

SPE 72385

Identifying Best Practices in Hydraulic Fracturing Using Virtual Intelligence Techniques



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October 2001



OUTLINE

- Objective
- Background
- Methodology
- Results & Discussion
- Conclusion



OBJECTIVE

- To identify Best Practices in Hydraulic Fracturing in Medina and Whirlpool sands of southwest New York State Using Virtual Intelligence Techniques



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BACKGROUND

- Medina and Whirlpool sands of southwest New York State are considered to be tight gas sands.
- Most wells in the Northeast of the United States, including the wells that are drilled into the Medina and Whirlpool sands, are fractured upon completion to provide economic amounts of gas.



BACKGROUND

- A dataset that included about 100 Medina and Whirlpool wells was collected during a GRI / NYSERDA sponsored project.



BACKGROUND

- Parameters available in the dataset.

Category	Parameter
Location	X
	Y
	Top of Upper Grimsby
Reservoir Quality	Net Phi-H Total Grimsby
	Net Phi-H Whirlpool
Completion	Perf Thickness
	Number of Perfs Medina
	Perf Diameter
Stimulation	BBLs of Water Medina
	MMCF N2 Medina
	Sacks of Sand Medina
	Breakdown Pressure Medina
	ISIP Medina
	Avg. Treating Rate Medina
Treating Pressure Medina	
Production	Remaining Gas
	Ultimate Gas
	Gas Months Prod
	Gas Last 1 Months
	Gas Date of First Production
	Gas Date of Last Production
OUTPUT	Gas 5 Year Cumulative



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METHODOLOGY

- The methodology incorporated in this study, with some minor modifications, can be used to identify best practices from any oil and gas database.
- The methodology that has been used to analyze the dataset in this study is known as data mining and knowledge discovery.



METHODOLOGY

- Although the terms data mining and knowledge discovery are not new, the combination of the integrated analytical tools used in this study to achieve the objectives of this data mining study are quite new and innovative.



METHODOLOGY

- A multi-step process that includes:
 - Conventional Statistical Analysis
 - Fuzzy Combinatorial Analysis
 - Neural Modeling of the process
 - Hard Clustering
 - Fuzzy Clustering
 - Forward Selection and Backward Elimination Neural Network



METHODOLOGY

- A multi-step process that includes:
 - Parametric Study on the model
 - Genetic optimization
 - Fuzzy decision support system
- A multi-step analysis
 - Single well
 - Groups of wells
 - Full Field



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RESULTS & DISCUSSION

- Fuzzy Combinatorial Analysis
 - To identify most influential variables in a dataset.
 - Each variable's contribution and influence on the process is evaluated in several steps.
 - Variable's contribution, all on its own.
 - Its contribution as affected by other variables.



RESULTS & DISCUSSION

- Using Fuzzy Combinatorial Analysis all the parameters involved in the process are ranked based on their influence on the process outcome.

