and Details

UWI	Licence #	Well Name	TV Depth	R/R Date	Status
00/16-34-081-22W4/0	197442	CNRES HZ BRINTNELL 16-34-81-22	412.3	03/12/1997	Producer
02/16-34-081-22W4/0	223817	CNRES HZ BRINTNELL 16-34-81-22	409.9	08/03/1999	Poly Injector
00/15-34-081-22W4/0	197441	CNRES HZ BRINTNELL 15-34-81-22	412.2	03/02/1997	Producer
02/15-34-081-22W4/0	223816	CNRES HZ BRINTNELL 15-34-81-22	409.6	08/09/1999	Poly Injector
00/14-34-081-22W4/0	197440	CNRES HZ BRINTNELL 14-34-81-22	411.9	02/22/1997	Producer

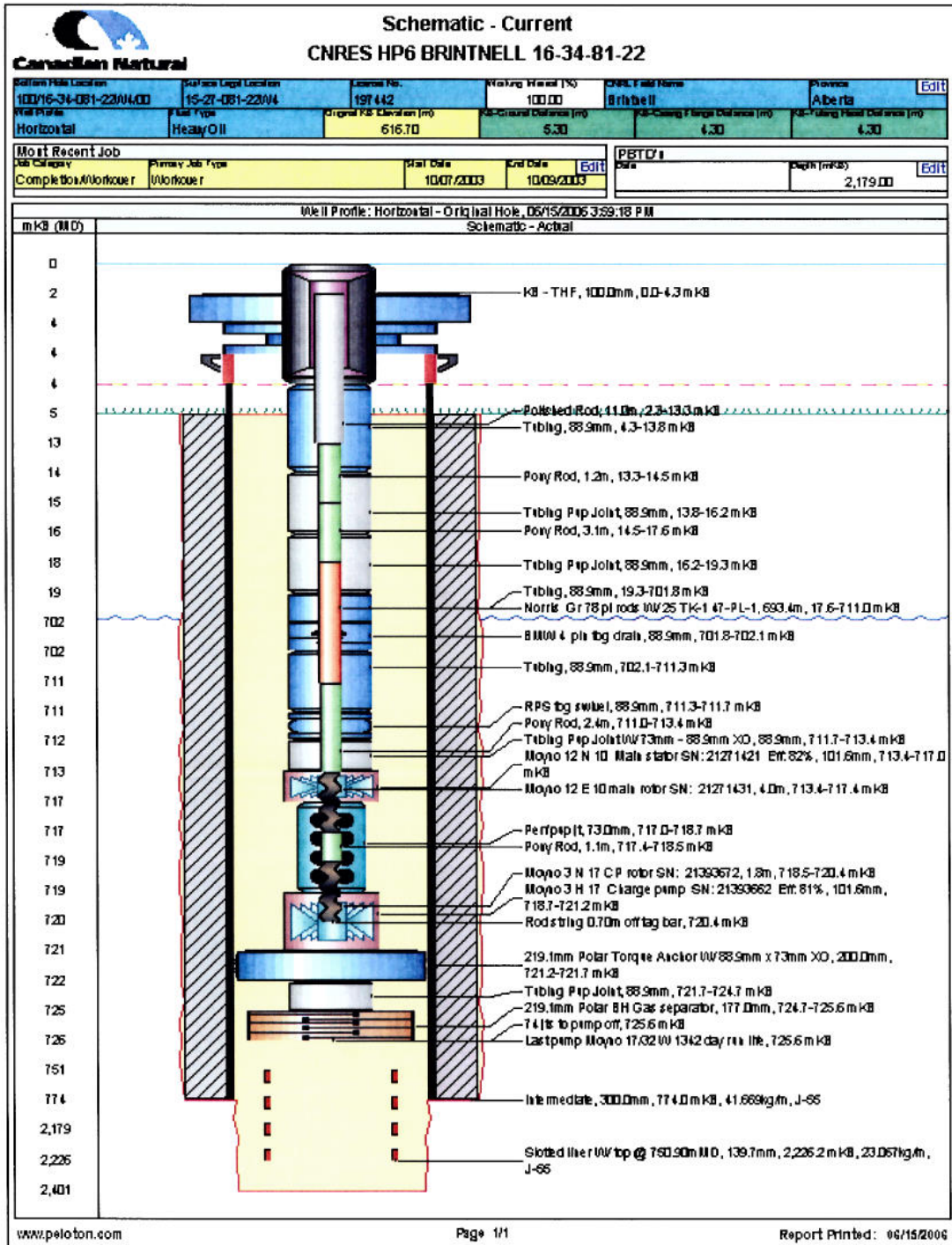
The following pages contain the wellbore schematics for the above wells involved in the polymer pilot.

