SPE 59767

Development of an Intelligent Systems Approach for Restimulation Candidate Selection

Shahab Mohaghegh — WVU

Scott Reeves — ARI

David Hill — GRI

SPE/CERI Gas Technology Symposium

April 2000

OUTLINE

- Introduction
- Objective
- Background
- Methodology
- Application
- Conclusion

INTRODUCTION

- In 1996, GRI began investigating potential for natural gas production enhancement via restimulation. Initial findings were:
  - Significant potential
    - >5 tcf incremental reserves in 5 years
  - Low reserve costs when successful
    - $0.10 - $0.20/Mcf
  - Critical success factors
    - Candidate selection (85/15 rule)
    - Problem diagnosis
    - Treatment strategy

INTRODUCTION

- Major obstacles are:
  - Industry's (understandable) reluctance to restimulate "good" wells, which frequently are the best candidates.
  - Lack of "tools" or methods to cost-efficiently identify candidates and diagnose well performance problems.

OUTLINE

- Introduction
- Objective
- Background
- Methodology
- Application
- Conclusion

OBJECTIVE

- Develop cost-effective, reliable methodologies to identify wells with high restimulation potential.

Several methods were investigated both simultaneously as well as in conjunction with one another. Intelligent Systems seems to be one of the better approaches.

OUTLINE

- Introduction
- Objective
- Background
- Methodology
- Application
- Conclusion

BACKGROUND

- Using virtual intelligence techniques to select restimulation candidates.
  - This method had been applied to restimulation candidate selection in a gas storage field in the past and had shown promise.
- Using a hybrid approach
  - Artificial Neural Networks
  - Evolutionary Optimization
  - Fuzzy Logic

VIRTUAL INTELLIGENCE

- A collection of several analytical tools that attempts to imitate life.
- Exhibit an ability to learn and deal with new and dynamic situations
- Possess attributes of reason such as generalization, discovery, association and abstraction.

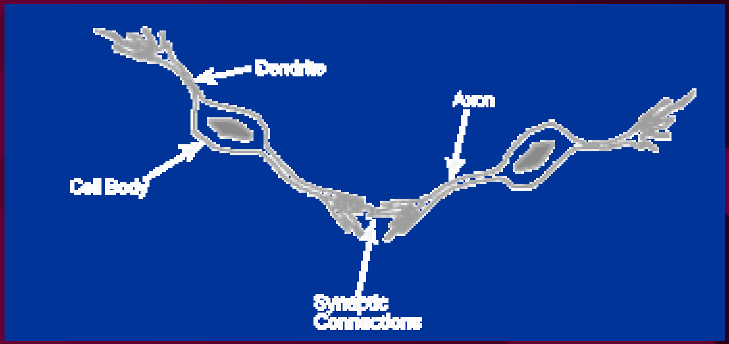
VIRTUAL INTELLIGENCE

Conventional Computing	Soft Computing
• Bivalent Logic	• Fuzzy Logic
• Numerical Analysis	• Neurocomputing
• Probability	• Probabilistic Reasoning
• Differential Equations	• Genetic Algorithms
• Functional Analysis	• Belief Networks
• Mathematical Programming	• Chaos
• Approximation Theory	• Rough Sets
Quantitative, Precise, Formal	*Qualitative, Imprecise, Informal*

Precision and certainty carry a cost

VIRTUAL INTELLIGENCE

- Biologically Inspired
- Adaptive learning
- Parallel, distributed information processing