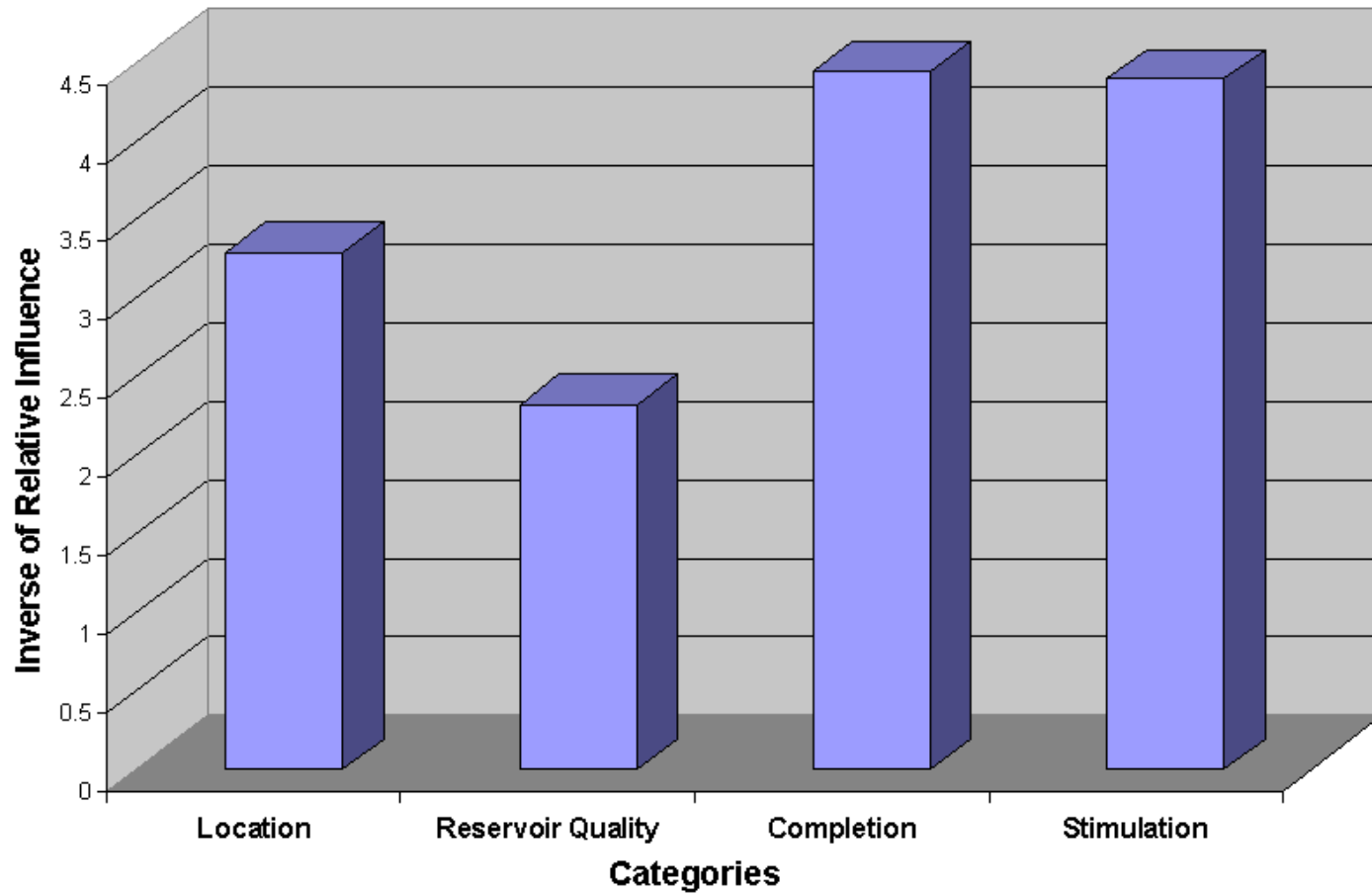


RESULTS & DISCUSSION

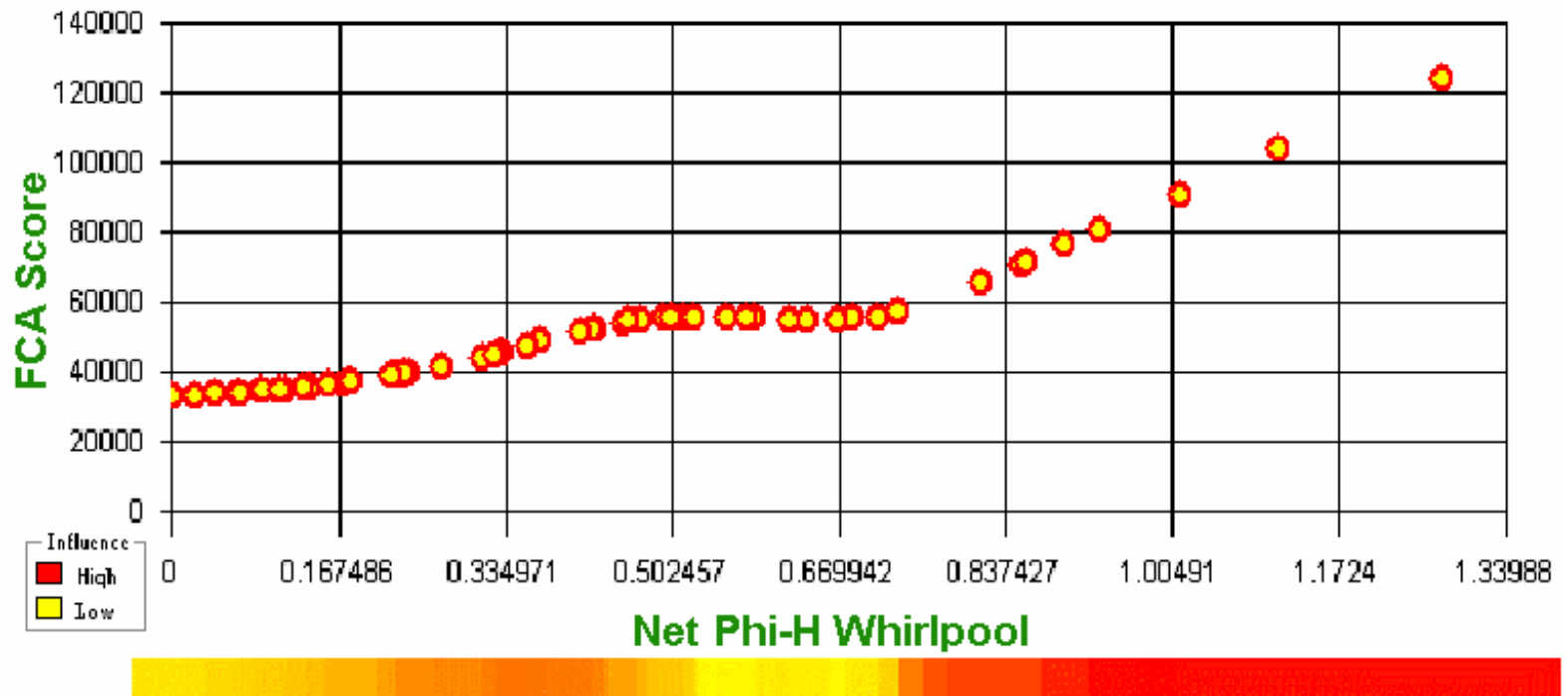
Rank	Category	Parameter	Inverse of Relative Influence
1	Reservoir Quality	Net Phi-H Whirlpool	0
2	Location	X	2.4296
3	Location	Y	3.5394
4	Location	Top of Upper Grimsby	3.8878
5	Stimulation	Avg. Treating Rate Medina	3.9747
6	Completion	Number of Perfs Medina	4.1497
7	Stimulation	Treating Pressure Medina	4.1543
8	Stimulation	Sacks of Sand Medina	4.367
9	Stimulation	ISIP Medina	4.3694
10	Completion	Perf Diameter	4.434
11	Stimulation	Breakdown Pressure Medina	4.5093
12	Reservoir Quality	Net Phi-H Total Grimsby	4.629
13	Stimulation	BBLs of Water Medina	4.6628
14	Stimulation	MMCF N2 Medina	4.6823
15	Completion	Perf Thickness	4.7257