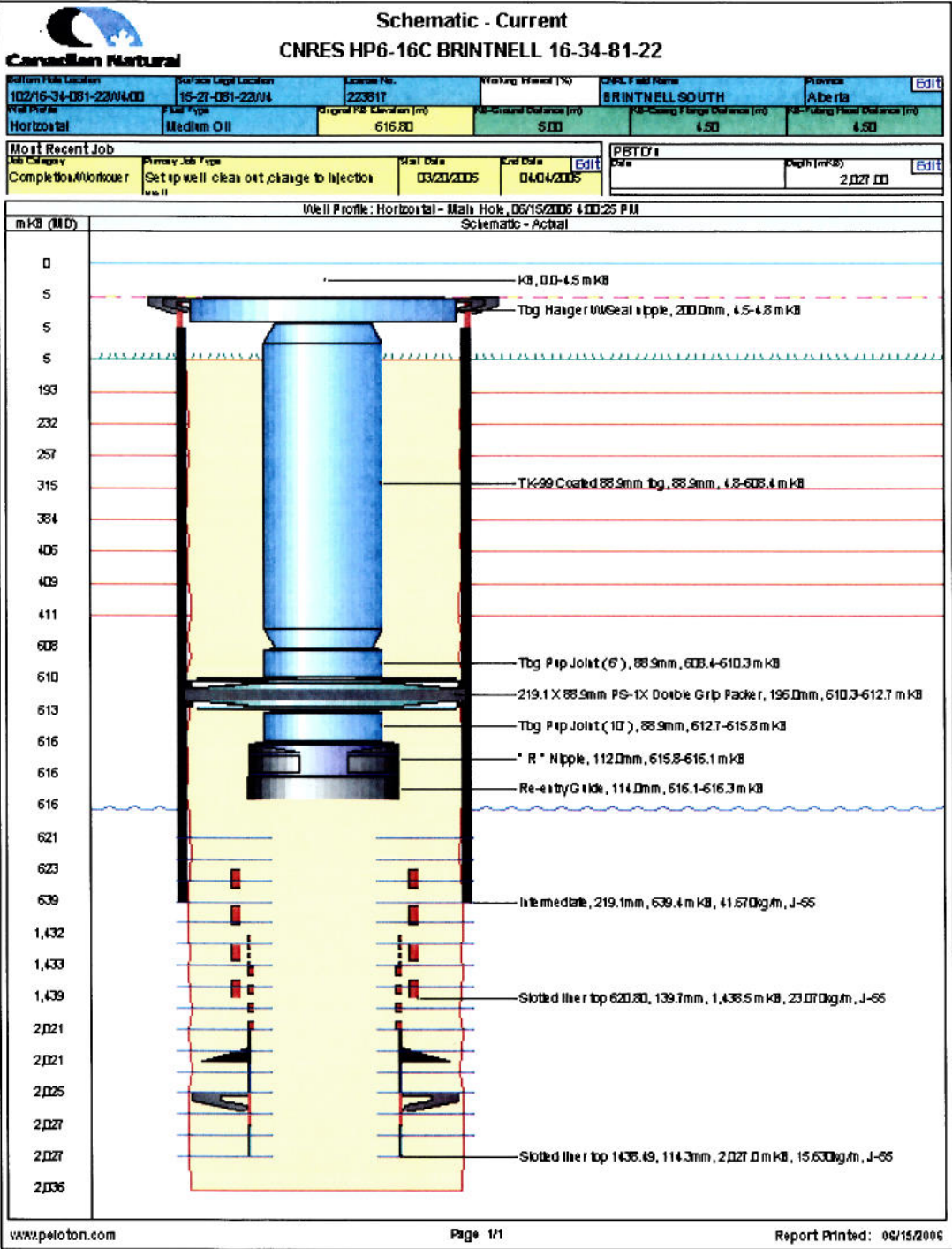
Wellbore Schematics

Producers:



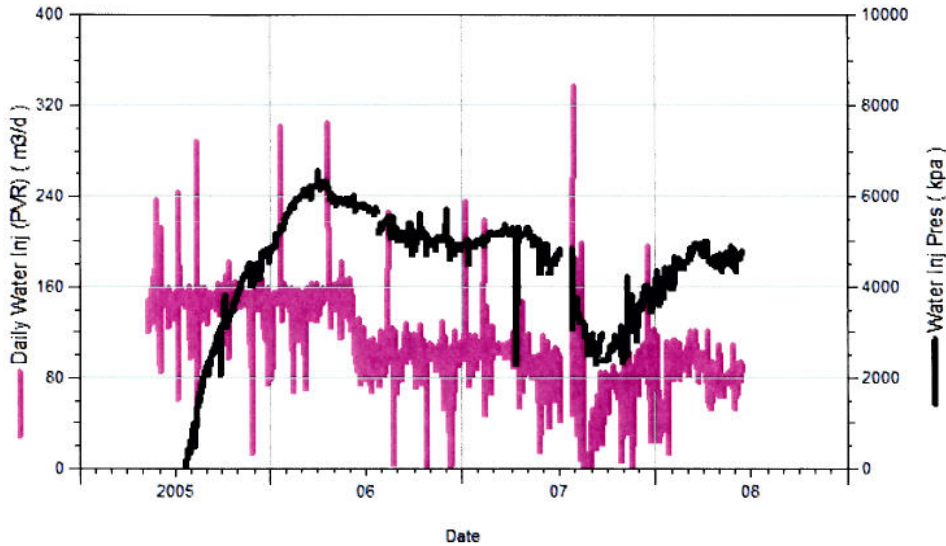
Injectors:



