Advanced Technologies For Stripper Gas Well Enhancement

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Presentation Outline

• Project Objectives
• Project Background
• Database Construction
• Stripper Well Remediation Methodology (SWARM) Software
Presentation Outline (continued)

• Additional Objectives
• Software Demonstration
• Example of Candidates Identified
• Conclusions
• Recommendations
Project Objectives

• Create a methodology able to identify underperforming natural gas stripper-wells
  – Easily, effectively, and inexpensively

• Utilize this methodology to recognize remediation candidates in an operating, stripper-gas, field
  – +/- 700 wells operated by Great Lakes Energy Company, and Belden & Blake Corporation have been evaluated
  – Field located in northwestern Pennsylvania
Project Background
Operators Frequently Face a Dilemma in Maximizing Production From Low-productivity Wells

- Hundreds of stripper wells covering thousands of acres
- Difficult for an operator to identify marginal wells easily and efficiently
In Most Fields There Are Wells That Do Not Perform As Expected

- May be due to:
  - Reservoir characteristics
  - Inadequate completions
  - Operational constraints
  - Mechanical problems
In Most Fields There Are Wells That Do Not Perform As Expected (Continued)

- Negative influence upon:
  - Overall field production
  - Economics

- Magnitude of reviewing vast amounts of data
  - Burden upon available work force
  - Strains corporate financial resources
First Step Is to Identify the Underperformers

- We recognized that operators can use an easier and faster method to identify suspect wells. Need to be able to:
  - Screen stripper wells within their field
  - Spot candidate wells that may need remediation
Assumptions

• General localized production trends exist within a field.
• Any abrupt change exhibited by an individual well, relative to an established trend in its vicinity, identifies that well as a potential remediation/restimulation candidate.
Database Construction

- Production history, location, and well data was provided to us by Great Lakes Energy Company and Belden & Blake
- This information was incorporated into various Microsoft Access databases and Excel files designed to facilitate our analyses
Fundamentals of SWARM (Stricker Well Remediation Methodology)

- Calculates appropriate production indicators
  - Representative of a target well’s production history over a chosen interval
    - (e.g. 4-Year Cum, 5-Year Cum, 7-Year Cum etc.)
    - Normalized rate = average monthly rate for the last year of the desired production period
- Compares an individual target well’s production profile to its offsets
- Streamlines identification process
A Target Well and Its Offsets Make up a Domain
SWARM

(Stripper Well Remediation Methodology)

• The Software compares the cumulative production of a target well over a user-specified time span, with all offsets within a fixed distance

• Depletion is taken into account by considering the date of first production (DOFP) versus a desired production-indicator (PI)
  – Lower PI’s over time

• Streamlines identification process
SWARM
*(Stripper Well Remediation Methodology)*

- If the PI of a Target well is lower than a given percentage (e.g. 50%, 70% etc.) it is flagged for additional review
- The entire list of wells is processed and all Target wells that meet the desired criteria are identified
- This is an efficient and rapid method of identifying potential remediation candidates
SWARM

(*Stripper Well Remediation Methodology*)

- After the first pass is completed, a review of each candidate's completion data, geologic information, production history, and operating environment should be conducted.
Example of a Target Well Performing Significantly Worse Than Its Offsets (Based Upon 4-year Cum)

4-Year Cum vs. DOFP

- 4 Year Cum = 3232
- 4 Yr Cum Avg of Offsets = 34252
- 4 Yr Cum Max of Offsets = 61127
- 4 Yr Cum Min of Offsets = 21139
- Total Cum = 3232
- Max Offset Dist = 4860'
- Total Wells = 6

Well 286 of 615 Wells

Offset Well

Target Well

Trend Line (Offset Wells)
Example of a Target Well Performing Significantly Worse Than Its Offsets (Based Upon Normalized Rate)

Performing Significantly Worse Than Its Offsets (Based Upon Normalized Rate)

Normalized Rate vs. Date of First Production

- Normalized Rate (4th Year avg mo prod) = 0
- Avg Norm Rate = 335
- Max Norm Rate = 560
- Min Norm Rate = 156
- Total Cum = 3232
- Max Offset Dist = 4860'
- Total Wells = 6

Well 286 of 615 Wells
Underperforming Target Well Relative to Offsets

Target Well Cum = 3,232 Mscf
Cum = 66,046 Mscf
Cum = 38,640 Mscf
Cum = 84,346 Mscf
Cum = 30,404 Mscf
Cum = 31,101 Mscf
Additional Objectives of This Project