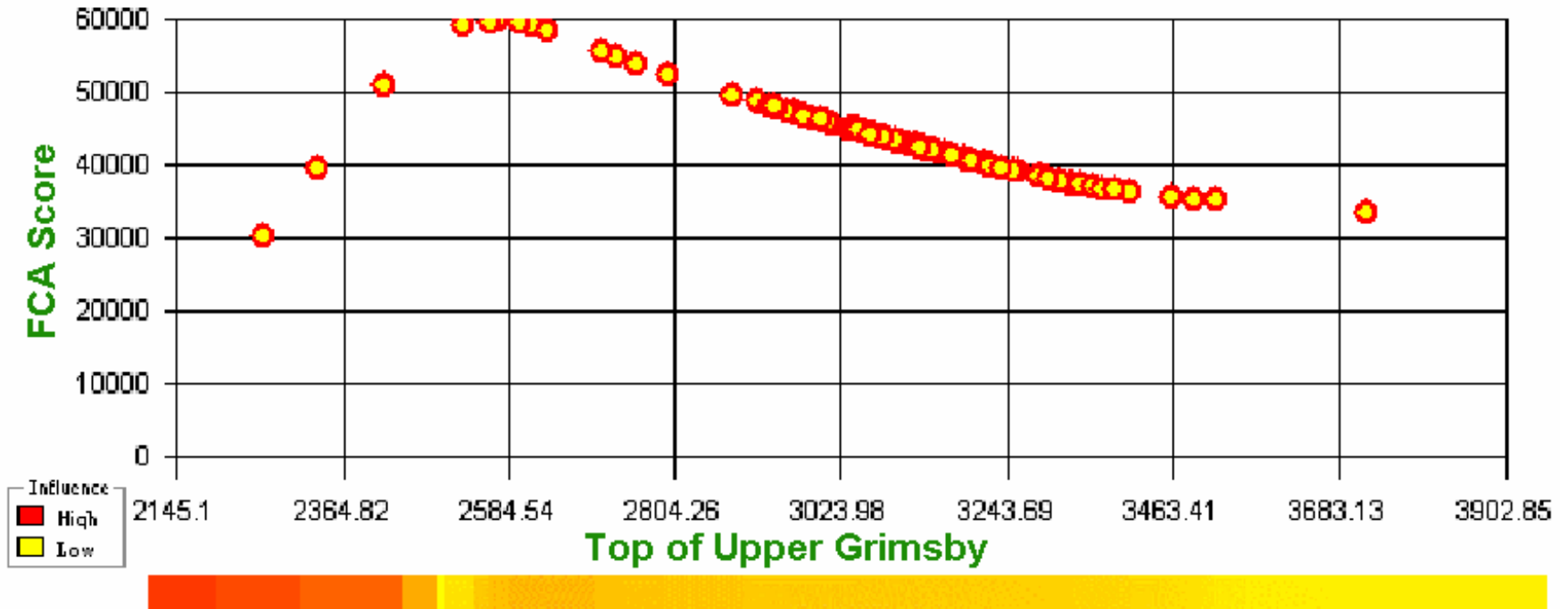
RESULTS & DISCUSSION



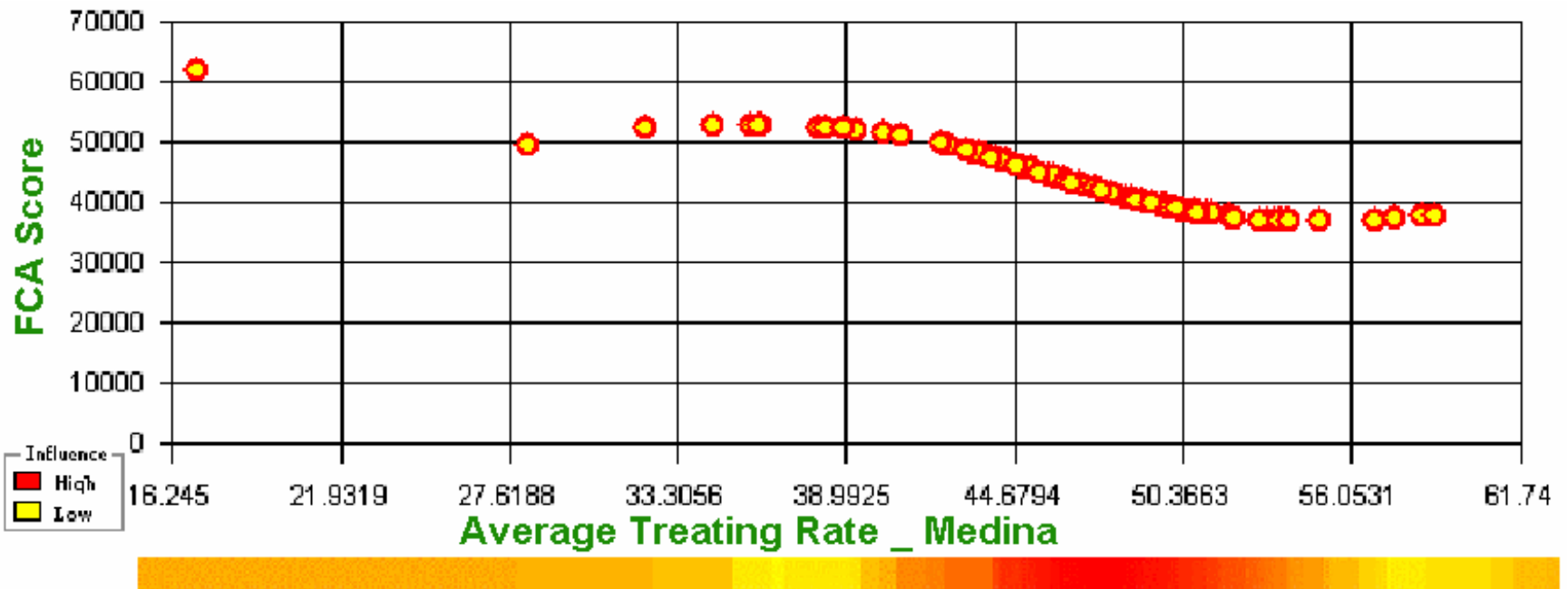
RESULTS & DISCUSSION



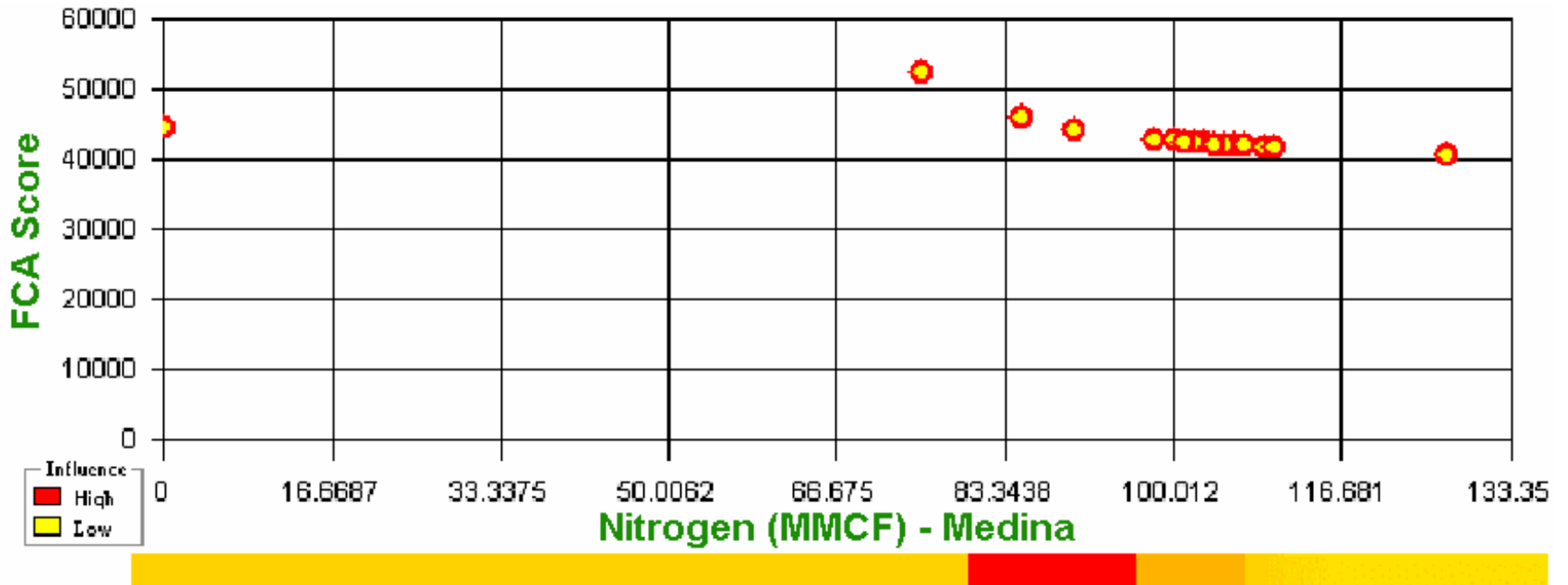
RESULTS & DISCUSSION



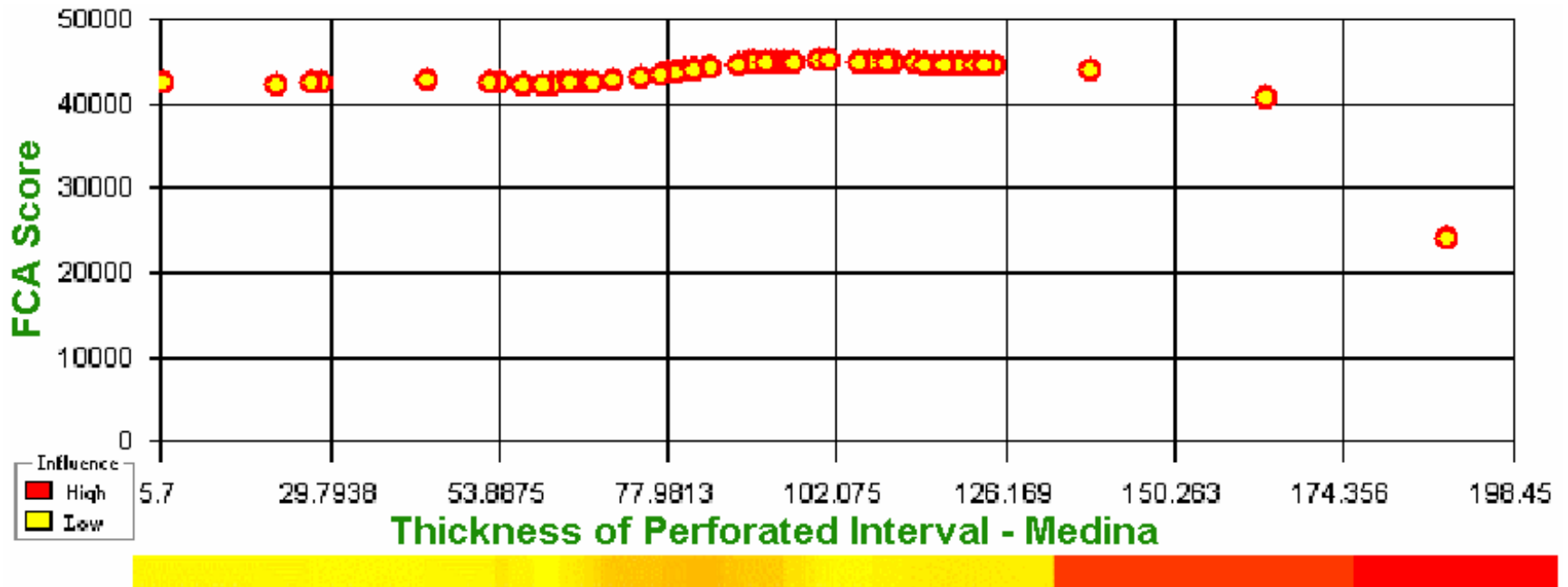
RESULTS & DISCUSSION