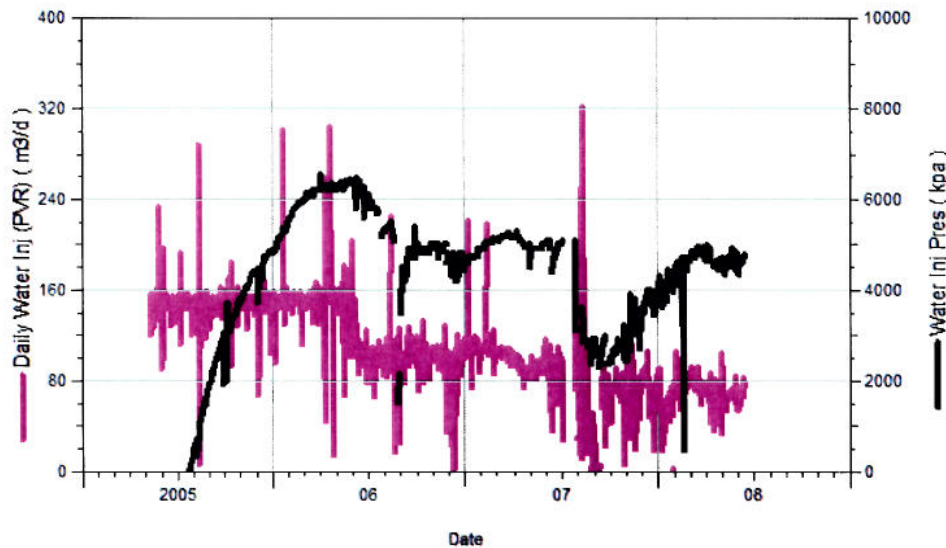


Production / Injection Performance and Data

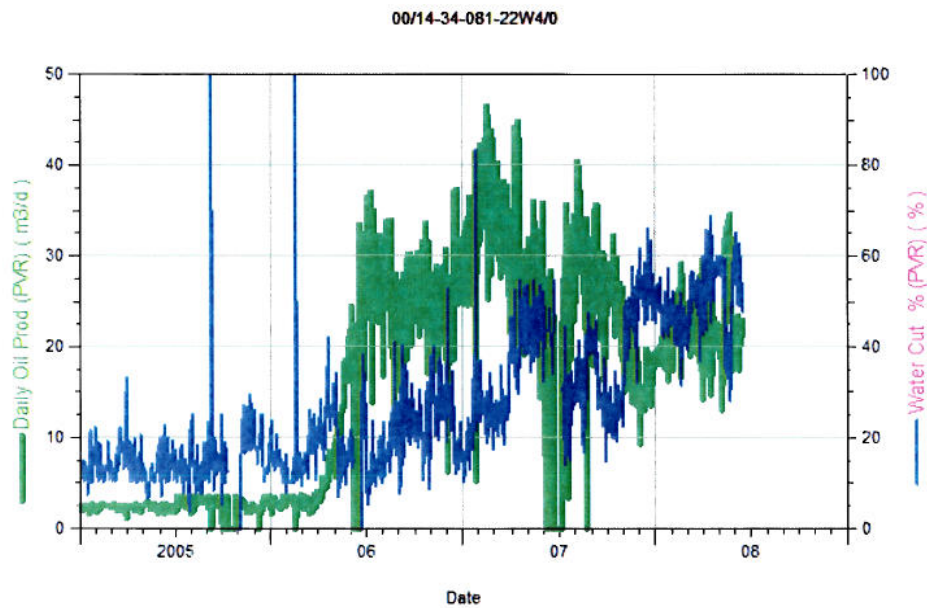
Below are individual and group plots for the wells included in the polymer pilot. Injection volumes and pressures are plotted against time with production volumes and cuts done on the same scale.



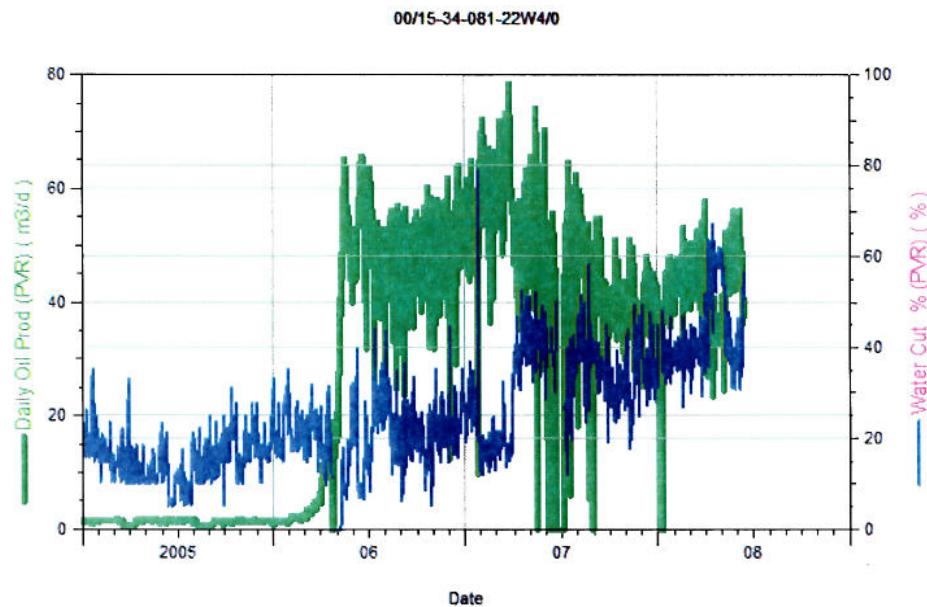
The 15-34 polymer injector has behaved as expected. As the pattern approached fillup the pressure began to level off. In the last year injection pressure was lost due to a shut in of injection during June of 2007 and some reduced injection rates. Recently the injection pressure has remained flat, at close to our maximum injection pressure.