_ P_NN_ S_V_D

_S _

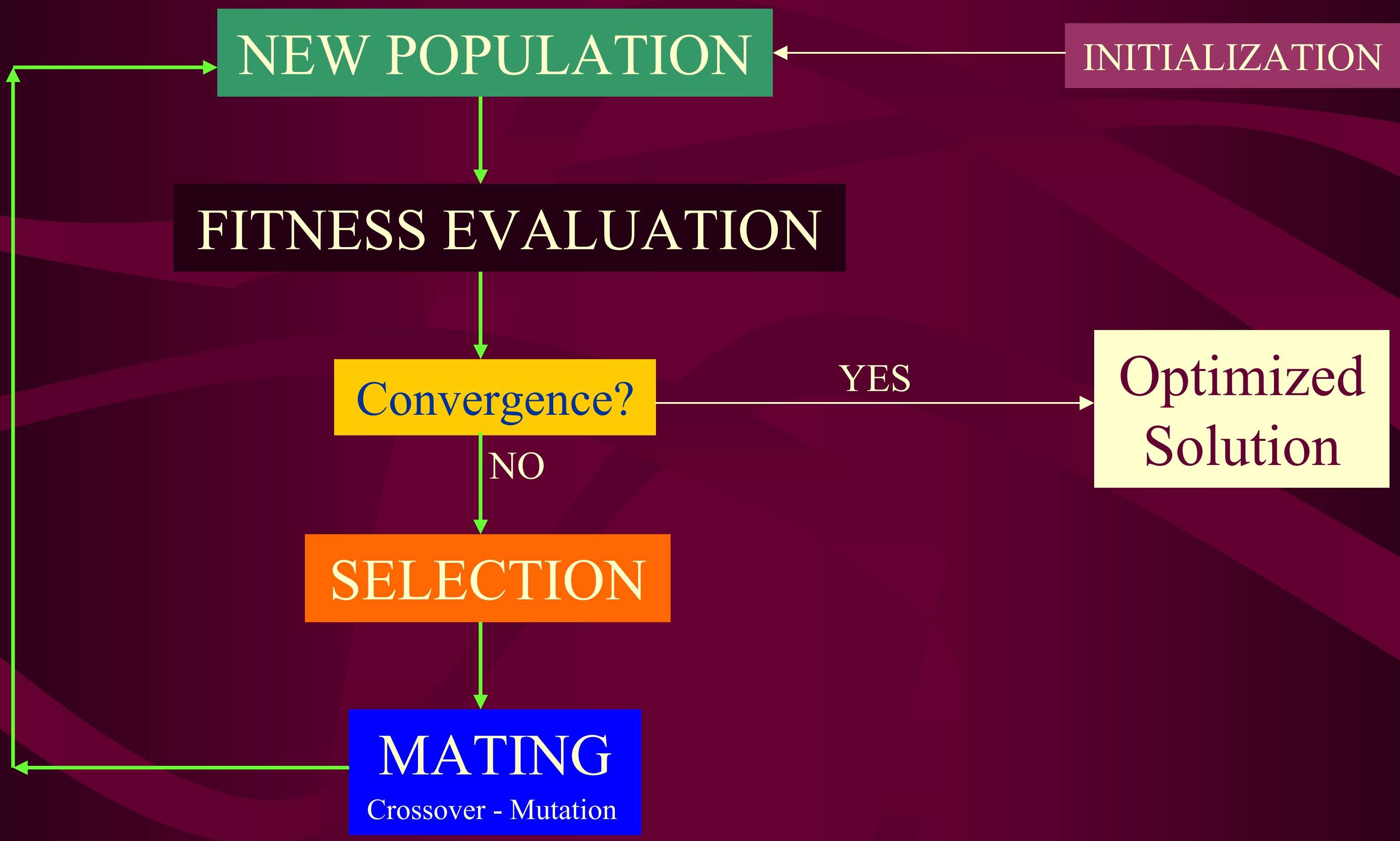
P_NN_ _ _RN_D

VIRTUAL INTELLIGENCE

VIRTUAL INTELLIGENCE

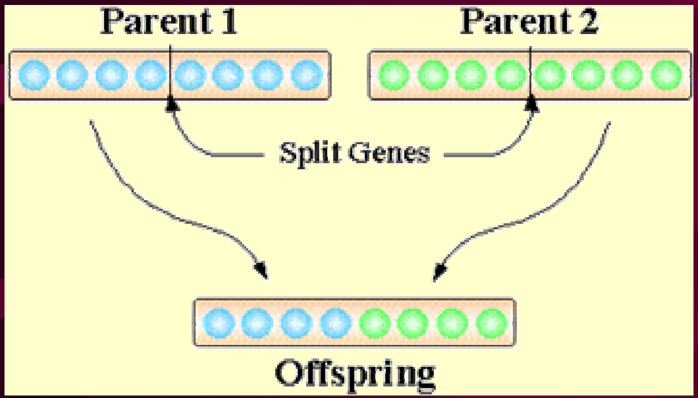
- The metaphor underlying evolutionary optimization is that of natural evolution. In evolution the problem each species face is one of searching for beneficial adaptations to a complicated and changing environment. The “knowledge” that each species has gained is embodied in the makeup of the chromosomes of its member.