RESULTS & DISCUSSION



RESULTS & DISCUSSION

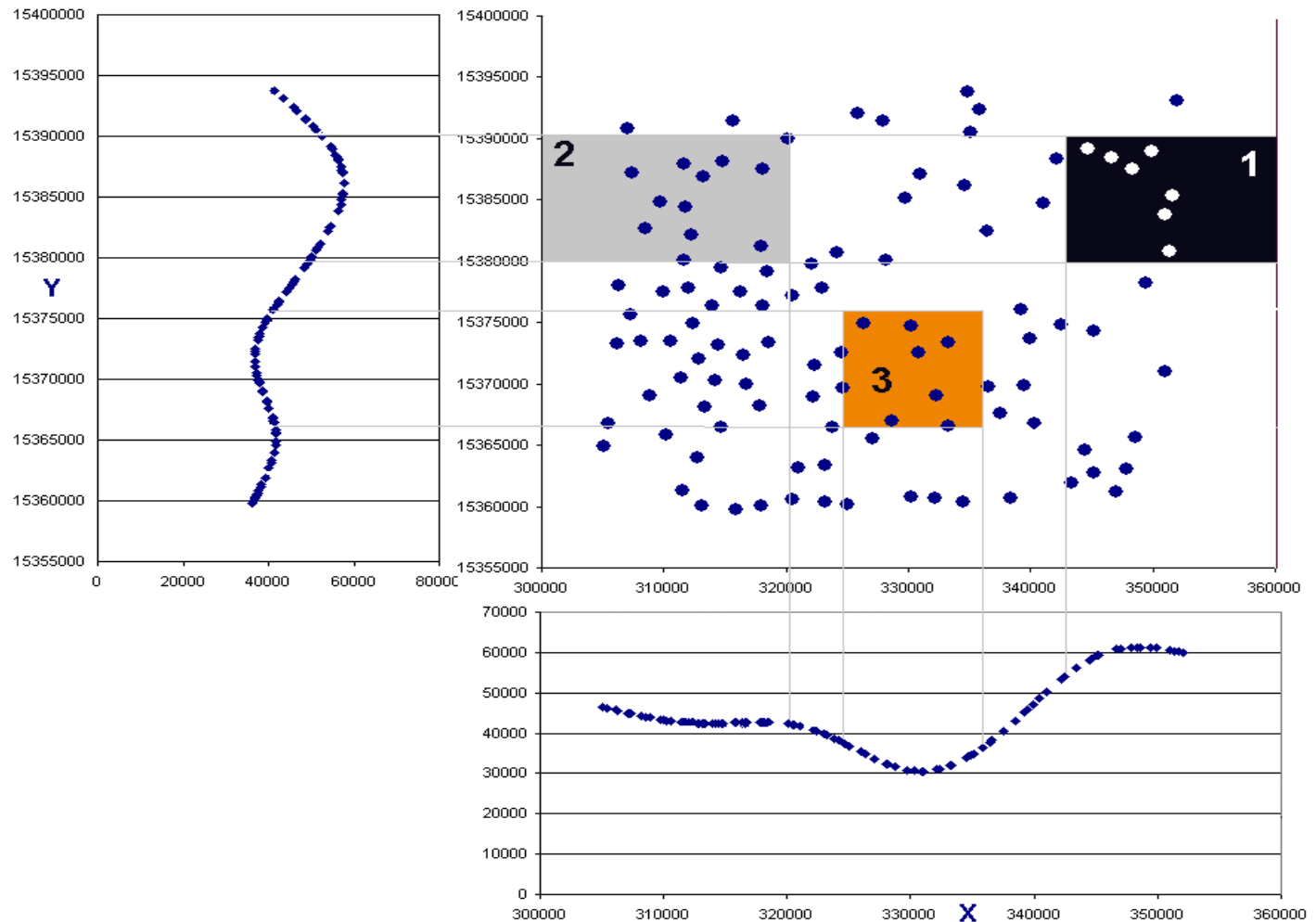




RESULTS & DISCUSSION

- Fuzzy Combinatorial Analysis
 - Identifies the range in which the variable has its most influence.
 - This can assist engineers in identifying sweet spots in a field.