The 16-34 polymer injector has performed very similar to the 15-35.

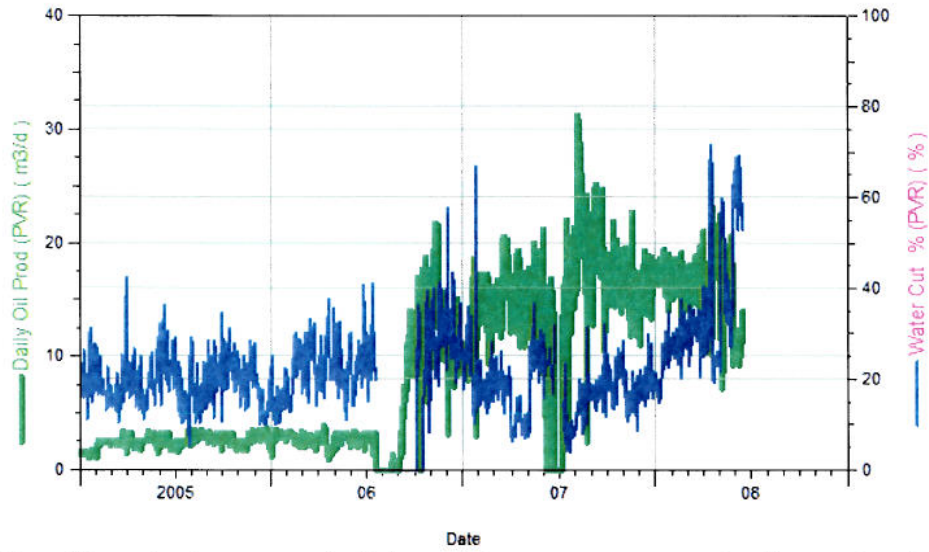


The 14-34 producer which offsets the 15-34 injector on the West has shown a reduced oil rate over the last 12 months as the total watercut has increased.