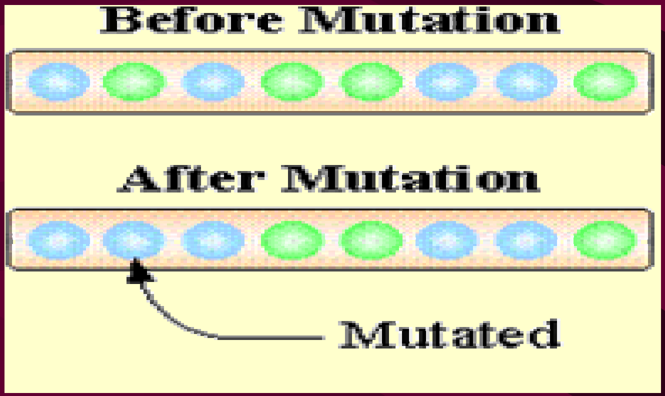
VIRTUAL INTELLIGENCE



VIRTUAL INTELLIGENCE

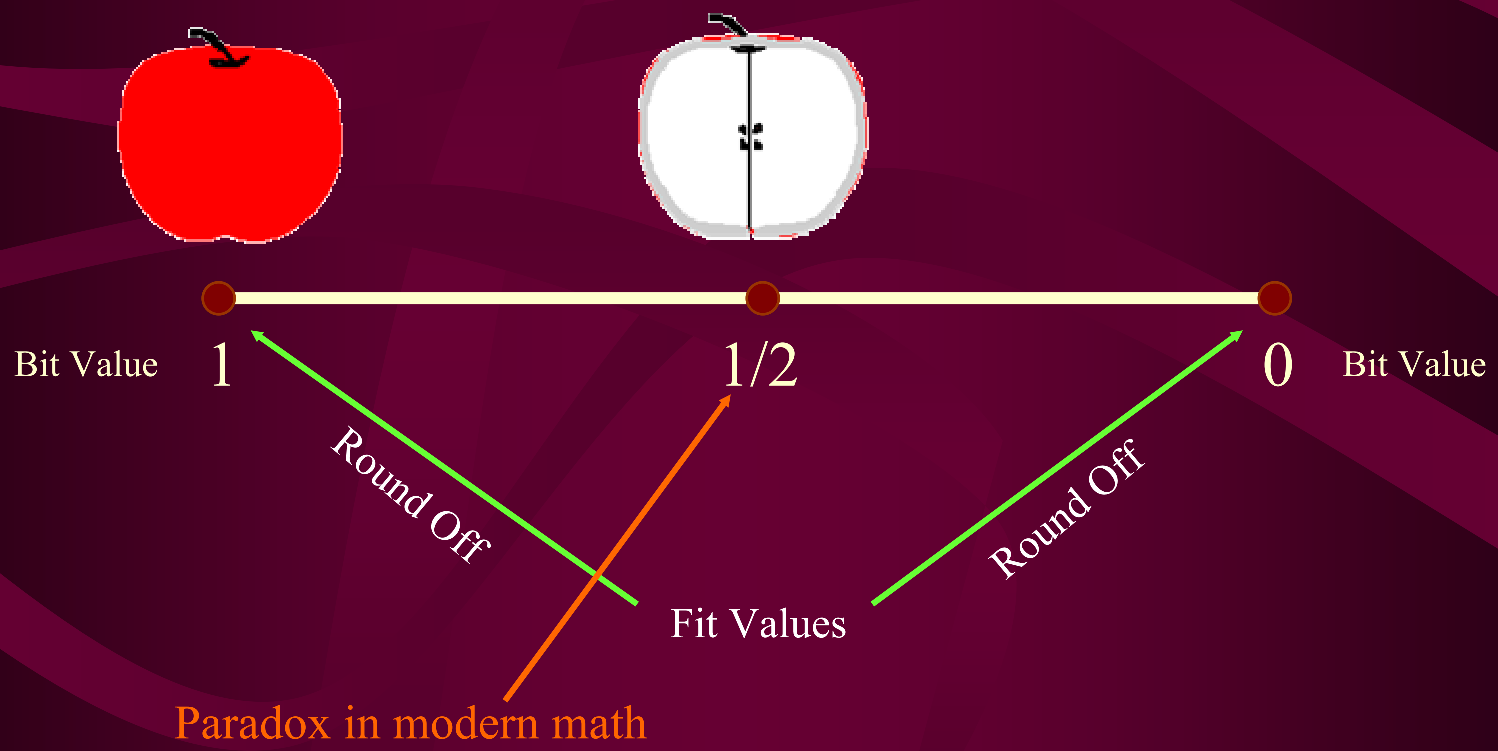
Crossover & Mutation



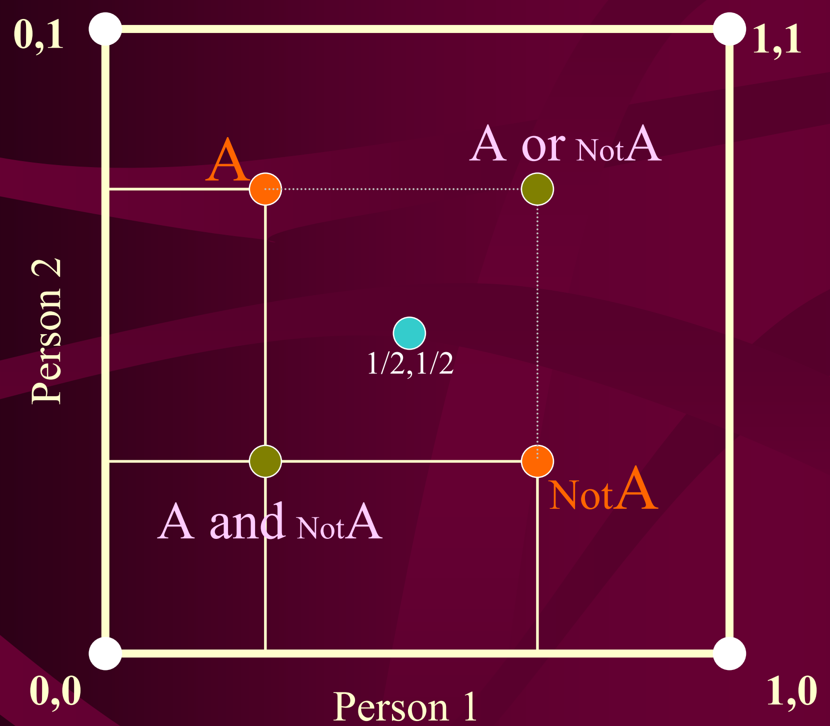


VIRTUAL INTELLIGENCE

EVERYTHING IS A MATTER OF DEGREES



VIRTUAL INTELLIGENCE

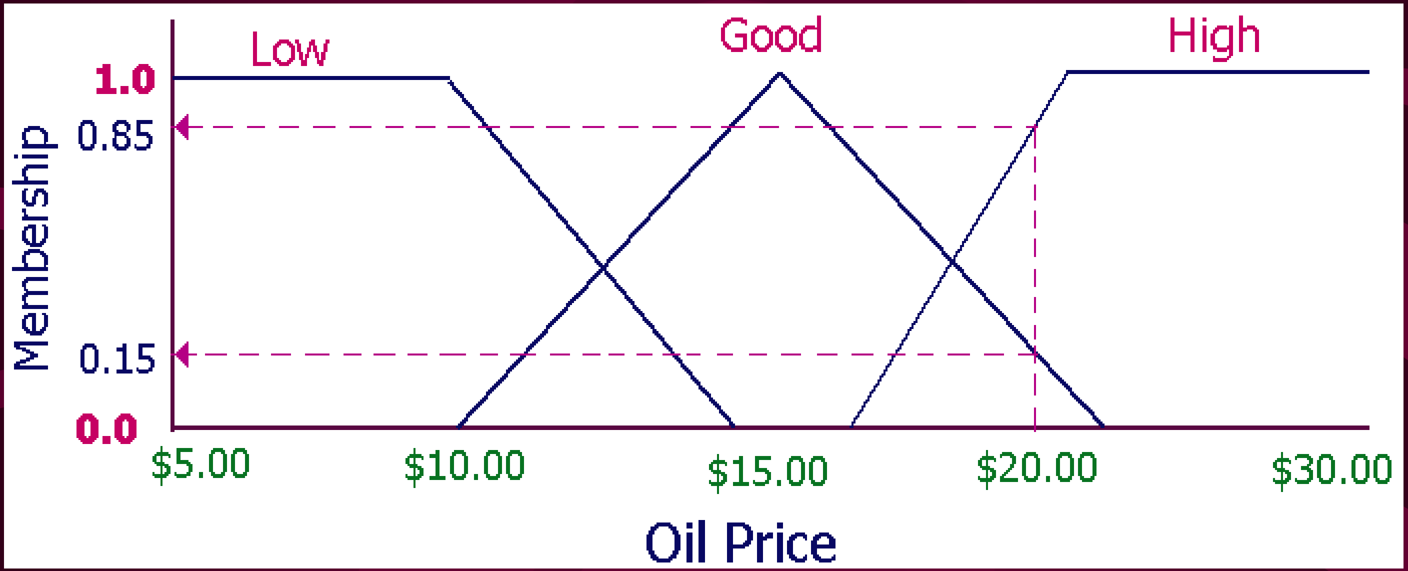


2 people answering the following question?

1 = Totally satisfied

0 = Totally unsatisfied

VIRTUAL INTELLIGENCE



OUTLINE

- Introduction
- Objective
- Background
- Methodology
- Application
- Conclusion

METHODOLOGY

- A three step process:

Step 1.

- Develop a reliable data set using well files and production data.
- Identify the production indicator (5 yr. cum. or Best 12 months production) to be used as model output.
- Build a representative neural model of the stimulation process in the formation.
- Test the neural model for accuracy.

METHODOLOGY

- A three step process:

Step 2.