RESULTS & DISCUSSION





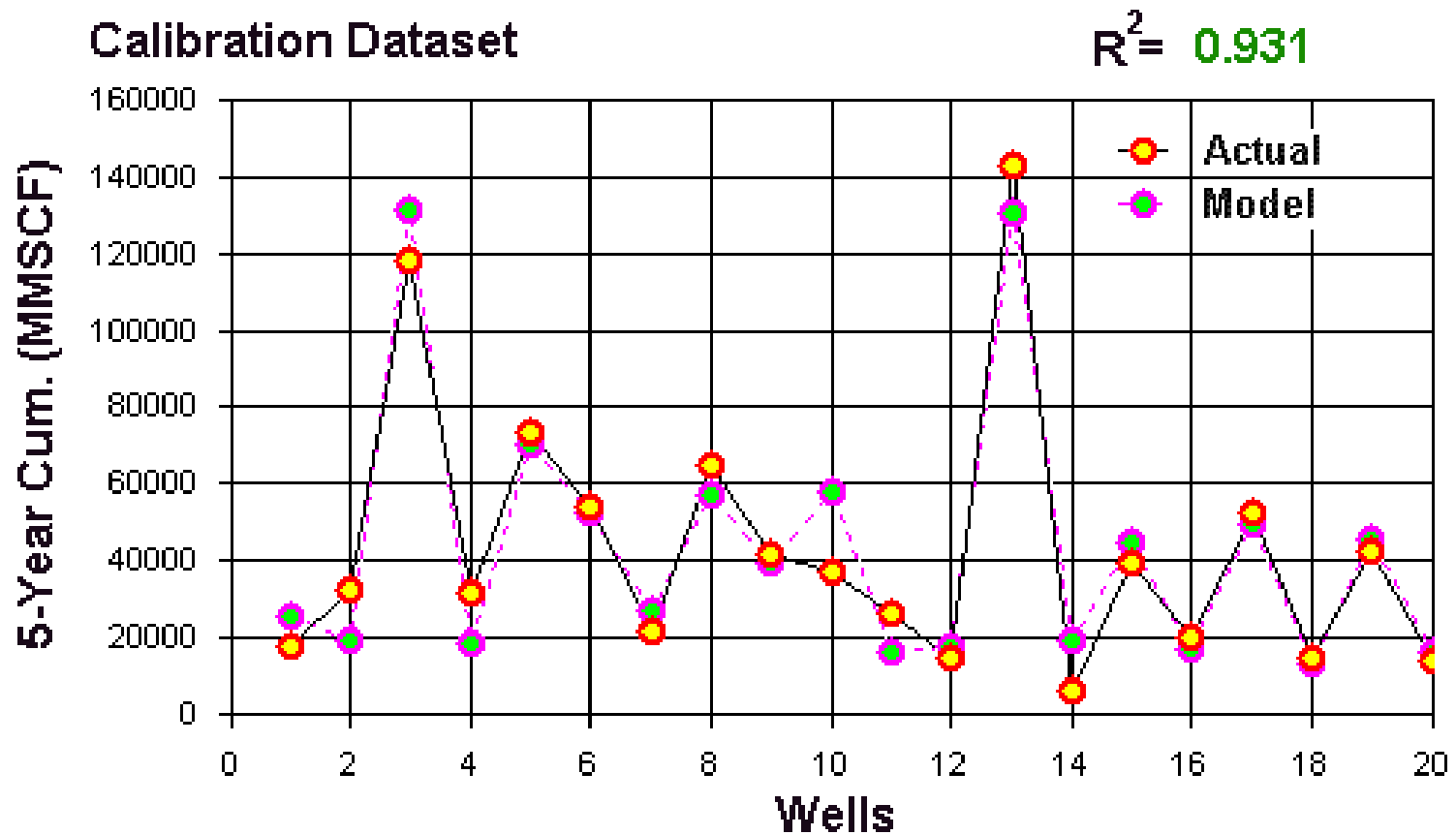
RESULTS & DISCUSSION

- Neural Modeling

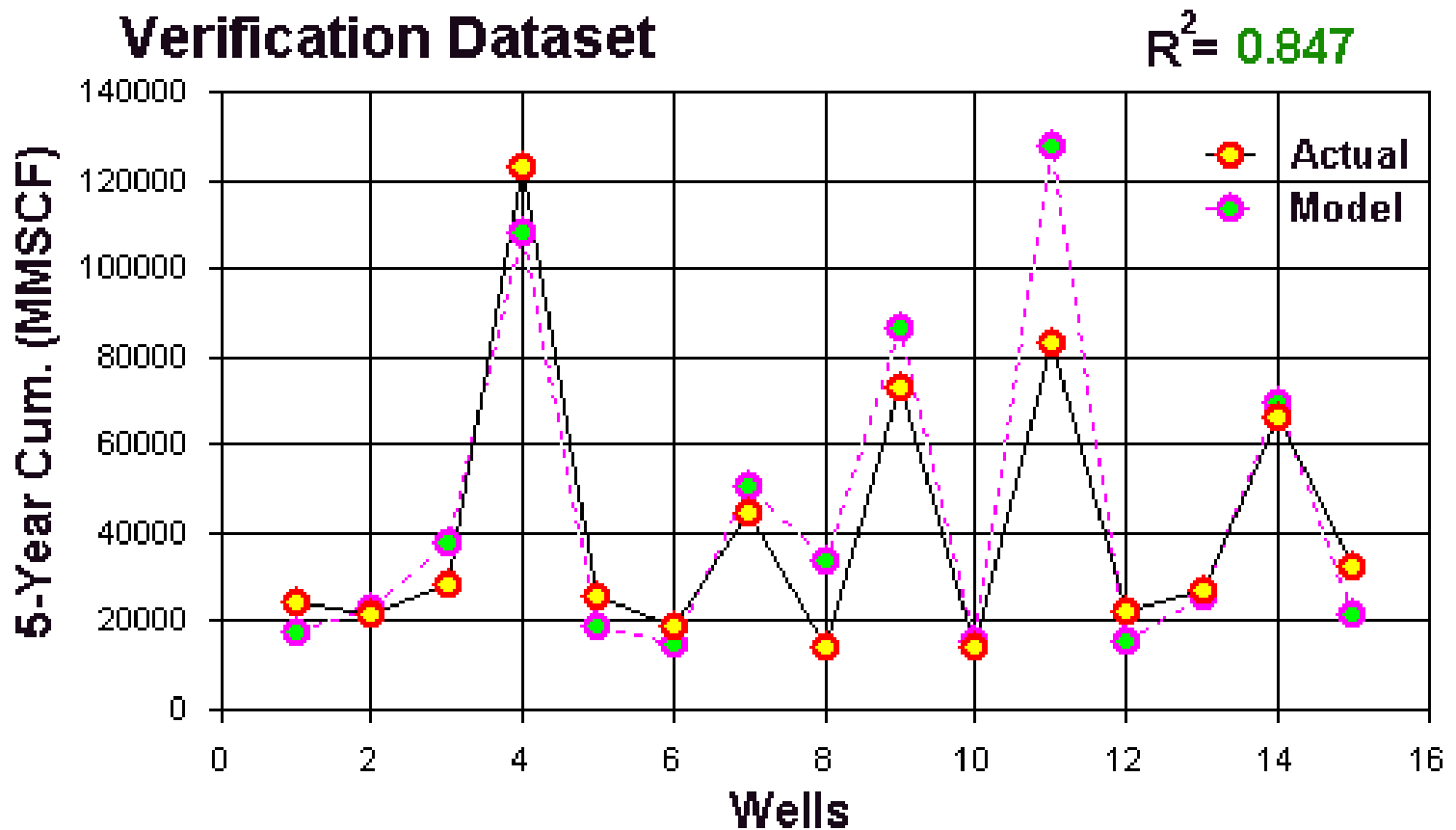
- Using several steps to prepare the dataset for the best results possible.
- Correlating all the available parameters to 5-yr cum. Gas production.
- Dataset is divided into three components
 - Training dataset
 - Calibration dataset
 - Verification dataset

Dataset	R Squared
Training	0.848
Calibration	0.931
Verification	0.847

RESULTS & DISCUSSION



RESULTS & DISCUSSION





RESULTS & DISCUSSION

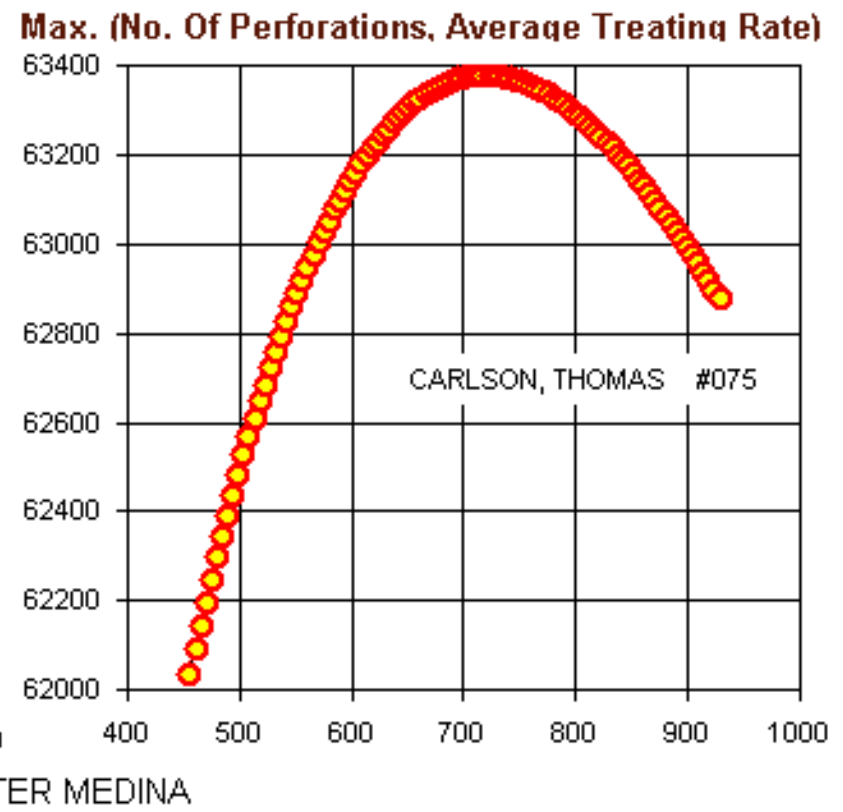
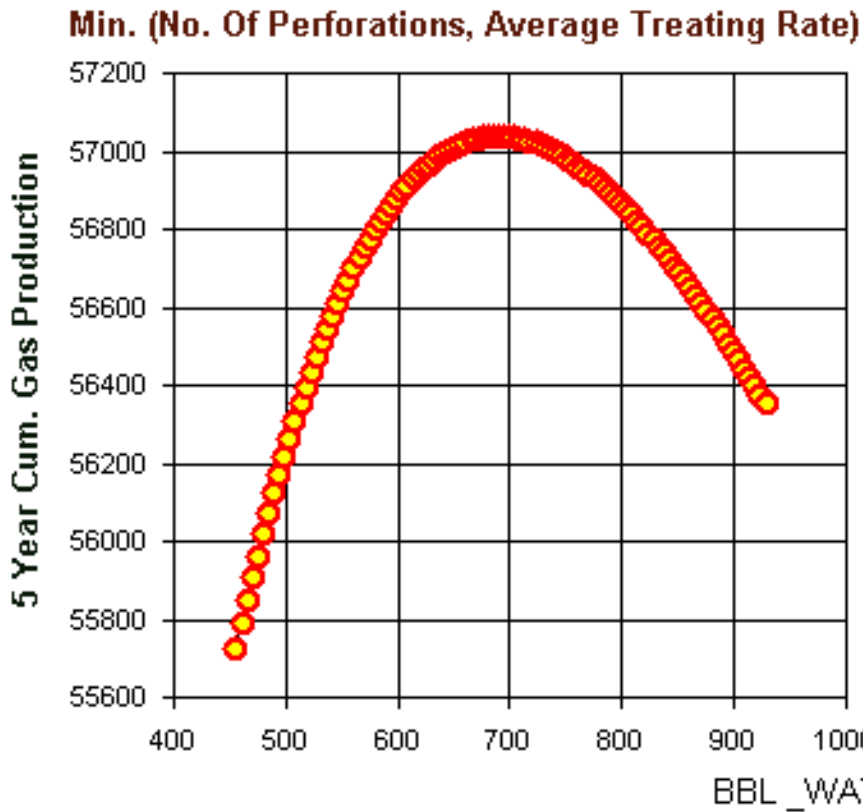
- Best Practices
 - Single Well Analysis
 - Groups of Wells Analysis
 - Full Field Analysis



