Charlton 30/31 Field Development Project
Final Design Presentation: 4/30/2016

Prepared for:
The Attendees of the Spring 2016 Undergraduate Research Day

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Introduction

• Optimal Development of the Charlton 30/31 Oil Field
  **OBJECTIVE**: Use static and dynamic models to find optimal well placement
Presentation Outline

• Project Schedule
  • Workflow
  • Gantt Chart
  • Risk Analysis

• Static Model

• Dynamic Model

• New Well Placement: Cases 1, 2, and 3
  • Simulated Future Production
  • Economic Analysis
  • The Case for Optimization
  • Permitting

• Conclusions and Final Remarks
Condensed Gantt Chart

Design Phase
• 9/14/15 to 12/13/15

Phase 1 – Formation Properties
• 10/26/15 to 1/30/16

Phase 2 – Static Model
• 10/26/15 to 1/30/16

Phase 3 – Dynamic Model
• 1/31/16 to 4/9/16

Phase 4 – Economic and Environmental Analysis
• 2/21/16 to 4/30/16
Design Phase

- Team Selection and Contact Information
- Vote on and Acquire Project
- Organize Given Information
- Specify Project Phases and Assign to Individuals
- Time Schedule: Gantt Chart
- Risk Analysis
- Initial Final Design
- Final Design
- Execute Design?
  - Yes: End Phase
  - No: Repeat

If the answer to 'Execute Design?' is No, the process loops back to 'Initial Final Design'.
Phase 1 – Formation Properties

Phase 1: Determine Formation Properties

- Analyze Well Logs
- Review Literature
  - Fluid Properties
  - Rock Properties
  - Historical Geology
  - Fluid Properties

Well Locations, Depth, and Geometries

Does Well Log Data match Literature Review?
- Yes
  - End Phase
- No

End Phase
Phase 2 – Static Model

Begin Phase

Phase 2: Load Data Into Petrel

Interpolate Logs and Develop Reservoir Properties Based on Literature Review

Do Static Model and Research Agree?

Yes

End Phase

No
Phase 3 – Dynamic Model

1. Begin Phase

2. Phase 3: Choose Appropriate Dynamic Model Simulation Package

3. Load Static Model into CMG

4. Apply Fluid Properties to Model

5. Refine Dynamic Model Through History Matching of Available Well Data

6. Dynamic Model

7. End Phase
Phase 4 – E & E

Phase 4: Economical and Environmental Analysis

- Acquire Permitting
- Create an Optimization Scenario and Input into CMG
- Calculate NPV, IRR, Payback Period of Scenario

Economic and Environmental Optimization?

- Yes: New Wellbore Locations for Optimization of Charlton 30/31 Field
- No: End Phase
Risk Analysis

- Phase 1: Data & Literature Review
- Phase 2: Static Model
- Phase 3: Dynamic Model
- Phase 4: Economics & Environment

Probability

Impact

- Low
- Moderate
- High
Static Model

- Available Data
  - Well Logs
    - Porosity
    - Water Saturation
    - Permeability
  - Seismic
  - Probability Information for Well Logs
- Interpreted Data
  - \( S_0 = (1 - S_w) \)
- Petrel
  - Built a 62ft x 62ft grid
  - Input Data
  - Up-scaled Well Logs for Properties
Static Model

Validation: Matching Toelle (2012)
• Topography Courtesy of Toelle (2012)
• Comparison to Seismic
• Sequential Gaussian Simulation
Static Model: Comparison to Toelle (2012)

Team #3  
Vs.  
Toelle (2012)
Static Model

Saturation of Oil

Permeability
Dynamic Model CMG

Variables Given
- Horizontal Permeability
- Porosity
- Oil Saturation
- Reservoir Top
- Reservoir Bottom
- Reservoir Thickness
- Bubble Point
- Reservoir Temperature
- Oil Density (API)

Variables Assumed
- Vertical Permeability
- Rock Compressibility
- Gas Density
- Production Data

Variables Generated
- Relative Permeability
- Capillary Pressure
- J Functions
- Dispersion Coefficients
- Endpoint Saturations
Dynamic Model CMG

• Problems with Production Data
  • Production Data Started January 1982
  • Each Well Had Matching Data
  • P&A Wells Had Production Data
  • Missing Data in Early 1990’s and Late 2000’s
  • No Dump Flood Production Data

• Problems with History Matching
  • No Injection Data
  • Simulation Indicated That Gas Was Present
Oil Production Data

- Actual Produced Oil ~2.4 MMBO
- Model Produced Oil ~136.3 MBO
Well Placement Scenarios

- Case 1
- Case 2
- Case 3

Porosity

- 8%
- 7%
- 6%
- 5%
- 4%
- 3%
- 2%
- 1%

Hydrocarbon Saturation

- 1.0
- 0.9
- 0.8
- 0.7
- 0.6
- 0.5
- 0.4
- 0.3
- 0.2
- 0.1
- 0

Permeability (mD)

- 10
- 1
- 0.1
## Economic Analysis – Assumptions and Process

### Before Tax NCF Model

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<thead>
<tr>
<th>General Info</th>
<th>CAPEX</th>
<th>OPEX</th>
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<td>Production Start</td>
<td>2017</td>
<td>Drilling ($M)</td>
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<td>LOE ($M/month)</td>
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<td>Production Until Completion</td>
<td>2031</td>
<td>Completion ($M)</td>
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<td>JOA ($M/month)</td>
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<td>Royalty Burden</td>
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<td>Facility ($M)</td>
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<td>NRI</td>
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<tr>
<td>Oil Price ($/STB)</td>
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<tr>
<td>Gas Production</td>
<td>Flared</td>
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</tr>
</tbody>
</table>

**Run Base Case** → **Δ Oil Case 1** → **Δ Oil Case 2** → **Δ Oil Case 3**
Economic Analysis – Δ Oil Production

Charlton 30/31 Field Yearly Oil Production vs. Time

- Base Case
- Case 1
- Case 2
- Case 3
Economic Analysis – Net Cash Flow

10% Disc. Net Cash Flow vs. Time

- Case 1 CUM NCF
- Case 2 CUM NCF
- Case 3 CUM NCF

CUM. Net Cash Flow (M$)

Year

2016 2018 2020 2022 2024 2026 2028 2030 2032

$0 -$200 -$400 -$600 -$800 -$1,000 -$1,200 -$1,400 -$1,600 -$1,800
Economic Analysis – Base Case

Base Case Net Cash Flow vs. Time

NPV @ 10% & 15 YRS ($MM) $ (1.80)
IRR 170%
Technical Cost ($/STB) $ 570
T.C. ($/STB) Disc. @10% $ 518
Environmental – Permitting

• Follow DEQs Permitting Process
  • Application Permit to Drill/Operate a Well
  • Survey Record of Well Location
  • Bond for Conformance
  • Wellhead Blowout System
  • Well Permittee Organization Report
  • Inject Well Data
  • Soil Erosion and Sedimentation Control Plan
  • Environmental Impact Assessment
Conclusions and Recommendations

• Conclusions
  • Project Plan
  • Literature Review
  • Static Model
  • Dynamic Model
  • New Well Placement
  • Production Forecasting
  • Economic Analysis
  • Optimum Well Placement
  • Permitting

• Recommendations

• Learning Outcomes

Optimal Well Placement

*NO NEW WELLS!*
Thank You

Questions?