- Identify the controllable (fluid type, sand concentration, …) and uncontrollable (pay thickness, porosity) parameters in the neural model.
- Develop a multi-dimensional, evolutionary optimization process to find the best combination of controllable parameters that results in maximum output (5 yr. cum. …)

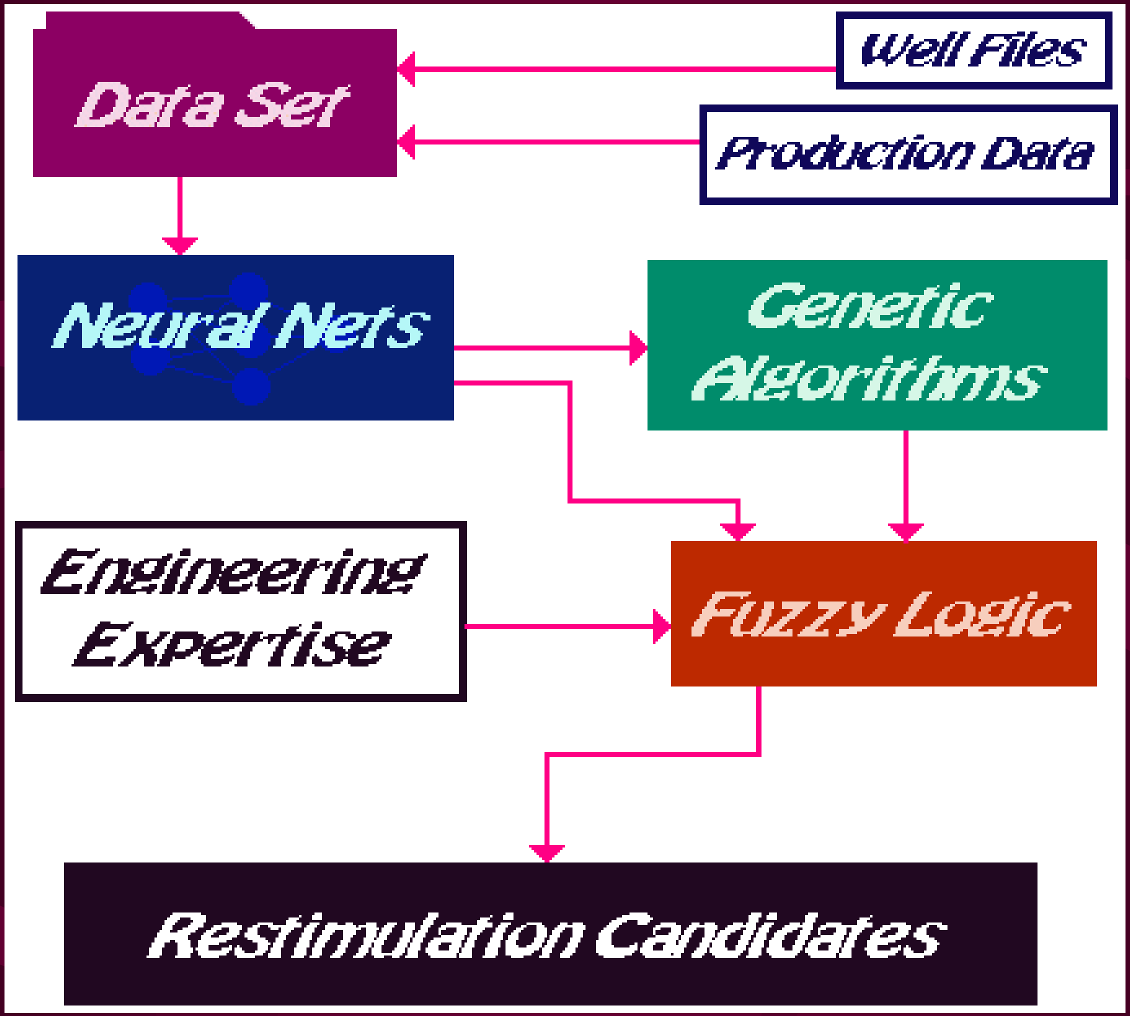
METHODOLOGY

- A three step process:

Step 3.

- Using general engineering expertise and field engineers input to identify parameters that would have an impact on the decision making process. These parameters do not have to be precise in value.
- Build a fuzzy decision support system that incorporates the results from steps 1 and 2, and combine them with engineering expertise for final candidate selection.