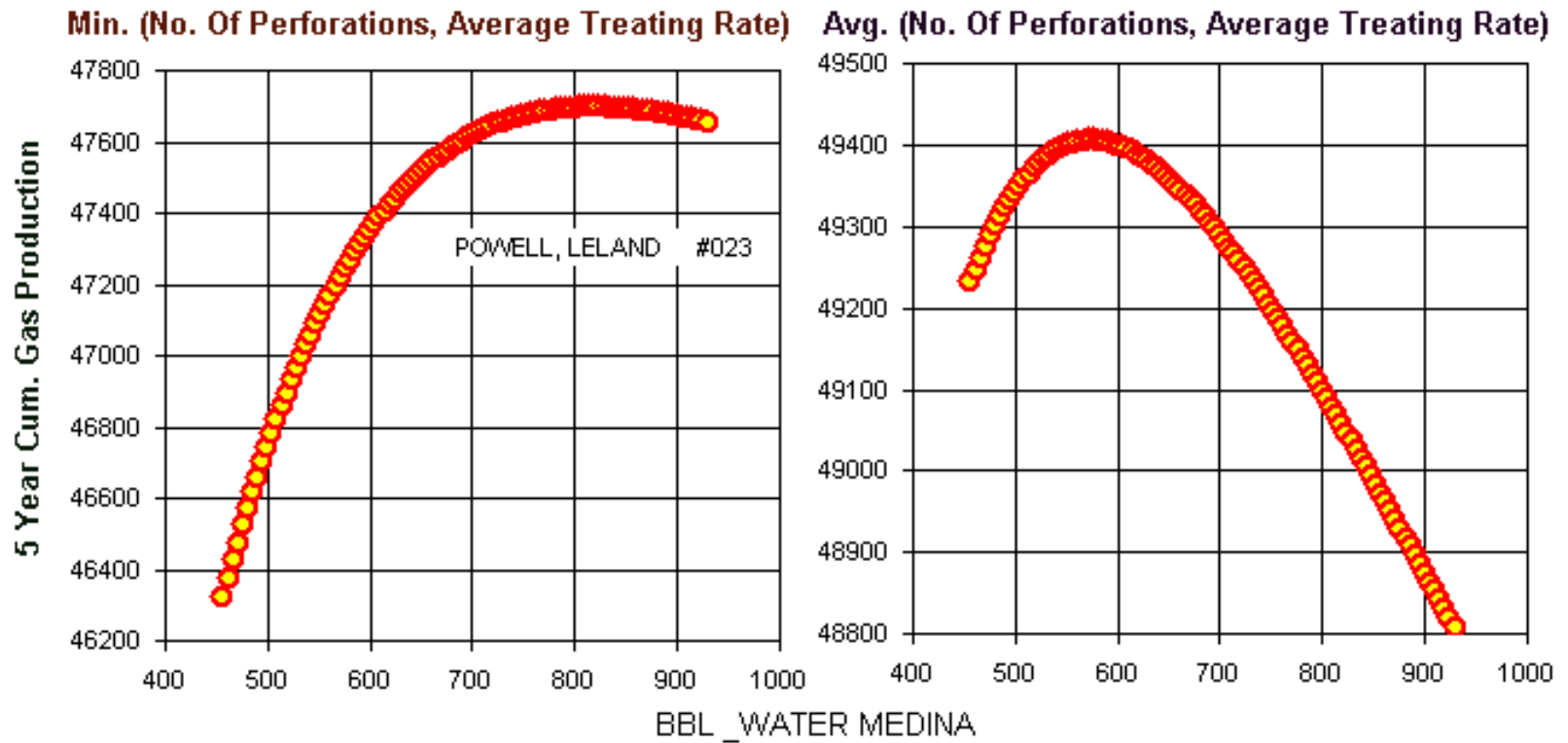
RESULTS & DISCUSSION

- Single Well Analysis
 - Keeping all but three of the parameters for a particular well constant.
 - Holding two of the three parameters at their minimum, average or maximum values.
 - Changing the third parameter between minimum and maximum.
 - Calculating the 5 year Cum. Gas production

