Big Sand Draw Tensleep
A Unique CO₂ EOR Opportunity

2014 Wyoming EORI CO₂ Conference
July 9/10, 2014
Beaver Creek Madison Update

Big Sand Draw Tensleep

Location and Scoping
Geology
Production history
Reservoir characterization
Analogy
EOR Design
Model forecast response
Field work
Additional activities
Geologic Properties
Matrix – Limestone/Dolomite
Productive Area – 914 Acres
Depth – 11,235’ TVD
Oil Column – 828’
Net Pay – 212’ avg.

Reservoir Properties
Porosity - 10%
Permeability – 9 md. Avg.
$S_{wi}$ - 8 to 10%
Temperature – 234º
Oil Gravity – 39.5º API
Oil Viscosity - .64 cp (orig.)
MMP – 2650 psig
Beaver Creek Madison
CO₂ Flood Response and History

Initial response
November 2008

Initial CO₂ Injection
July 2008

Peak Rate 5540 Bopd
November 2012

Cumulative Oil Produced
since flood start = 7.0 MMbo
Big Sand Draw Field
Geographic locator

Wind River Basin

Beaver Creek

Big Sand Draw

CO₂ Pipeline

Lost Soldier Field
Supporting Factors

- Reservoir & Geological characterization identifies positive attributes consistent with successful CO₂ floods
- Very high primary recovery to date of 39% OOIP
- Analogous fields successfully CO₂ flooded
- Reserve Potential of up to 26-31 MMbo enhanced recovery reserves
- Favorable oil price
- Proximity to Beaver Creek and Devon CO₂ pipeline
- Experience in design, construction and management
Big Sand Draw Tensleep
Geology & Reservoir

Geologic Characteristics
Eolian Sandstone
Approx. Prod. Area = 1000 Acres
Approx. Oil Column Height = 980’
Avg. Net Pay Thickness = 307’
Avg. Depth to Tensleep Top = 7,669’

Reservoir Characteristics
Porosity = 13.8%
Permeability = 91 md
Reservoir Temp = 175-180°F
BHPi = 3303 psia
Swi = 10-43% (not yet determined)
Oil Gravity = 34.6° API (1.2% Sulfur)
Big Sand Draw Tensleep Production History (1945-2013)

1st Production: 1945 (17 Initial Wells + 23 Infill)
Peak Rate: 8600+ Bopd (1954 – 12 Wells)
Cum Oil: 55 MMbo (42% OOIP)
Rem: 0.3 MMbo
Current Rate: 110 Bopd + 49,000 Bwpd (16 current active completions)
BSD #26

Porosity vs. Permeability

**Average**
- Porosity = 15.3%
- Permeability = 69 md
EORI Lab Results (Sheena Xie, Rituraj Borgohain, Haifeng Jiang, Curtis Chopping, Tashi Herzmark)

- 33.7° API Gravity
  - 4.2% wax & <1% asphaltenes
  - Wax precipitation @ 70.9°F
- Slim Tube MMP 2700 - 2800 psi
- Rising Bubble MMP 2502 psi (Hycal)
- Swelling test
- Viscosity reduction from 2.6 cp to 0.6 cp at 60 mol% CO₂@ 3000 psi
Lost Soldier Field
CO₂ Flood Analogy for Big Sand Draw

• 48 miles SE of Big Sand Draw Field
• Tensleep producing formation
• Comparable reservoir and geology to BSD
  - Faulted anticline
  - 108 completions
  - 1402 acres
  - 5000’ depth (avg)
  - BHPi = 2520 psig
  - 35° gravity oil
  - Net pay = 210’ avg. 9.9% porosity & 31 md.