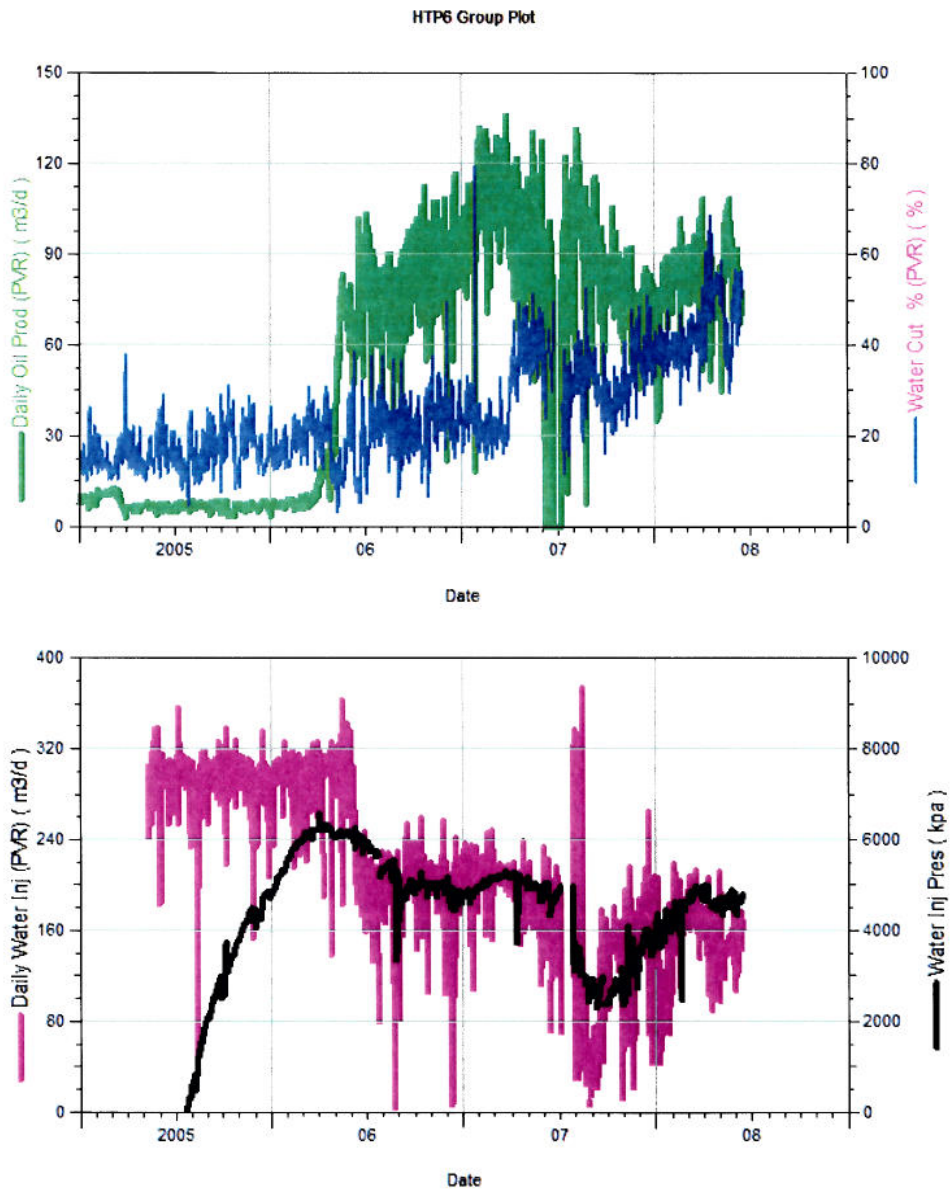


The greatest production response has been observed at the 15-34 producer. Intuitively this makes sense as this producer is in the middle of the two polymer injectors and thus is receiving support from both directions. Production over the last 12 months has been flat to slightly increasing throughout the year.

00/16-34-081-22W4/0



The 16-34 well on the far east end of the pad has now seen mostly flat production throughout the year, with a sharp increase in watercut in the last month.



The above plot shows the entire pilot area. As can be seen the production response (oil shown in green) has been relatively flat throughout the past year. The response to date supports the theory being tested that the polymer will allow for pressure response without catastrophic break though early in the program. Constant learning's are occurring as we monitor the production response at the producers.

Wellhead Fluid Composition

Injected viscosity over the last year has targeted 25 cp. The injected Polymer since 2005 has been SNF 3630 polymer with a relatively low molecular weight.

Predicted Vs Actual Performance (Simulation Work)

Early in 2006 IFP produced an updated set of predictive runs to better match the actual pressure profiles of the polymer injectors. Originally the simulations predicted a much more gradual rise in pressure over time. Changes to estimates in rock compressibility and absolute permeability have allowed much better history matching with the data obtained over the past year. Canadian Natural has chosen not to perform any additional simulation work. Additional core flood work is being evaluated and is planned to start in late 2008.

Details of the IFP report were included in the 2006 Annual Report.

Pilot economics to date

Updated information is included in Appendix A:

- Sales volumes of natural gas and by-products.
- Revenue.
- Capital costs (include a listing of items with installed cost greater than \$10,000).
- Direct and indirect operating costs by category (e.g. fuel, injectant costs, electricity).
- Crown royalties, applicable freehold royalties, and taxes.
- Cash flow.
- Cumulative project costs and net revenue.
- Explanation of material deviations from budgeted costs.

Facilities

Facilities at the polymer pilot site have not been changed at all since installation and commencement of injection. All plans and process diagrams submitted with the original application should be considered valid.