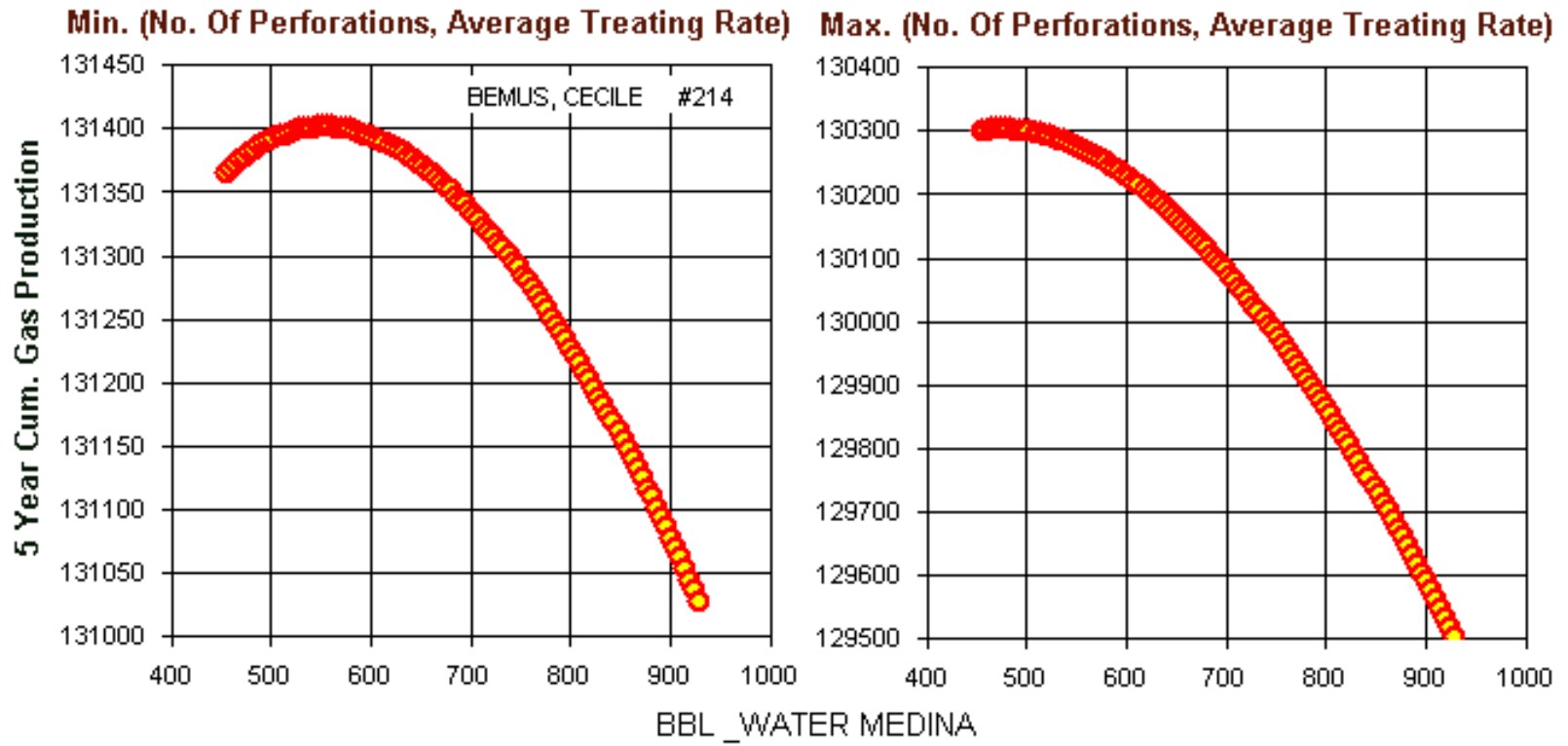
RESULTS & DISCUSSION



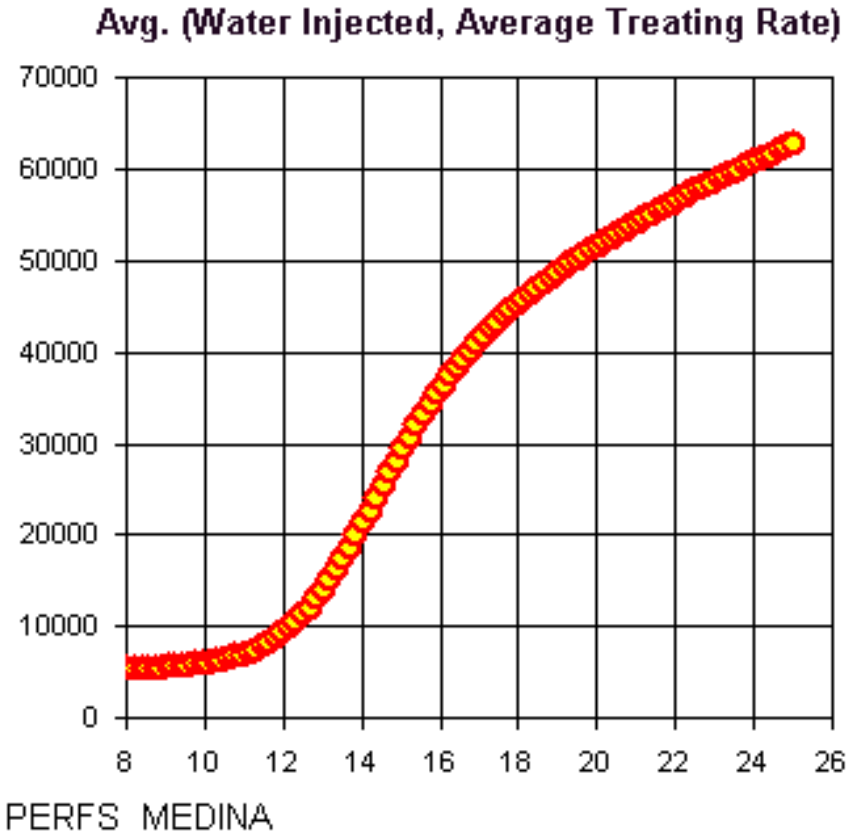
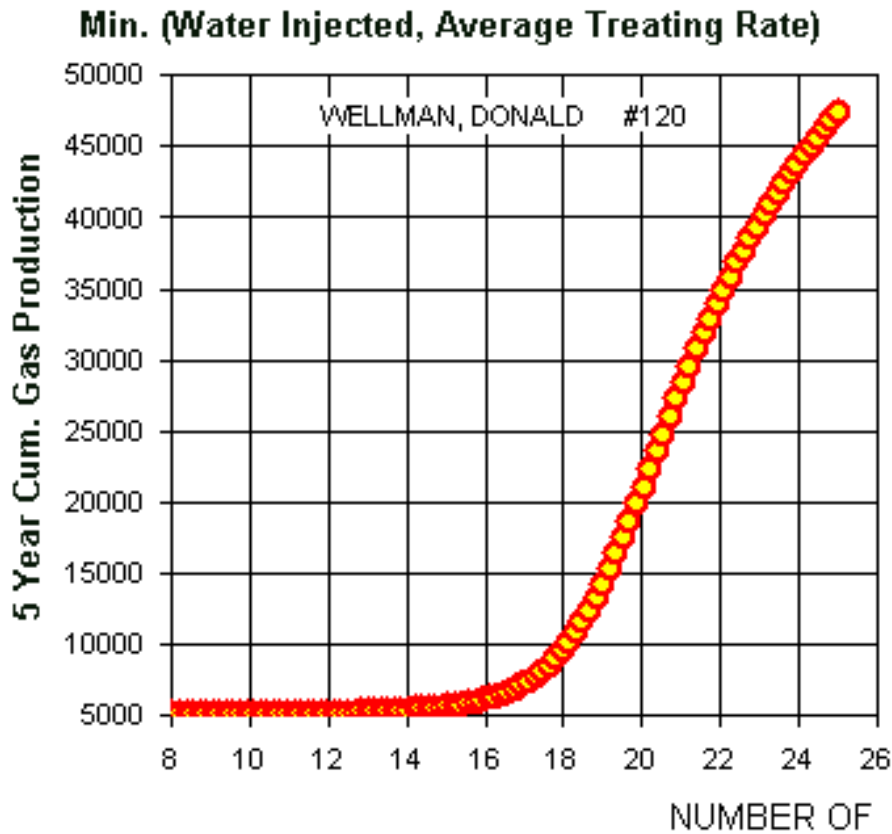
RESULTS & DISCUSSION



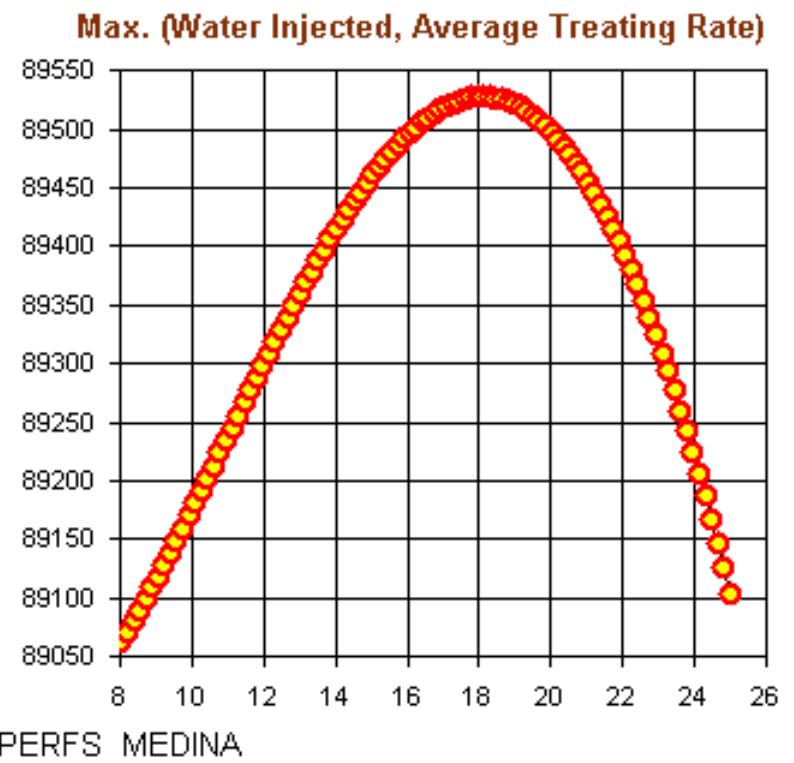
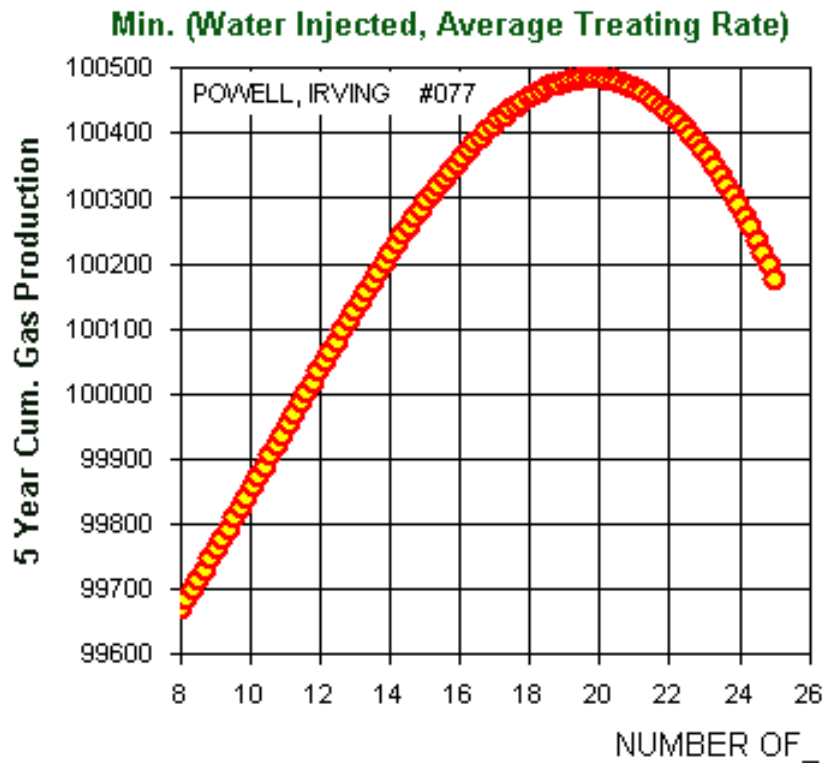
RESULTS & DISCUSSION



