Agenda

• Introduction to TOP Analysis
  – Top Analysis Software
  – Top Regulatory Software

• Initiatives in oil sands
  – Saskatchewan Developments
    • Previously depleted resource
  – Start up techniques
  – Co-injection
    • Gas
    • Solvent
  – Infill Wells
What is TOP Analysis

TOP Analysis offers multi discipline software solutions designed to expedite the evaluation of thermal developments in Alberta and Saskatchewan. The combination of the TOP Analysis and TOP Regulatory software allows any organization to maintain thermal surveillance with reduced resources.

TOP Analysis Software

- Administered linked wells to pairs, pairs/infill wells to pads and pads to projects
- Volumetric data, well design and operational information such as pressures and temperatures
- Regulatory applications automatically linked to objects within the company tree

TOP Regulatory Software

- A searchable application database updated daily
- Applications available for immediate download
- All AB application and category types, including all SK Thermal applications
Saskatchewan Thermal

Target formations – Mannville group
   – Colony, Cummings, Lloyd, McLaren, Sparky, Rex, GP, Waseca

Smaller prolific channels
   – 3000 – 10000 bbl/d (most recent designs < 6000 bbl/d)
   – 10-15 year resource base

Economic advantages
   – Low capital requirement due facility simplicity (No water recycle, River source typical)
   – Favorable/certain regulatory structure (Short application turnaround)
   – Low OPEX (little to no diluent, Low SOR, reduced emissions implications)

Undisturbed favorable thermal resource limited
   – Significant Husky and CNRL land holdings
   – Existing projects already have extremely small resource base
   – Husky has started its first SAGD project (Edam West) in previous depletion
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Saskatchewan Regulatory

Husky – Edam West (4K bbl/d)
Application Size ~ 11 MB
Application Length ~ 28 Pages
Supplemental Information Requests
- 1 round < 10 Questions
Approval Time ~ 4 Months

Application submission to first steam
~ 16 Months*

*Based on PX/Onion Lake
*Husky/Paradise Hill ~ 12 Months

Athabasca Hangingstone (12K bbl/d)
Application Size ~ 93 MB
Application Length ~ 476 Pages
Supplemental Information Requests
- 2 rounds > 100 Questions
Approval Time ~ 19 Months

Application submission to first steam
~ 48 Months

*Based on PXX/Onion Lake
Post CHOPS potential

Drilling through depletion
- Plan for and manage lost circulation
- Potential variation from planned drilling strategy

Operational challenges
- Bottom water influence more difficult to manage
- Accumulated solution gas could hinder heat transfer (not always bad)
- Conformance impacts
  - Robust downhole completion (ICD’s, rod pumps, high temp ESP’s)
- Operational upsets can result in significant reservoir changes
- Horizontal primary producers increase the potential issues encountered

Benefits
- Potential for larger resource base (vs undeveloped assets)
- Low initial reservoir viscosity
- Shorter start up
- Primary support (thermal and primary drainage)
- Existing infrastructure
Initiatives in Oil Sands

• Co-Injection (~100+ Regulatory Applications)
  – Natural Gas, Solvent, Surfactant

• Infill Wells (~60+ Regulatory Applications)

• Start Up Strategies (~45+ Regulatory Applications)
  – Solvent Soak, Dilation, Solvent Circulation, Electric Heat

• Inflow/Outflow control devices (Applications not always submitted)
  – Longer wells, reduced oil/water contact offset, chamber conformance

• Manipulating Reservoir Characteristics (~5+ Regulatory Applications)
  – Gas cap creation, lean zone dewatering, bottom water de-pressurization
Challenges

The largest challenge facing operators is the uncertainty of the performance of these different initiatives as development moves toward less desirable or unpredictable resource.

• Start Up Strategies
  – Each well needs to be evaluated for the likelihood of **failure** with a given strategy based on both drilling and reservoir characteristics.

• Co-Injection
  – Natural gas timing is crucial depending on its intent
  – Solvent success will vary significantly across each development area

• Infill Wells
  – Infill well timing, capital constraints, energy markets, and resource quality all play an important roll in how an infill well is deemed successful or not
Start Up Strategies

Circulation (Often combined with a bullhead phase)
Bullhead (Steam, Water, Solvent or any combination)
Solvent Soak (Diluent landed in producer/injector prior to start up)
Dilation (Steam, Water, Solvent or any combination)
Electric preheat
Co-injection

- Natural Gas
  - The majority of gas injected is immediately produced
  - Gas production a result of steam sweep, drag and dissolution
  - Partial pressure effect causes cooling and a slowdown of chamber growth
  - The reduction in steam quickly results in a reduction in oil production equivalent to the pre co-injection SOR, with only a short benefit on that wellpair

- Solvent
  - Multiple trials with vaporizing and condensing mixtures (Hexane dominated)
  - The solvent will increase incremental oil rate, but success is ultimately a function of reservoir retention (and surface solvent recovery)
  - Major obstacles are measurement uncertainty, reservoir retention (through losses and pore space retention) and lack of recovery equipment
  - Burning the solvent in boilers configured for natural gas has resulted in significant boiler outage and associated well downtime (from solvent trials)
Injected Fluid Well Counts

bar chart showing well counts by different categories:
- AB SAGD Wellpairs: 1,779 (1,387 have volumes, 392 drill only)
- AB Infill Wells: 28 (263 have volumes, 2 have drill only)
- SK SAGD Wellpairs: 14 (203 have volumes, 1 drill only)
- SK Infill Wells: 1

bar chart showing WP's with co-injection:
- Condensate: 39 (AB) 22 (SK)
- Solvent: 6 (AB) 4 (SK)
- Pentane Plus: 4 (AB) 2 (SK)
- Butane: 2 (AB) 2 (SK)
- Propane: 2 (AB) 4 (SK)
- Natural Gas: 204 (AB) 19 (SK)
- Carbon Dioxide: 4 (AB) 21 (SK)
- Air: 4 (AB)
- Oil: 21 (AB)
Infill Well Performance

• Analysis is often difficult as no reservoir or even wellpad has consistent well performance which ultimately drives infill well success

• Recovery of offsetting wellpairs (timing of infill well)
• Resource quality and unique characteristics (ex. Varying viscosity gradient)
• Parent wellpairs steam chamber shape
  – Lower conformance is often a driver of success of an infill well as it helps with initial communication
• Wellpair separation and reservoir thickness
• Presence of bottom water and associated landing depth
• Start up strategy and completion
Infill Timing – Cum Recovery Impact

Cumulative Oil

Volume (bbl)

Month

0 12 24 36 48 60 72 84 96 108 120 132

8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0

Infill Well Online
Solvent Co-Injection

Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
Group 7
Group 8
Group 9
Group 10
Group A
Group B
Group C

CVE/CL Pad B01/B02
Infill Timing – Cum Recovery Impact

Cumulative Oil

Infill Well Online
Gas Co-Injection

Volume (bbl)

Month

Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
Group 7

MEG/CL Pad A01
Infill Timing – Cum Recovery Impact

HSE/Lashburn Pad L7 (Waseca Formation)
Thermal development forecast

• Lower tier asset development
  – Previously exploited resource thermal developments (SK)
  – Subsurface patterns with thinner pay, more bottom water, presence of lean zones and general lower quality resource
  – **Longer circulation periods**, reduction in peak rates, an increase in SOR and ultimately an increase in downhole equipment and capital

• Longer wells, often at the sacrifice of recovery factor
  – ICD and completion optimization will help reduce RF impact

• Reduction new pad development cost through turnkey offerings
  – Corporate structure and philosophies will have to change
Questions/Comments?