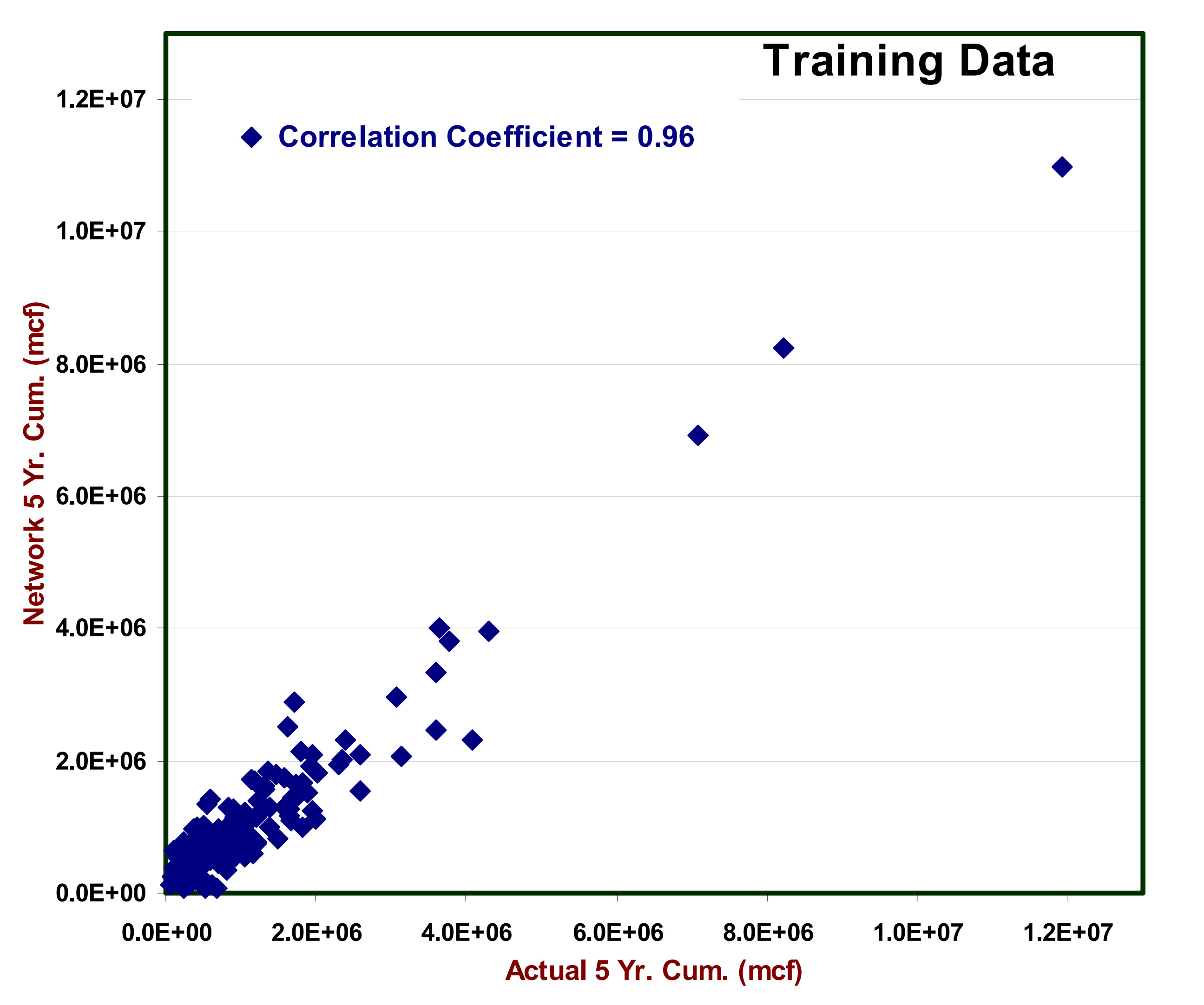
METHODOLOGY



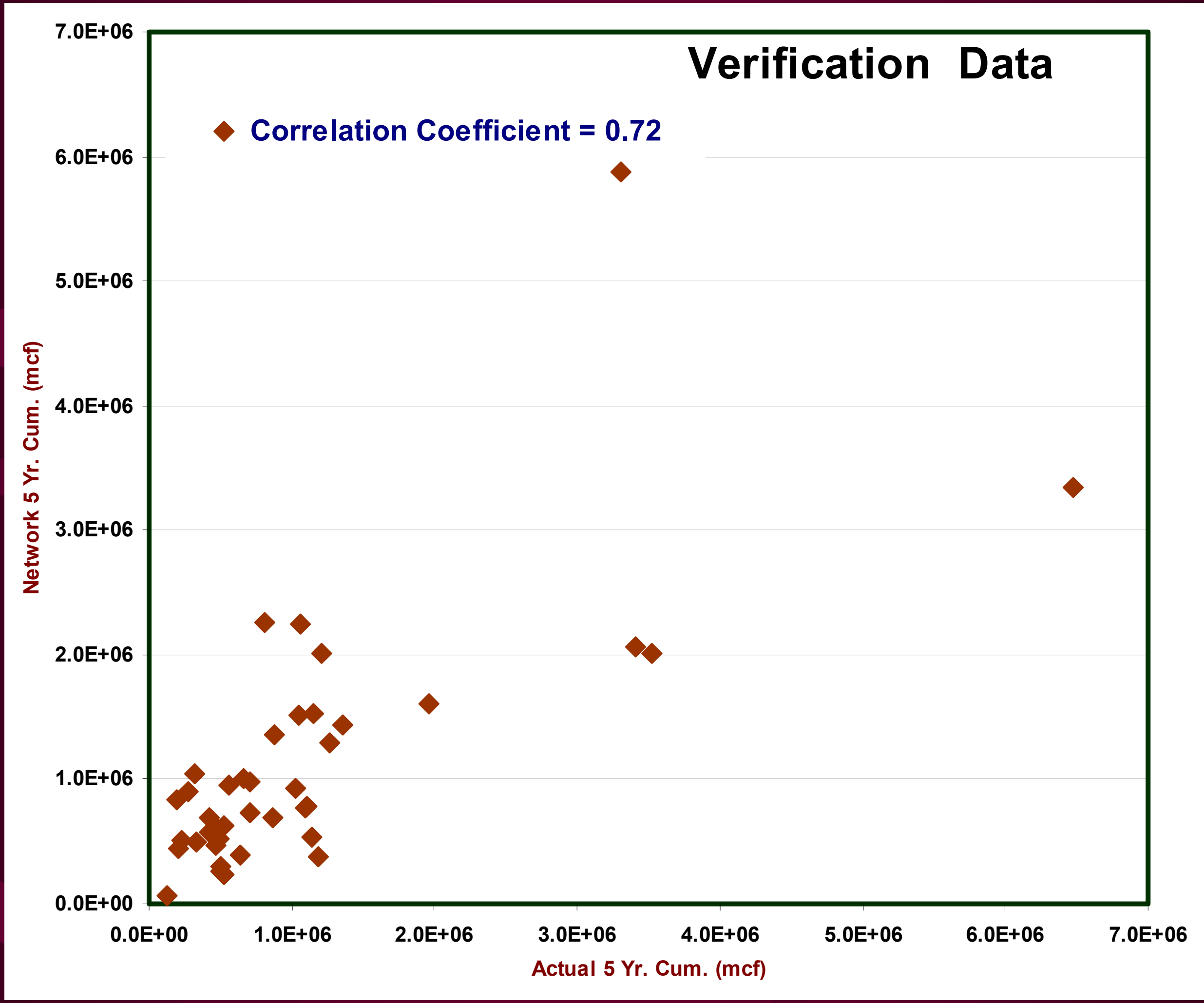
METHODOLOGY

Category	Input Parameter	Comments
Location	X	X coordinates of the well (east-west)
	Y	Y coordinates of the well (north-south)
	KB Elevation	Kelly Bushing Elevation
Reservoir	Permeability	From Type Curve matching analysis
	Drainage Area	From Type Curve matching analysis
	Total Gas-Ft	Sum(Porosity * gas saturation * net pay) (all zones)
Completion	Total H Completed	Total completed thickness (all zones)
	Total No. of Holes	Total number of perforation holes
	Completion Date	Date of well completion
	Number of Zones	Total number of zones completed
Frac	Frac Number	A well may have up to 7 frac jobs
	Fluid type	Gelled oil, ungelled oil, linear gel, cross-linked gel
	Fluid Volume	Total amount of fluid pumped in all fracs
	Proppant Amount	Total amount of proppant pumped in all fracs