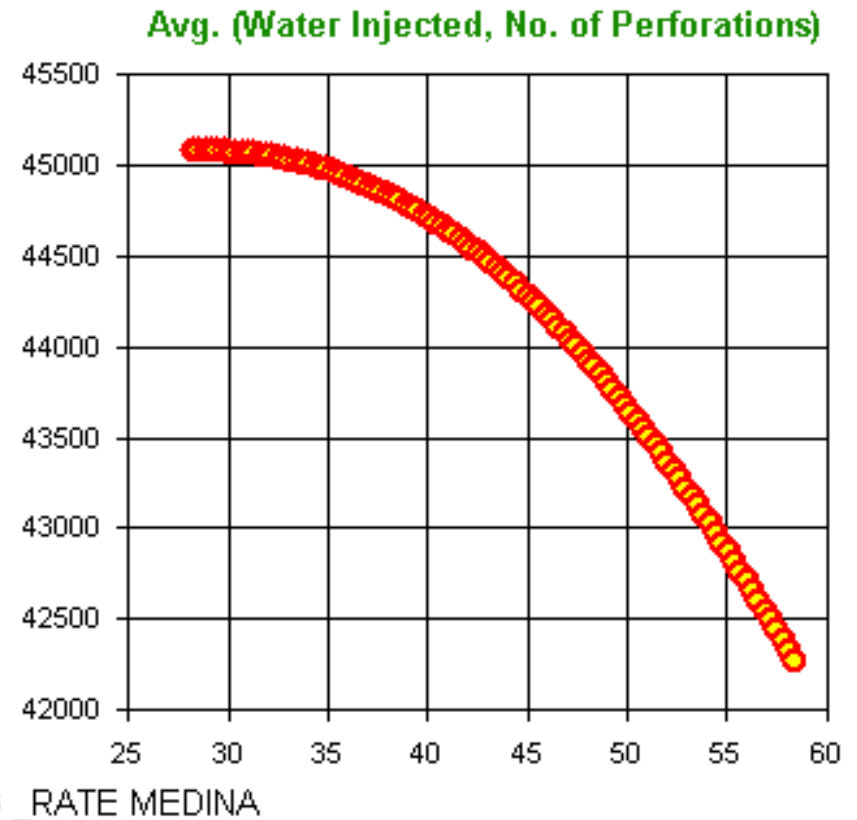
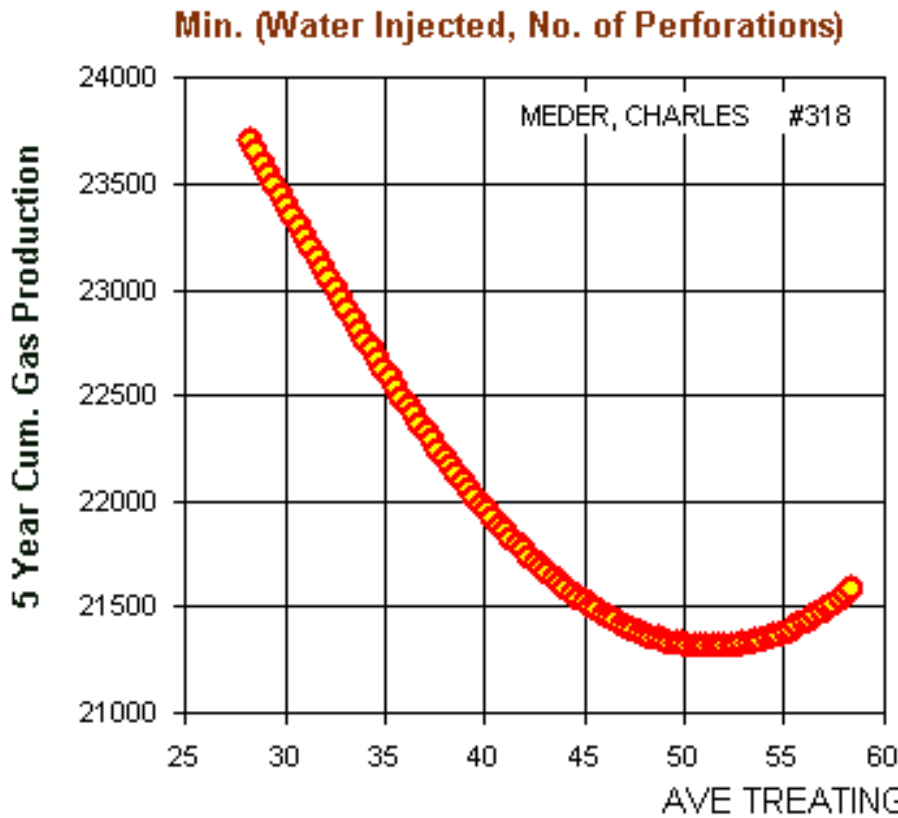
RESULTS & DISCUSSION



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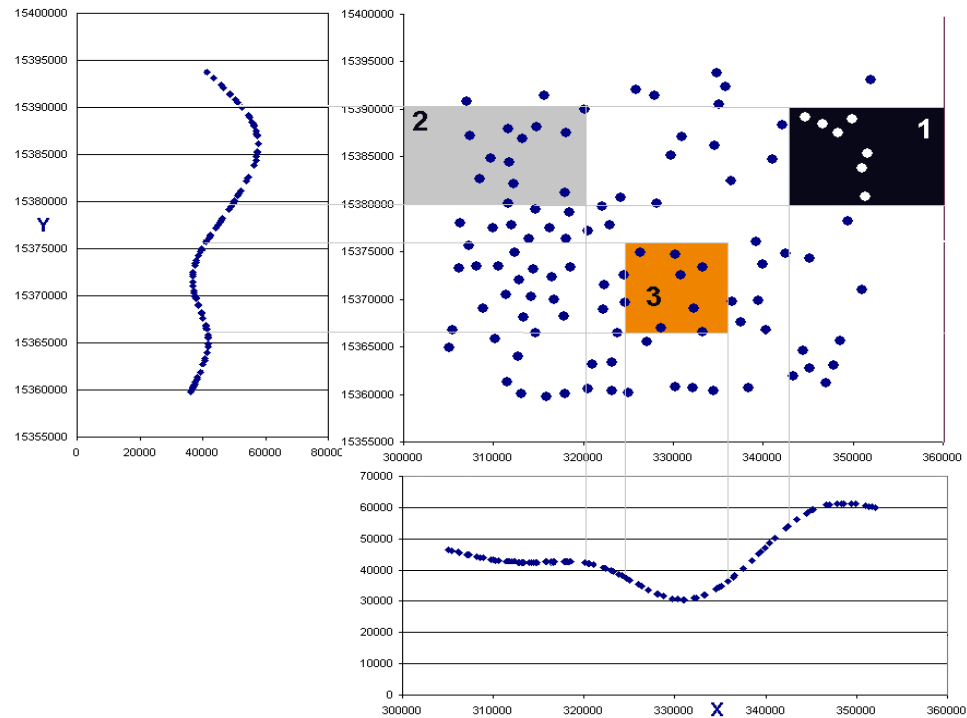


RESULTS & DISCUSSION



RESULTS & DISCUSSION

- Groups of Wells
 - Using the clustering of the wells performed during the FCA





RESULTS & DISCUSSION

- Groups of Wells

Average Values Per Group of Wells						
Parameters	Group ONE		Group TWO		Group THREE	
	Optimized	Actual	Optimized	Actual	Optimized	Actual
NUMBER OF PERFS MEDINA	25	19	25	15	25	15
AVERAGE INJECTION RATE	38.5	46.0	47.8	43.4	45.6	50.6
BBL WATER MEDINA	625	557	717	645	819	575
Ultimate Gas	177,574		136,317		68,859	
Gas_5-Yr_Cum	91,746	70,657	64,117	47,688	50,142	21,954
% increase due to optimization	23%		26%		56%	



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CONCLUSIONS

- A new process has been introduced that employs data mining and knowledge discovery methodologies to identify the best practices during the hydraulic fracturing process in the Medina and Whirlpool sands of southwest New York State.
- The results provided by this process demonstrate the potential of these methodologies in identifying the best practices in oil and gas industry.