• OOIP = 240 MMbo
• Primary + secondary recovery
  = 101.7 MMbo (44% OOIP)

Lost Soldier Tensleep
Production History

Enhanced incremental recovery = 33.4 MMbo (13.9% OOIP) to date

CO₂ Flood Start January 1989
Future Operations

- 19 Injectors
  - 10 new drill
  - 9 conversions
- 26 producers
  - 9 new drill
  - 17 existing wells
- Multiple recompletions of producers to chase oil bank down structure
- Production and recycle facilities
- New flow lines and injection lines to be installed
- 175-200 MM$ infrastructure capital
Big Sand Draw Tensleep
Production History plus EOR Projection

Modeled EOR Recovery
>26 MMbo (>20% OOIP)

Estimated Available Records

Oil Rate (Bopd)
Water Rate (Bwpd)
Base Forecast
CO2 Projection
Active Well Count
Extrap Oil
Water Bwpd
Water Cut %
Big Sand Draw
Forecast - Case 1: 2015

Map view

Cross section view

BSD Field Rate Forecast - Final Results

- Oil rate
- CO2 purchase rate
- CO2 recycle rate

Layer 10 of 65
Layer 55 of 65
Big Sand Draw
Forecast - Case 1: 2018

Map view

Layer 10 of 65

Layer 55 of 65

BSD Field Rate Forecast - Final Results

- Oil rate
- CO2 purchase rate
- CO2 recycle rate


0 5 10 15 20 25 30 35 40

Oil rate (bbl/d)

CO2 rate (MMscf/d)
Big Sand Draw Forecast - Case 1: 2019

Map view

Layer 10 of 65

Layer 55 of 65

Cross section view

BSD Field Rate Forecast - Final Results

Oil rate [bbl/d]

CO2 rate [MMScf/d]
Big Sand Draw
Forecast - Case 1: 2020

Map view
Cross section view

BSD Field Rate Forecast - Final Results

Layer 10 of 65
Layer 55 of 65
Big Sand Draw
Forecast - Case 1: 2025

Map view

Layer 10 of 65

Layer 55 of 65

Cross section view

BSD Field Rate Forecast - Final Results

Oil rate (bbl/d) vs. CO$_2$ rate (MMscf/d)

- Oil rate
- CO$_2$ purchase rate
- CO$_2$ recycle rate
Big Sand Draw
Forecast - Case 1: 2030

Map view

Cross section view
Big Sand Draw
Forecast - Case 1: 2035

Map view

Layer 10 of 65

Layer 55 of 65

Cross section view

BSD Field Rate Forecast - Final Results

Oil rate (bbl/day)

CO₂ rate (MMscf/d)


Oil rate
CO₂ purchase rate
CO₂ recycle rate

BSD 20
BSD 21
BSD 22
BSD 23
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BSD 99
BSD 100

A

B
Big Sand Draw
Forecast - Case 1: 2040

Map view

Cross section view

BSD Field Rate Forecast - Final Results

Layer 10 of 65

Layer 55 of 65
Big Sand Draw
Forecast - Case 1: 2050

Map view

Cross section view

BSD Field Rate Forecast - Final Results

- Oil rate (bbl/d)
- CO2 purchase rate
- CO2 recycle rate

Layer 10 of 65
Layer 55 of 65
Big Sand Draw
CO₂ Flood Facilities

- New injection lines & wellheads (carbon steel)
- Electric Generation 5.6 MW Total Load
- Plant and Recycle Compression 30 MMCFD CO₂ Capacity
  - Expandable to 60 MMCFD Capacity
  - 2 Compressors in 4th Qtr ‘14 followed by 2 add’l units
  - Operating at 400 - 2,000 psig
- Production Facility - 400 psi Inlet
  - Higher pressure production flowlines & wellheads
  - Compression reduced to 2 stages - Lower LOE
Big Sand Draw Tensleep
Implementation Challenges

- BLM - Permitting
- Wildlife Stipulations
- Short construction window (Modular construction to help expedite)
- Electric Power
- Old Field (1917) with Excavation Hazards
- CO₂ Supply
Big Sand Draw Construction is Underway!
Big Sand Draw Tensleep
Current Project & Facilities Status

• Workovers - 10 of 22 completed

• Drill Wells
  - 12 of 12 drilled
  - 9 of 12 completed

• Injection header system complete
  - Injection initiated 4/24/2014- Four wells
  - Seven injection wells currently injecting
  - Injection flow lines 95% complete

• Production flow lines
  - 90% complete in south
  - 60% complete in north

• Production facilities
  - Foundations initiated
  - Delayed due to air permit
  - March 2015 projected start up
Currently coring BSD #62 for analysis
- Oil saturations
- Rel/Perm
- Por/Perm
- Vertical Permeability
- Core flood experiments
- Natural fracture characterization

Seismic shoot starting July/August

Possible model update with new data
Thank You.

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