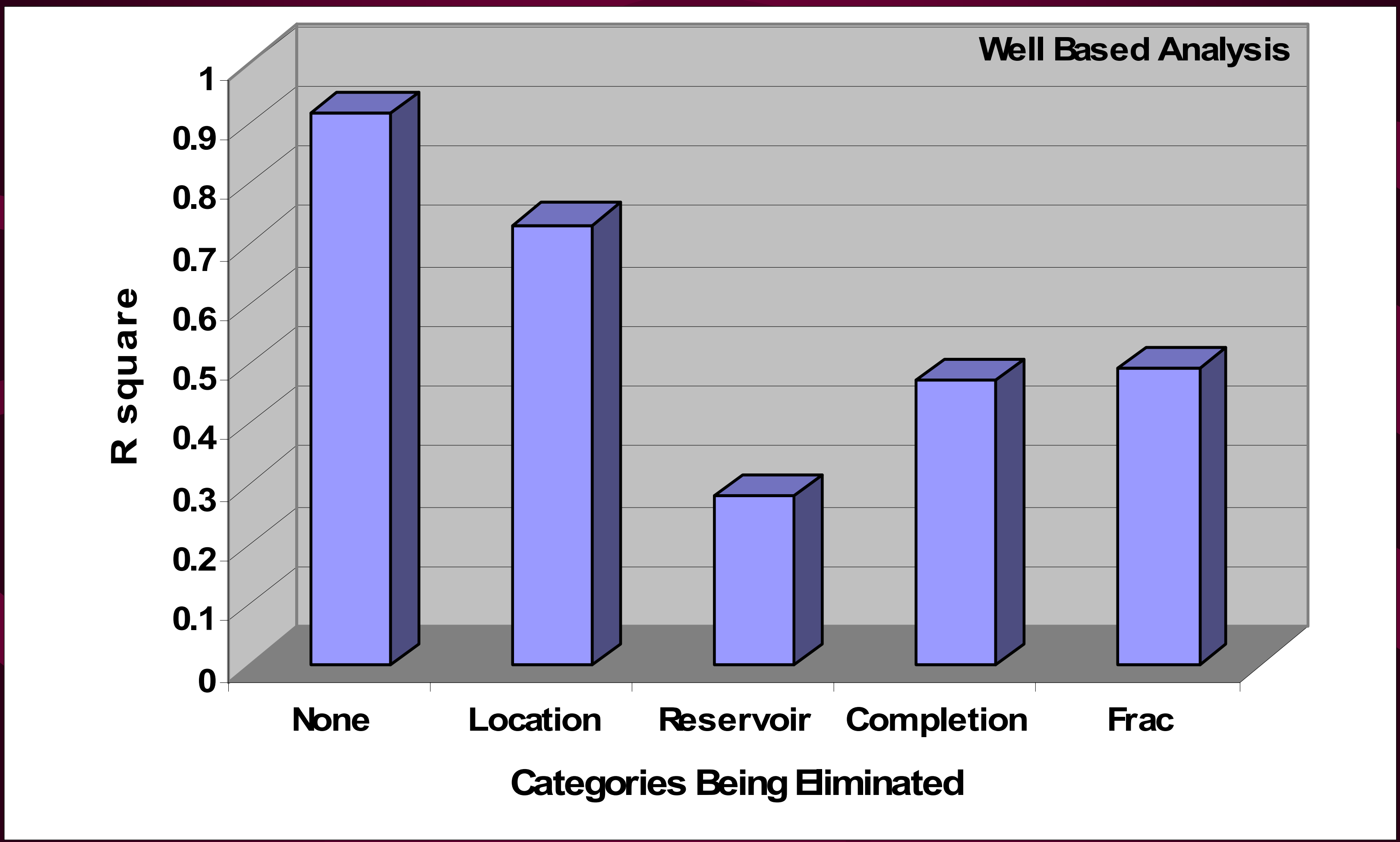
METHODOLOGY



METHODOLOGY



METHODOLOGY



METHODOLOGY

Category	Input Parameter	Comments
Location	X	X coordinates of the well (east-west)
	Y	Y coordinates of the well (north-south)
	KB Elevation	Kelly Bushing Elevation
Reservoir	Permeability	From Type Curve matching analysis
	Drainage Area	From Type Curve matching analysis
	Total Gas-Ft	Sum(Porosity * gas saturation * net pay) (all zones)
Completion	Total H Completed	Total completed thickness (all zones)
	Total No. of Holes	Total number of perforation holes
	Completion Date	Date of well completion
	Number of Zones	Total number of zones completed

Uncontrollable Parameters

Frac	Frac Number	A well may have up to 7 frac jobs
	Fluid type	Gelled oil, ungelled oil, linear gel, cross-linked gel
	Fluid Volume	Total amount of fluid pumped in all fracs
	Proppant Amount	Total amount of proppant pumped in all fracs

Controllable Parameters

METHODOLOGY

$$\frac{\text{Post-Optimization 5 yr. cum.} - \text{Pre-Optimization 5 yr. cum.}}{\text{Potential 5 yr. cum.}}$$

METHODOLOGY

	Pressure			Pressure			Pressure		
	LOW			Medium			High		
Fracs/Zone	**Potential Five Year Cum.**			**Potential Five Year Cum.**			**Potential Five Year Cum.**		
	Low	Med.	High	Low	Med.	High	Low	Med.	High
Low	No T	MayBe fT	MayBe fT	MayBe T	Yes fT	Yes fT	Yes T	Yes VT	Yes VT
Med.	No VT	No T	MayBe fT	No fT	MayBe T	Yes fT	MayBe VT	Yes T	Yes VT
High	No VT	No VT	No T	MayBe fT	No fT	MayBe T	MayBe VT	MayBe VT	Yes T

A sample fuzzy rule.