Environment/Regulatory/Compliance

To demonstrate compliance, CNRL has previously included all associated approvals received for the polymer pilot. These include:

1. Alberta Energy and Utilities Board Approval #10147B for Enhanced Oil Recovery (Polymer Injection Scheme)
2. Alberta Energy and Utilities Board Approval for Application 1418578 (Request for Increase of Maximum Allowable Wellhead Injection Pressure) at Pilot Polymer Flood Injector Wells
3. Alberta Environment Water Source Well License Documentation

CNRL is fully in compliance with all regulatory agencies; all applications necessary for operation have been received.

Safety remains a high priority for CNRL and all personnel operating on site are versed in the emergency procedures associated with field operation and all polymer plant specific issues. The emergency response plan for the field includes the polymer pilot pad and all procedures are reviewed periodically to ensure new operating issues and concerns are addressed.

Future Operating Plan

Milestones

- Completed core flood studies, polymer type selection and initial reservoir simulation. Dec 2004 ✓
- Project startup occurred May 3, 2005. Commissioned injection facility and commenced injection of polymer/water mixture. ✓
- Attaining cumulative liquid voidage replacement ratio of 1.0 and first production response. June 2006. ✓
- Attaining peak oil production rate of 750 bopd from the pilot project. February 2007 ✓
- Evaluation of switching from polymer to water injection will occur if polymer breakthrough is significant. Breakthrough has not been significant enough to date to consider.
- Obtaining sufficient production data to extrapolate results to an ultimate recovery with a high degree of confidence. Production is still flat, making an estimate with high certainty still difficult.

Deliverables

- Proof of applicability of polymer flooding as secondary recovery mechanism to increase oil recovery and minimize water use in heavy and medium oil reservoirs similar to the Pelican Lake Wabiskaw reservoir. Proof of success will lead to greatly increased use of polymer flooding, producing oil reserves which would otherwise remain unrecovered.
- Accurate estimates of ultimate recovery factors attainable using polymer flooding in reservoirs of this type.
- Polymer design strategy and optimized operating practices.
- Documentation and resolution of technical problems which may arise during polymer flooding.

Part of the cost optimization strategy will be in determining the timing for the switch from polymer injection to water injection. This will greatly reduce the cost per barrel injected while maintaining the pressure in the reservoir and aiding recovery of the oil resource.

Salvage Update

At such time as abandonment's become necessary all government requirements will be observed in the process.

Interpretations and Conclusions

The subject polymer pilot has shown excellent continued results over the past 12 months. All three of the producers have shown relatively flat response to the polymer injection. This response has been greater than expected at more than 10 times the previous depleted primary oil production. This production response has been constant over the last twelve months with very little if any decline in production noted

CNRL has periodically checked the polymer concentration in the produced water, and current concentrations are 400-450 ppm. As a reference the injected concentrations are 800-1000ppm. The amount of breakthrough has increase over the last 12 months, with average water cuts for the pilot increasing from 40% to 50%.

The challenges that exist with respect to the pilot centre on being the trial run for the polymer injection. Without analogous patterns that have polymer injection there is no basis for comparison. Every effort is being made to make changes to one variable at a time so that there is an easy to establish cause-and-effect trend with the data. Test frequency and data accuracy has been paramount to the success of the pilot and continues to be a high priority as the project moves forward. This pilot has served as the baseline for future expansion and CNRL maintains it's commitment to the integrity of the data being collected on this pilot.

Technical and economic viability are constantly being assessed. With the last twelve months of production the pilot is approaching both a technical and economic success. As more production data is collected the ultimate recovery estimate from the pilot becomes more accurate.

CNRL has proceeded with the expansion of polymer flooding in other areas of the Brintnell Field with the results to date from the pilot. As continued learning's occur from the pilot these are applied to the other expanded polymer flood areas. The pilot continues to be an important learning tool to CNRL. The pilot has the longest, most accurate data on the implementation operation and response from polymer injection.

APPENDIX A