• Evaluate workover/recompletion potential of the Whirlpool/Medina Formation in western Pennsylvania

• Objective included quantifying the number of remediation candidates and their geographic location

• Great Lakes Energy Company (Great Lakes), and Belden & Blake provided information for more than 700 wells
Location Map of Study Area
Location Map Showing Wells

Location Map of Study Area Wells

Crawford, Venango and Warren Counties, Pennsylvania

~700 wells
SWARM Software
Example Screen Shots of SWARM Microsoft™ Access Database

Step 1

Open SWARM Access Database
Screen Shot of SWARM Access Database (Step 2)

Populate Well and Production Tables

Step 2
Screen Shot of SWARM Access Database (Step 3)

Click on Macro Button

Step 3
Screen Shot of SWARM Access Database (Step 4)

Click on Offset Calculations Button
Screen Shot of SWARM Access Database (Step 5)

Enter Maximum Radius Desired For Target Well to Offset Analysis and Input Cumulative Time Period for Production Indicator

Click Run

Step 5
Access File Ready for Excel Processing

- Our Access file is now ready for processing by a SWARM Microsoft Excel™ spreadsheet.
- Note imaginary well names and locations.
Screen Shot of SWARM Excel Spreadsheet (Step 1)

Enter Path to Access Database Here

<table>
<thead>
<tr>
<th>No.</th>
<th>Well_ID</th>
<th>Well Name</th>
<th>Misc Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37039212301527500</td>
<td>(Well Name)</td>
<td>(Operator Name)</td>
</tr>
</tbody>
</table>
Screen Shot of SWARM Excel Spreadsheet (Step 2)

Click on “Update Well List” to Import Data from Access
Choose Filter Desired (e.g. No Filter, “x”-year Cum, or Normalized Rate)
If Using a Filter, Enter Desired Percentage that a Target Well must be Below its Offsets for it to be Flagged
Screen Shot of SWARM Excel Spreadsheet (Step 5)

1) Activate These Check Boxes If Batch Printing of Plots for Qualifying Wells Is Desired,

2) Then Click on “Batch Print” Button
Screen Shot of SWARM Excel Spreadsheet (Step 6)

Click “Next Well” to View Next Qualifying Target Well
Screen Shot of SWARM Excel Spreadsheet (Step 7)

Click Any of These Buttons to View Cum Vs. DOFP, Normalized Rate, Rate-time Plot, or Location Map
Screen Shot of SWARM Excel Spreadsheet (Rate-Time Plot)

Production Plot
Well: 37123401391527500 (Well Name)
Misc Info: (Operator Name)

Total Cum = 3232
4 Yr Cum = 3232
Norm Rate = 0

Well 285 of 450 Wells
Screen Shot of SWARM Excel Spreadsheet (Normalized Rate Plot)

Norm Rate vs DOFP
Well: 37123401391527500 (Well Name)
Misc Info: (Operator Name)

R² = 0.078

Date of First Production
Well 285 of 450 Wells
Screen Shot of SWARM Excel Spreadsheet ("x"-Year Cum vs. DOFP Plot)

4 Yr Cum vs DOFP
Well: 37123401391027500 (Well Name)
Misc Info: (Operator Name)

4 Yr Cum = 3232
4 Yr Cum Avg = 37531
4 Yr Cum Max = 61127
4 Yr Cum Min = 22605
Total Cum = 3232
Max Offset Dist = 4860
Total Wells = 5

Cumulative Production (Mcf)

Date of First Production

Well 285 of 450 Wells
Screen Shot of SWARM Excel Spreadsheet (Location Map)

Location Map of
Well: 37123401391527500 (Well Name)
Misc Info: (Operator Name)

X-distance, ft

Y-distance, ft
Recommendations (Continued)

- List of candidates should be high-graded for economic viability based upon recompletion and workover potential
Map of Remediation Candidates

Map Showing Candidates

- Wells
- Candidate Well
Conclusions

• A PC-based, Stripper Well Remediation Methodology (SWARM) software package capable of quickly and easily identifying underperforming gas stripper-wells has been designed, built, and tested.

• We identified candidates to be reviewed for possible inadequate completions, operational constraints, and/or mechanical problems.
Recommendations

- Rework candidates should be evaluated for geologic, completion, and operational factors that may have led to underperformance.
- Contributing factors should be corrected if possible (e.g. Line pressure, well tending, pipeline constraints etc.).
Recommendations (Continued)

• List of candidates should be high-graded for economic viability based upon recompletion and workover potential
SWARM Program Review

- Easier process for operators to examine their wells
  - Life is much simpler now