IF the well has a HIGH potential 5 yr. cum. AND

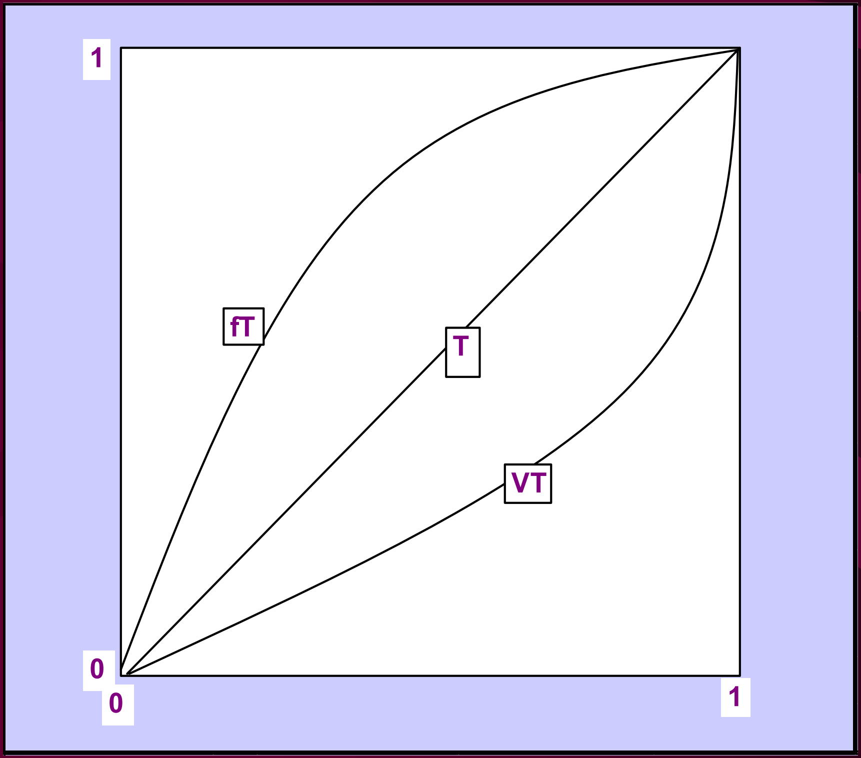
demonstrates HIGH pressure AND

the ratio of the number of fracs per number of zones is LOW

THEN the well IS A CANDIDATE

METHODOLOGY

Approximate Reasoning	
Truth Qualification	
Fairly True	fT
TRUE	T
Very True	V



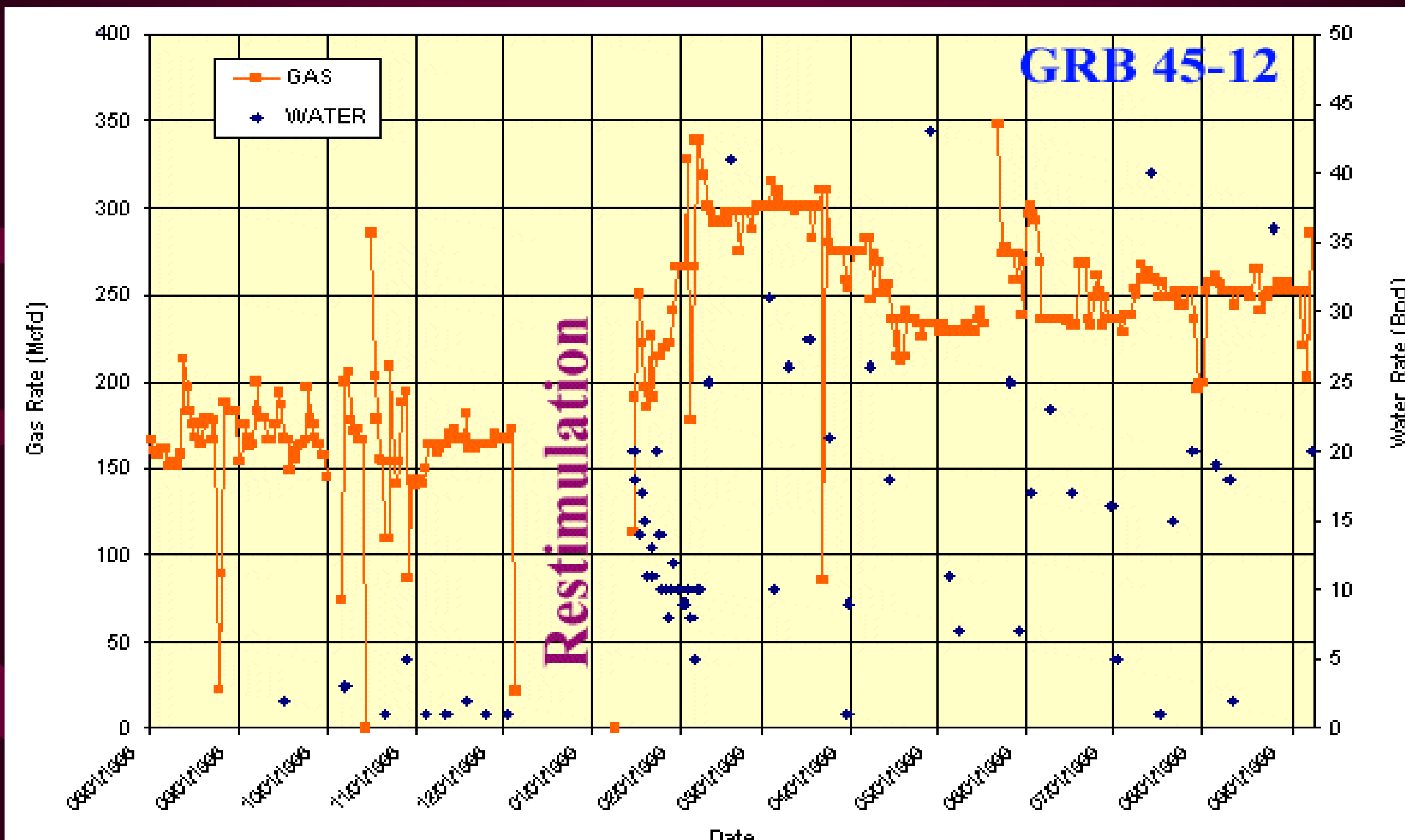
OUTLINE

- Introduction
- Objective
- Background
- Methodology
- Application
- Conclusion

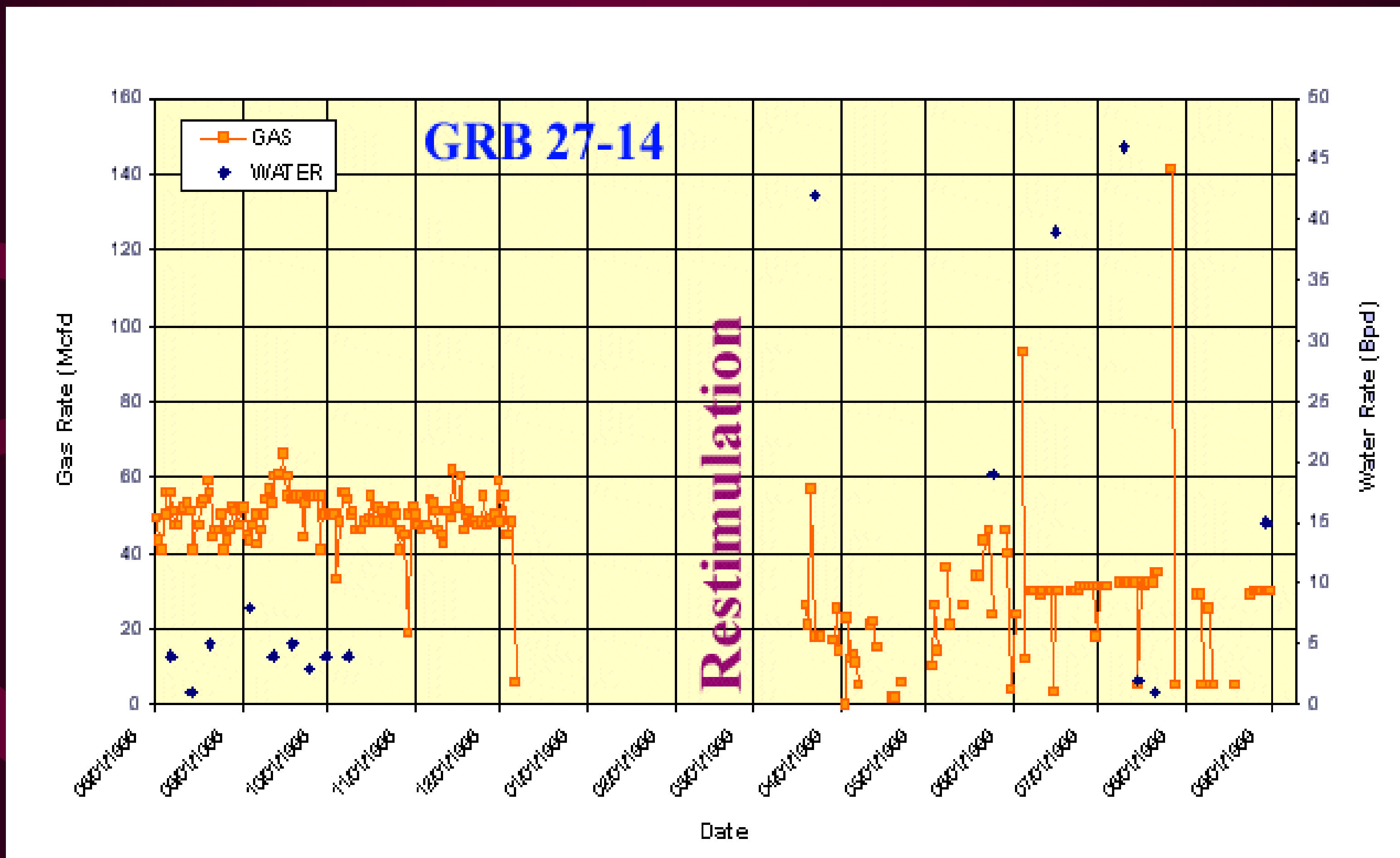
APPLICATION

Candidate Well	Ranking using the new approach
GRB 45-12	20
GRB 27-14	112
NLB 57-33	No Pressure Data
Wells in the analysis	123

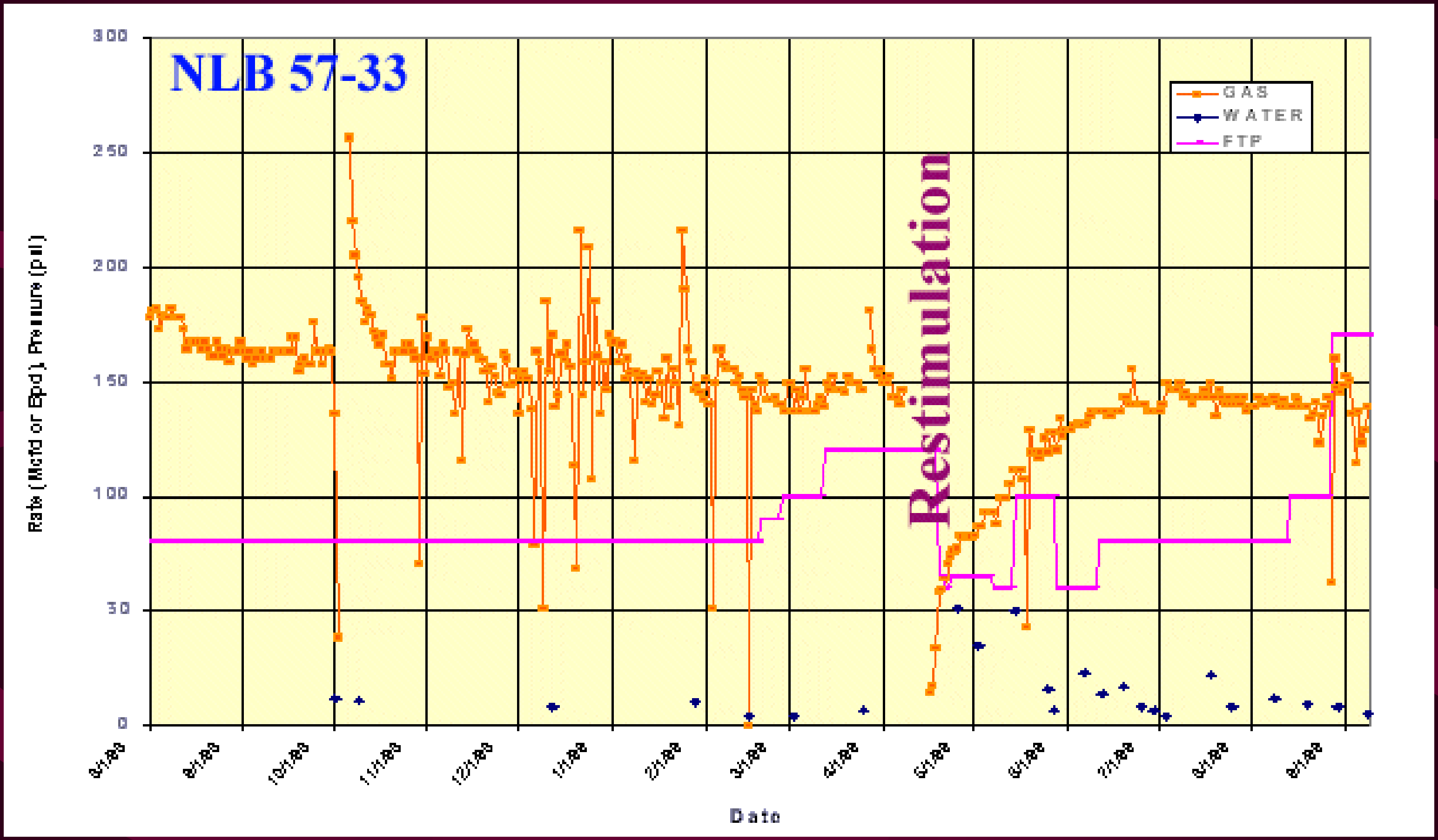
APPLICATION



APPLICATION



APPLICATION



OUTLINE

- Introduction
- Objective
- Background
- Methodology
- Application
- Conclusion

CONCLUSIONS

- Preliminary results indicate that intelligent systems demonstrate good potentials in selecting successful restimulation candidates.
- The tool developed in this study has the potential to learn and grow as the restimulation project in the field proceeds.